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DEPARTMENT OF HORTICULTURE

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REPORDUCTIVE GROWTH, YIELD AND POSTHARVEST QUALITY RESPONSE OF TWO GARDEN EGGS CULTIVARS TO APPLICATION OF BIOZYME BIO-STIMULANT IN THE FOREST AGRO-ECO ZONE.

BY

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Reproductive Growth, Yield and Postharvest Quality Response of Two Garden Eggs Cultivars to Application of Biozyme Bio-stimulant in the Forest Agro-eco Zone.

KNUST

By

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A thesis submitted to the school of research and Graduate Studies, Kwame Nkrumah University of Science and Technology, Kumasi, in Partial Fulfilment of the Requirements for the Award of Master of Philosophy (MPhil.) Postharvest Technology) Degree.

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DECLARATION

I, hereby declare that except for references from other peoples' work which have been duly acknowledged, this write-up, submitted to the school of research and Graduate Studies, KNUST, Kumasi is the result of my own original research and that this thesis has not been submitted for any degree elsewhere.

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DEDICATION

This dissertation is dedicated to all the people and individuals who have allowed Almighty God to use them as conduit through the exciting experience to a meaningful end of my degree program.

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ABSTRACT

Garden egg (*Solanum gilo*) is an important food crop in most West African countries. Small holder farmers prefer growing garden egg both as vegetable and annual crop due it tolerance to all soil type. These poor farmers have suffered the effects of excessive use of chemical fertilizers which causes soil acidification and reducing soil biological activities resulting to poor yield quality and postharvest quality characteristics in fruits and vegetables. Biozyme (Biostimulant) is an acceptable plant growth regulator which contains macro and micro nutrients, vitamins, cytokinins, amino acids abscisic acid and auxins that promote cellular metabolism in treated plants to enhanced growth and yields qualities and postharvest quality characteristics. The properties Biozyme hydrolysis proteins that improve complex uptake of unavailable nutrients to be used by plants. This study determined Biozyme levels that was lower than the commercially recommended 500ml/ha to curb and misuse, but still enhance garden egg yields under the erratic rainfall pattern in the Forest Agro Ecozone of Ghana. A factorial experiment pots were arranged in a randomized complete block design, replicated three times in the field while complete block design was adopted for the laboratory studies with a pair-wise mean separation at probability level of <0.05% for the field and <0.01% for the laboratory studies. Biozyme levels (0.09, 0.07 and 0.05ml) significantly affected the growth parameter of stem diameter, plant height, number of leave and branches, LAI and number of flower respectively. The yield also improved to 7.13 ton/ha compared to 6.06 ton/ha observed in the control pots. Significant differences were also observed in the postharvest quality parameters with the highest value recorded in the amendment of Biozyme compare to the control pots. The significant differences observed in the varieties might have been due their growth habit of their genotypes.

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CHAPTER ONE

1.0 INTRODUCTION

The preference for fresh horticultural fruits and vegetables from sub-Saharan Africa by buyers across the world has been increasing in recent times Anifori (2010). The attractiveness of prices parroted by dealers from African countries whose market positins rely on low cost of production has contributed hugely in aiding the continent to expand the trade base that have primary depended on some few traditional export crops (Tossou *et al*., 2015).

Anifori (2010) reported that there was great market potential for fresh organic fruits and vegetables in Ghana. Subsequently, there has been an increased in the cultivation of organic vegetables from an estimated 5,453 hectares in 2003 to 19,132 hectares in 2006 (Willer *et al.* 2006). The export values have also increased substantially from US$11.5 million in 1995 to US$75.64 million in 2006. Locally, urban and peri-urban vegetable production and marketing play important roles in the socio-economic development of Ghana as they ensure employment generation, wealth creation and poverty reduction through provision of raw materials for local food industries and fast growing restaurants in most cities in the country (Owusu & Anifori, 2012).

Garden egg (*Solanum gilo*) is one of the most important members of the genus *Solanum* cultivated in West Africa. Most people prefer its fruits to those of other aubergine types because, the fruits of the former are less susceptible to blacken on peel. The fruits are consumed fresh as snack, or used in the preparation of stew and soup while the leaves are precious herbs in some communities (Gajewski *et al.,* 2009). Fruits are harvested at the physiological maturity, (unripe) stage but usually before full-seed maturation.

Low soil microbial activity and slow turnover of applied organic amendments are limiting factors for optimal crop productivity, especially in garden eggs where the nutrient requirements are high leading to reduced yields and severe postharvest losses (Pinto *et. al.,* 2008).

In response to this, biostimulants have been introduced in crop production which ensure high and sustainable yields as well as enhancement in fruit quality. Nardi *et al.* (2016) reported that the main function of a bio-stimulant was to elevate the capacity of the crop to nutrient uptake and/or resistance to biotic and abiotic stresses through the enhanced activity of rhizosphere microbes and soil enzymes with a resultant effect on the photosynthetic process. Biozyme, a biostimulant has been found to promote high yields of tomato and green pepper. The general objective of the study therefore was to determine the effects of Biozyme application on the reproductive growth, yield and postharvest fruit quality of two garden eggs cultivars (Abesim and Oforiwaa) in the forest eco-zone.

Specifically, the objectives were to;

- determine the effects of different levels of Biozyme on the reproductive growth and yield of two varieties of garden eggs
- determine the effects of Biozyme levels on the physical and chemical characteristics of the fruits from the two garden egg varieties
- evaluate the sensory attributes of the fruits from the two varieties as influenced by the different levels of Biozyme.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. BOTANY OF GARDEN EGGS

According to (Aziz, 2010), garden egg is known scientifically as *Solanum melongena* from the family *Solanaceae*. The fruits are either egg or pear shaped, round or long and cylindrical depending on the variety. Most of the local types are white or red fruits. They often grow up to 80 to 90 cm in height. Many wide genetic diversity has been observed among the species within this genus; therefore they are very interesting for breeding program of the economically important such as Garden Eggs. Eggplant, which is the exotic breed like those of Asian eggplant genotypes has different color, taste and shape other than the traditional dark violet fruits. “Garden egg-plant” is the name imitative from the shape of the fruits of some cultivars which are white and shaped like chicken eggs (Ozobia, et al., 2013)

2.2. ORIGIN OF GARDEN EGGS

Chioma *et al.,* (2011), reported that “Garden egg” (*Solanum gilo*) is one of the largest and most important Solanaceae families which are essentially of tropical origin.

These wild species which bear edible fruits (*S. aethiopiculum*, *S. macrocarpon*, and *S. muricatum*) are of West African origin. Brazil and Europe cultivate in small quantities the *S. aethiopicum*. In recent years, the introduction of the African Eggplant (garden egg) hybrid varieties has been very successful because of their high yield. Arias (2011), concluded that the Asian eggplant flowers early in spring with a comparable yields to that of the hybrid and the material for propagation did not seem to have influenced the development and fruit production of this crop which selected clones had a stable yield under a commercialized cultivation system.

2.3. GENERAL CHARACTERISTICS OF GARDEN EGGS

The West African scarlet eggplant (*Solanum aethiopicum* L.) is a non-tuberferous cultivated solanum species which is popularly edible. The plant is preciously grown for the leaf and fruit as vegetable. Most West African research findings showed that the vegetable and fruits are purposely grown for their curative and nutritional features. It also has other features that could be of importance to other some cultivars' genetic adjustment. For instance, Kouassi *et al.* (2014), reported that *S. aethiopicum* species holds susceptibility to many fungi (i.e. *Fusarium* spp.) and most other pathogens, bacteria root-knot nematodes (*Meloidogyne* spp.) and (*Ralstonia solanacearum*).

2.4. ECONOMIC POTENTIAL OF ORGANIC FARMING

The most important economic sector is Agriculture in Ghana which employs above 60% of the labor force. Agriculture is contributing approximately 33% of the country's gross domestic product (GDP) and accounts for more than 40% of export earnings. Horticultural crops production is playing important sociao-economic role which derived predominantly from subsistence to commercialized activities. Vegetable production subsidizes to insuring food security, providing crude products for industries, foreign exchange generation, providing employment and income for significant number of the population thus reducing poverty. However, most health hazards are caused by inappropriate use of chemical on vegetable production. The risk of consuming residual synthetic fertilizer in horticultural crops is probably due to the lack of knowledge of the farmers. In recent years the whole world is becoming more and more sensitive about the risk chemical residues pose to one's health. In other parts of the world, consumers have shifted from utilizing conventionally produced crops to organic ones which they are willing to pay for. The sustainable supply of organic vegetables and the label to guarantee the quality of the product are dominant factors in the consumers' decision

making. There is a consistent potential demand for organic vegetables but producers need to be sensitized about the health risk which is linked to chemical residues through sustained campaigns (Bamire *et al.*, 2004). The common vegetables cultivated in Ghana include eggplant / garden eggs, pepper and onion commercialized by smallholder and mechanized farmers even though some are efficient and specialized in the production of one or two crops (Botwe *et al*, n.d.).

2.5. NUTRITIONAL IMPORTANCE OF GARDEN EGGS

The essential parts of people's diet which are vital for health and wellbeing are vegetables and fruits. Most research showed that garden eggs and other members of the Solanaceae family are excellent sources of vitamins, minerals, antioxidant and many phytonutrients. Chinedu *et al.* (2011), concluded that significant differences showed in the fruits *Solanuim S. macrocarpon* L and *aethiopicum* L. showing their morphological features as well as chemical constituents. They further explained that the fruits holds within them beneficial phytochemicals and are nutritionally and therapeutically valuable with the potential of providing precursors for the synthesis of useful drugs.

2.6. SOILS AND ENVIRONMENTAL CONDITIONS FOR GARDEN EGG

The surrounding environment and the growing medium used during production are important factors for plant growth, yield quality and storage ability. The use of organic fertilizer can lead to the increase microbial activity in the soil. Humid acids and amino acids are obtained from broken down organic substances by soil life. Protozoa, fungi, actinomycetes, bacteria and algae are microorganism present in the soil. Usually concentrated and closed to the root surfaces in the rhizosphere, the microorganisms are living within dead roots and soil particles. It is a dynamic region where microorganisms play major role in the breaking down of soil particles and other organic matters. Addition of organic manure significantly enhance growth, yield and fruit quality which

is associated with the supply of essential nutrients by continuous mineralization of the soil and its favorable effect on physical and biological properties (Suge, 2011).

Wang *et al*. (2014), described soil sickness as a severe reduction in soil quality which defines the productivity and sustainability of agroecosystems of previously productive soil. The fundamental cause of declining in yield of crops in most part of the world is ultimate decline in soil fertility. Soil acidity is a major limitation in soil fertility maintenance predominantly in the tropics. The soil pH limits the availability of mineral elements to plants. It may also affect plant root growth directly or indirectly by impairment of nutrient relations which is directly connected to fruit settings and yield (Kurunc, 2010). Soil fertility enhancement can impact the physiological susceptibility of crops to disease or pest either by affecting the resistance of individual plant to be attacked or by altering plant susceptibility to plant eating pets. However, a range of conditions including temperature and relative humidity retard growth and affect fruit setting and quality. Hostile environmental conditions can harshly depress fertilization and consequently fruit development. Pollen dispersal and fertilization are affected by environmental factors such as relative humidity, light, temperature etc. It is the nutritional status of the plant which influences such factors as the growth pattern and onset of senescence of epidermal cells and degree of humunification, sugar concentration in the apoplast. More recently studies are addressing the issue of soil and environmental conditions which influence limited nutrient uptake, depress fertilization consequently poor fruit development and quality with the use of phytohormones (Pandolfini, 2009).

2.7. SOME CHALLENGES ASSOCIATED WITH GARDEN EGG PRODUCTION

Harsh climatic conditions and excessive rainfall can destroy garden egg plants, particularly if it is not cultivated in protected environment due to the spread of diseases and pests (Addo, 2010). Among the many challenges inherent to tropical crops production are soil acidity, excessive aluminum, deficient calcium and low organic matter. Additions of organic matter to soils are ways of attaining some economically productive soils. The benefit of improving soil quality and thereby enhancing long-term sustainable agriculture, is by increasing soil organic matter (Bello, 2008).

2.8. SOME COMMON PESTS AND DISEASE OF GARDEN EGGS

According to Horna *et al*. (2008), a native crop of Ghana, garden egg is attacked by several local pests and diseases. Fruit and stem borers are the most significant biotic constraints for garden egg which cause major economic losses.

Even though the numerous uses of the crop and its products, African eggplant fruits are prone to a wide range of pests and pathogens which causes severe loss at all stages of growth and development. The most significant and wide spread diseases are leaf blight and fruit rot (*Phomopsis vexans*), leaf spots (*Alternaria melongenae* and *Cercospora melongenae*) damping off (*Phythium aphandermatum*), wilt (*Verticulium dahliae*), bacterial wilt (*Pseudomonas solanacearum* and *Ralstonia solanacearum*) little leaf (*Mycoplasmacandidatus*) and root knot of the African Eggplant (*Meloidogyne incognita).* The crop is cultivated extensively as vegetable and its growing season coincides with the rainy season particularly the fruit bearing stage and therefore subjects the crop to many pest, nematode, bacterial, viral and fungal diseases. Foliar and fruit disease caused by fungi and pest have emerged as major constraint in economic production of the crop. Fruit rot or deterioration caused by fungal pathogens act as

conduit for secondary spread of infection, thus reducing the market value of fruits, and sometimes even leading to complete loss of crop under favorable weather conditions (Okwulehie & Okon, 2014).

2.9. EFFECT OF POULTRY MANURE

Manure, once valued as waste by farmers, is now treated as resource for the sustainability of the soil. Poultry manure has long been recognized as the most desirable of all natural animal fertilizers because the high nitrogen content. According to (Bello, 2008), the estimates of the fraction of organic N that is mineralizable in some manure indicated a range from 0.08 to 0.52 for swine, 0 to 0.51 for cattle, and 0.17 to 0.73 for poultry litter. Studies have shown nitrogen mineralization in poultry litter is strongly related to total nitrogen and uric acid concentration. Khalid, *et al*,. (2014), indicated that the increase in poultry manure amendment will result in the increase improvement in hydrologic and hydraulic composition of the sandy soil. Organic materials therefore, expand water holding capacity of sandy soils. Mandal *et al*. (2013), concluded that the increase in the incorporation of composted poultry manure enhances organic matter, pH, total water content, and cation exchange capacity thereby improving the soil chemical and physical activities compared to conventional fertilizers.

2.10. BIOZYME (Biostimulant)

Bakker *et al.* (2014), defined plant biostimulant (Biozyme) as "substance (s) which contain microorganisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress and crop quality. They further indicated that biostimulants are obtain from incredibly diverse set of biological and inorganic materials including microbial fermentations of animal or plant feedstock, living microbial cultures, macro and micro-alga, protein hydrolysate, hubmic and fulvic substances, composts, manures,

food and industrial wastes prepared using widely divergent industrial manufacturing processes. Biostimulants, a seaweed extracts, consists of organic materials (e.g. humates) and plant growth hormones (e.g. cytokinins) which promote plant growth of wide range of horticultural crops as well as some tree species (Kelting *et al*., 1997). In conformity with other studies, Abbas *et al*. (2013), another biostimulant (Humic acid) stimulated the photosynthetic pigments thereby aiding in higher photosynthesis rate and efficient plant growth. The most important requirement for plants adaptation and survival in difficult conditions is root development. Biozyme first target organic materials and influence root growth. Biostimulants (HS) have long been known to improve root growth and development in several plant species through the stimulation of root elongation, root hair and lateral root production (Tahiri *et al.*, 2016).

2.11. POSTHARVEST HANDLING AND LOSSES

The perishability and hugeness of fruit and vegetables make it difficult manage easily during postharvest period unlike those of dry grains. Due to such perishable tendency of fruits (garden eggs) and lack of improved skills as well as shortage of capital, horticultural industry in sub-Saharan Africa is often at its infant stage (Hailu, 2015). Effective marketing of fresh horticultural produce begins with production of a quality product and requires careful thoughtfulness to the details involved in postharvest handling which protects garden egg quality, nutritional value, and economic value and assures food safety. Fruit life span is described postharvest physiology as periods of fruits and vegetable maturation, ripening and senescence. Additional production of garden eggs derived from the application of improved technology and high value inputs therefore, equal attention should be given to the post-harvest technology like that of production, handling and marketing which is vital sector of this industry. It is safe to say that post-harvest losses occur in every parts of the chain but the magnitude of losses

and the effective remedial methods differ greatly from level to level. To solve specific problems in a specific area effectively and economically, a comprehensive knowledge of the nature of post-harvest losses should be considered (Kereth, et al,. 2013). Crops growers and direct marketers worldwide are often anxious over produce losses and quality maintenance during handling. Selecting the appropriate postharvest ideas can be a complex decision, based upon the needs of the produce, cost of the technology, available market outlets and the anticipated level of involvement of the marketer. Fortunately, there are many simples of postharvest handling methods from which to choose that will assist a producer to protect the value of crops and will immediately improve the return on investment. (Kitinoja & Gorny,

1999)

2.11.1. Postharvest Qualities of Fruit at Harvest

Good garden egg quality must have shiny fruit surface with color characteristic of its cultivar, a fresh unblemished calyx, and free of any decay, discoloration or other defects. Garden eggs are stored at low temperature to minimize the visible symptoms of weight loss due their susceptibility to water loss (Molinar *et al.*, 1996). Garden egg or fruits harvested at immature stage are more susceptible to water loss than mature fruit and vegetables. Signs of scuffing, brown discoloration of bruised tissues, cuts, punctures and abrasions sometimes are not visible at the point of loading but become noticeable during subsequent point along the chain.

2.11.2. Storage and Shelf Life

Vegetables and fruits are living commodities even though detached from the parent plant, respiration is of key importance to maintain quality due to their ability to exchange gas and loose water to the environment (Aked, 2002). It has been obviously observed that the more the respiration rate of perishable crop like garden egg, the shorter

the shelf-life. Immature garden egg fruits tend to have much higher respiration rate and shorter storage life caused by natural senescence whereas the opposite is true for mature storage fruits. Mahajan *et. al*., (2014), reported that fruits and vegetables (garden eggs) harvested are metabolically active and undergoing activities that must be controlled to prolong postharvest quality.

As soon as fruit or vegetable is detached from the parent plant and stored, it no longer receives water, minerals or photosynthesis. The processes of living tissues must be preserved, and energy for the many catabolic and anabolic responses must be provided by stored reserves thus, postharvest life usually does not extend long after fruits or vegetables lose their disease resistance, which is short at ambient temperatures. The storage period before disease resistance is lost is greatly prolong by low temperatures (Sommer, 1989). Also, the lower the temperature, the rapid is the inception of injury symptoms in a given variety. The respiration rate beyond low temperature alone is slow by modified atmospheres. Thus, in the case of climacteric fruits delay and reduce. Disease resistance period is lengthened to extend most varieties storage period.

2.11.3 Temperature Relative Humidity in Storage Facility

Incidence and severity in exposure of garden egg fruits to improper temperature influences deterioration (Kader, 1986). Qualities such as color, size, shape defects and decay are influenced by genetic and environmental factors, such as temperature, light, nutrients and water supply, and the presence of diseases and insects. Increasing the length of time fruits and vegetables can be stored is by lowering the temperature to an appropriate level i.e. 85-95% of high but not saturated relative humidity is required (Akdemir & Arin, 2006). Even though some loss of moisture take place during cold storage, but excessive moisture loss is a problem. Distribution of the air velocity, ambient temperature and relative humidity is important to protect crops in cold storage.

The fundamental cause of postharvest deterioration in fruits is metabolism caused by biotic or abiotic stress, which main technological interventions involves the control of temperature and humidity of the atmosphere around the fruits (Wills *et al*. 1989). Furthermore, Liberty *et al.* (2013) noted that low temperature extends storage life by reducing respiration rate as well as reducing growth of spoilage microorganisms.

2.12. SENSORY EVALUATION

Sensory evaluation of textural quality involves both finger feel and mouth feel. According to (Kader, 1986), objective evaluation methods for tomato firmness can be destructive. Fruit firmness testers, penetrometers, shearing, cutting, compression or their combinations of measuring tissue resistance are destructive methods. The main taste components in fresh produce are stringency, sweetness, acidity and bitterness. Sweetness of some fruits may advance over time during ripening attributed to starchsugar conversion, for example: pears, apples, bananas and mangoes. At the same time, astringent factors (tannins) will disappear (Tucker, 1993). Sugar levels of fruits are often measured to determine whether produce has reached the required ripeness for marketing. Aked (2002) indicated that the most comprehensive way of assessing overall quality is to use panels to conduct sensory evaluation of the products. In the fresh fruits and vegetable industry, sensory tests may simply involve the quality controller acting as a single experience taster or a trained sensory panels for the measure of quality attributes.

2.13. CHEMICAL COMPOSITION

2.13.1. pH and Titratable Acidity (TTA)

pH and titratable acidity assessment of fruits are used primarily to ascertain consumption of hidden quality attributes. Titratable acidity gives a measure of the

amount of acid present in fruits and vegetables while pH values give measure of alkalinity or acidity. Esa (2015) reported that the evaluation between sugar and acid content is an important contribution to postharvest quality of fruits.

2.13.2. Total Soluble Solids (TSS)

Sugar is the main component of total soluble solids in which soluble compounds form the soluble solids content of fruits. An increased amount of fruit total soluble solids is of major economic value for marketing garden egg, since the fruit is not yet widely consume due to it bitter taste. Temperature and respiration play significant role in the breaking down process of sugar and acids. Samira (2013) indicated that the longer the time of fruit respiration, the higher will be the rate of consumption of sugars and acids. Increase in temperature will result in the faster conversion of starch into watersoluble sugar of fruits stored in ambient condition. This condition increases the concentration of TSS content due to higher moisture loss compare to evaporative cooler with higher relative humidity.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. SITE CHARACTERISTICS

The experiment was conducted at Department of Horticulture experimental field, Kwame Nkrumah University of Science and Technology. The area lies approximately 260m above sea level is located between latitude 6°40”26’ North and longitude 1°35” West . The climate of the area is semi-deciduous forest zone, which is characterized by a wet and dry season with a double maxima rainfall regime. The major rainfall season happens between March and July and with a dry spell from mid-July to midSeptember. November to March is the major dry season making rainfall weak bimodal. The mean

annual rainfall is 1,500mm and the mean temperature is 35°C. The experiment was carried out from November 2015 to March 2016. (Evans *et al.*,

2015)

3.2. FIELD EXPERIMENT

3.2.1 Experimental Design

A pot experiment was setup in a two by four (2 x 4) factorial arranged in randomized complete block design (RCBD) with three replications. The factors were varieties at two levels: Oforiwaa and Abesim and four levels of Biozyme rates: 0.00ml Biozyme per plant; 0.05ml Biozyme per plant; 0.07ml Biozyme per plant; 0.09ml Biozyme per plant. Prior to the Biozyme applications, 600g of poultry manure was incorporated into the soil in each pot as basal application. Four pots representing a plot were spaced 80cm x 90cm apart.

3.2.2 Nursery Management

Seeds of the two garden egg varieties were obtained from CSIR-Crops Research Institute, Kwadaso, Kumasi. The seeds were nursed on September 25, 2015 in trays containing coco peat media in the greenhouse at the Department of Horticulture. The nursed seeds were watered on a regular basis.

3.2.3. Preparation of Pots for Planting

Top soil was sieved to remove heavy metals and stones. The sieved soil was sterilized using a metal container for an hour at 100^0C and left overnight to cool. The sterilized soil was weighed at 12kg per pot. Six hundred (600g) of poultry manure was added and treated with fungicide and watered for two weeks before transplanting. Soil and poultry manure samples were analyzed to determine the constituent nutrients and their concentrations.

3.2.4. Crop Management

Twenty two day-old seedlings were transplanted on October 28, 2015 into the pots and watered regularly. ACETA STAR, a dual systemic and contact insecticide was applied at a rate of 3ml/1 using a knapsack sprayer every two weeks after transplanting to control the observed whiteflies. All the pots were uniformly sprayed to avoid variation between treatments. Weeds were handpicked as and when necessary. The plants were staked at the flowering stage with sticks in all the pots to prevent lodging and fruit infection by contact with the soil.

3.2.5 Reproductive Data Collected

1. Climatic data - Minimum and maximum temperatures, relative humidity, rainfall amounts, solar radiation and wind speed were recorded daily over the experimental period.

2. Number of days to 50% Flowering – the number of days for each sample to attain 50% flowering was recorded from date of sowing to when 50% of plants of each plots had reached anthesis.

3. Total number of fruits per plant - All fruits harvested from each plant were counted to determine the total number of fruits per plant.

4. Total fruit weight per plot (kg) - The harvested fruits were weighed using a digital scale to determine the weight of fruits.

5. Fruit yield (t/ha) – The fruit weight per plot for each treatment was converted to fruit yield per hectare.

3.3. POST-HARVEST FRUIT QUALITY STUDIES

3.3.1. Preparation of Fruits for Laboratory Analyses

After harvesting, the fruits were removed from the field, sorted and immersed in cold water to remove field heat. Ten fruits of uniformed size for each treatment were selected for the shelf life studies. Another sets of uniformed size fruits for each treatment were selected for the destructive sampling.

3.3.2. Experimental Design

A 2 x 4 factorial arrangement in completely randomized design with three replications was used for the postharvest fruit quality analyses in the laboratory. Fruits of similar size per treatment were selected for both destructive and non-destructive analysis.

3.3.3 Data Collected

3.3.3.1 Determination of fruit pH

The pH meter was calibrated at 20^{o}C using two buffers (pH 4.00 and 7.00). Forty (40) grams of extracted garden egg juice was weighed into 100ml beaker. While stirring slowly, 60mls of boiling distilled water with a graduated cylinder was added to the extraction. The mixture was left to cool in a cold bath, while it was stirred occasionally. The pH was measured when the suspension had cooled to 20^{o}C. The measurements were performed in triplicate.

3.3.3.2. Determination of fruit Vitamin C content

This was determined by using the 2, 6-Dichloroindophenol Titrimetric method and the results reported as mg/100g of tomato fruit (AOAC, 2006). Ascorbic acid reduces oxidation-reduction indicator dye, 2, 6-dichloroindophenol to colourless solution. At end point, excess unreduced dye is rose pink in acid solution. Vitamin was extracted

and titration performed in presence of HPO_3-CH_3CHOOH solution to maintain proper acidity for reaction and to avoid autoxidation of ascorbic acid at high pH.

The results were recorded to one decimal place with the unit as degree brix (^{o}Brix).

3.3.3.3. Total Titratable Acidity (TTA)

10 ml of fruit juice was diluted with 50ml of distilled water and titrated against 0.1M NaOH. This was repeated three times for each replication and its titre values recorded. The average titre value was calculated for each replication. Total titrable acidity was calculated using the formula:

$$\text{Grams/litre acid} = \frac{\text{Normality of titrant x titre x Equivalent weight of predominant acid}}{\text{Volume of sample} \times 10}$$

3.3.3.4 Fruit firmness

Fruit firmness was determined using the fruit tester (Effegi type Bishop FT 237). A circular portion of the peel of diameter of about 2 cm from each of the three fruits from each plant were removed before applying the plunger of the firmness tester in order to avoid the effect due to the peel. Firmness was expressed in Newton (N) (Batu, 1998).

3.3.3.5. Fruit diameter

Fruit diameter was measured at the widest point of the fruit using two fruits per treatment (Ngouajio *et al*., 2003). This was done by dissecting the selected fruits into two parts from the equatorial region and measuring the widest points with a caliper.

The mean was calculated to represent the diameter for each treatment in millimeters (mm).

3.3.3.6 Fruit mesocarp thickness

A digital caliper was used to measure the thickness of the white layer under the skin at three randomly chosen locations around the fruit circumference for each of the two cut fruits per treatment. The mean was calculated to represent the fruit thickness for each treatment in millimeters (mm).

3.3.3.7 Determination of fruit nitrogen content

Total nitrogen was determined by the Kjeldahl method in which fruit sample was digested with concentrated sulphuric acid and hydrogen per-oxide with selenium as catalyst. About 20.0 g oven-dried fruit sample was ground in a stainless steel hammer mill with a sieve mesh of 1 mm, and mixed well to ensure homogeneity. Approximately 0.2 g of the fruit material was weighed into a Kjeldahl flask, a tablet of selenium catalyst was added and 5 ml of concentrated H_2SO_4 was also added to the mixture. This was digested on the Electrothermal Kjeldahl apparatus for three hours.

After the clear digest has cooled, about 20 ml of distilled water was poured into the Kjeldahl flask containing the digested material before it was transferred into a 100 ml distillation tube. In the distillation tube another 20 ml distilled water was added plus 20 ml 40 % NaOH then distilled for 4 minutes. The distillate was received in a conical flask containing 20 ml of 4 % boric acid with PT5 indicator (methyl red and bromocresol green indicators). The received greenish solution was titrated against 0.1 M HCl dispensed from a burette. % N was calculated from the volume of HCl used to attain end-point (Soil Laboratory Staff, 1984). (Bremner *et al.*, 1982) Calculation:

$$\%\ \mathrm{N\ DM^{-1}} = \frac{(\mathrm{a}-\mathrm{b})\ \times \mathrm{M}\ \times 1.4\ \times \mathrm{mcf}}{\mathrm{s}}$$

where

$\mathrm{a} =$ volume of 0.1 M HCl used for sample titration.

b = volume of 0.1 M HCl used for the blank titration.

M = molarity of HCl.

$1.4 = 14 \times 0.001 \times 100\%$ (14 = atomic weight of N)

s = weight of sample in gram.

3.3.3.8. Determination of fruit phosphorus and potassium contents

Phosphorus and potassium were determined in fruit ash using the VanadoMolybdenum method. Approximately 0.5 g of the fruit sample was weighed into a porcelain crucible and ashed in a muffle oven at a temperature of 450 – 500 ^{0}C. The ashed sample was removed from the oven after cooling then made wet with 1–2 drops of distilled water and 10 ml of 1:2 dilute HNO_3 added. The crucible was then heated on a water bath until the first sign of boiling was observed. The crucible was removed and allowed to cool. The content was filtered into a 100 ml volumetric flask using a no. 540 filter paper. The crucible was washed two times with about 5 ml distilled water followed by the filter which was also washed two times with about 20 ml distilled water. After 10 ml each of ammonium vanadate and ammonium molybdate solutions were added and shaken thoroughly. The solution was allowed to stand for 10 minutes for full color development and then filled to the 100 ml mark. A standard curve was also developed concurrently with P concentrations ranging from 0, 1, 2, 5, 10, and 15 to 20 µg P per millilitre of solution. The absorbance of the sample and standard solutions were read on the spectrophotometer (spectronic 21D) at a wavelength of 470 nm. A standard curve was obtained by plotting the absorbance values of the standard solutions against their concentrations. Phosphorus concentration of the samples was determined from the standard curve. Potassium in the ash solution was determined using a Gallenkamp flame analyzer. Potassium standard solutions were prepared with the following concentration: 0, 10, 20, 40, 60 and 100 µg K per millilitre of solution. The emission values were read

on the flame analyzer. A standard curve was obtained by plotting emission values against their respective concentrations. (Chapman, 1961).

3.3.3.9. Determination of fruit calcium and magnesium contents

For the determination of calcium and magnesium, a 25ml aliquot of the extract as described in the determination of phosphorus and potassium was taken and transferred into an Erlenmeyer flask. The following reagents were added, potassium ferrocynide (1ml), buffer solution (5ml) and a drop Eriochrome Black T indicator and the solution titrated against Ethylene Diamine Tetra Acetic (EDTA) to a blue end point (FAO, 2008).

3.3.3.10. Determination of fruit manganese content

Fruit samples were oven-dried at 70 ^{o}C for 48 hours then removed, milled and passed through a 1mm mesh. About 0.5g of the samples were then weighed into crucibles and placed in a muffle furnace at a temperature of 450 ^{o}C for 3 hours. They were left to cool after which the samples were removed from the furnace and 10ml of 1:2 dilute Nitric acid solution was added to each sample. They were placed on a hot plate until the first sign of boiling is observed. After which the samples were filtered into 20ml flask and made to the mark with distilled water. The concentration of manganese was determined using the Atomic Absorption Spectrophotometer (AAS) after calibrating the AAS with standards of the element to be determined (Jones, 2001).

3.3.3.11. Sensory evaluation of fruit of two garden egg varieties

Sensory evaluation for the fruits was performed according to (Gajewski *et al*., 2009) method in a sensory laboratory, a panel consisting of 5 postharvest students were selected and trained to carry out the evaluation. In part, brainstorming sessions were run to select attributes for the fruits. The set of fruits were boiled 1800C, and then left to

cool to ambient temperature. Fruits samples were coded and covered with lids and served to the assessors.

3.4. DATA ANALYSIS

The data collected were analyzed by performing an Analysis of Variance (ANOVA) using STATISTX Version 9 software. Mean comparisons were based on Tukeys (HSD) were carried out to determine significant differences at set probability levels. For the field experiments, P was set at 005 (P = 0.05) while for the laboratotry studies, P was set at 0.01 (P = 0.01).

CHAPTER FOUR

4.0. RESULTS 4.1. CHEMICAL PROPERTIES OF SOIL AND POULTRY MANURE

ANALYZED BEFORE PLANTING

The chemical properties of the soil used during the study are shown in Table 4.1. The pH of the soil was 6.4, depicted slightly acidic conditions. The soil was low in nitrogen (0.73%) and potassium (0.14%) and medium in organic carbon (1.52%) and available phosphorus (6.89 %). Similarly the poultry manure was slightly acidic, high in nitrogen, medium in potassium but low in phosphorus.

Table 4.1 Chemical content of soil and poultry manure used in the study

Nutrients	Soil	Poultry manure
Organic carbon (%)	1.52	-
Organic Matter (%)	2.61	N/A
Total N (%)	0.73	1.23
Ca2+ cmol/kg	6.64	-
K+ cmol/kg	0.14	0.84
Mg2+ cmol/kg	0.56	-
Na+ cmol/kg	0.32	-

Available P mg/kg	6.89	1.59
pH	6.35	6.36

4.2. CLIMATIC DATA DURING EXPERIMENTAL PERIOD

October had the highest mean monthly rainfall and least mean solar radiation (Table 4.2). The highest temperature and solar radiation were recorded in December. The highest mean relative humidity was recorded in November while the lowest was observed in December.

Table 4.2 Climatic data recorded during the experimental period

Climatic data	October	November	December
Temperature (^{0}C)	31.8	32.1	33.2
Relative Humidity (%)	73	76.5	48
Rainfall (mm)	16.36	4.32	00
Solar radiation	678.2	768.3	874.1

4.3. REPRODUCTIVE GROWTH AS AFFECTED BY BIOZYME RATES

4.3.1. Number of flowers of two varieties as affected by Biozyme at 34 day

There were significant variety x Biozyme interaction for the number of flowers at 34 days after transplanting (Table 4.3). Abesim variety to which 0.09ml Biozyme was applied produced the highest number of flowers, significantly greater than the others except Oforiwaa to which 0.09ml Biozyme was applied. The least number of flower was produced by Abesim to which 0.05ml Biozyme was applied. Among amendments, 0.09ml Biozyme application led to the production of the highest number of flowers, 68.9 % greater than the least produced by 0.05ml Biozyme per plant application. As regard the variety, Oforiwaa produced significantly more flowers than Abesim.

Table 4.3: Effect of Biozyme on the number of flowers of garden egg at 34 days

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09 ml Biozyme	Means
Oforiwaa	10.76	11.33	13.67	17.15	13.23
Abesim	11.68	9.17	11.83	17.42	12.53
Means	11.22	10.25	12.75	17.29	
HSD (5%)	amendment = 1.22, variety = 0.64, amendment * variety = 2.09				

4.3.2. Number of flowers of garden egg varieties as affected by Biozyme at 48 days

There were significant amendment x variety interaction for the number of flowers at 48 days after transplanting (Table 4.4). Oforiwaa variety to which 0.09ml Biozyme was applied produced the highest number of flowers, significantly greater than the other treatment interactions. The least number of flower was produced by Oforiwaa to which 0.05ml Biozyme was applied. Among the amendments, 0.09ml Biozyme application led to the production of the highest number of flowers, 71% greater than the least produced by 0.05ml per plant application. As regard the variety, Ofriwaa produced significantly more flowers than Abesim.

Table 4.4: Effect of Biozyme on the number of flowers of garden egg at 48 days

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Mean
Oforiwaa	13.00	13.67	18.67	25.83	17.79
Abesim	13.10	10.75	13.60	15.90	13.35
Mean	13.08	12.21	16.13	20.88	
HSD (5%) amendment = 1.69, variety = 0.89, amendment*variety = 2.89					

4.3.3. Number of flowers of two varieties as affected by Biozyme rates at 62 days

Significant amendment x variety interaction for the number of flowers at 62 days after transplanting was observed (Table 4.5). Oforiwaa variety to which 0.09ml Biozyme was applied produced the highest number of flowers, significantly greater than all other treatment interactions. The least number of flower was produced by Abesim to which no treatment was applied. Among amendments, 0.09ml Biozyme application led to the production of the highest number of flowers, 78.2% greater than the least produced by 0.05ml Biozyme per plant application. As regard the variety, Oforiwaa produced significantly more flowers than Abesim.

Table 4.3: Effect of Biozyme on the number of flowers of garden egg at 62 days

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Mean
Oforiwaa	101.00	121.33	126.00	201.67	137.50
Abesim	97.67	115.67	120.33	152.33	121.50
Mean	99.33	118.50	123.17	177.00	
HSD (5%) amendment = 1.59, variety = 0.83, amendment*variety = 2.73					

4.3.4. Number of days to 50% flowering

There were significant amendment x variety interaction for number of days to 50% flowering (Table 4.6). Oforiwaa without Biozyme application took significantly the longest time to attain 50 % flowering. Both Abesim and Oforiwaa to which 0.09ml Biozyme was applied took the shortest time to attain 50% flowering. Among the amendments, 0.09ml Biozyme application led to the shortest time to 50% flowering,

6.4 days less time than the control which resulted in the longest time. Among the varieties, Abesim took the least time to attain 50% flowering, significantly shorter than the time for 50% flowering to be attain by Oforiwaa.

Table 4.6. Number of days to 50% flowering

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Mean
Oforiwaa	45.80	43.43	40.23	38.13	41.90
Abesim	42.80	40.60	40.20	37.80	40.35
Mean	44.30	42.02	40.22	37.97	
HSD (5%) amendment = 0.22, variety = 0.06, amendment*variety = 0.13					

4.3.5. Number of fruits of two varieties as affected by Biozyme rates

There were significant amendment x variety interactions for the number of garden egg fruits (Table 4.7). The variety Oforiwaa to which 0.09ml Biozyme was applied produced the highest number of fruits, 94.9% significantly more fruits than the least by Oforiwaa to which no Biozyme was applied. Fruit production by Oforiwaa to which 0.09ml Biozyme was applied was also significantly greater than the other treatment combinations. Among amendments, 0.09ml Biozyme application led to a significantly higher production of fruits, 52 % more fruits than the least produced by the control. In terms of the variety, Oforiwaa produced significantly more fruits than Abesim.

Table 4.7: Effect of Biozyme on the number of fruits counts of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Mean
Oforiwaa	106.33	125.33	135.33	207.33	143.58
Abesim	125.67	131.00	136.00	145.33	134.50
Mean	116.00	128.17	135.67	176.33	
HSD (5%) amendment = 4.77, variety = 2.50, amendment*variety = 2.50					

4.3.6. Marketable fruits of garden egg varieties as affected by Biozyme

There were significant Biozyme x variety interactions for the number of marketable fruits of two garden egg varieties (Table 4.8). Oforiwaa variety to which 0.09ml Biozyme was applied produced the highest number of marketable fruits, significantly greater than the others except Abesim to which 0.09ml Biozyme was applied. The least number of marketable fruits were produced by Oforiwaa to which no treatment (control) was applied. Among amendments, 0.09ml application led to the production of the highest number of marketable fruits, 46.7% greater than the least produced by control. As regards varieties, Oforiwaa produced significantly more number of marketable fruits than Abesim.

Table 4.8: Effect of Biozyme on number of marketable fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	55.00	117.67	126.33	201.33	125.08
Abesim	69.00	122.33	142.00	151.67	121.25
Means	62.00	120.00	134.17	176.50	
HSD (5%) amendment = 4.55, variety = 2.38, amendment*variety = 7.80					

4.3.7. Fruit weight of two varieties as affected by Biozyme rates

There were significant differences among the different levels of Biozyme on the fruit weight of Oforiwaa and Abesim (Table 4.9). Application of 0.09ml Biozyme led to production of significantly heavier fruits, 22.2 % and 14.4 % more heavy fruits than the least number of fruit produced by the control.

Table 4.9. Fruit weight of Abesim and Oforiwaa varieties

Treatments	Abesim Weight (t/ha)	Oforiwaa Weight (t/ha)
Control	5.40	6.72
Biozyme 0.05ml	6.47	6.83
Biozyme 0.07ml	6.04	7.40
Biozyme 0.09ml	6.60	7.69
HSD (0.05)	0.34	0.34

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4.4. FRUIT PHYSICAL QUALITY CHARACTERISTICS AS AFFECTED BY BIOZYME RATES

4.4.1. Fruits Diameter

There were significant variety x Biozyme interaction for the number of flowers at 34 days after transplanting (Table 4.10). Abesim variety to which 0.09ml Biozyme was applied produced the biggest fruit diameter, two times the size significantly bigger than the least by Oforiwaa to which no Biozyme was applied. Increased in diameter of fruit to which 0.09ml Biozyme was applied was also significantly bigger than the other treatment combinations. Among amendments, 0.09ml Biozyme application led to a significantly increased in fruit diameter, 36.6% of higher fruit diameter than the smallest diameter measured in the control. In the case of the variety, Abesim measured significantly bigger fruit diameter than Oforiwaa.

Table 4.10: Effect of Biozyme on diameter of the fruits of two garden egg varieties (mm)

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	30.41	33.73	36.38	40.42	35.24
Abesim	35.50	43.29	54.34	63.56	49.17
Means	32.96	38.51	45.36	51.99	
HSD (1%) amendment = 0.27, variety = 0.16, amendment*variety = 0.44					

4.4.2. Fruit Firmness

There were significant Biozyme amendment x variety interactions for the fruit firmness (Table 4.11). Variety Oforiwaa to which 0.09ml Biozyme was applied produced the highest fruit firmness, significantly greater than the others except Abesim to which 0.09ml Biozyme was applied. The least firmness value was recorded by Oforiwaa to which no Biozyme was applied. Firmness recorded in Oforiwaa to which 0.09ml Biozyme was applied was also significantly greater than the other treatment combinations. Among amendments, 0.09ml Biozyme application led to a significantly increased fruit firmness, two times more than the least fruit firmness recorded by the control. As regard the varieties, Abesim produced significantly more firmer fruits than Oforiwaa.

Table 4.11: Effect of Biozyme on firmness of the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	4.37	5.74	7.41	8.75	6.57
Abesim	4.49	7.81	8.36	8.36	7.44
Means	4.43	6.77	7.88	8.93	

HSD (1%) amendment = 0.77, variety = 0.44, amendment*variety = 1.24

4.4.3. Pericarp

There were significant differences in the Biozyme x variety interactions of pericarp thickness of garden egg fruits (Table 4.12). Abesim variety to which 0.09ml Biozyme was applied produced the biggest pericarp, significantly bigger than the least by Oforiwaa to which no Biozyme was applied. The biggest pericarp produced by Abesim to which 0.09ml Biozyme was applied was also significantly bigger than the other treatment combinations. Among amendments, 0.09ml application led to a significantly

thicker fruit pericarp, about three times more than the least produced by the control. In terms of the variety, Abesim produced significantly thicker fruit pericarp than Oforiwaa.

Table 4.12: Effect of Biozyme on Pericarp of the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	2.62	3.25	4.23	5.40	3.87
Abesim	3.01	3.53	5.22	7.09	4.71
Means	2.81	3.39	4.73	6.24	
HSD (1%) amendment = 0.09, variety = 0.05, amendment*variety = 0.15					

4.5. FRUIT CHEMICAL COMPOSITION AS AFFECTED BY BIOZYME RATES

4.5.1. Effects on fruit calcium content

Significant amendment x variety interactions for calcium content in garden egg fruits (Table 4.13). Abesim variety to which 0.09ml Biozyme was applied recorded the highest value of calcium content, more than two time higher than the least by Oforiwaa to which no Biozyme was applied. Calcium content in Abesim was also significantly greater than the other treatment combinations when 0.09ml Biozyme was applied. Among amendments, 0.09ml Biozyme application led to a significantly higher calcium content, 40% higher than the least observed by no Biozyme application. As regard the varieties, Abesim produced significantly more calcium content than Oforiwaa.

Table 4.13: Effect of Biozyme on calcium content in the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means

Oforiwaa	0.05	0.08	0.09	0.08	0.07
Abesim	0.07	0.07	0.09	0.12	0.09
Means	0.06	0.07	0.09	0.10	
HSD (1%) amendment = 0.01, variety = 0.01, amendment*variety = 0.03					

4.5.2. Effects on fruit manganese Content

There were significant differences among the different levels of Biozyme on the fruit weight of Oforiwaa and Abesim respectively (Table 4.14). Application of 0.09ml Biozyme led to the significantly higher manganese content in garden egg fruits, 53.3% and 34.5% more calcium content than the least produced by the control.

Table 4.14. Manganese Content in Oforiwaa

Treatment	**% Manganese Content of Oforiwaa**	**% Manganese content of Abesim**
Control	4.63	4.58
Biozyme 0.05ml	4.76	4.06
Biozyme 0.07ml	6.43	5.70
Biozyme 0.09ml	7.10	6.16
HSD (0.01)	1.19	1.19

4.5.4. Effects of fruit magnesium content

There were significant variety x Biozyme interaction for the magnesium content in the fruit of garden egg (Table 4.15). Abesim variety to which 0.09ml Biozyme was applied produced the highest magnesium content, 55.6% significantly more magnesium content than the least by Abesim to which no Biozyme was applied. Magnesium content in Abesim was also significantly greater than the other treatment combinations when 0.09ml Biozyme was applied. Among amendments, 0.09ml

application led to a significantly higher production of magnesium in garden egg fruit than the least observed in the control. In the variety, Abesim recorded higher magnesium content more than Oforiwaa.

Table 4.15. Effect of Biozyme on magnesium contents in the fruits of garden egg

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	0.37	0.39	0.38	0.42	0.39
Abesim	0.36	0.38	0.47	0.56	0.44
Means	0.36	0.39	0.43	0.49	
HSD (1%) amendment = 0.07, variety = 0.04, amendment*variety = 0.12					

4.5.5. Effects on fruit nitrogen content

There were no significant differences among the different levels of Biozyme for the magnesium content of Oforiwaa (Table 4.16). Abesim variety to which 0.09ml Biozyme was applied, produced the highest nitrogen content, 14% significantly more nitrogen content in garden egg fruits than the least produced by the control.

Table 4.16: Nitrogen content in Oforiwaa

Treatment	% Nitrogen content of Oforiwaa	% Nitrogen content of Abesim
Control	4.44	5.42
Biozyme 0.05ml	4.64	5.66
Biozyme 0.07ml	4.68	5.77
Biozyme 0.09ml	4.96	6.18
HSD (1%)	0.22	0.22

4.5.7. Effects on fruit phosphorus content

There were significant amendment x variety interactions for the phosphorus contents (Table 4.17). Abesim variety to which 0.09ml Biozyme was applied produced the highest phosphorus content in garden fruit, 28.6% significantly more phosphorus

content than the least by Abesim to which no Biozyme was applied. Phosphorus content in Abesim to which 0.09ml Biozyme was applied was also significantly greater than the other treatment combinations. Among the amendments, 0.09ml application led to a significantly higher production of phosphorus content, 42.9% more phosphorus than the least produced by the control. In the case of the variety, Abesim produced significantly more phosphorus content than Oforiwaa.

Table 4.17: Effect of Biozyme on Phosphorus contents in the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	0.07	0.07	0.09	0.09	0.08
Abesim	0.07	0.08	0.09	0.11	0.09
Means	0.07	0.08	0.09	0.10	
HSD (1%) amendment = 9.62, variety = 5.45, amendment*variety = 0.02					

4.5.8. Effects on fruit potassium content

There were significant amendment x variety interactions for the % potassium content of garden egg fruits (Table 18). Oforiwaa variety to which 0.09ml Biozyme was applied had the highest % potassium content, 82.2% significantly more potassium than the least by Oforiwaa to which no Biozyme was applied. Potassium content in fruits of Oforiwaa to which 0.09ml Biozyme was applied was also significantly greater than the other treatment interactions. Among amendments, 0.09ml Biozyme application led to the significantly higher production of potassium, 54.1% more potassium than the least produced by the control. In terms of the varieties, Oforiwaa produced significantly more potassium content than Abesim.

Table 4.18:4 Effect of Biozyme on potassium contents in the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	0.45	0.55	0.67	0.82	0.62
Abesim	0.50	0.54	0.55	0.65	0.56
Means	0.48	0.54	0.61	0.74	
HSD (1%) amendment = 0.04, variety = 0.02, amendment*variety = 0.07					

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4.5.9. Effects on fruit pH

There were significant amendment x variety interactions for pH in garden egg fruits (Table 4.19). Fruits of Abesim variety to which 0.09ml Biozyme was applied recorded the highest pH value in the fruit of garden egg, 34.3% significantly higher pH value than the least by Oforiwaa to which no Biozyme was applied. The pH value recorded in fruits of Abesim to which 0.09ml Biozyme was applied was also significantly higher than the other treatment combinations. Among amendments, 0.09ml Biozyme application led to a significantly higher pH value, 10.9% more pH than the least recorded in the control. As regard the varieties, Abesim recorded significantly higher pH value than Oforiwaa.

Table 4.19: Effect of Biozyme on pH of the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	5.02	5.21	6.03	6.05	5.58
Abesim	6.51	6.54	6.71	6.74	6.63
Means	5.76	5.88	6.37	6.39	
HSD (1%) amendment = 0.19, variety = 0.12, amendment*variety = 0.30					

4.5.10. Effects on fruit total soluble solids (TSS)

There were significant amendment x variety interactions for the TSS value of garden egg fruits (Table 4.20). Fruits of Abesim variety to which 0.09ml Biozyme was applied attained the highest TSS value, three times more TSS value than the least by Oforiwaa

to which no Biozyme was applied. The TSS value recorded in Abesim to which 0.09ml Biozyme was applied was also significantly higher than the other treatment interactions. Among amendment, 0.09ml Biozyme led to a significantly higher TSS value, 67.8% more than the TSS value recorded in the control. As regard the variety, Abesim recorded significantly higher than Oforiwaa.

Table 4.20: Effect of Biozyme on TSS of the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	1.39	1.32	1.50	1.66	1.47
Abesim	2.20	2.51	3.51	4.38	3.15
Means	1.80	1.92	2.51	3.02	

HSD (1%) amendment = 0.12, variety = 0.07, amendment*variety = 0.19

4.5.11. Effects on fruit total titratable acidity (TTA)

There were significant amendment x variety interactions for the TTA value of garden egg fruits (Table 4.21). Fruits of Abesim variety to which 0.09ml Biozyme was applied recorded the highest TTA value, ten times significantly more than the least by Oforiwaa to which no Biozyme was applied. TTA value recorded by Abesim to which 0.09ml Biozyme was applied was also significantly higher than the other treatment interactions. Among amendments, 0.09ml Biozyme led to a significantly higher TTA, four times more than the least recorded by the control. In terms of the variety, Abesim recorded significantly more TTA than Oforiwaa.

Table 4.21: Effect of Biozyme on TTA of the fruits of two garden egg varieties

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means

Oforiwaa	0.05	0.04	0.05	0.06	0.05
Abesim	0.11	0.23	0.46	0.69	0.37
Means	0.08	0.13	0.25	0.37	

HSD (1%) amendment = 0.03, variety = 0.02, amendment*variety = 0.05

4.5.12. Effects on fruit vitamin C content

There were significant amendment x variety interactions for the vitamin C content of garden egg (Table 4.22). Abesim variety to which 0.09ml Biozyme was applied produced the highest vitamin C content, two times significantly more than the least by Oforiwaa to which no Biozyme was applied. Vitamin C content recorded for Abesim fruit to which 0.09ml was applied was also significantly greater than the other treatment combinations. Among amendments, 0.09ml application led to a significantly higher fruit vitamin C content, 48.1% more than the least recorded in the control. In terms of the varieties, Abesim recorded significantly more vitamin C content than Oforiwaa.

Table 4.22: Effect of Biozyme on vitamin C content of garden egg fruit

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	2.12	2.34	2.49	2.63	2.39
Abesim	3.04	3.51	4.12	5.03	3.92
Means	2.58	2.93	3.30	3.83	

HSD (1%) amendment = 0.04, variety 0.02, amendment*variety = 0.06

4.6. SENSORY EVALUATION AS AFFECTED BY BIOZYME RATES

4.6.1. Effects on fruit Shelf life

There were significant amendment x variety interactions for the number of days to 50% fruit deterioration (Table 4.26). Oforiwaa variety with 0.05ml Biozyme application took

significantly the longest time to attain 50% deterioration. Fruits of both Oforiwaa and Abesim to which 0.09ml Biozyme was applied took the shortest time to attain 50% deterioration. Among the amendments, 0.05ml Biozyme application led to the longest time to 50% deterioration, 6.03 days more than 0.09ml Biozyme which resulted in the shortest time. As regard the varieties, fruits of Oforiwaa had longer shelf life than those of Abesim.

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Table 4.23. Effect of shelf life as affected by Biozyme application

	Amendments				
Varieties	Control	0.05ml Biozyme	0.07ml Biozyme	0.09ml Biozyme	Means
Oforiwaa	11.82	14.24	9.517	7.92	10.88
Abesim	10.85	13.22	9.213	7.48	10.19
Means	11.34	13.73	9.37	7.70	
HSD (1%) amendment = 0.15, variety 0.08, amendment*variety = 0.25					

CHAPTER FIVE

5.0. DISCUSSION 5.1. REPRODUCTIVE GROWTH AND YIELD OF GARDEN EGG AS

AFFECTED BY BIOZYME

The application of Biozyme resulted in early flowering and the average number of days to flowering decreased as the rate of Biozyme increased. Correspondingly, the number of flowers aborted decreased with elevated rate of Biozyme. This could mean that nutritional composition of Biozyme did not only provide the required nutrients for cell activation but also stimulated cellular differentiation, ensured more number and strength of flora buds that contributed to a higher number of flowers that resulted into fruits development. The results of the current study support the findings of Tobergte & Curtis (2013) who reported that the higher the rates of Biozyme, the higher the number of flowers and that Biozyme induces crops to withstand

environmental stress. Additionally, Marcelis *et. al.* (2004) reported that the effects of heat stress on abscission might also be the result of reduced assimilate availability, but heat stress may specifically reduce the metabolic activity of the flower or the flower bud as well. Furthermore, according to (Paradiković *et. al*, 2013), Biozyme (biostimulant) contains mineral components like carboxylic acid (COOH) and hydroxyl (OH) groups with ability to chelate positively charged ions. These might have played key roles in plant growth and development by regulating a number of fundamental cellular processes of cell division, cell elongation or cell differentiation.

As regard the varieties, Oforiwaa recorded the highest number of flowers over Abesim. The differences might have led to their genetic adaptation to the environment which might account for the observations made since both cultivars were under a breeding program (Barbosa *et al*., 2015)

Amendment of Biozyme increased the number of fruits per plot, marketable fruits, yield in ton/ha which could be as the result of assimilated soil chemical and microbial properties and positively effect of the uptake of available nutrients in the soil by the plants leading to the development of adequate photosynthetic structures which increased the synthesis of carbohydrates and subsequent accumulation in the fruits leading to the high yields. The result of the present study collaborates with findings of Kar *et, al.* (2013) who reported that when Biozyme was incorporated in adequate quantity, enhanced organic materials which resulted in improving soil physiochemical and biological properties that prevented leaching and volatilization losses but slowly releases nutrients with crop demand improving synthesis and translocation of metabolites to various reproductive structures resulting into yield and yield attributes. Moreover, (Okamoto *et al*., 2008) also reported that Biozyme's promotional effects to increase root proliferation and establishment, regulated the plant bio-physiological

activities (increased chlorophyll content in the leaves etc) which resulted in higher yield and yield attributes.

5.2. FRUIT PHYSICAL QUALITY CHARACTERISTICS AS AFFECTED BY BIOZYME

Biozyme level 0.09ml significantly influenced fruit diameter, firmness and pericarp thickness among the levels of amendment applied. Moreover, the effect of the highest level of Biozyme is clearly seen in the varieties of garden egg. This finding could be as the result of the positive growth stimuli generated by pollination and fertilization, fruit growth acting factors in the mature ovary which agrees with the report of Sutharsan *et al.* (2014) who conveyed that Biozyme played a significant role on the yield and yield attributes of garden egg. The increase in the fruit diameter, pericarp thickness and fruit firmness resulting into quality marketable yield were obtained from the highest treatment level. Again, Manna *et. al.*, (2013) stated that by elevating the rate of Biozyme in an expectable quantity, amplifies precursors of auxins, enzyme, protein and micronutrients responsible to improve vegetative growth and in turn yield of crops.

5.3. FRUIT CHEMICAL QUALITY CHARACTERISTICS AS AFFECTED BY BIOZYME

Biozyme (biostimulant) had positive effects on chemical composition of garden egg (Calcium, magnesium, phosphorus, potassium, vitamin C, pH, TSS and TTA). This could be attributed to the promoting influence of Biozyme on the efficiency of photosynthesis process resulting in an increase in higher quality fruits. Tobergte & Curtis, (2013) in similar studies concluded that the application of Biozyme (biostimulant) is a promising approach to obtaining quality fruits and achieving sustainable agriculture. Mohammed (2013) also stated that positive effect on fruit

quality by influencing fruit sugars, vitamin C, TTA, TSS and other mineral compositions leading to better fruit quality is as the result of the capability of Biozyme (biostimulant) to simulate plant roots to absorb nutrient from the soil. Furthermore, Ahmed (2010) suggested that elevation of Biozyme amendment rates to enable proper breakdown of amino acid with the presence of putrescine or vegimax will decrease the sodium concentration in fruit at the reproductive stage thus resulting into maximum chemical composition in fruits and vegetables. Results in the current study demonstrated increases of fruit chemical composition as the levels of Biozyme were elevated.

5.4. FRUIT SHELF LIFE AS AFFECTED BY BIOZYME

Application of the lowest rate of Biozyme increased the shelf life (13.37 days) of fruits whereas the highest rate of Biozyme reduced fruit shelf life (7.70 days). This might have been attributed to reduction in the respiration rate which arises from the slow breakdown of carbon compounds by metabolism. Aked (2002) indicated that physiological disorders are adverse quality changes that occur in fresh produce triggered by metabolic disturbances due to non-optimal environmental factors such as inappropriate storage temperatures or atmosphere compositions. In a similar study, Godlewska & Ciepiela (2013) observed that components in biostimulant such as auxins, gibberellic acid, cytokinins and amino acids increase the physiological activity of carbohydrate synthesis. Furthermore, Samira & Woldetsadik (2013) reported that shorter shelf life of garden egg under ambient storage condition could be attributed to high rate of Biozyme which influenced high moisture when under high temperature and high relative humidity, facilities respiration and speed up ripening and subsequently deterioration. In the present study it was observed that the highest rates of Biozyme

had similar effect on fruits while the effects were reversed at the lower rates of application.

CHAPTER SIX

6.0. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSION

This present study has shown that application of Biozyme (bio-stimulant) resulted in significant positive effects on the reproductive growth, whereby 0.09ml Biozyme increased flower production at 34, 48 and 62 days respectively. Higher Biozyme rate also increased the number of fruit per plot, increased the number of marketable fruits, and the total yield in ton/ha of the two cultivars of garden eggs.

Generally, application of 0.09ml Biozyme significantly increased the physical qualities parameters of fruit diameter, pericarp thickness and fruit firmness.

Application of 0.09ml Biozyme also had a positive effect on the mineral composition of calcium, magnesium, nitrogen, phosphorus, potassium and manganese including some chemical composition including vitamin C as well as pH, TTA and TSS.

On the other hand, the higher the rate of Biozyme applied, the shorter the life span of the garden egg fruit. The rate of the amendment hand an adverse effect where, as the levels increased it facilitated the physiological process to have a harmful effect on the fruit life span in ambient storage condition.

6.2. RECOMMENDATIONS

It is recommended that:

- The same rates of biozyme should be tested on other crops in different agroecological zones.
- The effects of Biozyme on seed and seed health quality should be assessed.
- Effects of Biozyme on other crops be studied under controlled (glasshouse) environment.

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APPENDICES

APPENDIX I

Analysis of Variance Table for Flow34day

Source	DF	SS	MS	F	P
AMENDMENT	3	174.527	58.1757	106.29	0.0000
VARIETY	1	2.968	2.9681	5.42	0.0333
AMENDMENT*VARIETY	3	10.498	3.4994	6.39	0.0047
Error	16	8.758	0.5474		
Total	23	196.751			

Grand Mean 12.877 CV 5.75

APPENDIX II

Analysis of Variance Table for Flower at 48 day

Source	DF	SS	MS	F	P
AMENDMENT	3	275.612	91.871	87.91	0.0000
VARIETY	1	118.148	118.148	113.06	0.0000
AMENDMENT*VARIETY	3	80.924	26.975	25.81	0.0000
Error	16	16.720	1.045		
Total	23	491.405			

Grand Mean 15.573 CV 6.56

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Source

APPENDIX III

Analysis of Variance Table for Flower at 62 day

	DF	SS	MS	F	P
AMENDMENT	3	660.708	220.236	235.57	0.0000
VARIETY	1	126.042	126.042	134.82	0.0000
AMENDMENT*VARIETY	3	46.750	15.583	16.67	0.0000
Error	16	14.958	0.935		
Total	23	848.458			

Grand Mean 18.833 CV 5.13

APPENDIX IV

Analysis of Variance Table for fruit count

Source	DF	SS	MS	F	P
AMENDMENT	3	12307.5	4102.49	656.40	0.0000
Varieties	1	495.0	495.04	79.21	0.0000
AMENDMENT*Varieties	3	5880.5	1960.15	313.62	0.0000
Error	16	100.0	6.25		

				F	**P**
Total		23	18783.0		

Grand Mean 139.04 CV 1.80

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APPENDIX V

Analysis of Variance Table for Marketable Source

	DF	**SS**	**MS**		
amend	3	0301.0	13433.7	1771.47	0.0000
var	1	88.2	88.2	11.63	0.0036
amend*var	3	4306.8	1435.6	189.31	0.0000
Error	16	121.3	7.6		
Total	23	44817.3			

Grand Mean 123.17 CV 2.24

APPENDIX VI

Analysis of Variance Table for total fruit weight in ton/ha

Source	**DF**	**SS**	**MS**	**F**	**P**
amend	3	3.4819	1.16064	7.18	0.0029

Source					
var	1	6.3757	6.37570	39.43	0.0000
amend*var	3	0.9258	0.30862	1.91	0.1689
Error	16	2.5871	0.16170		
Total	23	13.3706			

Grand Mean 6.6354 CV 6.06

APPENDIX VII

Analysis of Variance Table for calcium content

	DF	SS	MS	F	P
Amends	3	4.946E-03	1.649E-03	18.84	0.0000
Varieties	1	9.375E-04	9.375E-04	10.71	0.0048
Amends*Varieties	3	2.212E-03	7.375E-04	8.43	0.0014
Error	16	1.400E-03	8.750E-05		
Total	23	9.496E-03			

Grand Mean 0.0796 CV 11.75

APPENDIX VIII

Analysis of Variance Table for manganese content

Source	DF	SS	MS	F	P
Amends	3	16.9840	5.66133	5.68	0.0076

				F	**P**
Varieties	1	8.7242	8.72420	8.76	0.0092
Amends*Varieties	3	2.7127	0.90425	0.91	0.4593
Error	16	15.9413	0.99633		
Total	23	44.3622			

Grand Mean 5.1254 CV 19.47

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Source **F** **P**

APPENDIX IX

Analysis of Variance Table for magnesium content

	DF	SS	MS		
Amends	3	0.05725	0.01908	16.90	0.0000
Varieties	1	0.01870	0.01870	16.56	0.0009
Amends*Varieties	3	0.02635	0.00878	7.78	0.0020
Error	16	0.01807	0.00113		
Total	23	0.12036			

Grand Mean 0.4163 CV 8.07

APPENDIX X

Analysis of Variance Table for % Nitrogen

Source	**DF**	**SS**	**MS**	**F**	**P**
Amends	3	1.25683	0.41894	37.21	0.0000
Varieties	1	6.95527	6.95527	617.79	0.0000
Amends*Varieties	3	0.05050	0.01683	1.50	0.2538
Error	16	0.18013	0.01126		
Total	23	8.44273			

				F	P

Grand Mean 5.2183 CV 2.03

APPENDIX XI

Analysis of Variance Table for % Phosphorus

	DF	SS	MS	F	P
Amends	3	3.700E-03	1.233E-03	59.20	0.0000
Varieties	1	4.167E-04	4.167E-04	20.00	0.0004
Amends*Varieties	3	4.833E-04	1.611E-04	7.73	0.0021
Error	16	3.333E-04	2.083E-05		
Total	23	4.933E-03			

Grand Mean 0.0833 CV 5.48

APPENDIX XII

Analysis of Variance Table for % potassium

Source	DF	SS	MS	F	P
Amends	3	0.22315	0.07438	189.91	0.0000
Varieties	1	0.02470	0.02470	63.07	0.0000
Amends*Varieties	3	0.04598	0.01533	39.13	0.0000
Error	16	0.00627	0.00039		
Total	23	0.30010			

Source

Grand Mean 0.5904 CV 3.35

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APPENDIX XIII

Analysis of Variance Table for fruit diameter

Source	**DF**	**SS**	**MS**		
AMENDMENT	3	4918.6	1639.52	18631.8	0.0000
VARIETY	1	4659.7	4659.72	52953.9	0.0000
AMENDMENT*VARIETY	3	1190.8	396.93	4510.74	0.0000
Error	88	7.7	0.09		
Total	95	10776.8			

Grand Mean 42.204 CV 0.70

APPENDIX XIV

Analysis of Variance Table for Firm

Source	**DF**	**SS**	**MS**	**F**	**P**
AMENDMENT	3	267.747	89.2491	129.11	0.0000
VARIETY	1	18.227	18.2266	26.37	0.0000
AMENDMENT*VARIETY	3	13.737	4.5792	6.62	0.0004
Error	88	60.833	0.6913		

				F	P
Total	95	360.545			

Grand Mean 7.0032 CV 11.87

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APPENDIX XV

Analysis of Variance Table for friweight

Source	DF	SS	MS	F	P
AMENDMENT	3	13021.5	4340.49	2936.37	0.0000
VARIETY	1	2030.3	2030.26	1373.48	0.0000
AMENDMENT*VARIETY	3	865.7	288.57	195.22	0.0000
Error	88	130.1	1.48		
Total	95	16047.5			

Grand Mean 43.864 CV 2.77

APPENDIX XVI

Analysis of Variance Table for Pericap

Source	DF	SS	MS	F	P
AMENDMENT	3	167.965	55.9883	5913.13	0.0000
VARIETY	1	16.892	16.8924	1784.07	0.0000
AMENDMENT*VARIETY	3	7.567	2.5224	266.40	0.0000
Error	88	0.833	0.0095		
Total	95	193.258			

Grand Mean 4.2928 CV 2.27

APPENDIX XVII

Analysis of Variance Table for pH

Source	DF	SS	MS	F	P
AMENDMENT	3	7.6953	2.5651	64.39	0.0000
VARIETY	1	26.4285	26.4285	663.41	0.0000
AMENDMENT*VARIETY	3	3.2674	1.0891	27.34	0.0000
Error	88	3.5057	0.0398		
Total	95	40.8969			

Grand Mean 6.1016 CV 3.27

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APPENDIX XVIII

Analysis of Variance Table for TSS

Source	DF	SS	MS	F	P
AMENDMENT	3	23.038	7.6794	479.44	0.0000
VARIETY	1	68.091	68.0909	4251.07	0.0000
AMENDMENT*VARIETY	3	13.095	4.3650	272.52	0.0000
Error	88	1.410	0.0160		
Total	95	105.633			

Grand Mean 2.3089 CV 5.48

APPENDIX XIX

Analysis of Variance Table for TTA

Source	DF	SS	MS	F	P

AMENDMENT	3	1.21892	0.40631	402.42	0.0000
VARIETY	1	2.44482	2.44482	2421.43	0.0000
AMENDMENT*VARIETY	3	1.12381	0.37460	371.02	0.0000
Error	88	0.08885	0.00101		
Total	95	4.87640			

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Grand Mean 0.2102 CV 15.12

APPENDIX XX

Analysis of Variance Table for VC

Source	**DF**	**SS**	**MS**	**F**	**P**
AMENDMENT	3	20.6793	6.8931	3978.10	0.0000
VARIETY	1	56.1510	56.1510	32405.4	0.0000
AMENDMENT*VARIETY	3	7.6448	2.5483	1470.64	0.0000
Error	88	0.1525	0.0017		
Total	95	84.6277			

Grand Mean 3.1588 CV 1.32

Analysis of Variance Table for Number of days to 50% flower

Source	**DF**	**SS**	**MS**	**F**	**P**
Amends	3	130.055	43.3517	6936.27	0.0000
Varieties	1	14.415	14.4150	2306.40	0.0000

Amends*Varieties	3	11.295	3.7650	602.40	0.0000
Error	16	0.100	0.0063		
Total	23	155.865			

Grand Mean 41.125 CV 0.19

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Analysis of Variance Table for Shelf life

Source	**DF**	**SS**	**MS**	**F**	**P**
Amends	3	121.436	40.4788	8239.95	0.0000
Varieties	1	2.802	2.8017	570.31	0.0000
Amends*Varieties	3	0.605	0.2015	41.02	0.0000
Error	16	0.079	0.0049		
Total	23	124.921			

Grand Mean 10.533 CV 0.67