UNIVERSITY OF GHANA

COLLEGE OF BASIC AND APPLIED SCIENCES

POST-CERTIFICATION SURVEILLANCE OF MARKETED VEGETABLE SEEDS IN THE GREATER ACCRA REGION FOR SEED QUALITY MAINTENANCE

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WEST AFRICA CENTRE FOR CROP IMPROVEMENT

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By

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(ID. NO. 10602675)

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WEST AFRICA CENTER FOR CROP IMPROVEMENT

JULY, 2018

DECLARATION

I, Ahenkan Kwabena Appiah Radiant, do hereby declare that, except for references to the works of other researchers, which have been duly acknowledged, this thesis is the outcome of my own original study under supervision and has not been submitted elsewhere either in whole or in part for the award of any degree.

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ABSTRACT

Quality seeds constitute one of the basic and the most important inputs in any vegetable crop production endeavour. A post-certification surveillance was undertaken to evaluate the quality of certified imported and local vegetable seeds at commercial retailers' end in the distribution and marketing chains in the Greater Accra Region of Ghana. Structured questionnaires were administered to 18 commercial vegetable seed retailers who constituted the main vegetable seed delivery channels to farmers across the Greater Accra Region of Ghana. Survey data was analysed using SPSS to ascertain vegetable seed retailers' knowledge and experience on certified vegetable seeds and to determine marketing challenges they face in their operations. The results of the survey indicated that, certified vegetable seed retailers were experienced, well-educated and had adequate knowledge on standard procedures and practices related to the seed retailing business. The major problems faced by seed retailers were the lack of proper storage facilities which made them resort to storing seeds at temperatures ranging from 29 to 37 ^{0}C, lack of access to good communication network between them and farmers and complaints about high cost of vegetable seeds due to high import duties. Twenty vegetable seeds were initially sampled from fifteen out of the eighteen retail shops for initial seed quality evaluation at the Seed Testing Laboratory of the Ghana Seed Inspection Division (GSID) of the Plant Protection and Regulatory Services Directorate (PPRSD). Following the first sampling, a second informed selection of eight specific vegetable seeds common to nine retail shops were sampled for another evaluation. Both laboratory evaluations were arranged in a CRD with 4 replications and evaluated for percentage germination, percentage purity, moisture content, seed health and seedling vigour. Data collected from both laboratory evaluations were analysed using Genstat statistical package 12th Edition. Fishers' Protected LSD was used to separate treatment means at 5 % significance level. Results from the laboratory analysis showed that vegetable seed quality were up to the labelled recommended standards for most of the imported vegetable seeds except for eggplant and onion but quality of some locally produced vegetable seeds such as okra and hot pepper were below the labelled recommended values. Poor storage practices and re-packaging of seeds into smaller retail packs were identified to be responsible for the loss in seed quality. The study highlights the need for investments in infrastructure and equipment for maintenance of quality in the marketing and distribution value chain for vegetable seeds. Increase in the production of high quality locally produced vegetable seeds (hot pepper and okra) would ensure availability of these vegetable seeds for end users.

DEDICATION

This work is dedicated to the Lord God Almighty who made me and has brought me this far. May all glory and honour be ascribed to His holy name. Amen.

It is also dedicated to my parents; Rev. Joseph Stanley Ahenkan and Mrs. Cecilia Dufie Ahenkan and to all my siblings.

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LIST OF ABBREVIATIONS

AGRA	Alliance for Green Revolution in Africa
ANOVA	Analysis of Variance
AOSA	Association of Official Seed Analysts
ASTS	Alberta Seed Testing Standards
BUSAC	Business Sector Advocacy Challenge
CRD	Completely Randomized Design
CRI	Crop Research Institute
DAS	Days after Sowing
ECOWAS	Economic Community of West African States
FAO	Food and Agricultural Organisation
GDP	Gross Domestic Product
GLDB	Grains and Legumes Development Board
GSID	Ghana Seed Inspection Division
GSP	Ghana Seed Policy
IFDC	International Fertilizer Development Centre
ISHI	International Seed Health Initiative
ISTA	International Seed Testing Association
LSD	Least Significant Difference

MoFA	Ministry of Food and Agriculture
NGO'S	Non-Governmental Organizations
NSHS	National Seed Health System
NSS	National Seed Service
NSTA	National Seed Trade Association
NSTL	National Seed Testing Laboratory
OPV	Open Pollinated Variety
PASS	Program for Africa's Seed Systems
PPRSD	Plant Protection and Regulatory Services Division
QDS	Quality Declared Seeds
SARI	Savannah Agricultural Research Institute
SME	Small and Medium Enterprises
SPSS	Statistical Package for Social Sciences
SRID	Statistics, Research and Information Directorate
SSA	Sub-Saharan Africa
UPOV	International Union for the Protection of New Varieties of Plants
US	United States
WACCI	West Africa Centre for Crop Improvement
WCA	West and Central Africa

CHAPTER ONE

1.0 INTRODUCTION

Vegetables are essential crops due to their high yield potential and nutritional importance and an important component of our daily dietary intake (Slavin and Lloyd, 2012). They are relatively rich sources of vitamins and minerals, which are crucial for the maintenance of a healthy life and resistance against diseases (Oguntibeju *et al*., 2013). According to MoFA's Statistics, Research and Information Directorate (SRID), tomato, onion, okra, eggplant, green pepper and beans are the main vegetables cultivated and consumed in Ghana (MOFA, 2014). Of these vegetables, tomato and onion are the two most-consumed vegetables.

Vegetable productivity is influenced by the use of quality seeds (Mymensingh, 2001). Therefore, seeds constitute one of the basic and the most important inputs in any vegetable crop production endeavour. The use of high quality seeds constitute the primary factor for increasing crop yield without necessarily increasing land area. All other inputs like fertilizers, pesticides and improved implements will be of no effect unless accompanied by improved quality seeds (Mymensingh, 2001). Stressing on the importance of vegetable seeds, Tripp (2001), stated that vegetable seeds constitute the most cherished resource for vegetable growers and the sustainability of this agricultural system mainly pivots on the diversity and stability of the vegetable seed supply system. Therefore, ensuring the quality of seed of any crop variety is key to improving its productivity (Louwaars and De Boef, 2012). In relating good quality seeds to good crop establishment, Shetty (2000) specified that good crop establishment is directly accomplished by the quality of seeds employed.

In Ghana, seeds for planting are acquired from two main sources: those from the formal seed system established from a well organised and structured seed value chain, produced under certification and quality control with the needed checks and balances to ensure availability of quality certified seeds, and those from the informal seed system, usually farmer saved seeds which are usually not produced under stringent seed certification controls.

There are two types of vegetable seeds available in the Ghanaian vegetable seed market: Open-pollinated and hybrid varieties (Saavedra *et al.*, 2016). Most farmer-saved seeds are open-pollinated. Hybrid seeds have improved characteristics but are not extensively available. Currently in most African countries including Ghana, vegetable seeds being imported are hybrids. Vital issues that breeders consider when adapting improved varieties are climate requirements, soil requirements and resistance to damages by diseases, insects and other pests. The formal vegetable seed system in Ghana is characterized by a vertically organized distribution imported certified seeds of preferred varieties by private seed companies using agreed quality control mechanisms. Certified vegetable seeds imported to Ghana are supervised by The Ghana Seed Inspection Division (GSID) of the Plant Protection and Regulatory Services Directorate of the Ministry of Food and Agriculture (PPRSD of MoFA) who are mandated to ensure quality standards are met by the importers. Although low amounts of certified seeds are produced by the formal seed sector in Ghana, the sector continues to be an important source of assured good quality high yielding seed to farmers.

One of the limitations of vegetable seeds is that a significant part of the data concerning agronomic performance, yield, infection, resistance and most importantly quality, are related to assumptions and at any point, subject to thorough assessment (FAO and Accademia dei Georgofili, 1998).

One of the ways in which the National Seed Certification Agency ensures seeds of high quality are made available to farmers is to ensure that quality tests such as Seed health tests, germination tests, seed purity tests among others are carried out on seeds produced or imported and delivered to farmers by suppliers.

Nevertheless, these initial tests may not provide sufficient assurance that the seeds would reach the farmer (end user) in the same condition as it moves through the seed supply chain. Delays in seed delivery and how the seeds are stored (in transit and at the retailers' end) can have significant negative effects on the seeds (FAO, 2010). According to Krausova and Banful (2010), the Greater Accra Region of Ghana represents one of the regions recorded to have a significantly higher percentage of agro-dealers selling improved seeds with majority of these improved seeds being vegetables, hence the need for quality seeds in this region. It is therefore necessary that investigations are done as a check on seeds especially at the retailers end. This is referred to as post-certification surveillance, which is often not tracked by the certifying agency owing mainly to limited staff availability.

The objective of this research was to evaluate the quality of certified vegetable seeds at the commercial retailers end in the distribution and marketing chains in the Greater Accra Region of Ghana to ascertain the quality of vegetable seeds that end up with farmers for planting.

Specifically, the study sought to:

(1) Ascertain vegetable seed retailers' knowledge and experience on certified vegetable seeds.

(2) Assess the quality of certified vegetable seeds.

(3) Determine the vegetable seed marketing challenges faced by commercial vegetable seed retailers.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition and Concepts of Seeds

2.1.1 Seeds as Agricultural Inputs

Seed is a sexually produced matured ovule which is made up of an intact embryo, endosperm and or cotyledon with protective testa or, the part of a plant from which a new plant can be grown or an essential input in crop production (Bajrang, 2008).

It is a fundamental agricultural input, and access to preferred and well-adapted seeds is a requirement for sustainable agricultural production (Sperling and McGuire, 2010). The availability of quality seed buttressed by other services and inputs is important for increased crop yield and agricultural productivity and most often guarantee food security. Good supply systems of quality seeds ensure farmers' or households sustained ability to sufficient quality of the desired types of seed at the right time (Kiwanuka and Kintu, 2004).

Tripp (2001) asserted that seeds represent a key technological component for the improvement of agricultural productivity. Seeds are likewise depicted as the most valuable asset of farmers, and challenges facing sustainability is linked directly to the variety and stability of the seed supply system (Tripp *et al*., 2001). The use of good quality seeds by Ghanaian farmers can drive Ghana's economic and agricultural growth to achieve food security and increased nutrition for its citizenry.

2.1.2 Vegetable Seed Sources

Of all farm inputs, high-quality and adapted seeds and planting materials exert the most profound influence on agricultural productivity. A wider appreciation of the importance of quality seeds and their crucial role in agricultural and human development cannot be over-emphasized (Scowcroft and Scowcroft, 1998; Lanteri and Quagliotti, 1997; Cromwell *et al*., 1993). There are two types of vegetable seeds available in the Ghanaian vegetable seed market: Open-pollinated and hybrid varieties (Saavedra *et al*., 2016). Because they breed true, the seeds of open-pollinated plants are frequently kept by small-scale farmers. Hybrid seeds produced by breeders are likely to have improved features but are not extensively available. Currently in most African countries like Ghana, hybrid seeds are still being imported. Exotic vegetables such as cucumber, cabbage and lettuce have gradually become common in many Ghanaian diets and grow very well almost throughout the year; but farmers barely come by the approved quality seeds of these vegetables for cultivation (Saavedra *et al*., 2016).

According to farmers, The United States Agency for International Development (USAID) through the Ministry of Food and Agriculture (MoFA) is the fundamental source from which they can obtain quality vegetable seeds at subsidized prices. Nevertheless, the supply of such seeds have been frozen. Farmers therefore are compelled to depend on some few private outlets who sell seeds at exorbitant prices and most often when such seeds are planted they fail to grow well due to reduced quality (GhanaWeb, 2013).

This observation informed a BUSAC-funded research to determine the severity of the challenge, which showed that about 95 % of Ghanaian vegetable farmers recycle seeds from their own produce every season (GhanaWeb, 2013). This situation has affected the quality and quantity of exotic vegetable yields, especially carrots and cauliflower produced locally. As a result, the farmers primarily sell to expatriates thereby reducing the quantum apportioned for public consumption by the open market.

The outcomes of BUSAC disagrees with a research by the World Bank which revealed that up to 50 % of crop yield proliferations have come from improved certified seeds. However, farmers' access to quality seeds is a crucial factor in increasing food yield and nutrition in poor and developing countries (GhanaWeb, 2013).

2.2 Seed Quality

Seed quality is a measure of excellence of a seed lot with reference to standards. A seed lot (a specified quantity of seed that is physically and uniquely identifiable) is said to be of high quality if it is genetically pure, healthy, free from all inert materials, other crop seeds and objectionable weed seeds, with high germination capacity and vigour up to the recommended standards and is uniform in texture, structure and appearance. Seed quality is a multiple concept comprising varietal (genetic) purity, physical (analytic) purity, physiological quality, germination capacity, moisture content, seed vigour and seed health. Hampton (2002) defined seed quality as the overall worth of seed for its intended purpose and the performance of the seed measuring up to the expectations of the end user. This implies that if a seed lot meets the certification and quality standards of a country, it is good quality seed and if it does not meet the certification and quality standards, it is obviously of a lower seed quality (Copeland and McDonald, 1995).

The quality of seeds is considered as an imperative factor in expanding yield. The utilization of high value seeds helps to increase production per unit area.

2.3 Seed Quality Characteristics

Seed quality evaluates a group of components of seed believed to be important for the assessment of quality for propagating purposes (Esbo, 1980).

Thompson (1979) outlined ten seed quality attributes with varying degrees of practical significance to agriculture comprising analytical purity, species purity, freedom from weeds, genetic purity, vigour, size, uniformity, germination capacity, seed health and moisture content. The International Seed Testing Association (ISTA, 1985) occasionally publishes standard procedures for seed quality assessment which are internationally accepted.

Seed Quality can be grouped into four (4) main classes as follows:

- Physical/Analytical quality of the seed in a particular seed lot.
- Physiological quality which refers to aspects of performance and activity of the seed.
- Genetic quality which has to do with specific genetic features of the seed variety.
- Pathological quality which refers to the presence of diseases and pests within a seed lot.

At the point where the seed possesses great physical, physiological, genetic and pathological qualities, farmers have more remarkable prospects of delivering a decent product. Quality seed is crucial in attaining a good yield, plant stand and quick plant advancement even under stressful conditions although different factors, for instance, agronomic practices, soil quality and disease and pest control are likewise critical.

2.3.1 Physical Quality

Physical seed quality refers to the percentage pure seed of the desirable crop in a seed lot. Size of the seed is sometimes taken into consideration in pure seed definitions. It is measured by certain components such as moisture content, size, appearance, colour, insect infestation and presence of other undesirable materials such as inert matter, objectionable weed seeds among others (Hasanuzzaman, 2015).

Physical purity which is also called Analytical purity is an indication of the seeds of the species under test in the sample and also the amount of foreign materials contained in the sample in the form of other seeds. The purity attributes are mostly expressed as a percentage by weight of the seed sample analyzed (Scott, 1980).

The pure seed component of physical purity relates to the species specified by the source or the species predominantly discovered in the test. This pertains to all botanical varieties of that species. Other seed component indicates the seeds and seed-like structures of any plant species other than the pure seed component (Hasanuzzaman, 2015).

Certain species of weed seeds which are not universally present on all farms and which when established are difficult to do away with are known in physical purity terms as “Noxious” weeds.

Materials such as straw, chaff, dirt, stones, broken seed pieces or physically injured seeds that are less than half of the original size, dust and gall are separated as the inert matter portions (Thomson, 1971; ISTA, 1985).

The moisture content of a sample is the weight loss of the sample after drying or the amount of water amassed after it is distilled. This is calculated and expressed in percentage of the weight of the original sample.

2.3.2 Physiological Quality

Seed germination and seed vigour are attributes that are related to the physiological quality of a seed lot. The liveliness of a seed is referred to as viability. The capacity of the seed for production of seedling with standard root and shoot under nonthreatening conditions is referred to as germinability (Vikaspedia, 2018).

According to Hasanuzzaman (2015), the ability of a seed to germinate includes factors such as germination capacity, viability, vigour and other characteristics related to seed dormancy.

The significance of physiological quality can't be over emphasized. Seed can only satisfy its natural role when it is viable. Accordingly, physically uniform seed of an adapted variety will be useless if it is low in germination and vigour.

Greatest potential for germination and seed vigour occurs when seeds are physiologically matured; in any case, such seeds have high water content which affects automated harvesting (Marcos Filho, 2005). After physiological maturity, seed quality begins to reduce through the normal procedure of decay (Krzyzanowski *et al*., 2008), particularly when harvesting is postponed and furthermore under adverse climatic conditions.

Seed germination is dependent on conditions which are both internal and external. The most vital external factors include; air or oxygen, water, optimum temperature and in some instances, darkness or light (Raven *et al*., 2005). For a few seeds, their future germination reaction is affected by natural conditions amidst seed development resulting in some form of seed dormancy.

The germination rate portrays what number of seeds of a specific plant species, i.e. variety or seed lot, are most expected to sprout or grow over a specified time frame. It is a measure of germination time and is usually communicated as a percentage, e.g., an 85 % germination reveals that about 85 out of 100 seeds will most likely grow under normal conditions over the given germination time-frame.

The germination rate is needful in the estimation of seed prerequisites for a given area or the required number of plants on the field. To seed physiologists and seed researchers, "germination rate" is the corresponding estimation of time taken for the germination to occur and end starting with time of sowing. Then again, the quantity of seeds ready to complete germination in a populace (i.e. seed lot) is alluded to as the germination capacity of the populace.

Historically, seed quality has been synonymous to germination; the main purpose of germination testing being to bring forth knowledge about the planting worth of the seed lot.

According to Rickman *et al*. (2006), normal and abnormal seedlings are counted on the tenth day after planting to determine the germination percentage. Normal seedlings were defined by Schenidt (2000) as the seedlings which develops with all essential structures and abnormal seedlings as those that sprout during the assessment period but lack important structures such as cotyledons or are discoloured or infected by seed-borne pathogens.

Viability is the term given to seeds which possess the ability to sprout and give rise to normal seedlings. This reference is used synonymously with germination capacity. In this sense, a given seed is tagged as being viable or non-viable depending on whether or not it is able to germinate and create seedlings with normal attributes (Hasanuzzaman, 2015).

Germination at the right time and in the right place is very essential to presume and determine the probability of a seedling surviving to maturity (Thompson, 1979).

Seed vigour is defined as the capacity of a seed to emerge from the soil and survive under potentially stressful conditions and to grow rapidly under favourable conditions.

Certain theoretical parameters which have surfaced making clear the meaning of vigour in terms of seeds, seedlings and plant performance include: speed of germination, uniformity of germination and plant development under non-uniform conditions, wet and pathogen-infected soil, normal morphological development, germination and seedling emergence from cold temperatures and storability under optimum or adverse conditions.

Seed vigour provides a very good estimate of the potential field performance, and subsequently, the field planting value of a seed. Rickman *et al*. (2006) also reported that though the speed of germination varies across varieties, the seed is considered to have germinated if the seeds absorb moisture and produce roots and the first leaf within 5 days.

By knowing the seed vigour of a seed lot, farmers can then decide whether a seed lot is suitable for continued storage or for immediate planting (Tokpah, 2010).

The inability of a seed to germinate is the final step in a long process of deterioration (gradual loss of viability). Reduced seed vigour and other physiological changes happen before loss of germination. Thus, seed with acceptable germination may be low in vigour.

2.3.3 Genetic Quality

Genetic purity is the percentage of contamination by seeds or genetic material of other varieties or species. The genetic purity of any commercial agricultural product propagated by seed commences with the purity of the seed planted (Seedquest, 2015).

The genetic quality of a seed lot is determined by the inherent plant characteristics that result from the genetic potential of the embryo. Crops developed by seeds of a variety offer the same features and these characteristics are reproducible from one generation to another. Seed of varied varieties of the same crop are often difficult or not so easily distinguishable once it is harvested. A mixture of different varieties of the same crop or species can occur when the seed is sold and enters into the formal and informal marketing systems.

A blend of varieties can be an issue in light of the fact that: mixed varieties may develop at various circumstances which bring about issues in harvesting, post-harvest handling, and brings about reduced yields.

Moreover, each seed of an undesired variety in a mixture will create seed when it is sown and those seeds will give rise to more seed and consequently, the undesired variety ends up being more prominent.

It should however be noted that conventional varieties or landraces especially of cross pollinated varieties utilized by subsistence farmers are frequently from populations of plants that are not extremely uniform. This heterogeneous character can be advantageous under certain conditions such as low precipitation, low fertility and pest and disease pressure.

High yielding capacity of a plant is associated with a scope of plant attributes including how the plant is engineered, how it utilizes supplements, its adaptation to local conditions and its ability to tolerate pests and disease attacks. Increased yields implies more nourishment and provides income for farmers.

Maintenance of cultivar purity is the significant purpose behind the presence of the seed accreditation scheme (Scott and Hampton, 1985), and the smooth operation of the scheme depends on seed producers and seed traders adhering strictly to the right strategies.

2.3.4 Pathological Quality

Pathological quality sometimes referred to as seed health quality is the presence or absence of disease in or on the seed.

The disease-causing organisms present themselves in various forms such as bacteria, fungi, viruses, and animal pests, including insects and nematodes on or in the seed although conditions such as trace element deficiencies may also be involved (ISTA, 1985).

ISTA (1985) grouped the organisms that are commonly associated with causing diseases to seeds, seedlings and crops into five (5) categories, although some other diseases may result from inefficiencies of plant nutrients. Mechanical damage has also been found to impair seed quality.

The five (5) groups of organisms include;

- Fungi
- Bacteria
- Viruses
- Nematodes

- Insects

Fungi may assume an overbearing part in affecting the nature of seeds. About 150 species have been discovered in relation to grain seeds of different sorts. Fungi relationship in seeds will most likely be on the higher side in regions where the wet season prevails at the time of harvest or atmospheric humidity stays high amid the development of the seed. (Dharamvir, 1974).

Santos *et al*. (2016) also stated that improper storage management and crop husbandry can increase the incidence of fungal infection.

Bacterial diseases occur often in areas where high dampness or wet climate prevails amid the time reproductive organs are developed (Ghini *et al*., 2008). Numerous microscopic organisms that cause diseases in seeds are seed-borne.

Ghini *et al*. (2008) also noted that viral infections resulted in yield reductions of about 75 % in wheat and 64 % in barley.

Most diseases caused by nematodes are related to soil infections yet a few are seed-borne. Insects cause quantitative and qualitative losses to seeds placed in storage. Commonly found insects in storage include weevils, grain borers, grain moths and beetles among others.

2.4 Seed Testing

Seed testing is the science of evaluating the quality of seeds to determine their value for planting.

Seed testing is undertaken to assess the attributes of a seed lot and determine overall quality and value for the production and storage of seedlings. Standards for seed testing are based on scientific evidence and provide set procedures for facilities to conduct tests in a uniform manner and ensure comparable results for seed owners (ASTS, 2016).

Seed testing is essential for the assurance of the quality of seeds based on various seed quality characteristics. It gives a premise to cost and purchaser discrimination among seed lots and seed sources, decides the source of seed problems, encourages any restorative measure(s) that might be required and satisfies the legal and administrative requirements for certified seed classes by taking into consideration the movement of seeds across international boundaries. Strategies and benchmarks for performing seed testing for most crops are established by the International Seed Testing Association (ISTA). The methodology and measures are intermittently updated in light of new scientific proof.

According to the FAO four assessments are ordinarily conducted in seed testing laboratories. These include;

- Purity test
- Incidence of noxious weed seeds
- Germination test
- Moisture content.

Other seed tests carried out also include,

- Seed Vigour
- Varietal purity, and
- Seed Health Test.

2.4.1 Physical Purity Test

Physical purity test which is also recognized and referred to as analytical purity is the total percentage of the seed that is of an identical crop but not necessarily the same crop variety. The purpose of purity analysis are to determine the percentage composition by weight of the sample being tested and to identity the various seed species and inert particles constituting the sample. Pure seed refers to a constituent component obtained from sampled species stated by the applicant for seed purity analysis by a seed testing laboratory, or that component of a sample after analysis in the laboratory found to be predominant in the sample tested. It includes all botanical varieties and cultivars of that species (immature, undersized, shrivelled disease or germinated seed of a particular species) unless transformed into visible fungal sclerotia, smut balls or nematode galls (ISTA, 2013).

Pure seed therefore includes the following:

a) Intact seed units (commonly found as dispersal units i.e. achenes and similar fruits, schizocarp, florets etc.) as defined for each genus or species.

b) Pieces of seed units larger than, one half their original size, (ISTA, 2013).

The purity of a seed lot may be viewed from two angles: genetically and physically. Genetic purity of seeds refers to the trueness to type while physical purity of a seed lot refers to the physical composition of the seed (Anon., 2009). Physical purity analysis refers to the determination of the percentage composition by weight of the sample being tested and by inference the composition of seed lot and the identity of various species of seeds and inert particles constituting the sample (ISTA, 2013). Genetic purity refers to the percentage of contamination by seed or genetic material of other varieties or species (Seedquest 2015)

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).

2.4.2 Incidence of Noxious Weed Seed

This is an extension of purity test (analytical test) to indicate the degree of incidence of certain weed seeds which are considered dangerous to productivity and this test is normally selected by decree or by official guidelines.

2.4.3 Seed Germination Test

Germination is the emergence and development of the seedling to a stage where the 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 (ISTA, 2015). Germination of a seed can also be defined as the emergence and development from the seed embryo, of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favourable conditions (AOSA, 1999). This is to quantify the capacity of the seeds to sprout and create ordinary seedling.

The objective of a standard germination test is to determine the germination potential of a seed lot. The standard germination test is designed to provide a first and a final count. The purpose of the first count is basically to determine the strong seedlings (vigour) that have germinated and the final count is to provide a sufficiently long period that even weak seeds are provided every opportunity to be considered germinable (Byrum and Copeland, 1995). Germination percentage is the sum of strong and weak seedlings (Byrum and Copeland, 1995).

Four categories of standards are perceived by the International Seed Testing Association (ISTA, 2013) for seedlings which are deemed abnormal. These are, (a) damaged seedlings, (b) deformed seedlings, (c) decayed seedlings, (d) seedlings with unusual hypocotyl formation. These categories and their attributes are characterized in detail in the ISTA rules. In a laboratory test, most of the normal seedlings are generally expelled at the interim counts, yet the evaluation of the numerous unsure and abnormal seedlings must be left until the point that the test is concluded, to ensure that passively developing yet otherwise normal seedlings are not inaccurately characterized.

2.4.4 Moisture Content

The moisture content of a seed is the value of weight loss in the seed sample when it is dried. Moisture is expressed as a percentage of the mass of the genuine sample. It is one of the most significant factors with the aim of maintaining seed quality.

There is an immediate relationship between deterioration rates and moisture content, fungal attack, insect infestation level, susceptibility to mechanical damage and storability. However, this is not a compulsory test with a standard seed testing.

There are a few factors which are more essential to the quality and function of seed than moisture content. Moisture content is related to seed component and its function, including maturity, timing of the harvest, susceptibility to mechanical injury during threshing or handling, longevity in storage and injury due to heat, frost, fumigation, insects and pathogens. Due to this, moisture content is perhaps the most significant factor in the determination of the time seed is harvested, how it is handled after harvest and how long it can maintain its quality (Elias *et al.*, 2012).

With a specific end goal to quantify the moisture content of seeds, strategies can be extensively categorized in two classes: Direct technique and Indirect techniques.

2.4.4.1 Direct technique

Under this group, the seed moisture content is calculated directly by fall or rise in seed weight. These are:

- Desiccation method
- Oven-drying method
- Vacuum drying method
- Distillation method
- Karl Fisher's method
- Direct weighing balance
- Microwave oven method

2.4.4.2 Indirect technique

The indirect method is somewhat inaccurate; estimation is approximate but convenient and fast to use. They are, much of the time utilized at seed processing plants. This strategy can be utilized to test other physical parameters like electrical conductivity or electrical resistance of the moisture present in the seed. Qualities are measured with the assistance of seed moisture meters and these values are changed into seed moisture content with the assistance of calibration charts against standard air-oven strategy or basic reference technique for every species

The Karl-Fisher's technique has been regarded as the most accurate and the essential reference technique for standardizing different strategies for seed moisture determination. The constant temperature oven drying technique is the main useful technique recommended by International Seed Testing Association (ISTA) and other associations to be used for routine seed moisture determination in a seed-testing research facility.

The constant temperature oven drying method is broadly grouped into two categories:

- Low Constant Temperature Oven Method and
- High Constant Temperature Oven Method.

The suggested technique for seeds of the species rich in oil content or unstable substances is known as the low constant temperature oven technique. In this technique, the measured weights of moisture bottles alongside seed material are set in an oven upholding a temperature of 103 °C for about 17 hours ± 1 hour.

The relative humidity of the surrounding air in the research facility must be under 70 percent when the moisture content determination is being assessed.

For the high constant temperature oven technique, temperature of the oven is kept at 130 °C-133 °C with no distinct prerequisite regarding the relative humidity of the surrounding air in the facility during the determination of moisture in seed moisture testing.

2.4.5 Seed Vigour

ISTA (2013) defined seed vigour as the sum total of all those properties of the seed that determine the potential level of activity and performance of the seed or seed lot of acceptable germination and emergence in a wide range of environments. Thus a vigorous seed lot should perform well even if environmental conditions are not optimal for growth. Byrum and Copeland (1995) defined seed vigour as the sum of those properties that determine the activity and performance of seed lots of acceptable germination in a wide range of environments. The importance of a seed vigour test is to provide information about the planting value of seed lots in a wide range of environments and also on the storage potential of the seed (ISTA, 2013). Seeds with low vigour will show stunted growth and abnormalities in the developing shoot and root system and subsequently affect crop establishment (Caddick, 2007).

2.4.6 Varietal Purity

Varietal purity describes the proportion of the pure seed that will bring about plants which display the attributes of that particular crop variety. The most perfect method to decide the varietal purity is during field review when the seed is being produced.

On demand of a variety authentication trial, then seed samples are grown in plots alongside the plots of the known crop varieties. Observations are conducted from early seedling growth through pollination and seed development to confirm if the seed is the specific crop variety.

2.4.7 Seed Health Test

Standard principles and methodology are employed by mycologists and phyto-pathologists to figure out the presence of seed borne diseases and pathogens.

Seed health is the presence or absence of disease causing living beings, for example, fungus, nematodes, microscopic organisms, infections and creepy crawlies, and furthermore to the status of seeds in a seed lot (Mathur and Kongsdal, 2003).

A large number of high yielding varieties have exhibited susceptibility to various diseases which are seed borne. The developing seeds, also known as the seed primordia, may become contaminated either directly from the tainted plant, through the flower or fruit stalk and the seed stalk or directly from the surface through the testa or seed coat of the seed. The disease might also be presented from the outside through the stigma or ovary wall or pericarp and the flower or fruit stalk by a pathogen.

To guarantee that seed health tests are standardized and give solid and reproducible outcomes as per the given specifications of the test techniques, strategies ought to go through a peer review system and additionally, cooperative investigation among laboratories. Three essential associations publish standardized seed health tests: The International Seed Testing Association (ISTA), the International Seed Health Initiative (ISHI) and the U.S. National Seed Health System (NSHS) (Gullino and Munkvold, 2014).

ISTA technique approval basically inspects a seed quality test to guarantee that the depiction of the strategy is clear and complete and that the method gives exact, reproducible and repeatable outcomes (Hampton, 2007).

2.5 Seed Certification

Seed certification is a systematic process, whereby an independent agency monitors and supervises activities related to the production of seeds in line with minimum standards throughout the stages of seed production. It is system based on legislation for quality control of seeds throughout production and/or multiplication, processing and distribution.

Seed certification is one of the crucial mechanisms that ensures that farmers are provided with good quality seeds (Nishikawa, 2010). Since, farmers have issues evaluating the physical or hereditary characteristics of seeds before they are planted and developed, accreditation of seed quality is fundamental to give buyers quality confirmation and a method for review if desires are not met (Alemu *et al*, 2010).

Seed certification officers are responsible for registering seed growers and seed retailers. It is also part of their duty to inspect fields of seed growers to ensure that they are in line with all seed regulations and guidelines. The primary role of the Ghana Seed Inspection Division is laboratory testing of seeds to ensure that it meets the minimum standards in terms of purity and germination (Etwire *et al*., 2013).

2.6 Seed Marketing

Seed marketing in a formalised system can be direct from seed producer to farmer, or through a chain of actors including merchants, distributors and agro-dealers (ACB, 2012). It forms the very core of a successful seed industry. Seed marketing should aim to satisfy the farmers' demand for a reliable supply of improved seed varieties at affordable prices (Sirisha and Babu, 2014). Seed marketing connects producers to seed users through a continuum of intermediaries. It provides a two-way network: a forward linkage from seed producers and breeders to farmers, serving to convey the results of research and extension to farmers; and a backward linkage serving to send feedback from the users of the variety to the seed producers, breeders and extension agents on the usefulness or otherwise the product (National Seed Policy, 2013).

Farmers' satisfaction and subsequent sustainability of a vibrant seed market depends on a number of attributes including but not restricted to:

- The price of the seed,
- Timelines of availability,

- Appropriateness of the size and packaging
- Varietal and physical qualities,
- Need for and availability of complementary services, and
- Yield potential of the variety (National Seed Policy, 2013).

In Ghana, government and private sector (seed companies, agro input dealers, individual farmers and NGO`S) participate actively in seed trade and marketing. Advocates of the Green Revolution debate that agro-dealer networks remain the most suitable channels by which seeds are marketed.

Subsequently, this has become the focus of AGRA, which asserts to have trained more than 15, 000 rural agro-dealers under its PASS programme (AGRA, 2013).

The International Fertiliser Development Centre (IFDC), another main actor in the industry is undertaking projects on agro-dealer networks in thirteen countries in SSA (IFDC, 2015).

Seed merchants in Ghana have minimal issues in advertising their seeds. Key witnesses uncovered that agriculturalist, co-agent social orders and NGOs as a rule like to acquire their seeds through government offices as a result of their apparent closeness to farmers in the remote regions. The significant seed advertising issue is that the seed framework is ruled by the agriculturists' routine with regards to reusing seeds. Farmers do not promptly purchase enhanced seeds in light of the fact that a large portion of them cannot stand to pay about US$ 1.00/kg as the cost of guaranteed seeds. One of the deterrents to the buying of enhanced seeds is the farmers' powerlessness to purchase the chemical fertilizer required for the enhanced seeds to achieve the full yield potential (Tahirou *et al*., 2009).

However, educating farmers on the utilization of improved seeds have achieved some level of adoption (Alhassan and Bissi, 2006). To increase adoption rates among farmers in Ghana, seed companies should promote some new and high yielding vegetable seed varieties that possesses more climatic features. Again, seed companies may have to reduce package sizes for vegetable seeds to make seeds more attractive and economically viable for farmers.

2.7 Seed Transportation and Distribution

There is awareness that the increasing movement of seed cultivars around the world provides an avenue for the spread of crop pathogens (Hampton and Tekrony, 1995).

The potential advantages from the dissemination and utilization of good quality seeds of enhanced assortments are huge, and the accessibility of value seed of an extensive variety of assortments of products to farmers is critical to accomplishing nourishment security in Ghana. Improved profitability, higher gather list, lessened dangers from pest and diseases and higher livelihoods are a part of the immediate advantages achieved by farmers (Wright and Tyler, 1994).

2.8 Seed Retailing and Associated Challenges

Commercial seed business is a central component of industrial agribusiness (Tripp, 2001). Additionally, seed promotion is a key connection between the seed markets and the farmers who eventually make use of the seeds (OMaliko, 1998).

Successful seed supply requires convenient conveyance of proper assortments and support to the neighbourhood seed creation and cultivating frameworks (NSS, 2000).

One noteworthy constraint on the productivity of retailers is the clear absence of information concerning the attributes of the assortments they retail. This makes it difficult for them to teach farmers on obtaining seed assortments appropriate for the farmers' environment (Tahirou *et al*., 2009).

It is a common practice that seed retailers in Ghana keep seeds together with agro-chemicals. There is increasing alarm about the quality of seeds stored together with agro-chemicals.

Nodule development was repressed at expanded levels of bentazone, chlorsulfuron, glyphosate and mancozeb (Martensson, 1992).

Contact of fungicide with seed diminished wax content and altered its morphology, causing cracks and loss of crystalloids that made the plant more susceptible to disease infestation and drying up (Lichston *et al*., 2006).

Dane and Dalgic (2005) also asserted that Benomyl had negative consequences on mitotic divisions in onion root tip cells. Thus, retailers' practice of storing seeds together with agro-chemicals especially in cases of chemical spillage on seeds can have significant negative effect on seed quality thus, safer seed storage practice should be considered.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Sites

The study comprised field survey and laboratory experiments. Field survey was conducted from 4th December, 2017 to 28th February, 2018 whereas laboratory experiments were conducted from 1st March, 2018 to 31st May, 2018. Field survey was carried out in the Greater Accra Region of Ghana. Laboratory experiments were carried out at the Ghana Seed Inspection Division's (GSID) Seed Testing Laboratory of the Plant Protection and Regulatory Services Directorate (PPRSD) Head Office.

GSID is located at Pokuase a suburb of Accra, off the Accra-Kumasi highway at a Latitude 5^0 42' 0" North and Longitude 0^0 18' 7.2" West.

3.2 Survey Implementation

Prior to sampling for seeds, a survey was conducted using the paper surveying technique. The selected vegetable seed retailers were interviewed one on one at their respective retail outlets by the aid of a six-paged pre-tested questionnaire. The questionnaire combined both open-ended and closed-ended questions and focussed on demography of respondents, vegetable seeds retailed, seed suppliers, delivery channels, storage practices, labelling, packaging and marketing challenges (Appendix 1).

An IN-OUT Thermo-Hygrometer was used in recording the storage temperature and relative humidity at all the commercial retail shops sampled.

3.3 Vegetable Seed Sampling Technique

Vegetable seed samples dully certified officially by PPRSD and were on sale were collected from different seed sale points in the Greater Accra Region. This supposes that before the vegetable seeds entered the seed distribution and marketing channels, they had passed the minimum seed certification standards applicable for Ghana and had been given certification labels. A total of 18 commercial vegetable seed retailers who constituted the main vegetable seed delivery channels to farmers across the Greater Accra region were identified using purposive sampling technique.

3.4 Certified Vegetable Seed Sampling

3.4.1 First Sampling

Twenty (20) vegetable seed samples (Table 3.1) each of weight 25 g were initially purchased from 15 out of the 18 vegetable seed retail shops from 2nd January, 2018 to 31st January, 2018. The other three (3) vegetable seed retail shops had run out of stock at the time of seed sample collection. Vegetable seed samples were collected using simple random sampling technique.

Table 3. 1 : Twenty (20) vegetable seed samples purchased from the various retail outlets.

Vegetable/Variety	Retail Outlet	Label
Beetroot *var.* Detroit Elna	Dizengoff Gh. Ltd.	B-D
Tomato *var.* Prado	Agriseed Gh Ltd.	T-AS
Onion *var.* Early Texas Grano	Agriseed Gh Ltd.	ON-AS
Okra *var.* Labadi Dwarf (Local)	Farmers Friend Agric Shop	OK-FF (L)
Cabbage *var.* Fortune	Farmers Friend Agric Shop	CA-FF
Okra *var.* Lady's Finger (Local)	Agrimat Gh. Ltd.	OK-AM (L)
Eggplant *var.* Kpando Nice (Local)	Agrimat Gh. Ltd.	E-AM (L)
Sweet Pepper *var.* Goliath	Agrimat Gh. Ltd.	SP-AM
Lettuce *var.* Kaizer	Aglow Agric Products	L-AG
Cucumber *var.* Green Slam	Aglow Agric Products	CU-AG

Eggplant *var*. Kalenda	Mobile Link Agroshop	E-ML
Eggplant *var*. Legon 1	Univ. of Ghana-Crop Sc. Dept.	E-UG
Hot Pepper var. Legon 18	Univ. of Ghana-Crop Sc. Dept.	HP-UG
Tomato *var*. Rio Grande	Nanafico Marketing Co. Ltd	T-NF
Cucumber *var*. Darina	Nanafico Marketing Co. Ltd	CU-NF
Onion *var*. Red Creole	Meridian Seeds and Nurseries Gh. Ltd	ON-M
Cabbage *var*. Fortune	Meridian Seeds and Nurseries Gh. Ltd	CA-M
Sweet Pepper *var*. California Wonder	Crop2Life	SP-C2L
Onion *var*. Red Creole	Jafel Agro-farma Ent.	ON-J
Eggplant *var*. Kombara	Jef Agrofarma Agric Agent	E-JE

Each sampled packet or can was then checked for the labelled seed quality parameters (% germination, % purity, % moisture content among others) after which quality tests were conducted for seed germination percentage, percentage purity, moisture content, seedling vigour and seed health from March to April, 2018 to evaluate these parameters after specified number of days in the distribution and marketing channel.

3.4.2 Second Sampling

Following the first sampling, a second informed selection of 34 vegetable seeds (Table 3.2) each of weight 25 g comprising one variety each of carrot, okra, cabbage, sweet pepper, hot pepper, cucumber and two varieties each of onion and tomato were collected from different retail outlets from 5th February to 28th February 2018 to compare quality parameters of same vegetable varieties across the different retail outlets. Seed samples were collected using purposive sampling technique.

Seed samples were analysed for percentage germination, percentage purity, moisture content, seed health and seedling vigour.

Table 3. 2 : Second Informed 34 Selected Vegetable Seeds Sampled from Different Retail Outlets

Vegetable/Variety	Retail Outlet	Label
Carrot *var.* Amazonia	Agrimat Gh Ltd.	C-AM
	Farmers friend Agric Shop	C-FF
	Meridian Seeds and Nurseries Gh Ltd	C-M
	Agriseed Ltd	C-AS
Okra *var.* Clemson spineless	Farmers friend Agric Shop	OK-FF
	Meridian Seeds and Nurseries Gh Ltd	OK-M
	Agriseed Ltd	OK-AS
Cabbage *var.* Fortune	Agriseed Ltd	CA-AS
	Farmers friend Agric Shop	CA-FF
	Meridian Seeds and Nurseries Gh Ltd	CA-M
Sweet Pepper *var.* Yolo wonder	Agriseed Ltd	SP-AS
	Meridian Seeds and Nurseries Gh Ltd	SP-M
	Crop2Life	SP-C2L
Hot pepper *var.* Legon 18	Agrimat Gh Ltd.	HP-AM
	University of Ghana	HP-UG
	Aglow Agric Products	HP-AG
Onion *var.* Texas Early Grano	Agrimat Gh Ltd.	ON-AM1
	Agriseed Ltd	ON-AS1
	Farmers friend Agric Shop	ON-FF
	Aglow Agric Products	ON-AG
Onion *var.* Red Creole	Agrimat Gh Ltd.	ON-AM2
	Agriseed Ltd	ON-AS2
	Meridian Seeds and Nurseries Gh Ltd	ON-M
	Jafel Agro-farma Ent.	ON-J
Cucumber *var.* Marketer	Agriseed Ltd	CU-AS
	Dizengoff Gh Ltd	CU-D
	Meridian Seeds and Nurseries Gh Ltd	CU-M
Tomato *var.* Pectomech	Agriseed Ltd	T-AS1
	Agrimat Gh Ltd.	T-AM
	Meridian Seeds and Nurseries Gh Ltd	T-M
	Aglow Agric Products	T-AG
Tomato *var.* Tropimech	Farmers friend Agric Shop	T-FF
	Agriseed Ltd	T-AS2
	Nanafico Marketing Co. Ltd	T-NF

3.5 Seed Quality Analysis (Laboratory Experiments)

3.5.1 Experimental Design

Seed samples collected were arranged in a Completely Randomized Design (CRD) in 4 replications with 50 seed samples.

3.5.2 Seed Germination Test

Seed germination potential were tested in four replications (100 seeds per replication) using the blotter paper method (Top of paper) at 25 ^{0}C. First and final germination counts were done at 5 DAS and 14 DAS respectively to estimate germination percentage of the samples (ISTA, 2013). Results from the germination tests were evaluated for percent normal seedlings, abnormal seedlings, hard seeds, fresh un-germinated seeds and dead seeds per each replicate using seed germination test sheet. Germination percentage was estimated by finding the average of the normal seedlings from the four replications.

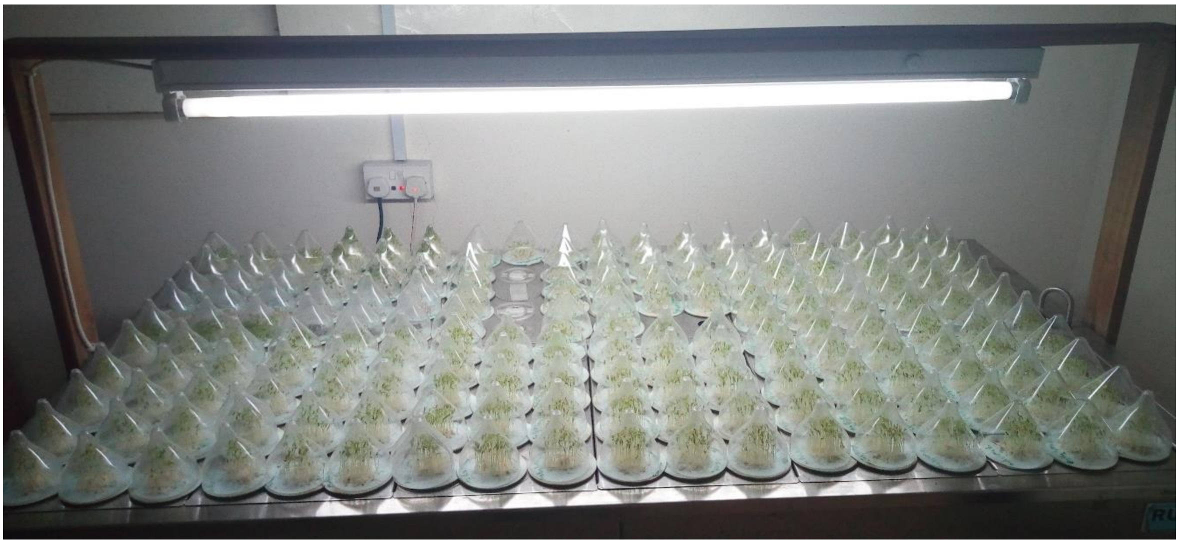

Figure 3. 1: Vegetable seed germination test using the blotter paper method

3.5.3 Seed Moisture Content Test

The constant temperature oven method was adopted to determine moisture content of the submitted vegetable seed samples. The principle behind the constant temperature oven method is that the Moisture Content in a seed is determined by the loss in weight after the working sample has been dried for a specific time in a drying oven set at a specific temperature. The temperature and amount of time used is species dependent. The equipment used for this analysis included;

- an oven with a stable and a high capacity capable of providing a uniform temperature.
- a well calibrated grinder/mill.
- a sensitive balance capable of weighing at least up to 3 decimal places.
- containers made of a non-corrosive metal (stainless steel), with random numbers inscribed on their lids.
- desiccators with plates at the bottom capable of holding samples after drying during cooling.

The desiccants are usually placed in the desiccator to absorb the moisture removed from the environment of the desiccator. This ensures samples cooled in a desiccator do not reabsorb moisture.

Before the process was started, the oven was turned on so as to build heat to the required temperature before the samples were placed in.

With the oven building up heat, containers with their lids were first weighed and recorded on a moisture form. Vegetable seed samples were opened, mixed with spoon and three subsamples drawn at different positions with the spoon and placed in the container (Replicate A). The weight of the set-up (container + sample + lid) was taken using the "COBOS precision" weighing balance and recorded. The above procedure was repeated in a replicate container called replicate B. Samples were placed in an oven with containers open, sitting on top of their lids. Oven temperature was monitored, confirmed and recorded. A timer was set for the required drying period. At the end of the drying period, temperature was recorded. Samples were taken out of the oven, covered quickly with their lids and placed in a desiccator for 45 minutes after which the final weight of samples (incl. container and lid) was taken and recorded.

Each replicate was calculated separately using the formula:

$$\frac{(container\ wgt + sample\ wgt\ before\ drying) - (Wgt\ of\ container\ and\ sample\ after\ drying)}{sample\ wgt\ before\ drying} \times 100$$

The maximum tolerance between replicates was not greater than 0.2 %

Final moisture content was calculated as follows:

$$\frac{\text{Moisture (\%) for replicate A} + \text{Moisture (\%) for replicate B}}{2}$$

3.5.4 Purity Analysis

Purity test on vegetable seed samples was carried out with the aid of the current ISTA (2017) rules and 3rd Edition (2010) ISTA handbook on pure seed definitions.

The Hand-halfing method was used to divide submitted samples to obtain working samples. Working samples were drawn into thin line using spatula and each particle was individually examined to separate pure seed from other crop seeds, weed seeds and inert matter. Each sample under test was evaluated for the component of pure seed, weed seeds (noxious weeds), other crop seeds and inert matter (sand particles, stone particles, stem pieces, leaves, lemmas, empty glumes, chaff, insect debris, stalks and spikelet) and were recorded and weighed in a dish in grams to three decimal places using a digital scale.

The weights were tallied and the total recorded.

Their percentage were calculated using the formula; $Fraction\ \% = \frac{Fraction}{Total} \times 100$

3.5.5 Seed Health Test

Seed health test was conducted using the Blotter method (ISTA, 2013; Mathur and Kongsdal, 2003). For each sample tested, 200 seeds were plated in 9 cm petri dishes lined with wet blotters. Twenty-five (25) seeds were plated per petri dish of 8 replicates. Of the first 20 samples tested, 4000 seeds were plated for the test and examined. Therefore for each infection case recorded, the incidence was from a total of 4000 seeds.

Of the second 34 seed samples tested, 6800 seeds were plated for the test and examined.

Seeds were incubated under ultra violet light for 7 days under 12 alternating cycles (12 hours of light and 12 hours of darkness at 20 ^{0}C).

At the end of the incubation period, each seed was thoroughly examined under different magnifications of a stereomicroscope for the growth of fungi. Identification of fungi was based on ‘habit characters’, the way individual fungi develop on seeds and on the morphological characters of spores, fruiting bodies and conidia observed under the compound microscope.

Seed Health Testing was done on samples collected for investigation to check for the presence or absence of pathogens on, in or among them. This serves as an important factor in the control of crop diseases and field establishment.

3.5.6 Seedling Vigour Index

Seedling vigour tests were conducted for vegetable seed samples at 10 DAS using the seedling growth rate test. Seedling root and shoot length (seedling length) were measured and recorded from 10 sampled seedlings per replication by the use of a centimetre rule and used as an indicator of vigour since healthy and vigorous seedlings would grow faster and lengthier compared to less vigorous seedlings.

Seedling vigour index was calculated by finding the product of percentage germination of seed and average seedling length (Abdul-Baki and Anderson, 1973). Seed lot with the highest vigour index were ranked more vigorous. Seedling vigour were also estimated using first count germination percentage.

3.6 Statistical Analysis

Data on percentage seed germination, percentage seed moisture content and percentage seed vigour were arcsine transformed to stabilize the variance. A general analysis of variance (ANOVA) for the various seed quality indices were conducted using GenStat statistical package 12th Edition. Mean separation was done by using Fishers' Protected LSD to compare the significant differences between treatments at 5 % level of significance.

Data on questionnaire were analysed using Statistical Package for Social Sciences (SPSS).

CHAPTER FOUR

4.0 RESULTS

4.1 Profile of Vegetable Seed Retailers and Retail Outlets in the Study Area

A total of eighteen (18) commercial vegetable seed retailers identified from the Greater Accra Region of Ghana and their frequencies and percentages are presented in (Table 4.1). Apart from Agriseed Limited, Nanafico Marketing Company Limited and Farmers Friend Agric Shop which had two separate retail outlets representing an equal percentage of 11.1 %, all the other retail shops had only one retail outlet representing a percentage of 5.6 %.

Table 4. 1: Commercial Vegetable Seed Retailers

Retailers	Frequency	Percent
Dizengoff Gh Ltd	1	5.6
Callighana Co. Ltd	1	5.6
Agriseed Ltd	2	11.1
Agrimat Gh Ltd	1	5.6
Crop2Life	1	5.6
RMG Ghana Ltd	1	5.6
Aglow Agric Products Ltd	1	5.6
Meridian Seeds and Nurseries Gh Ltd	1	5.6
Nanafico Marketing Co Ltd	2	11.1
Mobile Link Agro-shop	1	5.6
Farmers Friend Agric shop	2	11.1
University of Ghana, Legon	1	5.6
Jafel Agro-farma Ent	1	5.6
Jef-Agrofarma Agric Agent	1	5.6
God is coming soon Agro-shop	1	5.6
Total	**18**	**100.0**

4.1.1 Demographic Characteristics of Respondents

4.1.1.1 Gender Distribution

Analysis of the gender of vegetable seed retailers' showed that majority of the retailers were Males (67 %) and the remaining (33 %) were Females (Figure 4.1).

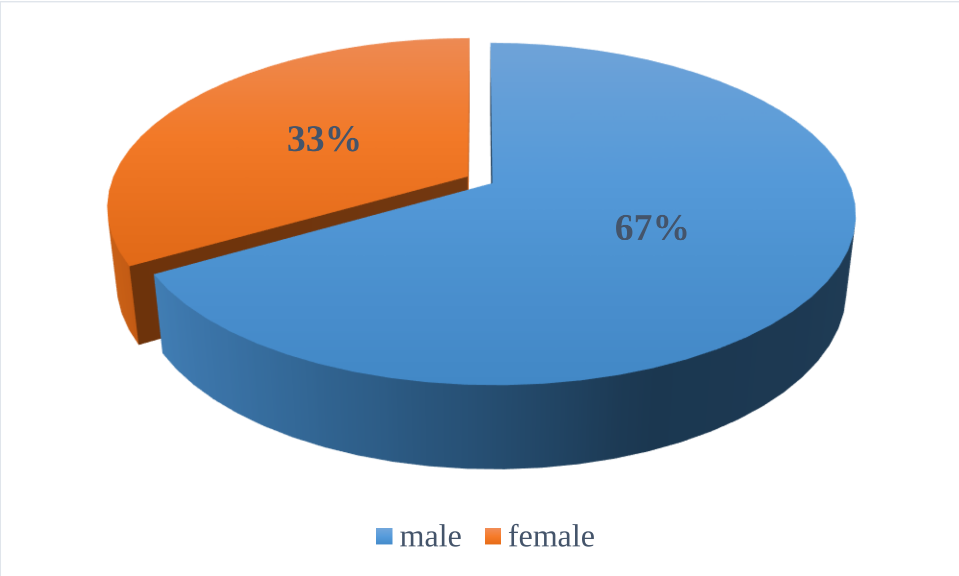

Figure 4. 1 : Gender of respondents

4.1.1.2 Marital Status of Retailers

Majority of the retailers were married forming 50 % of the total number followed by those who were single (44.4 %) with those separated (5.6 %) being the least among them (Table 4.2).

Table 4. 2: Marital Status of Retailers

Options	Frequency	Percent
Single	8	44.4
Married	9	50.0
Separated	1	5.6
Total	**18**	**100.0**

4.1.1.3 Age Distribution of Respondents

Using a range of < 25 years to > 36 years, majority of the retailers were reported to be between the ages of 26 and 35 years forming 44.4 % of the total. Those above 36 years formed 38.9 % of the total. The least group were those whose ages were below 25 years which corresponded to 16.7 % (Table 4.3).

Table 4. 3: Age Distribution of Respondents

Ages (years)	Frequency	Percent
Below 25	3	16.7
Between 26-35	8	44.4
Above 36	7	38.9
Total	**18**	**100.0**

4.1.1.4 Educational Level of Respondents

Majority of the retailers interviewed were first degree holders forming 44.4 % of the total. The next were HND holders who formed 16.7 %. Second degree holders (masters) constituted the least percentage (5.6 %) while undefined levels were 11.1 % and the percentage was same as that of SHS and Diploma graduates (Figure 4.2).

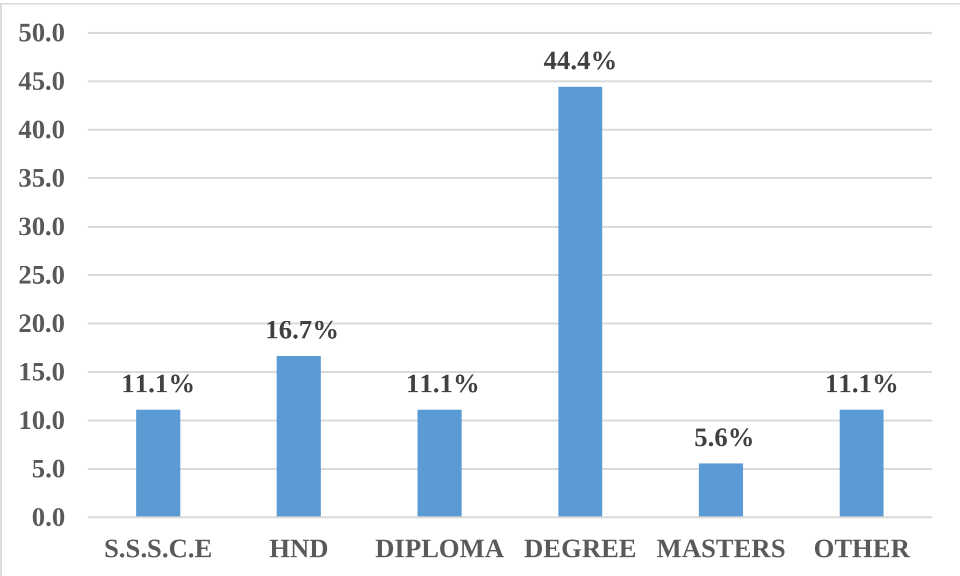

Figure 4. 2 : Educational Level of Respondents

4.1.2 Demographic Characteristics of Retail Outlets

4.1.2.1 Type of Business

The various retail shops had different types of businesses. Some were limited liability companies, partnerships, companies and sole proprietors. Majority of the businesses were partnerships forming 38.9 % of the total. Retail shops that were companies formed 22.2 % while Sole proprietors and Limited liability companies had an equal percentage of 16.7 % (Table 4.4).

Table 4. 4: Type of Business

Options	Frequency	Percent
Sole Proprietorship	3	16.7
Partnership	7	38.9
Company	4	22.2
Limited Liability	3	16.7
Others	1	5.6
Total	**18**	**100.0**

4.1.2.2 Temperature of Retail Shops

The results indicated that majority of the retail shops forming 44.4 % had temperatures ranging between 31.01 and 32.9 ^{0}C. Retail shops with temperatures between 35 ^{0}C to 36.9 ^{0}C formed the least with 11.1 % only. Retail shops with temperatures between 29.01 ^{0}C and 31.0 ^{0}C and 33.0 ^{0}C and 34.9 ^{0}C had equal percentages of 22.2 % (Table 4.5).

Table 4. 5: Temperatures of Retail Shops

Temperatures (^{0}C)	Frequency	Percent
29.01 - 31.0	4	22.2
31.01 - 32.9	8	44.4
33.0 - 34.9	4	22.2
35.0 - 36.9	2	11.1
Total	**18**	**100.0**

4.1.2.3 Relative Humidity of Retail Shops

The results of the analysis concerning the measurement of relative humidity of the various retail shops indicated that more than half (61.1 %) of the retail shops had relative humidity between 56.1 % and 60 % followed by those with relative humidity between 48 % and 52 % Retail Shops with relative humidity ranging from 60.1 % to 64 % and 52.1 % to 56 % formed the least groups with equal percentages (11.1 %) (Table 4.6).

Table 4. 6: Relative Humidity of Retail Shops

Relative Humidity (%)	Frequency	Percent
48 - 52	3	16.7
52.1 - 56	2	11.1
56.1 - 60	11	61.1
60.1 - 64	2	11.1
Total	**18**	**100.0**

4.1.2.4 Skilled Employees in Retail Sector

The results of the number of skilled employees of the various retail shops indicated that majority (64.3 %) had the number of skilled employees between 1 to 5 workers followed by a percentage of 14.3 % each who were retail shops with between 6 to 10 workers and between 16 to 20 workers respectively. The least recorded was 7.1 % which corresponded to one retail shop with between 21 to 25 workers being skilled employees (Table 4.7).

Table 4. 7: Skilled Employees in Retail Sector

Skilled Employees	Frequency	Percent	Valid Percent
1 - 5	9	50.0	64.3
6 - 10	2	11.1	14.3
16 – 20	2	11.1	14.3
21 - 25	1	5.6	7.1
Total	14	77.8	100.0
No Response	4	22.2	
Total	**18**	**100.0**	

4.1.2.5 Unskilled Employees in Retail Sector

For the unskilled employees, majority of the retail shops indicated that they do not have any. For them, all the employees are skilled. They formed 68.8 % of the total respondents. Those who had only one unskilled employee formed 12.5 % of the total (Table 4.8).

Table 4. 8: Unskilled Employees in Retail Sector

Unskilled Employees	Frequency	Percent	Valid Percent
0	11	61.1	68.8
1	2	11.1	12.5
2	1	5.6	6.3
5	1	5.6	6.3
6	1	5.6	6.3
Total	16	88.9	100.0
No response	2	11.1	
Total	**18**	**100.0**	

4.1.2.6 Number of Years in Business

How long the retail shops have been in existence is reported in Figure 4.3. Majority (33.3 %) had been in existence for 20 years and over, whiles those that had been in existence for between 10 to 20 years formed 27.8 %. Retail shops that had existed between 5 to 10 years constituted the least with only 16.7 %. Retail shops that had been in existence below 5 years were 22.2 %.

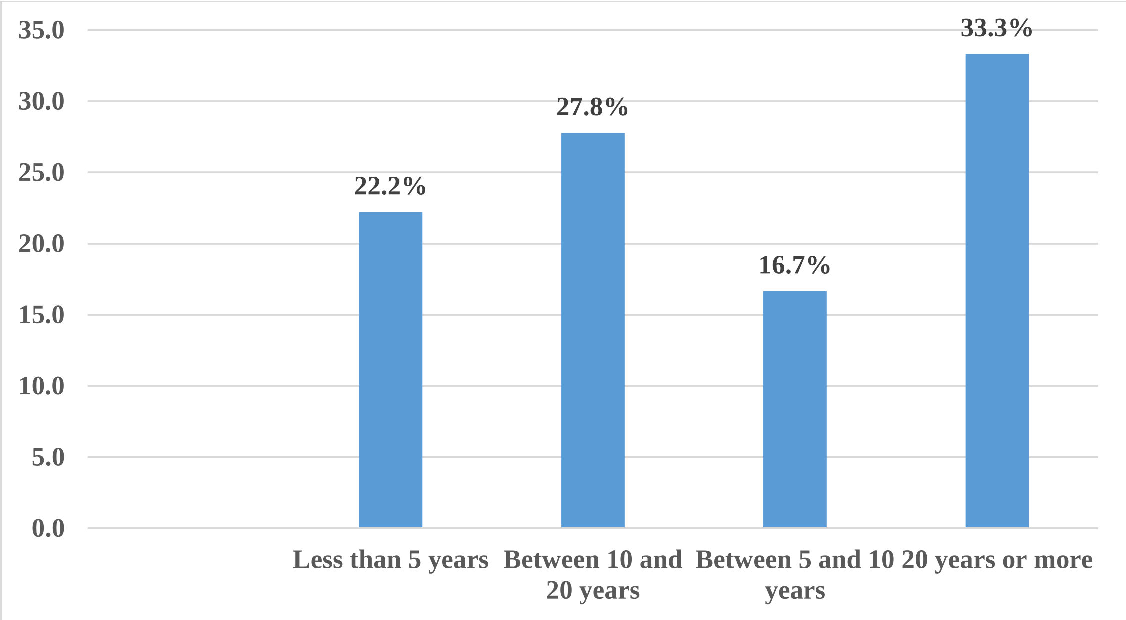

Figure 4. 3 : Number of Years in Business

4.2 Seeds Retailed, Seed Suppliers and Delivery Channels

4.2.1 Type of Seeds Retailed

Results of the multiple response analysis of the type of seeds the retail shops retail is shown in Table 4.9. Majority of the respondents retailed vegetable seeds (34.7 %) while 22.4 % retailed cereal seeds. Lawn seeds were retailed by 10.2 % while Legumes and Fruits were retailed by 18.4 % and 14.3 % respectively.

Table 4. 9: Type of Seeds Retailed

	Responses	
Seeds Retailed	**Frequency**	**Percent**
Vegetables	17	34.7
Cereals	11	22.4
Legumes	9	18.4
Lawn Seeds	5	10.2
Fruits	7	14.3
Total	**49**	**100.0**

4.2.2 Seeds Most Sold by Retailers

In identifying the most sold crop seeds, respondents indicated that for majority, it was vegetables. Vegetable seed sales accounted for 34.8 % of sales while the second highest selling seeds were that of cereals (23.9 %) with Lawn seeds being the least at 8.7 % (Table 4.10).

Table 4. 10: Seeds Most Sold by Retailers

	Responses	
Seeds	**Frequency**	**Percent**
Vegetables	16	34.8
Cereals	11	23.9
Legumes	9	19.6
Lawn Seeds	4	8.7
Fruits	6	13.0
Total	**46**	**100.0**

4.2.3 Vegetable Seeds Most Sold by Retailers

In terms of ranking, the retailers were examined on what their highest selling vegetable seeds were. The results showed that tomatoes, cabbage and sweet pepper were the highest selling vegetable seeds at 22.2 %. Onions, chilli pepper, cucumber and lettuce constituted 5.6 % each (Table 4.11).

Table 4. 11: Vegetable Seeds Most Sold by Retailers

Vegetable Seeds	Frequency	Percent
Tomatoes	4	22.2
Cabbage	4	22.2
Onions	2	11.1
Chilli Pepper	1	5.6
Cucumber	2	11.1
Lettuce	1	5.6
Sweet Pepper	4	22.2
Total	**18**	**100.0**

4.2.4 Request for Unavailable Vegetable Seeds.

Analysis about whether or not buyers asked for vegetable seeds which were unavailable showed that for a majority (55.6 %) that was not the case. For the remaining 44.4 %, they encountered cases where buyers indeed asked for vegetable seeds which were unavailable (Figure 4.4).

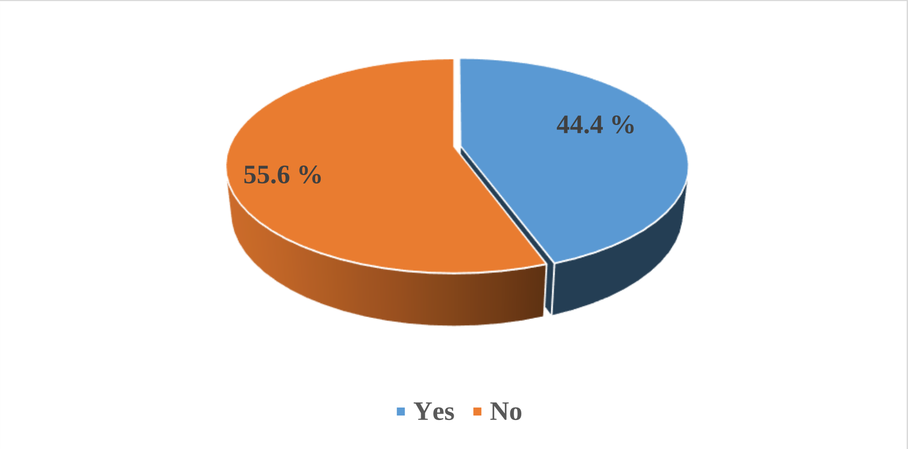

Figure 4. 4 : Request for Unavailable Vegetable Seeds.

4.2.5 Vegetable Seeds Requested for that Retailers did not have

Further probing was done to find out those vegetable seeds buyers requested for that were unavailable. The results showed that of all the vegetable seeds, carrot and cucumber were the seeds most (23.1 %) sought after followed by French beans, mint, celery and spring onions constituting 7.7 % each (Table 4.12).

Table 4. 12: Vegetable Seeds Requested for that Retailers did not have

	Responses	
Seed Varieties	**Frequency**	**Percent**
Carrot	3	23.1
Cucumber	3	23.1
French beans	1	7.7
Mint	1	7.7
Celery	1	7.7
Spring Onions	1	7.7
Total	**10**	**100.0**

4.2.6 Complaints from Buyers about Purchased Vegetable Seeds

The results of the analysis as to whether or not the respondents received complaints from buyers about purchased vegetable seeds indicated that 78 % received complaints while 22 % said there were no complaints (Figure 4.5).

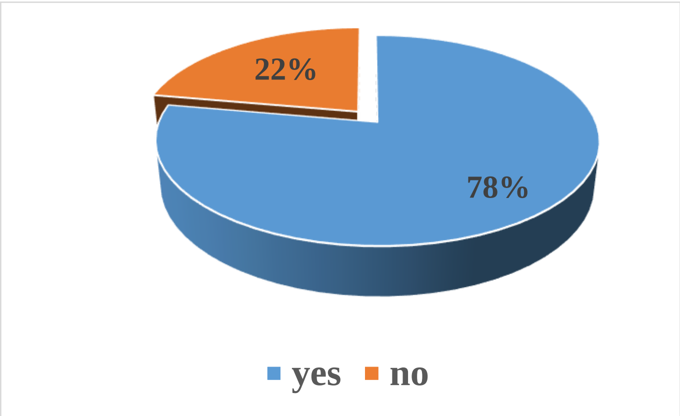

Figure 4. 5 : Percentage Respondents Indicating Receipts of Complaints after Purchase of Vegetable Seeds.

4.2.7 Nature of Complaints Received from Buyers

In a multiple response analysis of which complaints retailers received from buyers showed 35.7 % complaining about poor germination of the seeds. The next was about the presence of insects when seeds are planted (17.9 %) followed by the presence of viruses (14.3 %). Complaints about low establishment and presence of mould happened to have equal percentages of 10.7 % while those who complained about discolouration of seeds when planted formed 7.1 %. Complaints about varietal mix up happened to be the least (3.6 %) amongst the various complaints received from buyers (Table 4.13).

Table 4. 13: Nature of Complaints Received from Buyers

Complaints	Responses	
	Frequency	Percent
Poor Germination	10	35.7
Presence of Insects	5	17.9
Discolouration	2	7.1
Mould	3	10.7
Presence of Virus when Planted	4	14.3
Low establishment	3	10.7
Varietal Mix up	1	3.6
Total	**28**	**100.0**

4.2.8 Certified Vegetable Seed Suppliers

Results on a multiple response analysis of sources of vegetable seeds showed that for most retail shops, vegetable seeds were obtained from other seed companies (72.7 %) followed by those who indicated that they obtained their vegetable seeds from other seed growers (22.7 %). A few others (4.5 %) provided vegetable seeds for themselves (Table 4.14).

Table 4. 14: Certified Vegetable Seed Suppliers

Seed Suppliers	Responses	
	Frequency	Percent
Seed Growers	5	22.7
Cooperatives	0	0.0
Seed Companies	16	72.7
Others (Self – supply)	1	4.5
Total	**21**	**100.0**

4.2.9 Mode of Transport of Vegetable Seeds to Retail Shops

Concerning how vegetable seeds were transported to the various retail shops, majority of the vegetable seed retailers (55.6 %) indicated that it is done through ordinary vans whiles 33.3 % reported transport in air-conditioned vans. The least group were those who indicated that seeds were transported via cold vans (11.1 %) (Table 4.15).

Table 4. 15: Mode of Transport of Vegetable Seeds to Retail Shops

Conditions	Frequency	Percent
Cold van	2	11.1
Air conditioned van	6	33.3
Ordinary van	10	55.6
Total	**18**	**100.0**

4.3 Certified Seed Storage, Labelling and Packaging Materials

4.3.1 Vegetable Seed Packaging Materials

In a multiple response analysis, results concerning which packaging materials were used for vegetable seeds purchased by retailers showed 34.9 % being cans, followed by aluminium foil (23.3 %). The employment of transparent plastic bags and paper sachets as packaging materials were 18.6 % and 20.9 % respectively. Transparent plastic containers recorded the least (2.33 %) (Table 4.16).

Table 4. 16: Vegetable Seed Packaging Materials

	Responses	
Packaging Materials	**Frequency**	**Percent**
Aluminium Foil	10	23.3
Cans	15	34.9
Paper Sachets	9	20.9
Transparent Plastic Bags	8	18.6
Transparent Plastic Container	1	2.33
Total	**43**	**100.0**

4.3.2 Storage Location of Delivered Vegetable Seeds

Majority (44.4 %) of the retailers interviewed indicated that they keep the delivered vegetable seeds at the retail shops, whiles an equal percentage of 27.8 % indicated that they store seeds in warehouses and cold rooms (Table 4.17).

Table 4. 17: Storage Location of Delivered Vegetable Seeds

Location	Frequency	Percent
Warehouse	5	27.8
Retail Shop	8	44.4
Cold Room	5	27.8
Total	**18**	**100.0**

4.3.3 Vegetable Seed Label Information

In a multiple response analysis concerning the information on vegetable seed labels, majority (22.5 %) indicated that germination percentage was provided. Next was an equal percentage (21.3 %) who indicated that varietal name and batch number were provided. Those who indicated that packaging date, lot number, percentage weed seeds and other crop seeds were provided on seed labels were 12.5 %, 11.3 %, 5.0 % and 3.8 % respectively. The least (2.5 %) were those who indicated the presence of percentage inert matter content on seed label (2.5 %) (Table 4.18).

Table 4. 18: Vegetable Seed Label Information

	Responses	
Seed Label Information	**Frequency**	**Percent**
% Germination	18	22.5
Batch Number	17	21.3
Varietal Name	17	21.3
% Weed Seeds	4	5.0
% Other Crop Seeds	3	3.8
Packaging Date	10	12.5
Lot Number	9	11.3
% Inert Matter	2	2.5
Total	**80**	**100.0**

4.3.4 Conditions under which Vegetables Seeds are Stored over Time

Equal percentage of a majority (33.3 %) indicated that the conditions under which vegetable seeds were stored over time are room temperature or under air-condition whiles 22.2 % indicated that vegetable seeds were stored in cold rooms. The least (11.1 %) indicated that vegetable seeds were stored in the freezer (Table 4.19).

Table 4. 19: Conditions under which Vegetables Seeds are Stored over Time

Conditions	Frequency	Percent
Room Temperature	6	33.3
Cold room	4	22.2
Air-conditioned room	6	33.3
Freezer	2	11.1
Total	**18**	**100.0**

4.3.5 Duration of Storage of Vegetable Seeds in Retail Shops

The analysis concerning the duration of seeds in stock showed that for a majority (33.3 %), seeds are stored for a period of between 1 to 3 months, followed by 22.2 % who indicated that seeds are stored for a duration of between 10 to 12 months. Those who indicated that seeds are stored for a period of between 4 to 6 months or 7 to 9 months formed 16.7 %. The least recorded (11.1 %) were those who indicated that seeds are stored for over 12 months (Table 4.20).

Table 4. 20: Duration of Storage of Vegetable Seeds in Retail Shops

Duration (Months)	Frequency	Percent
1-3	6	33.3
4-6	3	16.7
7-9	3	16.7
10-12	4	22.2
Over 12	2	11.1
Total	**18**	**100.0**

4.3.6 Retailers Response as to whether they carry over Certified Seed Stock from One Season to Another

Results concerning whether or not retailers carried over certified vegetable seed stock from one season to another showed that more than half (61 %) of the total do so while the remaining 39 % did not carry over certified seed stock to the next season (Figure 4.6).

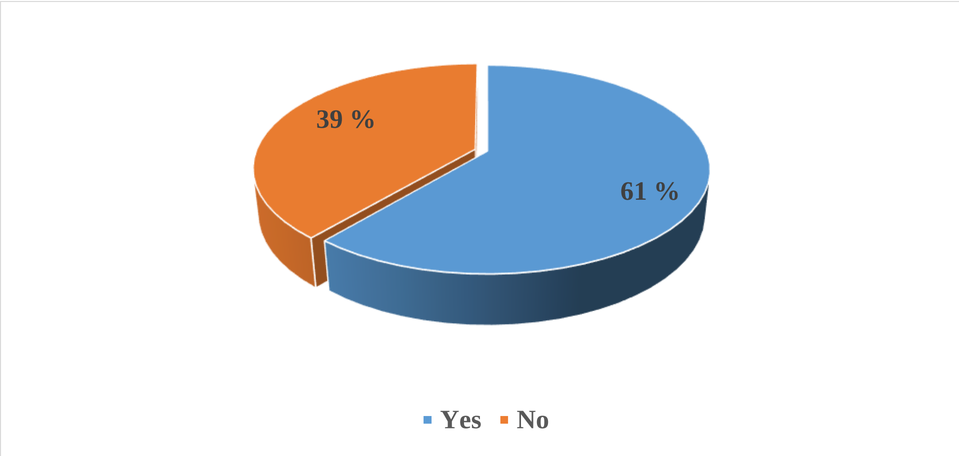

Figure 4. 6 : Retailers Response as to whether they carry over Certified Seed Stock from One Season to Another.

4.3.7 Storage Conditions of Carried-over Vegetable Seed Stock.

The results of the analysis of conditions under which carried-over vegetable seed stock were stored showed that, majority (54.5 %) store such seeds in a cold room whereas 18.2 % and 27.3 % indicated that they stored such seeds under air condition and at room temperature respectively (Figure 4.7).

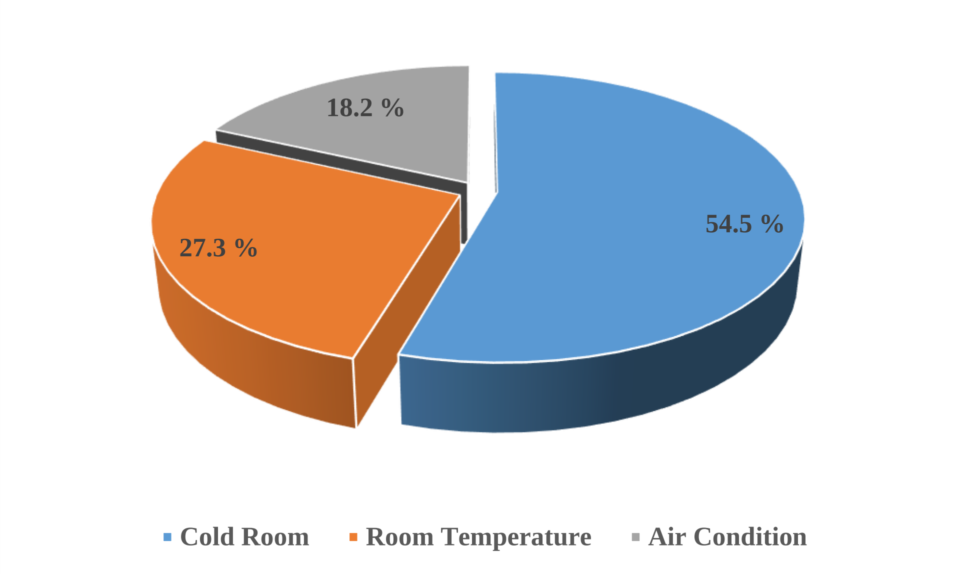

Figure 4. 7 : Storage Conditions of Carried-over Vegetable Seed Stock

4.3.8 Factors Affecting Vegetables Seeds in Storage.

In a multiple response analysis of what factors affect vegetable seeds in storage, results showed that for majority (25 %), storage temperature affected vegetable seeds the most. Next was that of humidity and heat with equal percentages of 15.3 %. Those who also indicated that the presence of pests and poor processing affected vegetable seeds in storage were 13.9 % and 9.7 % respectively. Pathogens were the least (8.3 %) mentioned factor that affected vegetable seeds in storage (Table 4.21).

Table 4. 21: Factors that Affect Vegetables Seeds in Storage.

	Responses	
Factors	**Frequency**	**Percent**
Storage Temperature	18	25.0
Moisture Content	9	12.5
Humidity	11	15.3
Pests	10	13.9
Poor Processing	7	9.7
Heat	11	15.3
Pathogens	6	8.3
Total	**72**	**100.0**

4.3.9 Impact of Proximity of Agro-chemicals on Vegetable Seeds in Retail Shops

Analysis regarding whether or not retailers had identified any negative effects of agro chemicals on vegetable seeds showed that for more than half of the retailers (58.8 %), that had not been the case while 11.8 % also responded in the affirmative. A total of 29.4 % did not give any response since they did not store vegetable seeds together with agro-chemicals (Table 4.22).

Table 4. 22: Impact of Proximity of Agro-chemicals on Vegetable Seeds in Retail Shops

Response	Frequency	Percent	Valid Percent
Yes	2	11.1	11.8
No	10	55.6	58.8
No Response	6	33.3	29.4
Total	**18**	**100.0**	**100.0**

4.4 Retailers Knowledge on Certified Seeds

4.4.1 Retailers Perception on Best Condition for Transporting Vegetable Seeds to Retail Shops

Concerning the opinions of vegetable seed retailers as to which was the best condition for transporting vegetable seeds to retail shops, more than half (55.6 %) indicated that transporting seeds in cold vans was the best practice, followed by those (33.3 %) who indicated that transporting seeds in air-conditioned vans is the best practice. The least (11.1 %) was recorded for those who indicated that transporting seeds in an ordinary van was the best practice (Table 4.23).

Table 4. 23: Retailers Perception on Best Condition for Transporting Vegetable Seeds to Retail Shops.

Conditions	Frequency	Percent
In cold van	10	55.6
Air conditioned van	6	33.3
Ordinary van	2	11.1
Total	**18**	**100.0**

4.4.2 Retailers Perception on the Effect of Length of Storage Time on Vegetable Seed Quality

Almost all (94.4 %) of the vegetable seed retailers indicated that the length of storage time affected the quality of vegetable seeds. The longer the storage time the more the seeds reduced in quality (Table 4.24).

Table 4. 24: Retailers Perception on the Effect of Length of Storage Time on Vegetable Seed Quality

Response	Frequency	Percent
YES	17	94.4
NO	1	5.6
Total	**18**	**100.0**

4.4.3 Retailers Awareness of Factors that Affect Vegetable Seeds in Storage

The results of the analysis about retailers' awareness of factors that affected vegetable seeds in storage showed that almost all (94.4 %) were aware of such factors (Table 4.25).

Table 4. 25: Retailers Awareness of Factors that Affect Vegetable Seeds in Storage

Response	Frequency	Percent
Yes	17	94.4
No	1	5.6
Total	**18**	**100.0**

4.4.4 Retailers Perception on Whether Vegetable Seeds are Properly Labelled.

Analysing whether or not vegetable seeds were properly labelled showed that for most (83.3 %) of the retailers, they were properly labelled (Table 4.26).

Table 4. 26: Retailers Perception on Whether Vegetable Seeds are Properly Labelled

Response	Frequency	Percent
Yes	15	83.3
No	3	16.7
Total	**18**	**100.0**

4.4.5 Retailers Response on Whether They Keep Vegetable Seeds with Agro-chemicals

Majority (66.7 %) of the retailers indicated that they did not store vegetable seeds with Agro chemicals while 33.3 % responded in the affirmative (Table 4.27).

Table 4. 27: Retailers Response on Whether They Keep Vegetable Seeds with Agro-chemicals

Response	Frequency	Percent
YES	6	33.3
NO	12	66.7
Total	**18**	**100.0**

4.4.6 Retailers Response to Whether They Perform Germination Test on Sourced Vegetable Seeds

Whether or not retailers performed germination test on sourced vegetable seeds prior to retailing showed that majority (72.2 %) did not perform any germination test on these seeds. The remaining 27.8 % performed germination tests on sourced vegetable seeds (Figure 4.8).

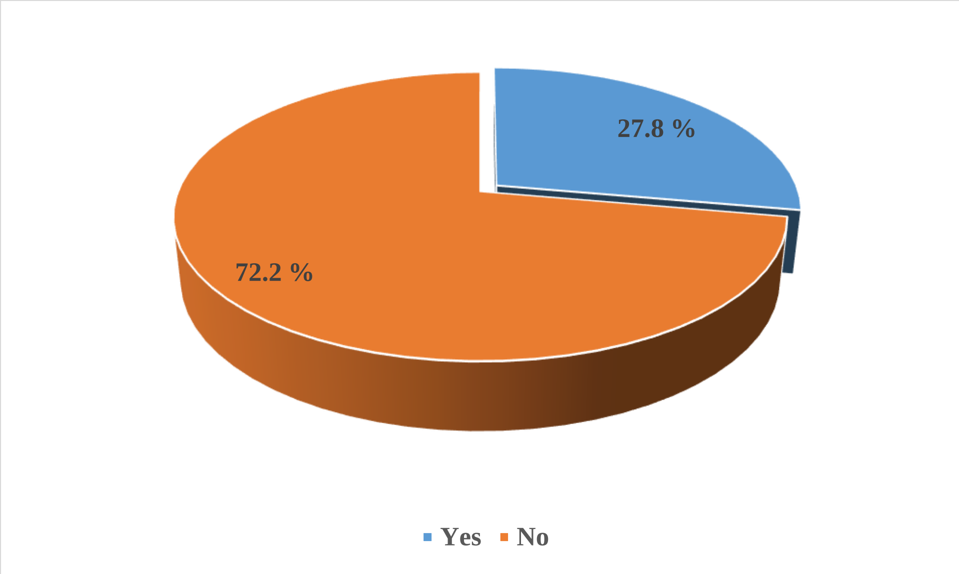

Figure 4. 8 : Retailers Response to Whether They Perform Germination Test on Sourced Vegetable Seeds

4.4.7 Retailers Response on Whether They Perform Germination Test on Carried-over Vegetable Seed Stock before Selling

Whether or not retailers performed germination test on carried over seed stock before selling showed that majority (66.7 %) did not do that while 22.2 % indicated that they did perform such test. (Table 4.28).

Table 4. 28: Retailers Response on Whether They Perform Germination Test on Carried-over Vegetable Seed Stock before Selling

Response	Frequency	Percent	Valid Percent
Yes	4	22.2	22.2
No	12	66.7	66.7
No response	2	11.2	11.2
Total	18	100.0	100.0

4.4.8 Retailers Perception on the Effect of Length of Storage Time on Vegetable Seed Quality

Analysis of how the quality of vegetable seeds were affected by length of storage time showed that majority (61.1 %) were of the view that the longer the storage time the poorer the germination and reduction in vigour while others (16.7 %) believed that, it caused seed viability to reduce. Others were of the view that the length of storage time had no effect on seeds except for the mode of storage (11.1 %) and the preservative chemical employed (5.6 %) (Figure 4.9).

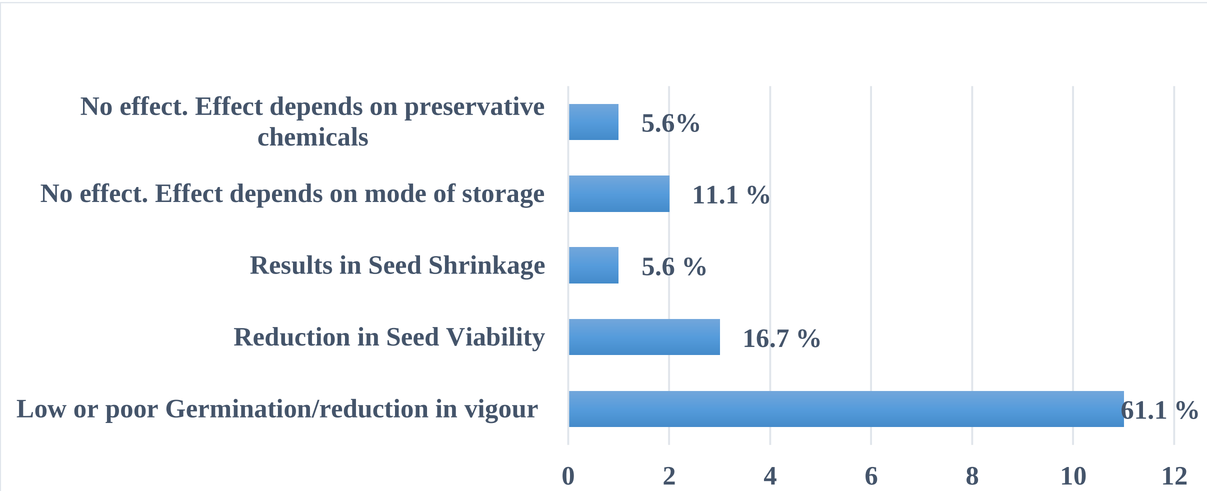

Figure 4. 9 : Retailers Perception on the Effect of Length of Storage Time on Vegetable Seed Quality

4.5 Seed Marketing Challenges and Proposed Solutions by Vegetable Seed Retailers

4.5.1 Vegetable Seed Marketing Challenges

With regards to the marketing challenges encountered by vegetable seed retailers, using multiple responses, majority indicated that access to good communication network was their main challenge (17.0 %), followed by those (14.9 %) who indicated that storage and pricing were their main marketing challenges. Off-season challenges, seasonal challenges, late maturing challenges, access to credit facilities and challenges with regards to packaging sizes formed 10.6 %, 6.4 %, 8.5 %, 8.5 % and 12.8 % respectively. The least (2.1 %) were those who indicated that most of the seeds sold were early maturing (Table 4.29).

Table 4. 29: Vegetable Seed Marketing Challenges

	Responses	
Challenges	**Frequency**	**Percent**
Early maturing	1	2.1
Seasonal	3	6.4
Late maturing	4	8.5
Off-Season	5	10.6
Promotion	2	4.3
Storage	7	14.9
Access to Credit Facilities	4	8.5
Access to Good Communication Network	8	17.0
Pricing	7	14.9
Package Sizes	6	12.8
Total	**47**	**100.0**

4.5.2 Retailers Suggested Solutions to Vegetable Seed Marketing Challenges

Among the various suggestions about how to curb seed marketing challenges, few seeds should be sourced and stored at a time to prevent carrying over seed stock to the next season was the most (20 %) popular (Table 4.30).

Table 4. 30: Retailers Suggested Solutions to Vegetable Seed Marketing Challenges

Suggestions	Frequency	Percent	Valid Percent
Employment of sale agronomists to serve as a bridge between farmers and retail shops.	1	5.6	10.0
Engaging farmers ahead of time to know exactly the kinds of seeds they want prior to seed sourcing	1	5.6	10.0
Farmers should be encouraged to buy quality seeds irrespective of their prices.	1	5.6	10.0
Vegetable seeds should be sourced from cheaper sources.	1	5.6	10.0
More promotional channels should be created and more storage facilities for sourced seeds.	1	5.6	10.0
Price reduction of vegetable seeds to enhance purchase by buyers.	1	5.6	10.0
Repackaging of seeds so buyers can afford.	1	5.6	10.0
More Seed Scientists should be trained.	1	5.6	10.0
Few seeds should be sourced and stored at a time to prevent carrying out seed stock to the next season.	2	11.2	20.0
Total	10	55.6	100.0
No response	8	44.4	
Total	**18**	**100.0**	

4.5.3 Retailers Awareness of Agency/Institutional Assistance

The results regarding whether or not retailers were aware of any agency or institution that can assist them with their marketing challenges indicated that most (88.9 %) were not aware of any of such agencies or institutions (Table 4.31).

Table 4. 31: Agency/Institutional Assistance

Response	Frequency	Percent
Yes	2	11.1
No	16	88.9
Total	**18**	**100.0**

4.5.4 Seed Retailers Personal Suggestions on What Can Be Done to Improve their Seed Retailing Business

With regards to what could be done to improve the vegetable seed business, with an equal percentage of 15.4 %, various suggestions such as making viable seeds available at moderate prices, government assisting seed retailers with import challenges, provision of storage and processing facilities and training more seed experts to boost the seed business were all mentioned by the retailers (Table 4.32).

Table 4. 32: Seed Retailers Personal Suggestions on What Can Be Done to Improve Their Seed Retailing Business

Suggestions	Frequency	Percent	Valid Percent
A central cold room should be established to help reduce the cost on storage.	1	5.6	7.7
Availability of good viable seeds at moderate prices.	2	11.1	15.4
Form and empower vegetable seed retailers Association.	1	5.6	7.7
Government should assist seed retailers with import challenges.	2	11.1	15.4
Local seed producers should reduce prices of local seeds	1	5.6	7.7
Prices of imported seeds should be reduced.	1	5.6	7.7
Provision of storage and processing facilities.	2	11.1	15.4
Provision of technical advice and assistance	1	5.6	7.7
Training of more seed experts to boost the seed business.	2	11.1	15.4
Total	13	72.2	100.0
No response	5	27.8	
Total	**18**	**100.0**	

4.2 Laboratory Evaluation of Vegetable Seed Samples

4.2.1 Seed Quality Characteristics of First 20 Seeds Sampled from the Various Retail Outlets

Results from the laboratory analysis showed that there were significant differences ($p<0.05$) in mean germination percentages recorded for the first 20 vegetable seeds (Table 3.1) across the various retail outlets with the highest mean germination percentage recorded for CU-AG followed by CA-M. The lowest mean germination percentage was however recorded for ON-J (Table 4.33).

The results also showed significant differences ($p<0.05$) in percentage moisture content of seeds sampled across the various retail outlets (Table 4.33). The highest mean percentage moisture content of 9.50 % was recorded for B-D with the lowest mean percentage moisture content of 4.55 % recorded for CA-FF (Table 4.33).

Vigour index calculated for the tested seeds also showed significant differences ($p<0.05$) (Table 4.33). The highest vigour index of 888.55 was recorded for CU-AG. The least (345.48) vigour index was however recorded for HP-UG (Table 4.33).

Results obtained for mean percentage purity indicated that there were significant differences ($p<0.05$) among the sampled seeds across the various retail outlets (Table 4.33). Seed samples showed high percentage purity with the highest mean percentage purity (99.80 %) recorded for SP-AM with the lowest (89.65 %) being E-UG (Table 4.33).

Table 4. 33: Seed Quality Characteristics of First 20 Seeds Sampled from the Various Retail Outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
B-D	85.3	9.5	615.5	98.5
T-AS	87.5	8.7	516.5	99.5
ON-AS	85.3	7.0	628.1	98.4
OK-FF (L)	75.8	8.8	684.7	90.4
CA-FF	87.0	4.6	399.7	97.7
OK-AM (L)	70.8	8.8	569.6	99.5
E-AM (L)	82.0	8.0	399.5	92.4
SP-AM	86.5	5.3	347.4	99.8
L-AG	78.0	6.6	474.6	97.5
CU-AG	98.0	6.3	888.6	98.3
E-ML	69.3	7.0	349.5	99.3
E-UG	76.0	8.0	376.5	89.7
HP-UG	84.5	7.7	345.5	92.5
T-NF	89.3	6.9	468.8	99.5
Cu-NF	84.8	7.2	715.9	98.4
ON-M	80.5	6.6	583.2	98.1
CA-M	90.0	4.8	442.4	99.4
SP-C2L	82.0	6.8	345.6	90.4
ON-J	65.0	6.8	486.0	92.2
E-JE	67.5	7.3	389.9	98.3
LSD (0.05)	4.3	0.2	27.2	1.8
Grand Mean	81.2	7.1	501.4	96.5
CV (%)	3.7	1.6	3.8	0.9

4.2.2 Seed Health Analysis for First 20 Seed Samples

From the seed health analysis, it was found that six (6) fungal species were associated with the first 20 seed samples tested (Table 3.1). The identified species were;

Aspergillus flavus, *Fusarium moniliforme*, *Colletotrichum dematium*, *Macrophomina phaseolina*, *Curvularia lunata* and *Fusarium oxysporum*.

Out of the twenty (20) randomly sampled seeds, eleven (11) showed fungal infections whereas the remaining nine (9) were free of fungal infection (Table 4.34).

Overall, the total fungal counts representing fungal incidences recorded was 490 out of the total 4000 seeds plated. Out of this, *Aspergillus flavus* had the highest number (353) of incidence representing 72.04 % of the total, followed by *Macrophomina phaseolina* which recorded 100 corresponding to 20.41 % (Figure 4.10). Again, *Fusarium moniliforme*, *Curvularia lunata* and *Fusarium oxysporum* recorded incidences of 17 (3.47 %), 13 (2.65 %) and 5 (1.02 %) respectively. The lowest incidence was *Colletotrichum dematium* which recorded 2 corresponding to 0.41 % (Figure 4.10).

Table 4.34: First 20 Seed Samples and their Associated Fungal Species

Vegetable/Variety	Fungi
Beetroot *var.* Detroit Elna	*Aspergillus flavus*
Tomato *var.* Prado	No fungi
Onion *var.* Early Texas Grano	No fungi
Okra *var.* Labadi Dwarf (Local)	*Fusarium moniliforme*
	Aspergillus flavus
	Colletotrichum dematium
Cabbage *var.* Fortune	*Aspergillus flavus*
Okra *var.* Lady's Finger (Local)	*Macrophomina phaseolina*
	Aspergillus flavus
	Curvularia lunata
	Fusarium oxysporum
	Fusarium moniliforme
Eggplant *var.* Kpando Nice (Local)	*Fusarium moniliforme*
	Fusarium oxysporum
	Aspergillus flavus
	Curvularia lunata
Sweet Pepper *var.* Goliath	No fungi
Lettuce *var.* Kaizer	*Aspergillus flavus*
	Curvularia lunata
Cucumber *var.* Green Slam	No fungi
Eggplant *var.* Kalenda	No fungi
Eggplant *var.* Legon 1	*Aspergillus flavus*
Hot Pepper var. Legon 18	*Aspergillus flavus*
	Fusarium moniliforme
	Curvularia lunata
Tomato *var.* Rio Grande	No fungi
Cucumber *var.* Darina	No fungi
Onion *var.* Red Creole	*Aspergillus flavus*
	Fusarium moniliforme
Cabbage *var.* Fortune	No fungi
Sweet Pepper *var.* California Wonder	No fungi
Onion *var.* Red Creole	*Aspergillus flavus*
Eggplant *var.* Kombara	*Aspergillus flavus*

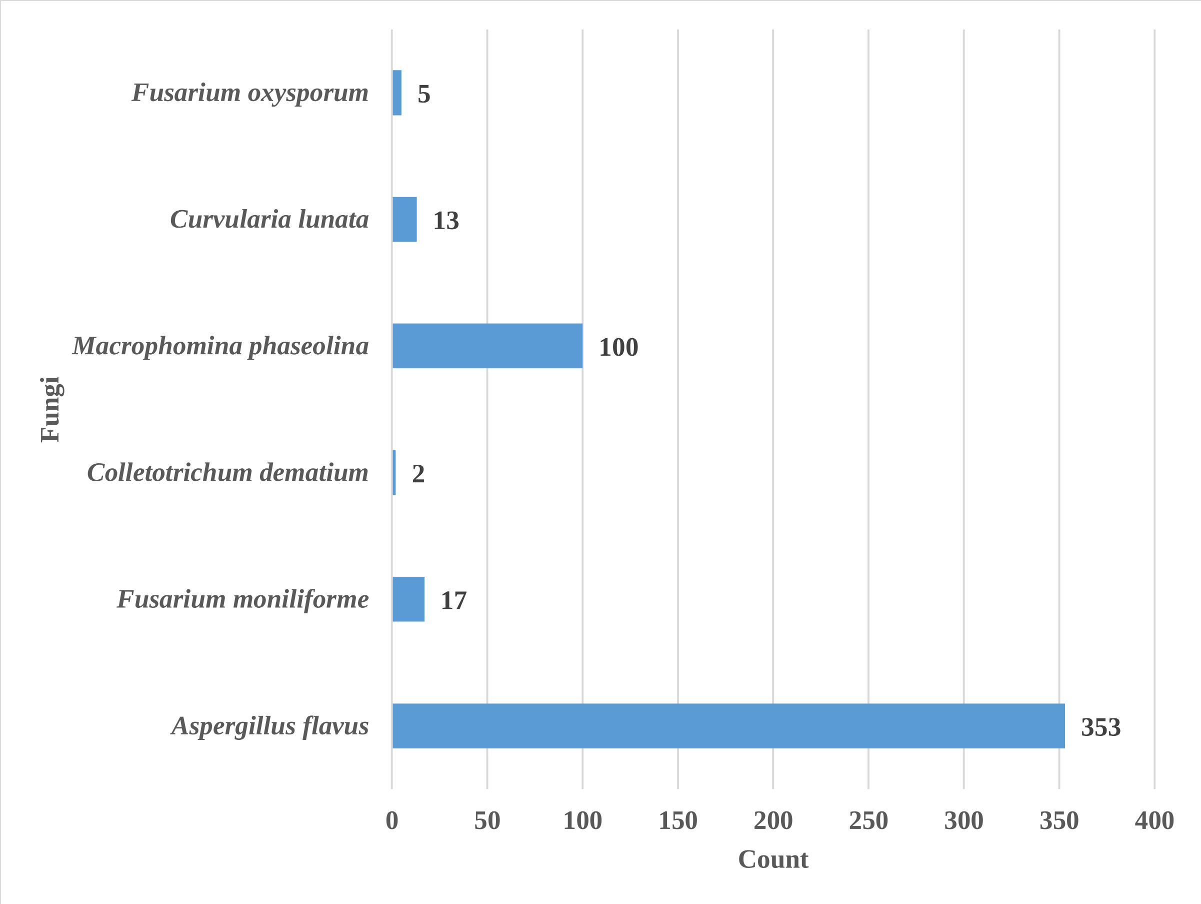

Figure 4. 10 : Fungal Species Incidence for First 20 Seed Samples.

4.2.3 Comparison of Seed Quality Characteristics of Second Informed 34 Selected Vegetable Seeds Sampled from Different Retail Outlets

4.2.3.1 Seed Quality Characteristics of Carrot Seeds Sampled from Four (4) Retail Outlets

Results from the analysis showed high germination percentages for sampled carrot seeds across the four (4) retail outlets. There were significant differences ($p<0.05$) in mean germination percentages with the highest mean germination percentage recorded for C-FF and the lowest being C-M (Table 4.34).

However, results showed no significant differences (p>0.05) among the sampled carrot seeds for moisture content, percentage purity and vigour index (Table 4.34).

Table 4. 35: Seed quality characteristics of Carrot *var.* Amazonia seeds sampled from four (4) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
C-AM	83.3	7.1	407.4	99.9
C-FF	88.3	6.6	387.1	97.6
C-M	80.3	6.9	396.8	99.3
C-AS	87.0	6.7	407.4	98.2
LSD (0.05)	3.6	0.3	28.7	1.7
Grand Mean	84.7	6.8	399.3	98.7
CV (%)	2.8	1.8	4.7	0.6

4.2.3.2 Seed Quality Characteristics of Okra Seeds Sampled from Three (3) Retail Outlets

From Table 4.35, it is evident that there were significant differences (p<0.05) in mean germination percentages recorded for the sampled okra seeds with the highest mean germination percentage being OK-FF.

Moisture content analysis also showed significant differences (p<0.05) in mean moisture content values (Table 4.35).

Purity analysis conducted showed significant differences (p<0.05) in mean purity percentage values recorded for okra seed samples across all the three retail outlets (Table 4.35).

Seedling vigour index calculated also showed significant differences (p<0.05) for the sampled okra seeds with the highest seedling vigour index (751.9) recorded for OK-FF and the lowest (498.1) for OK-AS (Table 4.35).

Table 4. 36: Seed quality characteristics of Okra *var.* Clemson spineless seeds sampled from three (3) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
OK-FF	76.8	8.2	751.9	97.2
OK-M	67.3	9.0	544.2	98.2
OK-AS	62.5	8.3	498.1	99.7
LSD (0.05)	5.1	0.2	51.5	0.9
Grand Mean	68.8	8.5	598.1	98.4
CV (%)	4.7	0.8	5.4	0.3

4.2.3.3 Seed Quality Characteristics of Cabbage Seeds Sampled from three (3) Retail Outlets

Results showed high germination percentages for all cabbage seed samples analysed. However, there were no significant differences ($p>0.05$) in the mean germination values recorded (Table 4.36).

There were significant differences ($p\leq0.05$) in mean values recorded for percentage moisture content for the sampled cabbage seeds (Table 4.36) with the highest moisture content recorded for CA-AS and the lowest CA-FF.

Results for percentage purity and vigour index however showed no significant differences ($p>0.05$) although cabbage seed samples tested were highly vigorous and had high percentage purity (Table 4.36).

Table 4. 37: Seed quality characteristics of Cabbage *var.* Fortune seeds sampled from three (3) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
CA-FF	95.8	4.7	430.9	98.5
CA-M	94.0	4.9	416.1	98.9
CA-AS	90.8	5.6	446.6	96.3
LSD (0.05)	8.6	0.3	43.6	2.3
Grand Mean	93.5	5.0	431.2	97.9
CV (%)	5.7	2.0	6.3	0.8

4.2.3.4 Seed Quality Characteristics of Sweet Pepper Seeds Sampled from Three (3) Retail Outlets

Results showed high germination percentages for sweet pepper seed samples across all the retail outlets. However, there were no significant differences ($p>0.05$) in mean germination percentages recorded (Table 4.37).

Moisture analysis conducted showed significant differences ($p<0.05$) in mean moisture percentage values recorded (Table 4.37).

Sampled sweet pepper seeds had high percentage purity. However, there were no significant differences ($p>0.05$) in mean purity percentage values (Table 4.37).

Vigour index calculated for sweet pepper seed samples showed significant differences ($p<0.05$) among the treatment means.

Table 4. 38: Seed quality characteristics of Sweet pepper *var.* Yolo Wonder seeds sampled from three (3) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
SP-AS	83.3	7.0	339.2	99.7
SP-M	87.8	6.6	296.3	99.6
SP-C2L	83.5	6.5	335.1	98.9
LSD (0.05)	5.6	0.3	33.6	1.3
Grand Mean	84.8	6.7	323.6	99.4
CV (%)	4.1	1.5	6.5	0.4

4.2.3.5 Seed Quality Characteristics of Hot Pepper Seeds Sampled from Three (3) Retail Outlets

Results from quality analysis conducted for hot pepper seeds showed that there were significant differences ($p<0.05$) in mean percentage moisture content values (Table 4.38). The highest moisture content was recorded for HP-AM and the lowest recorded for HP-UG.

There were no significant differences ($p>0.05$) in mean germination percentage recorded for all the seed samples (Table 4.38). Vigour index and percentage purity values also indicated no significant differences ($p>0.05$) in all the sampled hot pepper seeds (Table 4.38).

Table 4. 39: Seed quality characteristics of Hot pepper *var.* Legon 18 seeds sampled from three (3) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
HP-AM	78.3	8.6	321.5	90.5
HP-UG	83.5	7.7	293.9	92.1
HP-AG	80.3	8.5	326.9	92.0
LSD (0.05)	7.2	0.4	32.00	2.4
Grand Mean	80.7	8.3	314.1	91.5
CV (%)	5.6	1.5	6.4	0.8

4.2.3.6 Seed Quality Characteristics of Onion Seeds Sampled from Four (4) Retail Outlets

Results for mean germination percentage showed significant differences ($p<0.05$) for all sampled onion seeds with the highest germination percentage going for ON-AS1 and the lowest being ON-AG (Table 4.39).

There were significant differences ($p<0.05$) in mean moisture percentage values recorded for the sampled seeds (Table 4.39). Same could be said about seedling vigour index values (Table 4.39) that also showed significant differences ($p<0.05$) among the sampled seeds.

Mean percentage purity values showed no significant difference ($p>0.05$) among the sampled onion seeds (Table 4.39).

Table 4. 40: Seed quality characteristics of Onion *var.* Texas Early Grano seeds sampled from four (4) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
ON-AM1	79.5	7.5	605.0	98.8
ON-AS1	85.5	6.4	721.8	99.5
ON-FF	74.0	7.1	544.6	94.5
ON-AG	68.8	7.8	451.4	99.4
LSD (0.05)	3.5	0.3	27.2	9.1
Grand Mean	76.9	7.2	580.7	98.1
CV (%)	3.0	1.6	2.9	3.3

4.2.3.7 Seed Quality Characteristics of Onion Seeds Sampled from Four (4) Retail Outlets

Mean germination percentage values recorded showed significant differences ($p<0.05$) for the sampled onion seeds (Table 4.40). Mean germination value for ON-J was significantly different ($p<0.05$) from the other three onion samples (Table 4.40).

Mean percentage moisture values recorded also showed significant differences ($p<0.05$) for the sampled onion seeds (Table 4.40). Same could be said of seedling vigour index and percentage purity values that also showed significant differences ($p<0.05$) among the sampled onion seeds (Table 4.40).

Table 4. 41: Seed quality characteristics of Onion *var.* Red Creole seeds sampled from four (4) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
ON-AM2	80.0	6.2	655.8	98.2
ON-AS2	80.8	5.5	594.6	99.4
ON-M	76.3	5.6	540.5	97.5
ON-J	65.0	6.7	251.0	96.5
LSD (0.05)	7.3	0.2	55.4	1.8
Grand Mean	75.5	6.0	510.5	97.9
CV (%)	6.3	1.4	7.0	0.7

4.2.3.8 Seed Quality Characteristics of Cucumber Seeds Sampled from Three (3) Retail Outlets

Results for seed quality analysis showed that there were significant differences ($p<0.05$) in values recorded for mean germination percentage for the sampled cucumber seeds (Table 4.41).

The highest mean germination percentage was recorded for CU-AS whereas the lowest was recorded for CU-D (Table 4.41).

Mean moisture content and mean seedling vigour index values however did not show significant differences (p>0.05) for the sampled cucumber seeds (Table 4.41).

Mean percent purity values for the sampled cucumber seeds were high and showed significant differences (p<0.05) (Table 4.41).

Table 4. 42: Seed quality characteristics of Cucumber *var.* Marketer seeds sampled from three (3) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
CU-AS	92.0	6.8	733.0	98.7
CU-D	72.8	6.6	718.2	99.8
CU-M	88.5	6.6	753.9	99.3
LSD (0.05)	4.3	0.3	54.7	0.8
Grand Mean	84.4	6.7	735.0	99.3
CV (%)	3.2	1.4	4.6	0.2

4.2.3.9 Seed Quality Characteristics of Tomato Seeds Sampled from Four (4) Retail Outlets

Results for seed quality analysis showed that there were significant differences (p<0.05) in percentage germination, percentage moisture content and seedling vigour index for the sampled tomato seeds (Table 4.42). Means for germination percentage were high for the sampled tomato seeds with the highest mean percentage germination value recorded for T-AS1 whereas the lowest was recorded for T-M (Table 4.42).

Mean percentage purity values were high, they however did not show significant differences (p>0.05) for the sampled tomato seeds (Table 4.42).

Table 4. 43: Seed quality characteristics of Tomato *var.* Pectomech seeds sampled from four (4) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
T-AS1	95.8	7.0	464.3	98.7
T- AM	92.0	6.6	576.3	98.5
T-M	80.3	6.8	546.1	99.4
T-AG	85.0	7.2	579.0	97.9
LSD (0.05)	7.5	0.3	49.2	1.6
Grand Mean	88.3	6.9	541.5	98.6
CV (%)	5.5	1.4	5.9	0.6

4.2.3.10 Seed Quality Characteristics of Tomato Seeds Sampled from Three (3) Retail Outlets

Results for seed quality analysis showed that there were no significant differences ($p>0.05$) in percentage germination, percentage purity and seedling vigour index for the sampled tomato seeds (Table 4.43). Means for germination percentage were high for the sampled tomato seeds with the highest mean percentage germination value recorded for T-AS2 (Table 4.43).

Mean percentage moisture content values however showed significant differences ($p<0.05$) for the sampled tomato seeds (Table 4.43).

Table 4. 44: Seed quality characteristics of Tomato *var.* Tropimech seeds sampled from three (3) different retail outlets

Treatments	% Germination	Moisture Content	Vigour Index	% Purity
T-FF	88.8	8.3	437.4	99.5
T-AS2	93.8	7.9	454.2	99.8
T-NF	87.3	8.1	422.0	99.4
LSD (0.05)	6.3	0.2	29.3	1.9
Grand Mean	89.9	6.8	437.9	99.6
CV (%)	4.4	0.7	4.2	0.3

4.2.4 Seed Health Analysis of Second Informed 34 Selected Vegetable Seeds Sampled from Different Retail Outlets.

Six (6) fungal species were identified in the 34 seed samples evaluated from the 18 retail shops. The identified species were;

Aspergillus flavus, Fusarium moniliforme, Alternaria tenuis, Phoma spp, Curvularia lunata and *Fusarium oxysporum*.

Out of the thirty-four (34) sampled seeds, Eleven (11) showed fungal infections whereas the remaining twenty-three (23) were free of fungal infection (Table 4.45). Therefore for each infection case recorded, the incidence was from a total of 2200 seeds analysed.

All tomato seed samples *var.* Pectomech and Tropimech purchased from 7 retail shops did not have any fungal pathogen. Similar observations were made for Sweet pepper *var*. Yolo Wonder obtained from 3 retail shops, Cabbage *var*. Fortune obtained from the 3 other retail shops and Okra *var*. Clemson spineless also obtained from the 3 other retail shops. All Carrot *var*. Amazonia seed samples obtained from 4 retail shops were infected with *Alternaria tenuis* except for C-FF which was infected with both *Alternaria tenuis* and *Aspergillus flavus* (Figure 4.11).

Table 4.45: Second Informed 34 Selected Seed Samples and their Associated Fungi

Seed Samples	Fungi
C-AM	*Alternaria tenuis*
C-FF	*Alternaria tenuis*
	Aspergillus flavus
C-M	*Alternaria tenuis*
C-AS	*Alternaria tenuis*
OK-FF	No fungi
OK-M	No fungi
OK-AS	No fungi
CA-FF	No fungi
CA-M	No fungi
CA-AS	No fungi
SP-AS	No fungi
SP-M	No fungi
SP-C2L	No fungi
HP-AM	*Aspergillus flavus*
	Fusarium moniliforme
	Fusarium oxysporum
HP-UG	*Aspergillus flavus*
	Fusarium moniliforme
	Curvularia lunata
HP-AG	*Fusarium moniliforme*
	Aspergillus flavus
ON-AM1	No fungi
ON-AS1	No fungi
ON-FF	No fungi
ON-AG	*Aspergillus flavus*
	Fusarium moniliforme
ON-AM2	No fungi
ON-AS2	No fungi
ON-M	*Aspergillus flavus*
	Fusarium moniliforme
ON-J	*Aspergillus flavus*
CU-AS	*Aspergillus flavus*
	Phoma spp.
CU-D	No fungi
CU-M	No fungi
T-AS1	No fungi

T-AM	No fungi
T-M	No fungi
T-AG	No fungi
T-FF	No fungi
T-AS2	No fungi
T-NF	No fungi

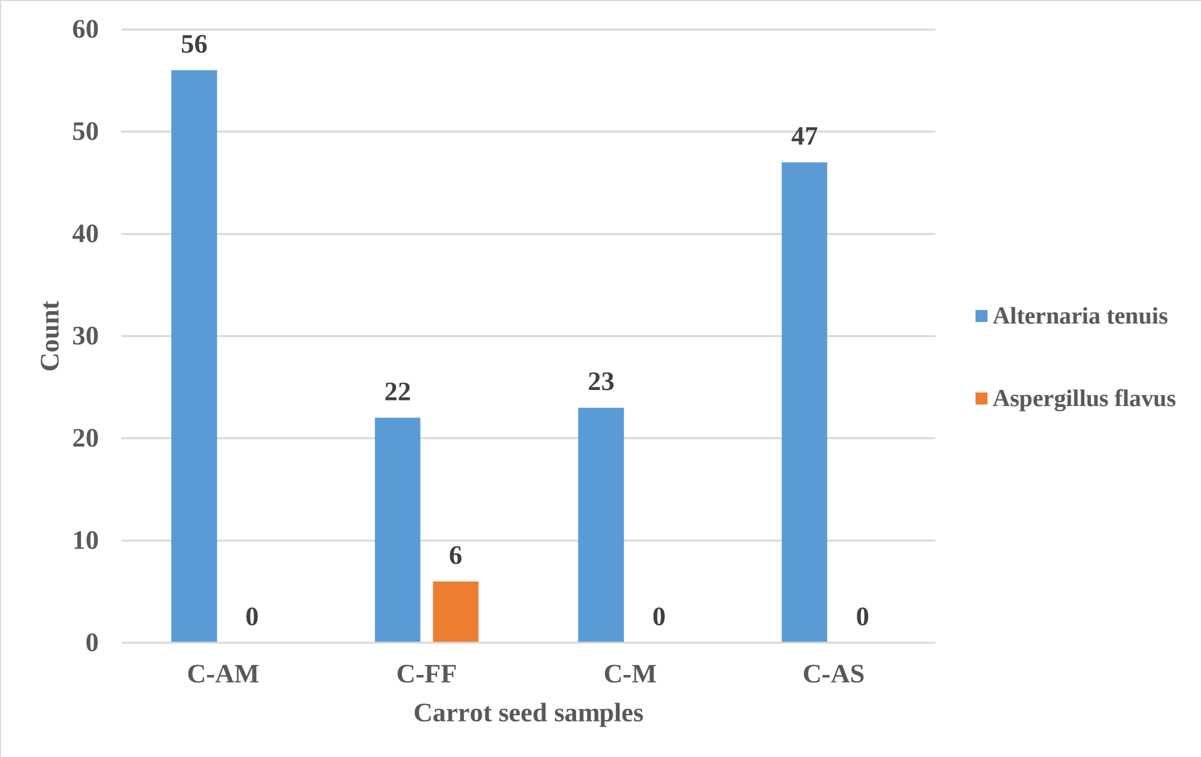

Figure 4. 11: Fungal species incidence for Carrot *var.* Amazonia seeds sampled from four (4) different retail outlets

All Hot pepper seed samples obtained from the 3 retail outlets were infected with at least two species of Fungi. HP-AM was associated with *Fusarium moniliforme*, *Fusarium oxysporum* and *Aspergillus flavus*; HP-UG was associated with *Fusarium moniliforme*, *Aspergillus flavus* and *Curvularia lunata*; HP-AG was associated with *Fusarium moniliforme* and *Aspergillus flavus* (Figure 4.12).

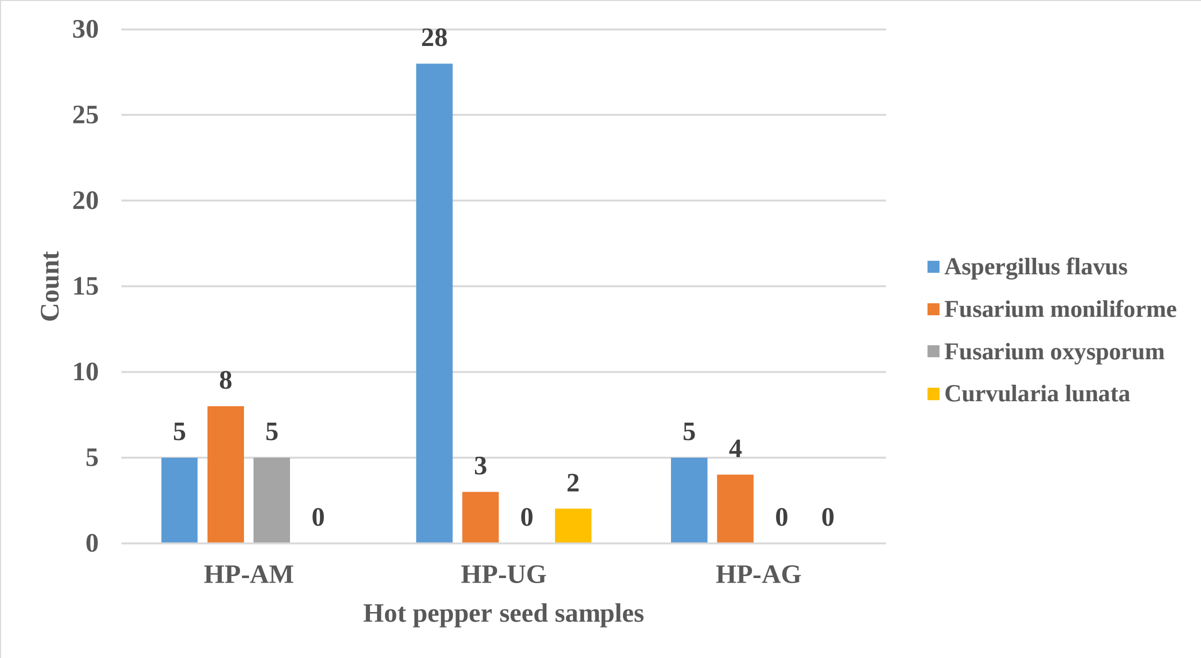

Figure 4. 12: Fungal species incidence for Hot pepper *var.* Legon 18 seeds sampled from three (3) different retail outlets

Of the 4 onion *var*. Texas Early Grano seed samples obtained from 4 different retail shops, only ON-AG had *Fusarium moniliforme* and *Aspergillus flavus* (Figure 4.13).

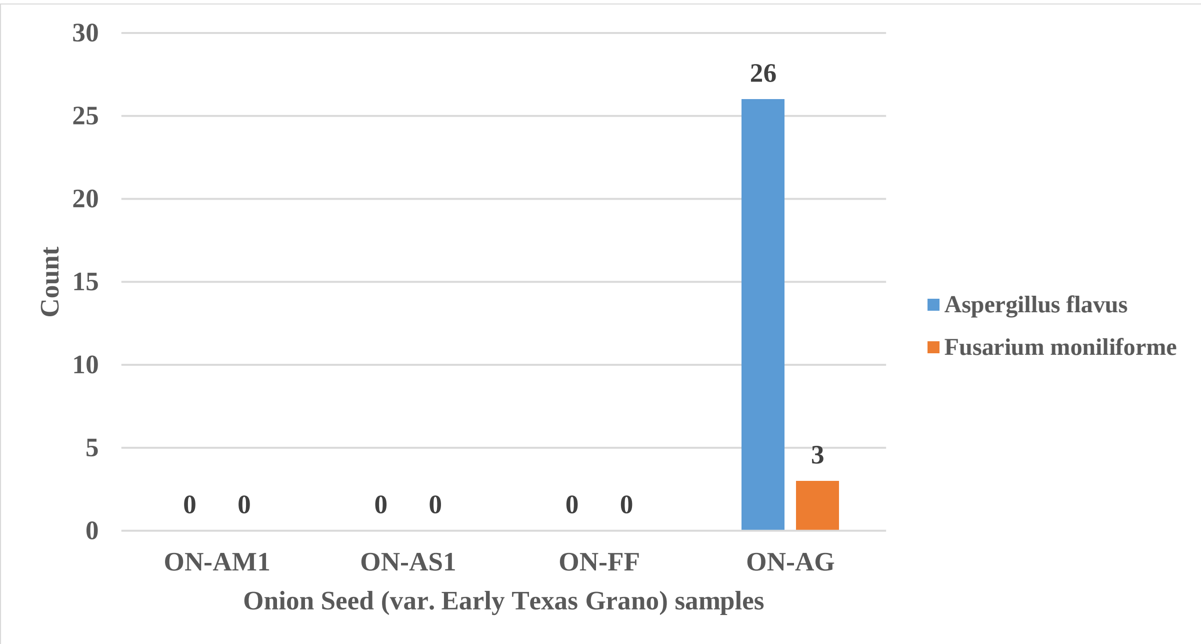

Figure 4. 13 : Fungal species incidence for Onion *var.* Texas Early Grano seeds sampled from four (4) different retail outlets

However, seed health analysis for onion *var*. Red creole seed samples obtained from 4 different retail shops revealed that ON-AM2 and ON-J were infected with *Aspergillus flavus* while ON-M was infected with both *Aspergillus flavus* and *Fusarium moniliforme* (Figure 4.14).

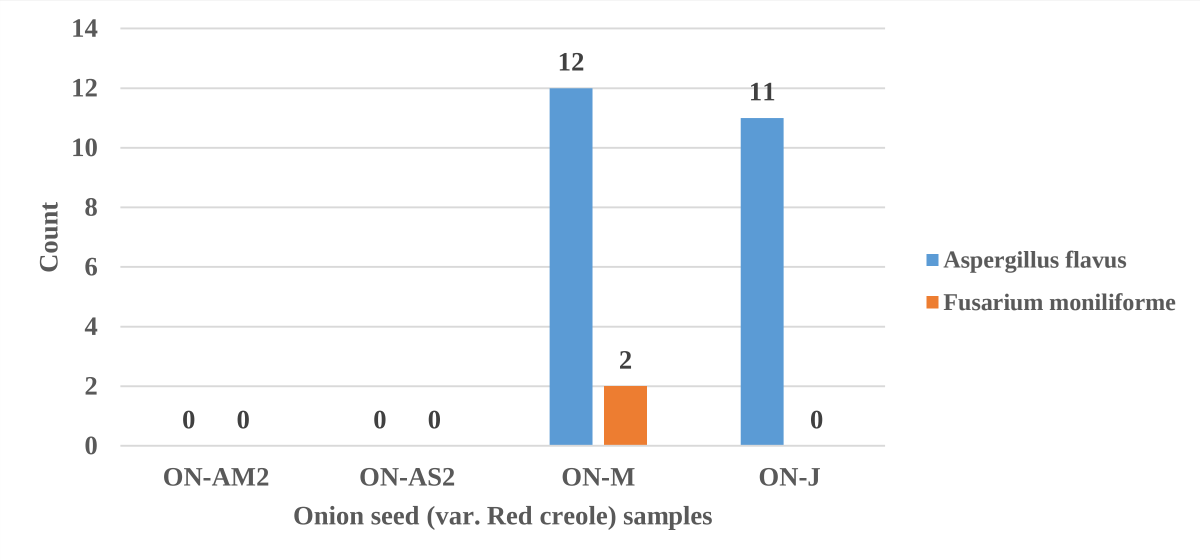

Figure 4. 14: Fungal species incidence for Onion *var.* Red Creole seeds sampled from four (4) different retail outlets

Of the 3 cucumber *var*. Marketer seed samples obtained from 3 retail shops, only CU-AS had *Aspergillus flavus* and *Phoma spp*. (Figure 4.15).

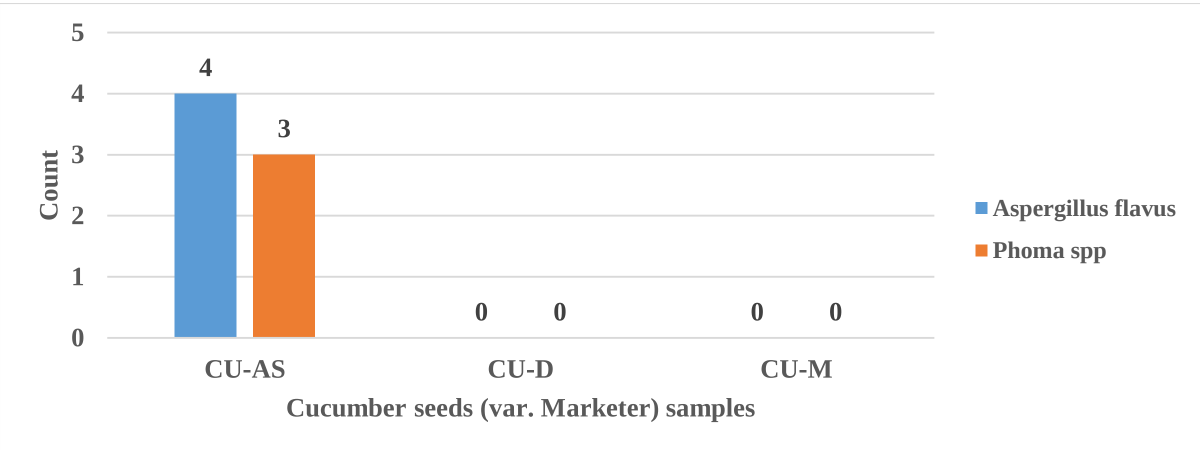

Figure 4. 15 : Fungal species incidence for Cucumber *var.* Marketer seeds sampled from three (3) different retail outlets

Overall, the total fungal counts representing fungal incidences recorded was 275 out of the total 6800 seeds. Out of this, *Alternaria tenuis* held the highest number (148) of incidence representing 53.82 % of the total, followed by *Aspergillus flavus* which recorded 97 corresponding to 35.27 %. Again, *Fusarium moniliforme*, *Phoma spp*. and *Fusarium oxysporum* recorded incidences of 20 (7.27 %), 3 (1.10 %) and 5 (1.82 %) respectively. The lowest incidence was *Curvularia lunata* which recorded 2 corresponding to 0.73 %.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Survey Results

5.1.1 Demographic Characteristics of Seed Retailers

Results from the survey revealed that majority (67 %) of the seed retailers were males. This observation is in agreement with an earlier report by Mabaya *et al*. (2017) where out of a total of 3,153 agro-input dealers surveyed across Ghana, 83 % were males. Krausova and Banful (2010) also reported that in Ghana, agro-dealerships representing a total of 81 % are primarily male-owned and owner managed. Male dominance in the certified seed retail business may be due to a corresponding male dominion in agriculture and other related fields. Although females represent an essential asset in agriculture and the economy through the varied parts they may play in the industry, they are confronted with extreme requirements in terms of access to beneficial resources (FAO, 2003). Despite the fact that female involvement in the seed trade business is a booster to encourage women participation to ensure balance in the future, female involvement is considerably more constrained either due to social, customary or sociological elements (FAO, 2003).

Age as a parameter is crucial in the seed industry since usually, the older the seed retailer, the lesser his/her interest in adopting new innovations (Malauni, 2009). The study showed majority (44.4 %) of the seed retailers to be between the ages of 25 and 35 years which may be a good indication of their willingness to accept and adopt new agricultural innovations.

The level of education and experience of seed retailers are other important factors influencing quality of seed in the industry. Thus, it is a vital input in crop production hence it would be necessary to ascertain the level of education of seed retailers as this will determine how technical services being packaged are delivered to end users (Malauni, 2009). The study revealed that all the seed retailers interviewed were literate, well informed, had at least 5 years of experience and could articulate logically in some fundamental practices related to seed business. This implies that seed retailers could easily receive and disseminate technical advice and training on the job as it pertains to standard procedures and practices in the seed retailing business whenever necessary. Adegbola and Gardebroek (2007) reported that educated seed retailers were able to better process information, allocate inputs more efficiently and effectively, and more accurately assess the profitability of new technologies, compared to seed retailers with little or no education.

5.1.2 Demographic Characteristics of Retail Outlets

According to Syngenta (2017), strong retail partnerships is a booster in the effective delivery of new technologies to farmers and other stakeholders in the seed industry. The results of the survey showed that majority of the businesses (38.9 %) were partnerships which is an advantage in making the most of opportunities and overcoming challenges pertaining to seed retailing. This results is in agreement with earlier reports by Krausova and Banful (2010) where out of the 10 regions surveyed, the Greater Accra region represented the region with the highest agricultural input dealer type of business being partnership.

It should be emphasised that the prevailing temperatures and relative humidity in retail shops was not due to lack of knowledge on the part of seed retailers since almost all respondents admitted to the fact that cold seed storage was the best practice. When asked, retailers alluded to high cost involved in maintaining cold rooms which may subsequently add up to the cost of seeds. High temperatures and relative humidity have significant adverse effects on the viability of seeds (Mbofung *et al*., 2013). They reported that treated seeds could be carried over for two seasons if the storage temperature is maintained at 10 ^{0}C and relative humidity below 40 %.

Vieira *et al*. (2001) also reported that the decline in seed viability is directly linked to the moisture content of the seed which depends on the relative humidity of the storage environment. The higher the relative humidity of the storage environment the more seeds pick up moisture.

5.1.3 Seeds Retailed, Seed Suppliers and Delivery Channels

Results from the survey showed that vegetable seeds were seeds most sold by retailers which could be due to the fact that seed retailers were taking advantage of the non-existence of locally produced vegetable seeds hence the importation of vegetable seeds to be sold in the market to make money. The lack of locally produced vegetable seeds may be due to the limited number of vegetable seed breeders in Ghana's research and breeding programs which results in Ghanaian vegetable farmers and seed retailers over-depending on farmer-saved seeds and imported vegetable seeds. The lack of germplasm for vegetable seed production in Ghana may be due to financial reasons since some tomato farmers in Ghana have revealed they do not see any economic benefit of investing in quality seed (Clottey *et al*., 2009). The reason being that fruit and vegetable prices on the market are the same irrespective of the type of seed used for their production thus, making farmer-saved and farmer-traded seed a dominant source of seed for 80-90 % of farmers in Sub-Saharan Africa (Almekinders *et al*., 1994; Walker *et al*., 1997a; Tripp, 2001).

According to the survey results, majority (55.6 %) of the respondents mentioned that the mode of transport of certified vegetable seeds to retail shops was by ordinary vehicles instead of custom-made cold vans. Some respondents attributed this to the absence of commercial custom-made mobile cold vans and if present, the high cost it may incur which may subsequently add up to the cost of seeds. Because seeds are biological products, other respondents also attributed the reason to temperature fluctuations which may increase reaction rates by affecting reactive enzymes as a result of transporting seeds in custom-made mobile cold vans and later exposing them to storage under high temperatures in retail shops.

Results also indicated that certified vegetable seeds were properly labelled with adequate product information for end users. This could be credited to the regulatory body which enforces certification and quality control measures in the area of seed distribution and marketing. Nishikawa (2010) reported that seed certification is one of the crucial mechanisms that safeguards the provision of good quality seeds to farmers. Alemu *et al*. (2010) also asserted that since farmers have issues evaluating the physical or genetic characteristics of seeds before they are planted, accreditation of seed quality is fundamental in giving buyers quality confirmation and a method for review if desires are not met.

Respondents affirmed that the quality of vegetable seeds was affected by the length of storage time. Majority were of the view that the longer the storage time the poorer the viability. According to Schmidt. (2000) seeds should not be stored for lengthy periods in tropical conditions to avoid problems with seed deterioration.

Majority of the respondents (72.2 %) did not perform simple germination test on sourced vegetable seeds prior to selling. This could be attributed to the fact that seed retailers believed sourced vegetable seeds had already undergone certification and other quality control procedures and have been certified by the regulatory body responsible for certification. However, reports by FAO (2010) state that deferrals in seed conveyance and how seeds are stored (in travel and at the retailers' end) can have serious negative impacts on seeds. Seed retailers should at least perform simple germination test on seeds to at least confirm germination percentage prior to selling.

5.2 Laboratory Evaluation of Vegetable Seed Samples

5.2.1 Impact of Moisture Content on Vegetable Seed Samples

With reference to Appendix 2 (Seed quality standards for emergency activities based on FAO Quality Declared Seed QDS), the maximum percentage moisture content based on the FAO Quality Declared Seed for vegetable seeds is 8 % or below. Individually the various seed samples possessed varied percentage moisture contents. Collectively, almost all tested vegetable seed samples had moisture content values at 8 % or below with an average moisture content value of 7.1 %. This results is in line with the QDS standards which indicates vegetable seeds attaining a maximum percentage moisture content of 8 % or below.

OK-AM (L) and OK-FF (L) both recorded an equal percentage moisture content of 8.8 % which is above QDS standards. Although both seeds are locally produced, the reason could not only be attributed to improper drying of seeds but also poor retailer storage practices since both retail shops recorded high relative humidity. Vieira *et al*. (2001) asserted that the decline in seed viability is directly linked to the moisture content of the seed which depends on the relative humidity of the storage environment. The higher the relative humidity of the storage environment the more seeds pick up moisture. Same reason could be attributed to B-D and T-AS which also had moisture content values of 9.5 % and 8.7 % respectively.

Results for the selected vegetable seed samples were in line with QDS standards which indicates vegetable seeds attaining a maximum percentage moisture content of 8 % or below. However, only 3 seed samples namely okra *var*. Clemson Spineless, hot pepper *var*. Legon 18 and tomato *var*. Tropimech had percentage moisture values above QDS standards. Percentage moisture values for HP-AM (8.6 %) and HP-AG (8.5 %) were above QDS standards as compared to HP-UG (7.7 %). The difference could be due to the different storage conditions the seed samples were subjected to. HP-AM and HP-AG were both stored in open spaces at room temperatures in retail outlets whereas HP-UG was stored under cold storage, which rendered HP-AM and HP-AG picking up moisture as a result of the prevailing high relative humidity in both retail outlets. Same reason could be given to T-FF (8.3 %) and T-NF (8.1 %) which had percentage moisture values above QDS standards because both were stored in open spaces at room temperatures in retail outlets as compared to T-AS2 (7.9 %) which was subjected under air-condition storage. All okra seed samples had percentage moisture values above QDS standards suggesting poor retail storage conditions.

5.2.2 Impact of Percentage Purity on Vegetable Seed Samples

Purity analysis conducted showed that the samples percentage purity values were relatively higher although the values varied among the samples. Almost all sampled vegetable seeds had percentage purity values within QDS standards with an average percentage purity value of 96.5 %. However, all sampled local vegetable seeds consisting of OK-FF (L), E-AM (L), E-UG and HP-UG (Table 4.33) recorded percentage purity values below QDS standards (Appendix 2). This could be attributed to challenges in harvester calibrations and post-harvest operations. SP-C2L and ON-J however had percentage purity values below QDS standards although they are imported seeds. This could be due to re-packaging of these seed samples into smaller transparent plastic bags which may have attracted the addition of inert matter.

Results for the selected vegetable seed samples were in line with the QDS standards except for hot pepper *var.* Legon 18 seed samples which could be attributed to challenges in harvester calibrations and post-harvest operations.

5.2.3 Impact of Germination Percentage and Seed Vigour on Vegetable Seed Samples

Results from the germination test showed that germination percentage values were greater than the minimum certification standard (80 %) (Appendix 2) with mean germination percentage recorded as 81.2 % (Table 4.33). This indicates that seed retailers were storing seeds well. This is in agreement with (Rindels, 1995) who reported that the viability of seeds depended on seed storage conditions.

In contrast, E-ML (69.3 %), ON-J (65 %) and E-JE (67.5 %) recorded lower germination percentage values than the FAO (QDS) standards. This was because seeds of E-ML were near expiration per its seed label and those of ON-J and ON-JE were stored under high temperatures and relative humidity. Mbofung *et al*. (2013) reported that high temperatures and relative humidity could have significant negative effects on the viability of seeds.

From the results of the selected vegetable seed samples, values for germination percentage of okra *var*. Clemson Spineless seed samples were all below QDS standards although germination percentage value for OK-FF (76.8 %) was higher and significantly different from OK-M (67.3 %) and OK-AS (62.5 %) (Table 4.35). The low germination percentage values recorded showed that retailers did not store seeds well and the significant differences among seeds sampled from the different retailers suggested that each retailer stored seeds differently thus accounting for the differences in the germination performances of each sampled okra seed (Rindels, 1995).

Again, germination percentage values for onion *var*. Texas Early Grano seed samples showed significant differences with only ON-AS1 above the QDS standard (Table 4.39). This is a clear indication of the difference in storage conditions across the four retail outlets. ON-AS1 was stored under air-condition whereas the rest were stored in open spaces at room temperature which exposed the seeds to relatively higher temperatures and humidity resulting in viability losses. These observations agree with reports by Rindels (1995). Similarly, onion *var*. Red Creole seeds tested showed that germination percentage values for ON-M (76.3 %) and ON-J (65.0 %) were relatively lower than the QDS standard (Table 4.40). Germination percentage value for ON-J was significantly different from the other 3 samples because while the other 3 were packaged in sealed paper sachets, ON-J was also re-packaged into transparent plastic bags which significantly affected its germination percentage due to light penetration which might have influenced respiration within the seed.

From Table 4.41, germination percentage value for CU-D (72.8 %) was lower than the QDS standards and significantly different from CU-AS (92.0 %) and CU-M (88.5 %). This observation may be attributed to CU-D having been in store for a longer period compared to the others. Apart from packaging material and storage condition which may affect seed viability, Rao *et al*. (2006) reported that storage duration had significant negative impacts on the viability of onion seeds.

It should be emphasised that, a large number of the sampled seeds tested recorded high germination percentages in the first count which was used in computing the seedling vigour parameter. A positive correlation was found between the seed vigour analysis and germination for most of the tested seed samples which is similar to reports by Tokpah (2010) meaning the highest vigour percentages resulted in a higher germination percentages. However, the study outcome revealed some discrepancies in seedling germination and seedling vigour as Perry (1981) reported variation in seedling vigour and germination due to the influence of either genetic characters or environmental factors.

Mahadevappa and Nandisha (1987) earlier stated that seeds possessing low vigour had the propensity to lose their viability faster as compared to those with a much higher vigour under the same conditions.

5.2.4 Impact of Seed Health on Vegetable Seed Samples.

Aspergillus flavus and *Macrophomina phaseolina* were found to have the highest incidence according to the results of the seed health analysis. These were followed by *Fusarium* *moniliforme, Curvularia lunata Fusarium oxysporum* and *Colletotrichum dematium* although the extent to which these fungal species were associated with seeds was not as high as *Aspergillus flavus* and *Macrophomina phaseolina*.

Again, from the results of the seed health analysis of the selected vegetable seed samples, it was found that six (6) fungal species were associated with the tested seed samples. The identified species were;

Aspergillus flavus, Fusarium moniliforme, Alternaria tenuis, Phoma spp, Curvularia lunata and *Fusarium oxysporum*. Of these, *Alternaria tenuis* and *Aspergillus flavus* recorded the highest incidences.

Abdelwehab *et al*. (2014) reported that fungi were the primary pathogens associated with seeds causing overwhelming effects on seed germination and emergence, plant growth, vigour and ultimately quality and quantity of seeds.

The ubiquitous fungal pathogen *Macrophomina phaseolina* as best known as the causal agent of charcoal rot and premature death (Fuhlbohm, 2013) was only found associated with OK-AM (L). This could be attributed to seed infection emanating from microsclerotia growing systemically through the plant after stem or root infection (Fuhlbohm, 2013). When such seeds are employed for sowing, seed-borne pathogens may cause disease or death of plants on the field resulting in crop loss (Morre and Tymowski, 2005).

The high incidence of *Aspergillus flavus* and *Alternaria tenuis* on vegetable seeds was also reported by Abdelwehab *et al*. (2014) who noted highest incidence of the genus *Aspergillus* followed by *Alternaria* on imported vegetable seeds. They added that the association of these seed mycoflora with vegetable seeds caused very low germination (15-79 %) and seedling emergence (12-75 %).

The incidence of the other fungal species on vegetable seeds may be due to re-packaging of seeds into smaller transparent plastic bags since most of these fungal species were detected on re-packaged seeds. During this act, seeds are exposed to the external environment which attracts the association of air-borne fungi with the seeds.

Since these fungi can be naturally present in the seeds, their hazardous effects on the growth of plants, vigour and productivity warrant further investigations on their control. Therefore, it is apparently crucial to develop and implement environmentally friendly and effective eradication measures for these seed-borne mycoflora (Abdelwehab *et al*., 2014).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the study conducted, the following conclusions can be made:

I. Vegetable seed retailers in the greater Accra Region of Ghana were literate, well informed, had at least 5 years of experience and could articulate logically in some fundamental standard procedures and practices related to the seed retailing business.

II. The major problems facing vegetable seed retailers were the lack of proper storage facilities, lack of a good communication network between the retailers and farmers and dissatisfaction of farmers about the high cost of vegetable seeds due to high import duties.

III. Vegetable seed samples taken from the retail outlets were not of inferior quality. Percentage moisture content values were within minimum standards with the exception of a few samples whose moisture contents were on the high side due to the high relative humidity of retail shops and re-packaging of seeds into smaller transparent plastic bags which made seeds pick up additional moisture from the surrounding environment.

IV. Seed samples analysed also had percentage germination within minimum standards except for a few which was attributed to the impact of high temperatures and relative humidity of the retail shops.

V. Seeds analysed possessed high analytical purity percentages with the exception of the locally produced vegetable seeds whose percentage purity values were below standards. Imported vegetable seeds that recorded lower purity percentages were also due to re-packaging into smaller transparent plastic bags which introduced some additional inert matter.

VI. Seed health analysis showed high incidence of seed-borne fungi on locally produced vegetable seeds. Most imported vegetable seeds showed little or no fungal incidences because they were pre-treated with fungicides (Topsin and Thiram). Imported vegetables that showed fungal incidences were as a result of re-packaging which exposed seeds to unfavourable external conditions which created room for fungal infection.

From these findings, it can be concluded that marketed vegetable seeds in the Greater Accra Region of Ghana following the post-certification surveillance indicated an acceptably high seed quality.

6.2 Recommendations

I. This study should be replicated in other regions to have a general view of the state of vegetable seeds in the distribution and marketing chains outside the capital.

II. Both government and private sectors should be committed to investing in the development of germplasm for locally consumed vegetables for production of foundation and certified seeds to reduce over-reliance on imported certified vegetable seeds.

III. Government through its one district one factory policy should explore the possibility of establishing or renovating seed processing plants and cold rooms to aid proper seed cleaning, drying and storage to ensure certified seeds meet both local and international seed quality standards.

IV. Seed Retailers should be encouraged to recognise seed retail as a business and solicit for the right investments to obtain sizeable cold rooms for seed storage since high temperatures adversely affect seed quality.

V. Seed Retailers must be trained on simple germination tests and be able to improvise simple nursery trays in their retail shops to at least test for seed germination especially when seeds are carried over from previous seasons.

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APPENDICES

Appendix 1: Research Questionnaire

INTRODUCTION

I am **Radiant Kwabena Appiah Ahenkan**, a Seed Science and Technology student from the West African Centre for Crop Improvement (WACCI) of the University of Ghana, Legon. As part of my research, I am conducting a survey on the topic **"Post-certification surveillance of Marketed Vegetable Seeds in the Greater Accra Region for Seed Quality Maintenance"** and I duly plead for your assistance and cooperation to achieve this task. Please answer the questions that follow by ticking the appropriate options (if provided) or writing unrestrictedly for open-ended questions. Please answer all questions freely but objectively.

The information is for academic purposes only and will be treated with the strictest confidentiality.

1. Name of Interviewee………………………………………………………………...
2. Sex: a. Male ☐ b. Female ☐

3. Marital Status

    a. Single ☐ b. Married ☐ c. Divorced ☐ d. Separated ☐

4. Age (years): a. Below 25 ☐ b. 26-35 ☐ c. Above 36 ☐

5. Highest Educational level attained

    a. B.E.C.E. ☐ b. S.S.S.C.E. ☐ c. HND ☐ d. Diploma ☐

    e. Degree ☐ f. Masters ☐ g. Other ☐

    h. No Formal Education ☐

6. Name of Shop/Company…………………………………………………………….

7. Address/Location…………………………………………………………………

8. Telephone No……………………………………………………………........

9. Type of business:

    a. Sole Proprietor ☐ c. Partnership ☐ e. Company ☐

    b. Franchise ☐ d. Limited Liability ☐ f. Other ☐

10. Employees (Number): Skilled………….. Unskilled……………..

11. How many years have you been selling seeds?

    a. Less than 5 years ☐ c. Between 5 and 10 years ☐

    b. Between 10 and 20 years ☐ d. 20 years or more ☐

12. Which seeds do you retail? a. Vegetable ☐ b. Cereals ☐ c. Legumes ☐

    d. Lawn seeds ☐ e. Fruits ☐ f. Other (Specify)………………………..

13. Which vegetable seeds do you retail?

Vegetable	Varieties	OPV/Hybrid	Period (Years)	Date supplied

14. State the highest selling vegetable seeds from your shop

a.…………………………..….   b.……………………………………

15. Are there vegetable seeds that buyers ask for that you do not have?

a Yes [ ]   b. No [ ]

16. If 'yes' to question 14, what are these vegetable seeds?

a.……………………………

b.……………………………

c.……………………………

d.……………………………

e.……………………………

17. Do you receive any complaints from buyers about vegetable seeds purchased?

a Yes [ ]   b. No [ ]

18. If 'yes' to question 16, State a few of these complaints

Complaint(s)	**Tick (where applicable)**
Poor germination	
Presence of insects	
Discolouration	
Mould	
Presence of viruses when planted	
Low establishment	
Varietal mix up	
Presence of weeds when planted	
Other (please specify) ……………………………….......... ……………………………………..	

19. Who is/are your certified vegetable seed supplier(s)? a. Seed growers [ ]

b. Cooperatives [ ] c. Seed companies [ ] d. Other (Specify)………………

20. How are the vegetable seeds delivered to you?

a. In a cold van [ ] b. In an air-conditioned van [ ] c. In an ordinary van [ ]

21. From question 20, which in your opinion is the best practice?

a. In a cold van [ ] b. In an air-conditioned van [ ] c. In an ordinary van [ ]

22. What sort of packaging material is used for your sourced vegetable seeds purchased?

a. Aluminium foil [ ] b. Cans [ ] c. Paper Sachets [ ] d. Transparent plastic bags [ ] e. Transparent plastic containers [ ] f. Other (specify)………………

23. Where are the delivered vegetable seeds kept?

a. Warehouse [ ] b. Retail Shop [ ] c. Other (Specify)………………………..

24. Are the vegetable seeds properly labelled? a. Yes [ ] b. No [ ]

25. Tick where appropriate the information on vegetable seed label.

a % Germination [ ]
e. % Weed seed present [ ]
b Batch number [ ]
f. % Other crop seed [ ]
c Varietal name [ ]
g. Packaging date [ ]
d Lot number [ ]
h. % Inert matter [ ]

26. Do you perform any germination test to ascertain seed quality standards as per the label? a Yes [ ] b. No [ ]

27. Under what condition(s) is/are your vegetable seeds stored over time?

a. Room temperature [ ] b. Cold room [ ]
c Air-conditioned room [ ] d. Freezer [ ]

28. How long do you keep the vegetable seeds in stock? a.1-3 months [ ]

b. 4-6 months [ ] c. 7-9 months [ ] d. 10-12months [ ]

29. In your opinion does the length of storage time affect vegetable seed quality?

a. Yes [ ] b. No [ ]

30. If 'yes' to question 29, How? ……………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

31. Do you carry over certified vegetable seeds from one year/season to the other?

a. Yes [ ] b. No [ ]

32. If 'yes' to question 31, how do you store such vegetable seeds?

a. In a Cold Room [ ] b. At room temperature [ ] c. Other (Specify)………………

33. Are you aware of factors that affect vegetable seeds in storage? a. Yes [ ] b. No [ ]

34. If 'yes' to question 33, give examples.

a. Storage temperature [ ] b. Moisture content [ ] c. Humidity [ ]

d. Pests [ ] e. Poor processing [ ] f. Heat [ ] g. Pathogens [ ]

35. Do you keep vegetable seeds together with agro chemicals? a. Yes [ ] b. No [ ]

36. Have you identified any negative effect of agro - chemicals on the seeds?

a. Yes [ ] b. No [ ]

37. If 'Yes' to question 36, what are these observable effects of agro-chemicals on vegetable seeds? ....

……………………………………………………………………………………..

……………………………………………………………………………………..

38. When it is time to resell carried over stocks do you do any Standard Germination test?

a. Yes [ ] b. No [ ]

39. What kind of marketing challenges are you facing with regards to supplying good quality vegetable seeds to farmers and dealers?

a. Early maturing [ ] b. Seasonal [ ] c. Late maturing [ ] d. Off-season [ ] e. Promotion [ ] f. Storage [ ] g. Access to credit facilities [ ] h. Access to good communication network [ ] i. Pricing [ ] j. Package sizes [ ]

40. What are you doing to solve the problem(s) above.………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………..

41. Are you aware of agencies/institutions that can assist you with these challenges?

a Yes [ ] b. No [ ]

42. Is there anything that can be done to help improve your vegetable seed business?

……………………………………………………………………………………………

……………………………………………………………………………………………

Appendix 2: Seed Quality Standard for Emergency Activities - Based on FAO Quality Declared Seeds (QDS)

Seed Quality Standards for Emergency Procurement

Based on FAO Quality Declared Seed (QDS)

VEGETABLES	Varietal purity[1] (min. %)	Analytical purity[2] (min. %)	Germination (min. %) [3]		Moisture content (max. %)[4]
			Local Tender	International Tender	
Amaranthus	98	95	70	80	8
Beetroot	98	95	70	80	8
Cabbage	98	98	70	80	8
Carrot	98	97	70	80	8
Cauliflower	98	98	70	80	8
Celery	98	97	70	80	8
Chinese Cabbage	98	98	70	80	8
Cucumber	98	98	70	80	8
Eggplant	98	98	70	80	8
Leek	98	97	70	80	8
Lettuce	98	97	70	80	8
Melon	98	98	70	80	8
New Zealand Spinach	98	97	70	80	8
Okra	98	98	70	80	8
Onion	98	97	70	80	8
Parsley	98	95	70	80	8
Radish	98	98	75	80	8
Spinach	98	97	70	80	8
Squash	98	98	70	80	8
Sweet Pepper	98	98	70	80	8
Swiss Chard	98	95	70	80	8
Tomato	98	98	75	80	8
Turnip	98	98	70	80	8

Watermelon	98	98	70	80	8

1

Varietal purity: the percentage of the pure seed that will produce plants that exhibit the characteristics of that specific crop variety. This can only be determined through DNA fingerprinting and/or field inspection of seed crop plots.

2

Analytical purity: the percentage of the seed that is of the same crop species but not necessarily the same crop variety. The balance can include inert matter, weed seed, damaged seed. While regular seed testing procedures may not, in all cases, distinguish between different varieties of the same species, the seeds of different crop (species) can be identified in the seed laboratory by close examination of the seed.

3

Germination: the percentage of the seed with the ability to germinate and that can develop into plants under appropriate field conditions of optimum moisture, aeration and temperature. For international procurements of vegetable seed the minimum germination should be 80%.

4

Maximum moisture content recommended for safe storage and good germination. Values may vary according with crop types (starchy vs. oil/protein seeds) and according to local conditions, in particular with environmental relative humidity and temperature. Local standards should be applied.

Appendix 3: List of Vegetable Seed Varieties Sampled from the Different Retail Outlets.

Vegetables	Variety/Brand	OPV/Hybrid	Distributer(s)	Manufacturer(s)
Tomato	Cobra	F1	Agriseed Ltd	Technisem
Tomato	Jaguar	F1	Agriseed Ltd	Technisem
Tomato	Kiara	F1	Agriseed Ltd/Callighana/Crop2Life	Technisem
Tomato	Nadira	F1	Agriseed Ltd/Agrimat Gh. Ltd./Callighana/Crop2Life	Technisem
Tomato	Roma savanna	OPV	Agriseed Ltd	Technisem
Tomato	Buffalo	OPV	Agriseed Ltd	Technisem
Tomato	Rio grande	OPV	Agriseed Ltd	Technisem
Tomato	Heinze	OPV	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Tomato	Pectomech	OPV	Agriseed Ltd/Agrimat Gh. Ltd.	Technisem/AGRIMAT USA LLC
Tomato	Roma VF	OPV	Agriseed Ltd/Farmers friend	Technisem
Tomato	Symbal	F1	Agriseed Ltd	Technisem
Tomato	Prado	F1	Agriseed Ltd	Technisem
Tomato	Celsius	F1	Agriseed Ltd	Technisem
Tomato	Rio grande	OPV	Nanafico Marketing Co. Ltd.	Monarch Seeds
Tomato	Amsterdam	OPV	Nanafico Marketing Co. Ltd.	Monarch Seeds
Tomato	Rio grande VF	OPV	Dizengoff Gh. Ltd	Dizengoff Gh. Ltd
Tomato	Cobra	F1	Agrimat Gh. Ltd.	Technisem
Tomato	Tropimech	OPV	Farmers Friend/Meridian seeds/Agriseed Ltd.	Technisem
Tomato	Kilele	F1	Callighana	Syngenta
Tomato	Ercole	F1	Callighana/Crop2Life	Syngenta
Tomato	UC-82	OPV	Callighana/Aglow Agric Products Ltd.	Bakker Brothers/Unigen
Tomato	Petomech	OPV	Aglow Agric Products Ltd.	Unigen seeds
Tomato	Roma VF	OPV	Callighana	Bakker Brothers
Tomato	UC-82	F1	RMG Ghana Ltd.	Starkes Ayres
Tomato	Petomech	F1	RMG Ghana Ltd.	Starkes Ayres
Tomato	Roma	F1	RMG Ghana Ltd.	Starkes Ayres
Tomato	Petomech	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Tomato	Cobra	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Tomato	Jaguar	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Tomato	Rodeo	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Tomato	Mongal	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem

Cucumber	Tokyo	F1	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cucumber	Kenzo	F1	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cucumber	Akito	F1	Agriseed Ltd	Technisem
Cucumber	Murano	F1	Agriseed Ltd	Technisem
Cucumber	Poinsett	OPV	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cucumber	Marketer	OPV	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cucumber	Darina	F1	Nanafico Marketing Co. Ltd.	Monarch Seeds
Cucumber	Supermarketer	OPV	Dizengoff Gh. Ltd./Wasambazaji	Amiran seeds
Cucumber	Olympic	F1	Farmers Friend	Technisem
Cucumber	Green Slam	F1	Aglow Agric Products Ltd.	Unigen seeds
Cucumber	Ashley	F1	RMG Ghana Ltd.	Starke Ayres
Onion	Russet	F1	Dizengoff Gh. Ltd	Hazera seeds
Onion	Texas Early Grano	OPV	Agriseed Ltd	Technisem
Onion	Red creole	OPV	Agriseed Ltd/Agrimat Gh. Ltd.	Technisem/AGRIMAT USA LLC
Onion	Julio	OPV	Agriseed Ltd	Technisem
Onion	Ares	OPV	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Onion	Bombay	F1	Nanafico Marketing Co. Ltd.	Monarch Seeds
Onion	Neptune	F1	Dizengoff Gh. Ltd.	Hazera seeds
Onion	Red creole	OPV	Dizengoff Gh. Ltd/Callighana	Dizengoff Gh. Ltd/Bakker Brothers
Onion	Sivan	F1	Dizengoff Gh. Ltd	Dizengoff Gh. Ltd
Onion	Texas Early Grano	OPV	Agrimat Gh. Ltd.	Emerald seeds
Onion	Texas Early Grano	OPV	Farmers Friend	Technisem
Onion	Violet damani	OPV	Farmers Friend	Technisem
Onion	Violet de Galmi	OPV	Callighana	Bakker Brothers
Onion	Red creole	F1	RMG Ghana Ltd.	Starke Ayres
Onion	Galmi	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Onion	Red damani	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Onion	BGS	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Onion	Trophy	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem

Onion	Orient	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Geronimo	F1	Agriseed Ltd	Technisem
Hot Pepper	Sunny	F1	Agriseed Ltd/Farmers Friend	Technisem
Hot Pepper	Forever	F1	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Cayenne	OPV	Agriseed Ltd/Callighana/Crop2Life	Technisem/Bakker Brothers (2)
Hot Pepper	Big sun	OPV	Agriseed Ltd/Callighana	Technisem
Hot Pepper	Antillais	OPV	Agriseed Ltd/Callighana/Crop2Life	Technisem
Hot Pepper	Cayenne	OPV	Dizengoff Gh. Ltd/Meridian seeds	Dizengoff Gh. Ltd/Technisem
Hot Pepper	Legon 18	OPV	Agrimat Gh. Ltd./Aglow Agric Products Ltd./University of Ghana	Aseda farms-Swedru/University of Ghana
Hot Pepper	cayenne long red	OPV	Agrimat Gh. Ltd.	AGRIMAT USA LLC
Hot Pepper	Balthazar	F1	Farmers Friend	Technisem
Hot Pepper	Bird eye	OPV	Callighana	Technisem
Hot Pepper	Shito Adope	OPV	RMG Ghana Ltd.	Starke Ayres
Hot Pepper	Yellow wonder	F1	RMG Ghana Ltd.	Starke Ayres
Hot Pepper	Safi	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Cheyene	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Sunny	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Forever	F2	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Habanero	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Scotch bonnet	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Hot Pepper	Thailand	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Sweet Pepper	Nikita	F1	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Sweet Pepper	Ulysse	F1	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Sweet Pepper	Nobili	F1	Agriseed Ltd/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Sweet Pepper	Goliath	F1	Agriseed Ltd/Agrimat Gh. Ltd.	Technisem

Sweet Pepper	Yolo wonder	OPV	Agriseed Ltd/Farmers Friend-madina/Callighana/Crop2Life	Technisem
Sweet Pepper	California wonder	OPV	Agriseed Ltd/Callighana/Crop2Life	Technisem/Bakker Brothers (2)
Sweet Pepper	Batie TMR	OPV	Nanafico Marketing Co. Ltd.	Monarch seeds
Sweet Pepper	California wonder	F1	Aglow Agric Products Ltd.	Unigen seeds
Sweet Pepper	California wonder	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Sweet Pepper	Goliath	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Sweet Pepper	Yolo wonder	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Supercross	F1	Agriseed Ltd	Technisem
Cabbage	Supercomet	F1	Agriseed Ltd	Technisem
Cabbage	Fortune	F1	Agriseed Ltd/Farmers Friend-madina	Technisem
Cabbage	Oxylus	F1	Nanafico Marketing Co. Ltd./Callighana/Crop2Life	Seminis
Cabbage	Vantar	F1	Agrimat Gh. Ltd.	AGRIMAT USA LLC
Cabbage	Fortune Santa	F1	Callighana/Crop2Life	Technisem
Cabbage	Cross tropical	F1	RMG Ghana Ltd.	Starke Ayres
Cabbage	Milor	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Fortune	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Bowie	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Capture	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Santa	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Tropical king	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Leader cross	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cabbage	Minotaur	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Egg plant	Kalenda	F1	Mobile link Agroshop	Technisem
Egg plant	Black beauty	OPV	Mobile link Agroshop	Technisem
Egg plant	Aragon	F1	Dizengoff Gh. Ltd.	Hazera seeds
Egg plant	Kpando Nice	OPV	Agrimat Gh. Ltd.	Aseda Farms-Swedru

Egg plant	Kombara	OPV	Agrimat Gh. Ltd./Farmers Friend	Technisem
Egg plant	Kotobi	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Egg plant	Djamba	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Okra	Clemson Spineless	OPV	Agriseed Gh. Ltd	Technisem
Okra	Clemson Spineless	OPV	Dizengoff Gh. Ltd./Wasambazaji	Amiran Seeds
Okra	Clemson Spineless	OPV	Dizengoff Gh. Ltd	Dizengoff Gh. Ltd
Okra	Pusa Sawani	OPV	Dizengoff Gh. Ltd	Dizengoff Gh. Ltd
Okra	Yodana	F1	Agrimat Gh. Ltd.	Technisem
Okra	Lady's finger	OPV	Agrimat Gh. Ltd.	Yonifah Seeds- Ada
Okra	Clemson Spineless	OPV	Farmers Friend/Meridian seeds.	Technisem
Okra	Indiana	OPV	Callighana/Crop2Life	Technisem
Okra	Labadi dwarf	OPV	Aglow Agric Products Ltd.	Local seed grower
Okra	Clemson Spineless	F1	RMG Ghana Ltd.	Starke Ayres
Okra	Essountem	OPV	Callighana/Crop2Life	Technisem
Okra	Volta	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Okra	Hire	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Okra	Labadi dwarf	OPV	Farmers Friend	Local seed grower
Carrot	Nantes	OPV	Dizengoff Gh. Ltd	Dizengoff Gh. Ltd
Carrot	Amazonia	OPV	Agrimat Gh. Ltd./Farmers Friend	Technisem
Carrot	Kuroda	F1	RMG. Ghana Ltd.	Starke Ayres
Carrot	Amazonia	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Carrot	Shakira	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Carrot	Kuroda	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Carrot	Talena	F1	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Carrot	Pamela	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem

Beetroot	Detriot dark red 2 'Christel'	OPV	Nanafico Marketing Co. Ltd.	Monarch seeds
Beetroot	Crimson Globe	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Beetroot	Detroit Elna	OPV	Dizengoff Gh. Ltd.	Amiran seeds
Cauliflower	Maya	F1	Callighana/Meridian seeds and Nurseries Gh. Ltd.	Technisem
Cauliflower	Snowball	OPV	Callighana	Bakker Brothers
Cauliflower	Snow crown	F1	Aglow Agric Products Ltd.	Takii
Cauliflower	Monte perle	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem
Parsley leaf	Plain leaved	OPV	Nanafico Marketing Co. Ltd.	Monarch Seeds
Amaranth	Fotete	OPV	Farmers Friend	Technisem
White radish	Minowase	OPV	Nanafico Marketing Co. Ltd.	Royal Seeds
Radish	Cherry belle	OPV	Agrimat Gh. Ltd.	Technisem
Water melon	Kaolack	OPV	Nanafico Marketing Co. Ltd./Meridian seeds	Monarch seeds
Water melon	Carribean Queen	Hybrid	Farmers Friend	Technisem
Lettuce	Eden	OPV	Callighana/Meridian seeds/Crop2Life	Technisem
Lettuce	Batavian De Pierre Benite	OPV	Callighana/Crop2Life	Bakker Brothers
Lettuce	Kaizer	OPV	Aglow Agric Products Ltd.	Takii
Aubergine	Black beauty	F1	RMG Ghana Ltd.	Starke Ayres
French beans	Contender	OPV	Meridian seeds and Nurseries Gh. Ltd.	Technisem