ASSESSMENT OF POSTHARVEST LOSSES OF YAM PRODUCTION IN THE KRACHI-EAST DISTRICT OF THE VOLTA REGION OF GHANA

BY

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JULY, 2013

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

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A THESIS SUBMITTED TO THE SCHOOL OF RESARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF

MASTER OF PHILOSOPHY

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BY

PHILIP KWAKU DAPAAH

JUNE, 2014

DECLARATION

I hereby declare that this thesis is the result of my own work towards the Mphil. Postharvest Technology programme, and that to the best of my knowledge, this study contains no material either previously published by another person or submitted for the award of any Degree of the University, except where acknowledgements have been made in the text.

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DR. BEN BANFUL ……………… ……………………

(HEAD OF DEPARTMENT) SIGNATURE DATE

DEDICATION

This thesis is dedicated to Almighty God for providing me with good health, courage, determination and above all protection. To my lovely children: Daniel, Joshua and Deborah for their patience while I studied in the University.

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There are numerous others whose names I cannot mention for lack of space. Ultimately, however, the responsibility for any shortcomings in this study is entirely mine.

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ABSTRACT

The study was carried out in the Krachi East – Distract of the Volta Region of Ghana to assess postharvest losses of yam. The research was carried out in two stages; the first stage was a survey to assess postharvest loss of yam in the Krachi East- District. The second stage was an in-depth study on losses of yam at both the farmer level and the marketer level by counting the losses of yam. A random sampling method was used to select both farmers and marketers of yam in the operational area. Data obtained from the study was analyzed using Statistical Package for Social Sciences. Linear regression using stepwise method was used in estimating the major factors of postharvest losses in yam production at the farmer and the marketers' levels. The study showed that majority of farmers in the district grew puna (55%), lalbako (57%), and water yam (58%). The study revealed that there was up to 30% loss of tubers at harvest, 32% loss of tubers at storage and more than 35.5% of tubers sprouting during storage. The study showed that: less than 5% of marketers experienced less than 52% loss at buying and less than 5 % of marketer's experienced 53% loss during off-loading. The regression analysis revealed that the major causes of postharvest losses at the farmer level included; pest attack, variety of yam cultivated and tools used in harvesting yams. The regression analysis also indicated that the major causes of postharvest losses at the marketer level included; type of vehicles used in transporting tubers, varieties of yam sold, cuts or bruises and exposure of yam to harsh environmental conditions. A follow-up (in-depth study), however, showed that there was an average loss of 17.72% at farm gate, 5.4% loss at the market level and 8.9% loss at retailer level. Mean temperatures at storage areas at the farm was 32.2 ^{o}C, at the market and 32.1 ^{o}C at the retail points. Pathological study showed that

Fusarium solani Fusarium oxysoporium, Botryodiplodia theobromae and *Rhizopus orazea* were the main rot- causing organism during storage.

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1.0 INTRODUCTION

Yam is the common name for some species in the genus *Dioscorea* (family *Dioscoreaceae)*. These are perennial herbaceous vines cultivated for the consumption of their starchy tubers in Africa, Asia and Latin America. The major cultivated species of yam include *Diocorea rotundata* (white yam), *Diocorea cayenensis* (yellow yam), *Diocorea alata* (water yam), *Diocorea bulbifera* (air potatoes), *Diocorea esculenta* (lesser yam), *Diocorea trifida* (cush-cush yam) and *Diocorea dumetorum* (bitter yam) (Kay, 1997).

Yam provides around 110 calories per 100 grams of product. It is high in vitamin C and B6, potassium, manganese, fats and sodium. A product that is high in potassium and low in sodium is likely to produce a good potassium balance in the human body and so protects against osteoporosis and heart disease. The product generally has a low glycemix index than potato products, which means that they will provide a more sustained form of energy and give better protection against obesity and diabetes (Walsh, 2003).

The Krachi-East District is located on the north-western part of the Volta Region of Ghana and lies between latitude $7^{o}40N$ and $8^{o}15N$ and longitude $0^{o}6N$ and 20^{o} E. It is bounded on the north-west by Krachi-West District, on the west and south-west is the River Volta, Biakoye District to the south-east, Kadjebi District to the east and Nkwanta District to the north. The district has a total surface area of 2528 square km (MOFA, 2011).

Most shortfalls in food supply to the majority of people in developing countries have been attributed to postharvest losses. Conservative estimates of losses were put at 30% of production in Ghana (Bani, 1991). Furthermore, most developing countries have identified the food supply to their people as a major problem and considerable resources have been committed to increasing agricultural production and decreasing field losses in order to produce more food. However, it is important to note that all attempts put in place by the government to increase food supply have become a failure simply because some of the food stuffs produced is lost after harvest. This is because most of the foods produced are lost through cuts, pest infestations, bruises and rots.

Postharvest losses have been one of the major problems facing yam farmers in the Krachi-East District of the Volta Region. These problems have caused occasional major losses of yam produced in the district during storage and in transit. (MOFA, 2011). Therefore, the main purpose of the study was to assess postharvest losses in yam production in the Krachi-East District of the Volta Region of Ghana, and specifically to determine:

- varieties of yam that are grown by farmers in the area;
- the handling methods farmers use after harvest; and
- the proportion of yam that is lost from harvesting till consumed marketed.

2.0 LITERATURE REVIEW

2.2 YAM SPECIES AND THEIR ORIGIN

Yam comprises several species of different origin. Domesticated yams are mainly from the traditional regions between the forest zones. *Discorea alata* (water yam) is taught to have originated in south–east Asia (Burma) and *Discorea esculata* (lesser yam) is believed to have the same origin (Akoroda and Hahn, 1995).

Dioscorea caynensis (yellow yam) originated in the forest zones of west-Africa where it is widely grown. *Discorea rotundata* (white yam) is botanically very similar to *Discorea caynensis* but it has certain characteristics of some of the savanna *Discoreacea*. *Discorea dumetorum* (bither yam) originated from Africa more especially in the zones which extends from Congo river to Cameroon and eastern Nigeria. *Discorea trifida* (cush-cush yam) is the only yam to have originated by the new world. It was probably domesticated by the Amerindians in the border regions of Brazil and Guyana before spreading to the West-Indies. *Discorea bulbifera* (aerial yam) exist in the world in both Africa and Asia is grown little nowadays (Romain, 2001).

2.2 ECOLOGICAL REQUIREMENT OF YAM

Yam requires adequate moisture throughout the growing period and there is a positive correlation between moisture supply, vine growth and tuber yield, but the humid period for vegetative growth must be followed by a dry period of harvesting. The critical period for adequate moisture supply appears to be during the 14-20 weeks of growth for most yam species. Rainfall of 1000mm-1500mm per annum with a definite dry season of 2 - 4 months give optimum yield although there are considerable variations in moisture requirement and drought resistance between the different species and cultivars. The length of the rainy season is particularly important. For instance, species such as yellow yam normally have a short period of dormancy and will not do well in an area with dry season of more than 2-3 months. However, most cultivars of white yam and water yam need less than ten months to complete their life cycle of vegetative growth and tuber development and thrive in both forest and savanna zones provided the rainy season is long to complete their life cycle (Tweneboah, 2000).

2.3 LAND PREPARATION AND PLANTING OF YAM

Yams are normally grown on newly land after a fallow period. Clearing and burning of the grasses begin in most yam growing areas in August-September to December followed by the raising of yam moulds. The mounds are prepared by drawing the top soil together with a hoe until sufficient depth of loose soil has been gathered. This process helps the tuber to penetrate through the loose soil without much hindrance thereby producing larger yield of tuber per plant in a uniform shaped tubers. Planting takes place just before the onset of the rainy season, where the season is short, the setts are placed in the mounds towards the end of the dry season to take advantage of the early rains. As a general rule, water yam and yellow yam are planted just before the beginning of the major season rains. But in the savanna zone, white yams are planted earlier often 1-2 months before the major season rains (Ennin *et al*., 2003).

Ofori and Nattu (1991) also indicated that weeds reduce the yield of yam production and therefore, regular weeding should be done with the use of hoe for a period of three to four times depending on the nature of weeds on the land. Yam takes between 6-8 months to mature after planting depending on the variety.

2.4 HARVESTING OF YAM

According to ICRA (1996), there are two main harvesting methods. This includes the double and single harvesting. In the double harvesting, each plant is harvested twice. The first harvesting is about six months after sprouting and this involves the use of cutlass. Care is taken not to damage the roots and vines of the crop. The tuber is separated from the crown and the mounds re-shaped. The second harvest takes place after the vines have dried up. Hoe is used during this harvest. The second harvest is generally fibrous and is used as planting material. In the single harvest, harvesting is delayed until the vines have dried up. During this harvesting period, earth chised and hoe are used in harvesting. Double harvesting is mainly practiced in the production of certain varieties of white yam but not suitable for other species. However, care is taken during this harvesting to avoid bruising of the tubers.

2.5 PREPARING YAMS FOR STORAGE

Yams belong to the most important food crops in the West African countries of Nigeria, Côte d'Ivoire, Ghana, Togo, Benin and the Republic of Guinea . Their production account for about 95% of the world production. Yams are grown in the northern forest and southern savannah zones but are consumed in all parts of these countries. Yams, particularly white yams, are considered a prestigious food and are preferred to other foods by the urban populations. Most yams are marketed as fresh tubers and prepared for consumption within their country of production. Transportation and marketing is carried out by the private sector, (Wang *et al*., 1998).

Traditional and upbringing yam farmers understand that only sound healthy tubers are suitable for storage. For this reason yam are harvested with great care, but because of varying sizes and shapes of yam tubers, some damages inevitably occurs. Farmers are known to reject unhealthy or damaged tubers which are then used for immediate consumption or processing (FAO, 1990).

A bruise or abrasion is more likely to lead to decay in storage than a clean cut and it is traditional practiced to cut away any bruised or decayed fleshed flesh and often together not rub the clean wound with alkaline material such as lime or wood ash to discourage re-infection, (FAO, 1990).

2.5.1 Storage Methods of Yam

Yam can be stored in bans on raised platforms or underground ditches. Tubers must be aerated and shaded to keep them relatively cool. They are frequently inspected and the rotten tubers removed from the lot. Other ways of storing yams include packing of tubers in aches and covering them with soil, covering tubers with grass mulch, yam vine mulch suspending tubers singly from brands or tying tubers to a framework of poles. Certain varieties naturally store better than others. Varieties of *Discora alata* are known to store for three months to one year. It is believed that when yams are stored in the barn it reduce the risk and attack of termite and rottening of tubers, (Degras 1993).

Bencini (1991) also indicated that yams are stored in the burn and should be covered with straw and enclosed within a fence for security. Inside the barn, the tubers may be tied individually to the vertical timbers or other arrangement to allow maximum air circulation. He, therefore, stressed that the maximum storage life of yams in the barn is six months. He further indicated that losses are reported to be 10% to 15% during the first three months and 30% to 50% after six months.

2.5.2 Scientific Method of Storing Yam

Although, the traditional storage of yam in barns is very popular in West-Africa, it can restrict ventilation and accentuate any tendency to deteriorations. Today, much research has been conducted in several areas of yam storage (Adesuyi 1999).

Lack of proper control of physical condition, physiological process and pest and micro-organisms had led to a considerable storage loss of 10-15% in weight in the first three months and approaching 50% after six months. He further stated that the temperature of 10^0 C or below is not suitable for the storage of water yam but suggested that a temperature of 12.5^0 C is recommended for the storage of yam (Adesuyi, 1999).

Yam loses its viability as a result of sprouting. Sprouting has been found to increase postharvest losses in yam storage. The weight of yam is lost through respiration reduction of food reserves and accelerated reduction of moisture content of the crop. Foliage sprays of maleic hydrazide on the crop about one month before harvest have contributed positively to the storage of yam production, (Adesuyi, 1999).

Bencini (1991) estimated that, one million tones of yam are lost annually during storage. However, there is no rot in the absence of bruises on the yam. He compared the traditional method and scientific method and came out that if yams are stored using the traditional method, about 38.4% would be lost as compared to the scientific method of 22.4%. He further stated that yam can store better if it is treated with a mixture of fungicides and insecticides. Thus, about 5% thiaberdazole, 2% malathion and 1.5% permethrim.

2.5.3 Losses in Traditional Yam Storage

Yams are seasonal crops. The tubers of white yams can be stored for several months under adequate storage conditions and under regular surveillance. However, there are considerable losses using traditional yam storage structures due to bacterial and fungal rotting, rodent attack, sprouting and other factors including theft which occurred in the storage facility. Over one million tons of tubers may be lost per annum during storage in West Africa (Odior and Orsarh, 2008).

Yam tubers are very delicate and easily bruised during harvest and handling. They spoil quickly due to physiological decay and rotting. High temperature may cause considerable physiological losses even to undamaged tubers. Rodents and other pests including insects attack the tubers, which are even more susceptible to rotting once they have been injured by pest organisms. Sprouting occurs easily and decreases the quality of the tubers indicating that sprouts should be removed. The amount of loss depends, in the first place, on storage system, yam variety and length of storage (Anon., 2011).

Traditional yam storage structures such as pits, trench silos and heaps in the field are very difficult to manage. These structures cannot protect the yam tubers sufficiently from losses described above. Continuous inspection of tubers is very difficult and in a lot of cases impossible in most of the traditional storage structures, so that losses are only detected when the yams are removed from the store for use or for sale. In many cases, the farmer cannot quickly sell when market prices are high because of the poor access to the store as a consequence of poor road conditions, especially during the rain seasons (Okigbo, 2003).

2.6 PROCESSING AND USES OF YAM

Yam is the most popular of tuber crops in Ghana and is eaten either in the form of fufu or in the form of boiled dry pieces. Most yams contain about 70% water, 3% protein and 20-25% carbohydrates but negligible amount of minerals and minerals. At least white yam and yellow yam are indigenous to West-Africa and prior to the introduction of staples such as cassava and cocoyam into the country. Yam was virtually the only staple crop grown in the forest areas. It is the traditional food in several areas especially in festivals when elders and traditional leaders offer prayers and then giving to the gods and blessings of the land (Bencini, 1991).

2.7 IMPORTANCE OF YAM PRODUCTION

Yam production in 2007 world-wide amounted to 52 million tons of which Africa produced 96%. This indicates that the world production of yam comes from West Africa, representing 94% with Nigeria alone producing 71%.Nevertheless, yam production is declining to some extent in some traditional producing areas due to declining soil fertility, increasing pest pressure and high cost of labour. Yams are grown by planting pieces of tubers or small white tubers (seed yam) saved from the previous season. Small-scale farmers, the majority of producers often intercrop yams with cereals and vegetables. The major pests that affect yams include insects such as leaf and tuber beetles, mealy bugs and scales; parasitic nematodes, fungi causing anthracnose, leaf spot, leaf blight and tuber rot; viruses, especially the yam mosaic virus (YMV) (IITA, 2008).

2.8 POSTHARVEST LOSSES AND HANDLING OF YAM PRODUCTION

Postharvest losses of tuber crops are more serious in developing countries than those in developed countries. An additional constraint to improving this situation is that in most developing countries the number of scientists concerned with postharvest food losses is significantly lower than those involved in production research. In the early days, increasing industrialization in technologically advanced nations gradually brought about improvement in crop handling. Also, improvement of product quality and reduction in postharvest losses has become the main concern of producers, middlemen, marketing specialists and the consumer (Boxall, 2011).

Handling procedures are not fully recognized in less developed countries. Production is not linked with marketing. However, with tuber crops such as yam, proper storage facilities, transport and handling technologies are practically non-existent hence considerable amounts of the product are lost. It is disheartening to note that so much time is devoted to the culture and the protection of the crop only to be wasted due to poor storage facilities, poor road network and poor handling methods adopted by the farmer from the production centre to the point of planting until the products reach the consuming public. There must be a mutual understanding between the grower and those who will handle the products after harvest (Bencini, 1991).

2.9 CURING OF YAMS

Yam tubers need to be properly cured as soon as possible after harvest to promote the formation of hard cork layer. Curing should be carried out near the place where the tubers will be stored to minimize handling after curing. The process is carried out for 4 to 7 days at a temperature of 32 to 40^0C and a relative humidity of 85% to 95%. Farmers can achieve these conditions in two ways (FAO, 1998).

Above ground, yams are carefully piled on the ground and covered by a layer of grass at least 15cm thick and finally a canvas tarpaulin or jute bags are used to cover the whole pile. Plastic sheets should not be used and curing pile should not be exposed to direct sunlight. The cover should be removed after 4 days (FAO, 1998).

Pit-curing: The yam tubers are placed on this lining and then covered with a thin layer of soil. The treatment takes about two weeks after which the tubers can be removed. Storage yam tubers which have been treated for two weeks by this method showed only 40% rotted tubers after 4 months of storage compared to 100% of untreated tubers (Hutton, 1998).

2.10 PROBLEM OF PESTS AND DISEASES

The production of yam in the Krachi-East District is mostly affected by pests and diseases. These had led to diseases in yam production, making the cultivation of yam unattractive. Nevertheless, yams in the area are affected by tuber rot. This is mostly caused by fungi. The tuber may be infested either in the field or during storage. The soft rot are caused by *Fusarium spp* and *Botryodiploda spp*, (MOFA, 2011).

Tuber rots affect white yam tubers especially in storage. This can be avoided by avoiding injuries to the tubers. Another disease which often affects yam production in the area is Anthracnose. It is a serious disease which results in blackening and dieback of the leaves. The disease is more severe on white yam than in other edible yam. The yam nematode, *Scutellonema bradys* and the root-knot nematode *Meloidogyne spp* also attack the yam. These nematodes cause damage to the growing region just beneath the tuber skin so that the affected tubers are very poor if used as planting material. The root-knot nematode gives the skin of the crop a warty appearance. The main insect pest of yam which are of economic importance in Ghana are the termites, yam beetles yam, scales and vine beetles. Termites reduce the percentage of setts that sprout by eating out the 'eye' of the planted setts. Furthermore, they damage the growing tubers by making unsightly tunnels in them (Ogundaria, 1998).

In the Guinea savanna zones, the greatest damage of yam tubers is caused by two species of Dynastid bettles. *Heterologus claudius* and *Heteroligus meles* are widespread in tropical Africa. It attacks the tubers. Adult beetles eat the planting setts and plants may wilt and die. The holes in tubers reduce market value. The beetles lay eggs in the soil close to river banks and this hatch to produce creamy white to grey larvae which feed on grass roots and other organic matter. From egg to adult takes 22-24 weeks and emergence coincides with the beginning of the rains and the planting of yams. Further, attack occurs just before harvest when the beetles again feed voraciously and then migrate to the breeding sites. These beetles can be controlled by planting as late as possible in the season. The scale insect, *Aspidiella harii*, occur in yams both the field and at storage especially during the dry season. The citrus mealy bug, *Planococcus citri*, has been observed as pest of yam tubers in the field and in storage. The heavily infested yams are usually smaller rounded and stunted and do not sprout when sown. The vine, *Crioceris livida*, causes defoliation of the crop (Ogundaria, 1998).

2.11 PROBLEM OF TRANSPORTATION AND CLIMATE

The major problems facing yam farmers in Ghana are poor road network leading to the producing area, inadequate transport facilities and unfavorable weather conditions. This sometimes leads to loss of crops as most of the produce is left in the farm. Sometimes the roads leading to the farms are impassable due to poor road network. However, in areas where there is no transport, farmers are over charged and some of them who cannot afford the fare leave their yams in the farm. The unstable climates in Ghana have affected the cultivation of yam and high temperatures usually result in tubers rot, transportation is a big and often the most important factor in the marketing of fresh produce. Usually transport would take produce from the grower directly to the consumer as in many developing countries. In a more complex marketing system, the cost of transport contributes significantly to the price paid by the consumer and sometime exceeds the valve of the new product. Losses directly attributed to transport conditions can be high Kumah and Olympio (2009). Maalekuu, (2008) also indicated that the estimates of postharvest losses of food grown in the developing countries from mishandling, spoilage and pest infestation are put at 25%. This means that one-quarter of what is produced never reaches the consumer to whom it was grown and the efforts and money required to produce it are lost for ever.

2.12 MARKETING OF YAM

A series of recommendations are helping exporters and market agents in Ghana to realize the full income generation and market potential of yams. Previously, biological and economic losses took a high toll on crops destined for local and overseas markets. Now, thanks to improved yam quality and new training and promotional material, exports to Europe and the US are growing. The strengthening of links between yam producers and exporters has improved the quality and quantity of yams provided, eliminating the need for intermediaries and ensuring that advance orders and better market information are available to growers (Godfred, 2005).

Ghana is a leading yam exporter, having exported 20,841 metric tons of yams in 2008. But with the increase in global demand for yams coming from Europe, the U.S and neighboring African countries, there is potential for high production and export volumes. Inadequate access and high cost of seed yams have prevented producers from expanding the area under yam production, despite the availability of fertile land and demand for yam domestically and abroad (MiDA, 2010).

2.12.1 Problems of Yam Marketers in Ghana

Dioscorea spp especially white yam (*Dioscorea rotundata*) is a highly valued commodity in Ghana, but the full potential for income generation both through domestic markets and the export market has not been realized due to problems of inefficiencies in the production, handling and trading systems. In the case of export, this is clearly illustrated by problems of bad or inconsistent quality of yams on arrival at countries of importation such as U.K. To improve the link between yam growers and traders in order to improve the quality and increase the quantity of yams provided by growers, the purchase of tubers for export directly from growers rather than through several middle men as at present would improve quality. This will also depend on a more secure advanced orders and increase market information to growers, and the development of higher value domestic market to expand the demand for quality produce (RIU, 2003).

The problems associated with the trading, transportation and marketing of yams had been largely overlooked. In a survey conducted at Techiman of the largest yam market in Ghana, the marketing system and the trading practices of the principal agent operating within the system are described. Traders cite transportation costs, seasonality of production, poor market infrastructure, lack of credit, mechanical damage, and rotten of tubers as their main constraints during the trading and marketing of yam. Observation suggests that during the early seasons, the lost of yam quality is associated with certain pre-harvest tissue damage associated with the stacking of tubers and various rots. Such deterioration may lead to price discount of 25 – 63% and absolute biological losses of 10% (RIU, 2003).

2.13 LOSSES OF YAM IN STORAGE

Postharvest and storage of yam is an essential aspect of economic development in Nigeria. Accurate figures on yam production in Nigeria are hard to come by, but it was estimated at 200 million Niara or 2 million Dollars. These losses are attributed to rot caused by bacteria, fungae and nematodes. Most of the pathogens of yam tubers are soil-born but the manifestations of the tuber disease are observed during storage (Ogali *et al.*1991).

It is frequently believed that yams are stored well, but the little documentary evident available on the magnitude of storage losses suggest that, substantial losses have occurred. In a review of yam losses, it is illustrated that, these losses vary considerably in magnitude from country to country, region to region, species to species and even variety to variety. The losses that occurred during storage even under the best conditions are much more serious than is generally realized. Although, there is a great variation among varieties, losses in weight of 10 – 20% after only three months storage and 30 – 60% after six months are not unusual even for sound tubers, and even greater losses occur if infection by rotten organisms takes place (Ogali *et al*. 1991).

2.13.1 Losses of Yam Due to Rot

Losses in storage of yam due to rot are considered heavy in Nigeria. The evaluation in rot in different parts of Nigeria show that the extent of rotting range from 0.5 – 18% at harvesting while storage rot range from 3 – 25%. Microbial rotting of yam tubers account for a substantial proportion of the annual losses in yam production in Nigeria. Postharvest rot is due to infections of micro-organisms in the soil. Okigbo and Ikediegwu associated the different forms of tuber rotting they observed in the storage barn to microbial attack that probably took place in the fields. Stored yams may suffer from fungal diseases causing rot which spread quickly (Okigbo and Ikediegwu, 2001).

It is significant to note that rotting in storage properly stated in the soil and progressed in storage. This may happen when infected tubers do not show perceptible external symptoms. Each type of rot is a characteristic of its causal organism. The incidence of rotting varies with the species and the varieties within each species of yam. They also noted that it will probably vary with the site of planting since the distribution of the causal organisms may vary from place to place. It has been observed that in the case of white yam, rotting appeared first at the tail end of the yam and then proceeded towards the head regions. Rot vary due to variation in the distribution of the micro-organism (Okigbo and Ikediegwu, 2001).

2.14 METHOD OF CONTROL OF LOSSES DUE TO POSTHARVEST DISEASES

2.14.1 Chemical Control

Various chemicals have been used in reducing postharvest spoilage. Those chemicals reported to reduce spoilage include sodium orthophenylphenate, borax, captan thiobendazole, and benomy. Losses due to rot can significantly reduce the storage period of ten weeks by lime washing the tubers (Okigbo and Ikediegwu, 2003).

2.14.2 Low Temperature

Low temperature storage also slows down the metabolism of pathogens and so frequently arrest rotting. However, the pathogens are really killed so that when the produce is returned to ambient temperatures, rotting may recommence rapidly. Some pathogens are low temperature tolerant, thus, the temperature required to kill the pathogen also caused chilling damage to yam. This is by lowering the rate of myriad of bio-chemical and physiological processes or reactions that ultimately lead to sprouting. Low temperatures are able to prolong the storage life of yam, and this calls for technically sophisticated facilities that require some education and skills to operate (Okigbo and Ikediegwu, 2003).

2.14.5 Curing

Curing is the process which involves the exposure of the freshly harvested tubers to temperatures of 29 – 40^0 C and relative humidity of 90 – 95% for 5 – 7 days. Basically, subjecting the tubers to a short period of high temperature encourages natural thickening of the tuber skin tissue and the healing of any surface wounds, thereby reducing the rate of water loss and preventing wound infection. The aim of curing is to promote the process of wound healing at those sides of tubers where mechanical cuts and bruises have been inflicted during harvesting and subsequent transportation and handling. (Okigbo and Ikediegwu, 2003).

2.14.6 Natural Plant Extract

There are several local plant species whose extracts or biocides have proved efficacious in protecting yam produce before and after harvest. The most popular one among them is the neem. Formulation of *Azadiracta indica (neem)* includes water dispensable powder, dust preparation, emulsifiable concentrate, neem seed after extract and neem cake water extract. The advantages of these natural plant products include its local availability, little or no toxicity to human and simple preparation procedures (Okigbo and Ikediegwu, 2003).

2.14.5 Biological Control

The use of micro-organisms to control crop pests and disease is an exciting and rapidly advancing branch of applied biology. Biological control of a plant disease involves any condition under which pathogens are reduced through the agency of any living organism with the result that there is reduction in the evidence of the disease caused by the pathogens. Biological control can be brought about either by introduction or by augmentation in the number of one or more species of controlling organisms or by a change in environmental conditions, designed to favour the multiplication and activity of such organisms or by combination of both procedures. Postharvest rot diseases of food and vegetables have been effectively controlled by artificially applying the antagonist to yams. The *microforal* on the surface of harvested commodities can be manipulated to enhance their resistance. It has been observed that epiphytic micro-organisms and ectomycorrhizae function act as part of the plant defense. Epiphytic micro-organism on the surface of fruit and vegetables could be managed to enhance resistance to postharvest diseases. The rot of yam tubers in storage barn has also been controlled by the introduction of antagonistic micro-organisms on the surface of the yam. When yams in storage are sprayed with the biological control agents, *Trichoderma viride,* it helps to reduce the yam pathogens at storage, (Okigbo and Ikediegwu, 2003).

3.0 MATERIALS AND METHODS

The research was carried out in two stages. In the first stage, a survey was conducted to assess postharvest losses of yam production in the Krachi-East District of the Volta Region using a well-structured questionnaire. The second stage was an in-depth study on losses of yam by counting the losses at the farm gate and the market level where three yam farmers and three marketers of yam were selected from the operational area.

3.1 THE AREA OF STUDY

The Krachi-East District is located on the north-western part of the Volta Region of Ghana and lies between latitude 7°40N and 8°15N and longitude 0°6N and 20° E. it is bounded on the north-west by Krachi-West District, on the west and south-west is the River Volta, Biakoye District to the south-east, Kadjebi District to the east and Nkwanta District to the north. The district has a total surface area of 2528 square km it has a low temperature of 24°C, a high temperature of 32°C and relative humidity of 70 – 80%. The farming communities that were selected for the study included: Dambai, Kparekpare, Tokorano, Abrawoanko and Katanga. This is because these areas are the most yam producing area in the district.

3.2 ADMINISTRATION OF QUESTIONNAIRE

Open and close-ended questionnaire were designed for the farmers and buyers from the five communities. In all there were 55 questionnaires for the farmers and 22 set of questionnaire for the buyers. This was to seek the views of both farmers and buyers on postharvest losses on the field and also the problems that buyers faced on transit.

3.3 DATA COLLECTION PROCEDURE

To ensure accurate and efficient data, questionnaires were given to farmers in towns and villages to answer. Farmers and buyers who were literate were given the questionnaires to answer. They were to respond by ticking the right responses in the case of the close-ended items and to state their views in the open-ended items. Respondents who could not read and write questionnaire, items were read and explained to them for them to make their choices in the close-ended item and to state their views in the case of the open ended questions.

3.4 THE TARGET POPULATION

The target population was all yam farmers and all marketers of yam in the Krachi-East District of the Volta Region.

3.5 SAMPLE AND SAMPLING PROCEDURE

The area of study was made up of 82 operational areas. Using purposive sampling method, five operational areas were selected; that is Dambai, Kparekpare, Tokurano, Abrawonko and Katanga because these towns were the most yam producing area in the district. 40 yam farmers were randomly selected from each of the five operational areas given a total of 200 yam farmers. 20 marketers were also randomly selected from each of the five operational areas giving a total of

100 marketers. In all, 300 hundred respondents were interviewed using questionnaires.

3.6 ANALYSIS OF DATA

The data collected was analyzed using the SPSS version 10.0 and the result was interpreted and presented using descriptive statistics in the form of frequency tables, pie charts and bar charts. A regression analysis version 9.0 was used at both the farmer and the marketer level to find the level of loss of yam.

3.7 IN-DEPTH STUDY

3.7.1 Parameters Studied at the Farm Gate

The following parameters were used to assess losses at the farm gate

3.7.1.1 The type of storage facility used to store yam after harvest

Most of the farmers at the farm gate used the barn system of storing yam. A typical example of the traditional barn system can be seen in plate 1 and plate 2.

Plate 1: An enclosed yam barn

Plate 2: An open Yam barn

3.7.1.2 The temperature range in the storage facility

Temperature range in the storage facility was recorded in the morning (25.3^0C), afternoon (39.4^0C) and in the evening, (33.2^0C) respectively.

3.7.1.3: The cause of loss of tubers in the storage facility

The tubers that were infected in the storage facility were identified when the buyer sorted out the infested tubers during the buying process. The buyer took time to count the infested tubers that were in the barn.

3.7.1.4: The percentage loss of tubers in the storage facility

The percentage loss of tubers in the storage facility was expressed as;

$$\text{Percentage loss (\%)} = \frac{T}{E} \times 100$$

Thus where; T = number of tubers at the time of sale

E= estimated number of tubers stored in the barn

%= Percentage loss of tubers

3.7.2: Losses of Yam at the Farmer Level

Three yam farmer field where yams were stored were randomly selected for the in-depth study of postharvest losses at the farm gate. Similarly, three marketers who buy yams at the farm gate were also randomly selected for the in-depth study. Farmers were selected from Abrewanko, Katanga and Dambai. This is because these towns are the most yam producing area in the district. One farmer each was selected from the farm and one marketer each was also selected for the in-depth study (A follow-up study).

The three farmers were farmer A, B and C and the three marketers were identified as marketer D, E and F. Farmer A and marketer D were monitored from the farm gate where tubers were bought. Marketer D` sorted out tubers which were diseased, rotten from the lot before the tubers were bought. Rotten tubers were counted the sorted tubers from the lot and the percentages lost at storage were computed. The assessment of losses at market A during the buying point at the farm gate can be seen in plate 3 and 4. The percentage of loss at the farm gate was computed as:

$$\text{Percentage loss (\%)} = \frac{T}{E} \times 100$$

Thus where; T = number of tubers at the time of sale

E= estimated number of tubers stored in the barn

%= Percentage loss of tubers

Plate 3: A buyer and a farmer at the farm gate

Plate 4: Sorted infested tubers at the farm gate

Farmer B and marketer E were monitored in the farm where yams were stored in the barn during the buying process. Marketer E sorted out the rotten tubers out of the lot before the rest of the tubers were bought. The rejected tubers were counted and the estimated percentage of the loss over the total tubers of yam stored in the barn was computed as:

$$\text{Percentage loss (\%)} = \frac{T}{E} \times 100$$

Thus where; T = number of tubers at the time of sale

E= estimated number of tubers stored in the barn

%= Percentage loss of tubers

Plate 5: A buyer in the stored yam barn

Plat e 6: A buyer counting infested tubers at the farm gate

Similarly, farmer C and marketer F was monitored from the farm gate. Marketer C sorted out the diseased tubers and they were counted. The diseased tubers were sent to the pathologists for studies. The percentage loss of tuber was computed as;

$$\text{Percentage loss (\%)} = \frac{T}{E} \times 100$$

Thus where; T = number of tubers at the time of sale

E= estimated number of tubers stored in the barn

%= Percentage loss of tubers

Plate 7: A heap of tubers at the farm gate   Plate 8: A buyer counting a diseased infested tubers

3.7.3: Losses of Yam at the Market Level

3.7.3.1: Parameters used at the market level

The following parameters were used to assess postharvest losses of yam at the market level

3.7.3.2 The type of vehicles marketeers used to transport yam to the market

At the farm gate most of the farmers used the KIA truck to convey their yams from the farms to the market centers. This can be seen in plate 9 below.

Plate 9: Vehicle loaded with yam from the farm to the marketing centre.

3.7.3.3 The nature of roads leading to market centers

Most of the farms visited had poor road leading to the marketing centers.

3.7.3.4. The off-loading habit of the loading boys in the market

Vehicles loaded with yam were monitored from the farms to the market centre. In the market, it was realized that most of the loading boys carelessly handled the yams during off-loading.

Plate10: Yam being off-loaded

Plate 11: Broken tubers after off-loading

3.7.3.5 Places where yams are stored in the market

Most of the yams that were sold in the market were in the open sun. A sample of this can seen in plate 12

Plate12: Tubers of yam exposed to the open sun in the market

3.7.4: Postharvest Losses of Yam at the Market Level

A Postharvets loss of yam at the wholesale level in market was estimated by tracking yam from the selected farms to the marketing centre. Three major centers where yams were marketed was in Dambai, Kpeve – all in the Volta Region and the Kokomba market in the Greater Accra Region

At each buying center, the total number of tubers of yam was sold to retailers and the number rejected was monitored and counted during off-loading. The percentage loss was determined by dividing the total number of tubers rejected by the retailers over the total number of tubers transported to the market center, multiplied by 100

Plate 13: Open Truck loaded with yam

Plate 14: Broken tubers

A postharvest loss at the retailer's level was also estimated when six retailers were randomly selected from the three major marketing centers. At each buying center, a total number of yam sold to consumers and then number rejected were monitored and counted as the consumers buy tubers in the market. The percentage loss at the retailer's level was determined by dividing the number by tubers bought multiplied by 100. The rejected tubers of the consumers during the buying process can be seen below


Plate 15: Retailer A sorted rejected tubers


Plate 16: Sample of rejected tubers

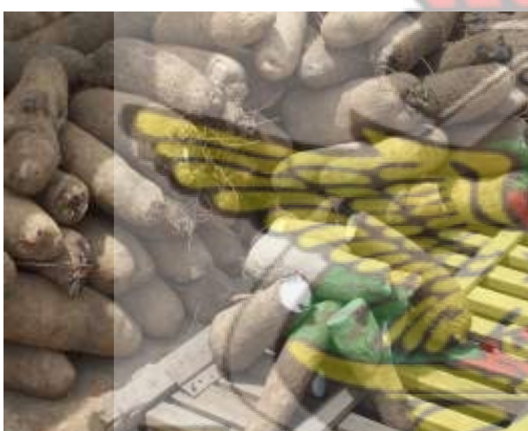
Plate 17: Retailer C rejected tubers by consumers


Plate 18: Retailer cutting off rotten yam


Plate 19:Retailers sorted out rot tubers


Plate 20: Sorted rotten tubers by consumers

4.0 RESULTS

4.1YAM FARMERS

4.1.1 Bio-Data of Yam Farmers

4.1.1.1 Sex distribution of farmers

Out of the 200 farmers interviewed, 90% were males while 10% represent females.

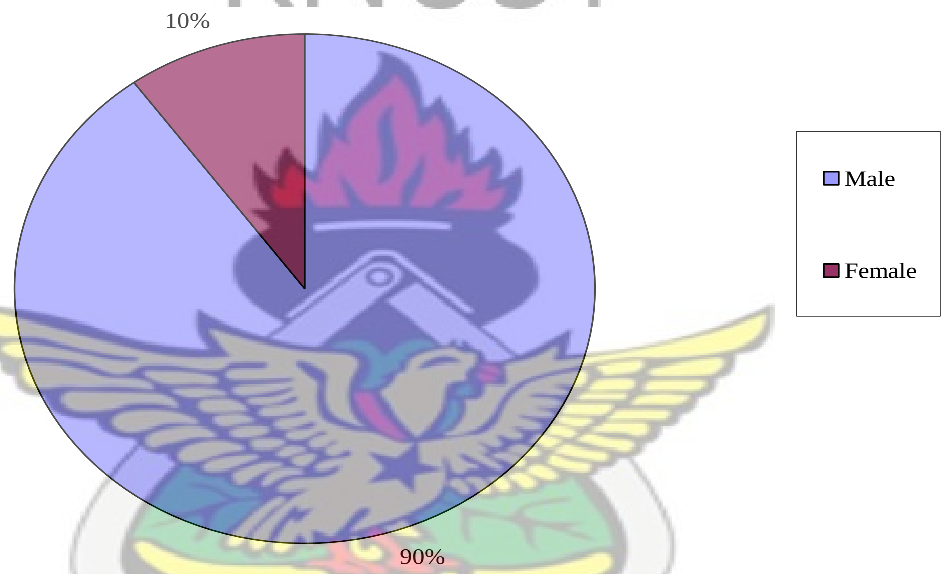

Figure 4.1: Sex distributions of farmers

4.1.1.2 Age distribution of yam farmers

On the ages of the farmers, 18.5%, 25%, 28.5% and 19% fell within 21 – 30, 31 – 40, 41 – 50 and 51 – 60 years respectively while 18% were more than 60 years.

Table 4.1: Age distribution of the farmers

Age	21–30	37	18.5
	31- 40	50	25.0
	41 –50	57	28.5
	51 –60	38	19.0
	>60	18	9.0
Total		200	100

4.1.1.3 Marital status of yam farmers

On the marital status of the farmers, 43% were single, 52% married but 5% were widowed.

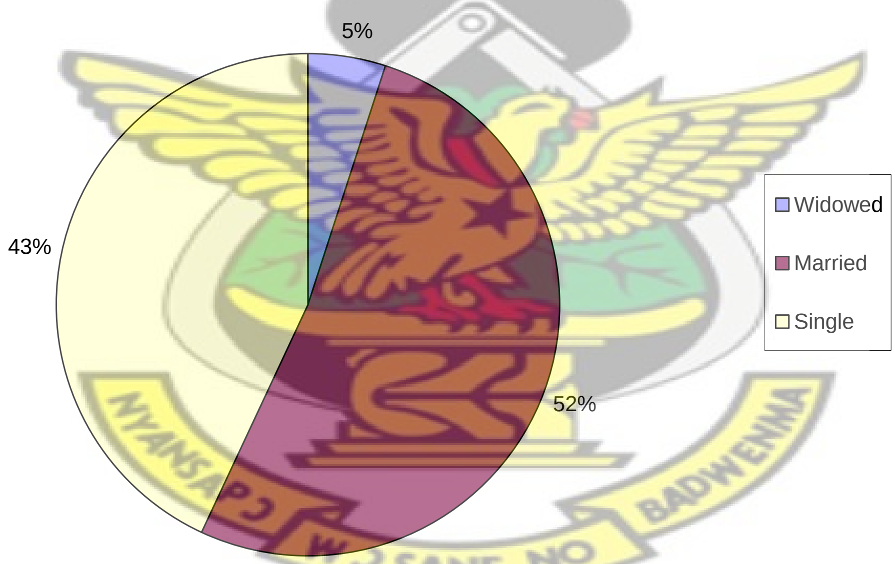

Figure 4.2: Marital status of yam farmers

4.1.1.4 Level of education of yam farmers

On farmers' levels of education as shown in Figure 4.3, 19%, 23%, 14%, 4% and 3% had primary education, Junior Secondary School (JSS), Senior Secondary School (SSS), Post-Secondary and Tertiary education respectively but 37% of them had non-formal education.

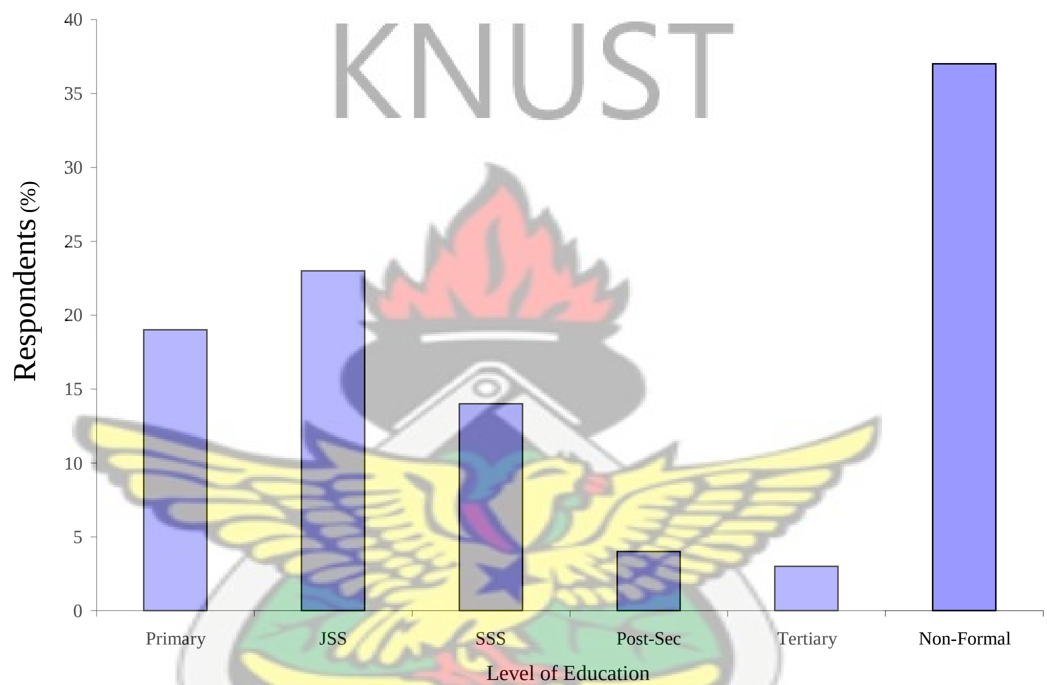

Figure 4.3: Level of education of farmers

4.1.2 Number of Dependants of Farmers

On the number of dependants as shown in Figure 4.4, 12% had no dependants, 24%, 33%, 15% had 1 – 3 years, 4 – 6 years, 7 – 9 years dependents respectively while 16% had above 9 dependants.

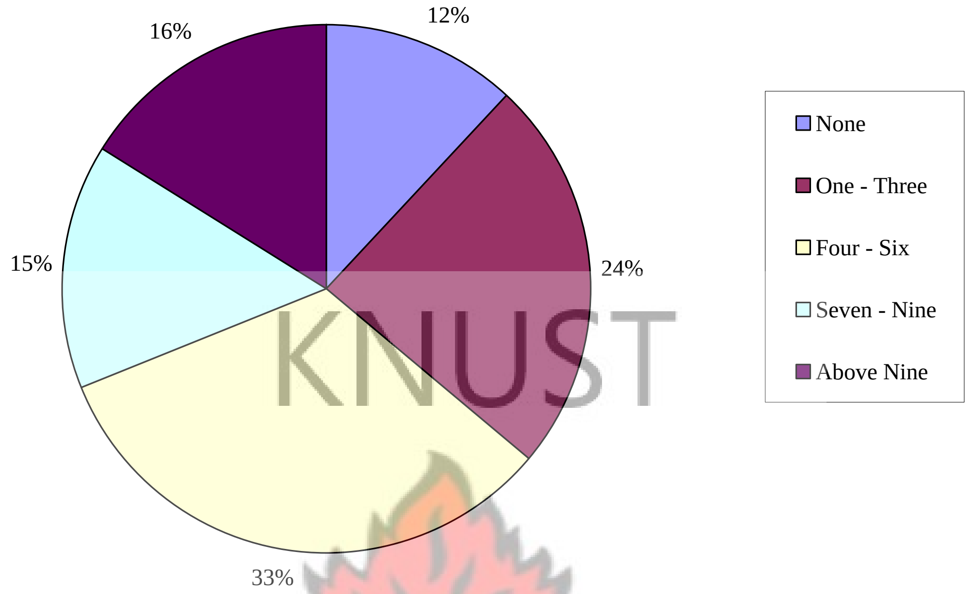

Figure 4.4: Number of dependants of farmers

4.1.3 The Main Occupation of Respondents

Out of the 200 yam farmers interviewed, 95% of them took farming as their major occupation, 1.5% did fishing, and 2% were civil servants while 1.5% did other jobs.

Table 4.2: Occupation of Farmers

		Frequency	Percentage
Occupation	Farming	190	95
	Fishing	3	1.5
	Civil Servant	4	2.0
	Others	3	1.5
Total		200	100

4.1.4 Pre-production Practices of Farmers

The table below showed the pre-production practice of the farmer and this included; the type of soil, planting materials, the period of clearing the land and the type of labour used on the land.

Table 4.3: Pre-production practices of farmers

		Frequency	Percentage
Soil type	Sandy	8	4.0
	Well-drained loamy	101	50.5
	Loamy	87	43.5
	Silt	4	2.0
Total		200	100
Planting Materials	Renowned yam farmers	40	20
	Friends	120	60
	Extension agents	10	5.0
	Markets	30	15
Total		200	100
Period of clearing land	Dry season	20	10.0
	Sept - October	77	38.5
	Middle of Year	54	27.0
	Rainy season	49	24.5
Total		200	100
Type of labour	Family	80	40
	Hired	90	45
	Permanent	18	9
	Casual	12	6
Total		200	100

On the type of soil used by the farmers in the cultivation of yam as shown in table 4.3, 4% of the farmers used sandy soil, 50.5% of them used well-drained sandy soil, and 43.5% used loamy soil while 2% used silt in their cultivation.

On where farmers get their planting materials before planting, it was found out that 20% had their yam setts from renowned yam farmers, 60% of them had it through friends, and 5% had it from the extension agents while 15% bought it from the market.

With regard to the time of clearing the land for planting, it was noted that 10% of them cleared their land in the dry season, 38.5% of them cleared their land between September to October, 27% of them cleared their land in the middle of the year while 24.5% cleared the land in the rainy season.

On the type of labour used to clear the land, it was found that 40% of them used family labour, 45% used hired labour and 9% used permanent labour while 6% used casual labour.

4.1.5 Farming Experiences of Yam Farmers

On the farming experiences of the farmer as shown in Figure 4.5, it was found out that 7% had less than 1 year experience of farming, 25.5%, 5.5%, 5%, 4.5% and 37% had 1 – 5 years, 4 – 10 years, 11 – 15 years, 16 – 20 years and 21 – 25 years farming experience respectively while 15.5% had more than 25 years farming experience.

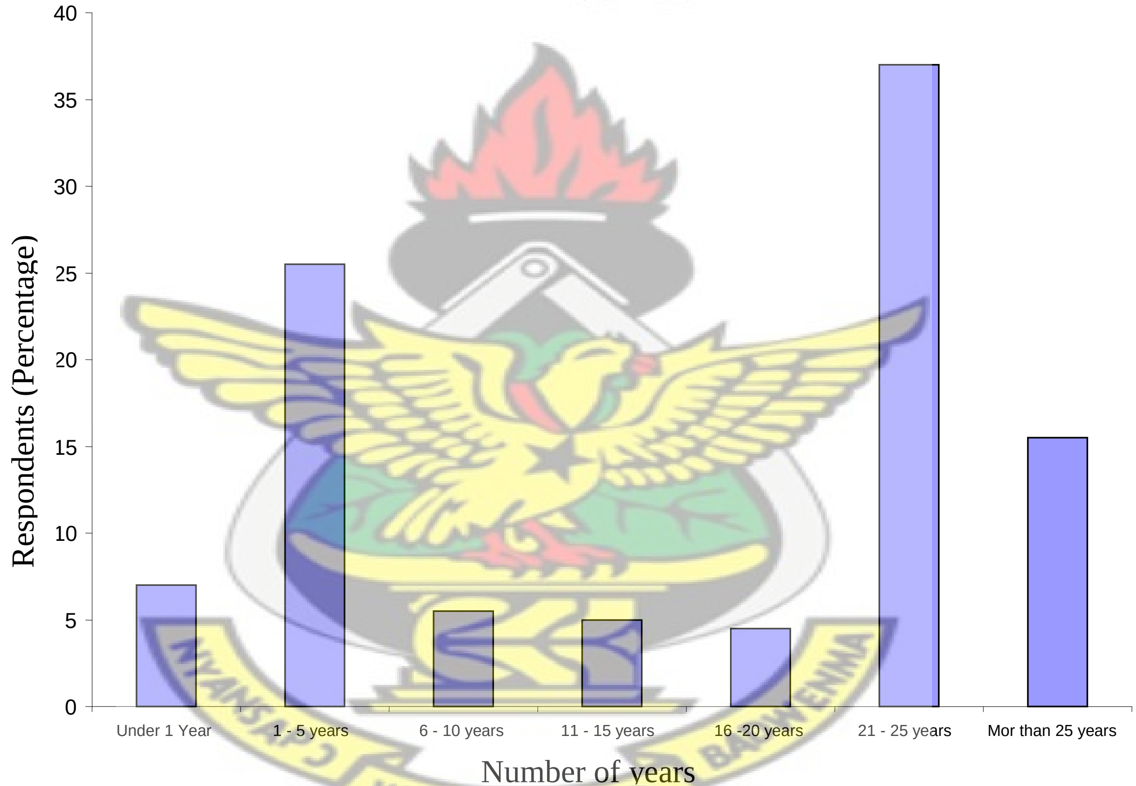

Figure 4.5: Farming experiences of farmers

4.1.6 Varieties of Yam Grown by Yam Farmers

Out of the 200 yam farmers interviewed as shown in Figure 4.6, 28% grew puna, 28% grew lalbako, and 29% and 15% grew water yam and white yam respectively.

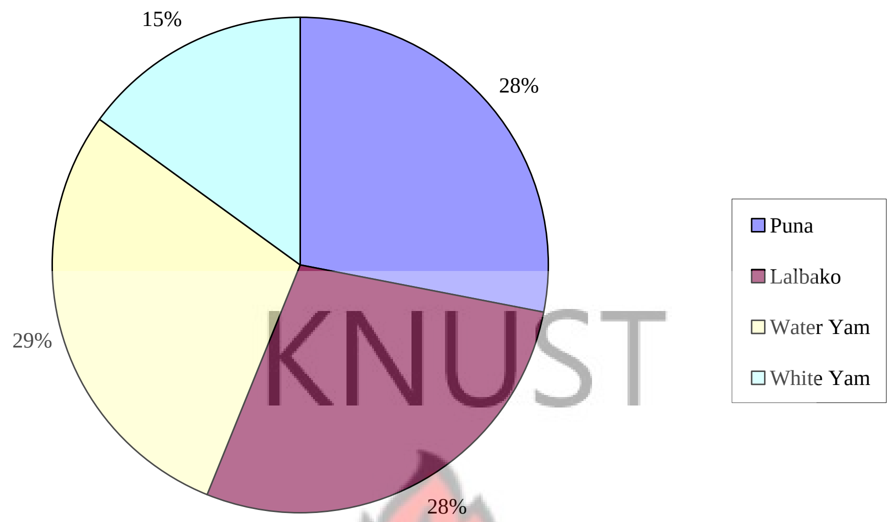

Figure 4.6: Variety of yam grown

4.1.7 Weed Control Methods Practised by Yam Farmers

The table below showed the weed control method practiced by the farmer and the number of time that farmers cleared their farms.

Table 4.4: Weed control methods practiced by yam farmers

		Frequency	Percentage
Weed Control	Manual	115	57.5
	Hand-picking	40	20.0
	Weedicides	25	12.5
	Chemicals	20	10.0
Total		200	100
Time of Weeding	Once	16	8.0
	Twice	27	13.5
	Four times	73	36.5
	More than 4 times	84	42.0
Total		200	100

On how to control weeds on the farm as shown in Table 4.4, 57.5% of the farmers controlled weeds through manual weeding, 20% practised hand-picking, 12.5% controlled weeds through the use of weedicides while 10% used chemicals to control weeds on their farms.

On the number of times in which weeds are cleared before harvesting, it was recorded that 8% of the farmers cleared their yams once before harvesting, 13.5% and 36.5% of the farmers cleared their farms twice and four times respectively before harvesting while 42% cleared their farms more than four times before harvesting their tubers.

4.1.8 Harvesting Operations of Yam Farmers

The table below showed the period in which farmers harvested their yams and the implements that they used in harvesting their yams.

Table 4.5: Harvesting operations of yam farmers

		Frequency	Percentage
Period of harvesting yam	6 – 7 months	127	63.5
	8 – 9 months	73	36.5
Total		200	100
Implements for harvesting yam	Cutlass	90	45
	Hoe	76	38
	Earth chisel	34	17
Total		200	100

From the above table, it was revealed that out of the 200 yam farmers interviewed as shown in Table 4.5, 63.5% harvested their yams between 5-7 months while 36.5% harvest their yams between 8-9 months.

On the implements that farmers used in harvesting their yams in table 4.4, it was recorded that 45% of the farmers used cutlass, 38% of them used hoe while 17% of them used earth chisel in harvesting their yams.

4.1.9 System of Farming Practised by Yam Farmers in the Krachi-East District

On the cropping system adopted by the farmers as shown in Figure 4.7 above, it was found out that 10% practised mono-cropping while 90% practised mixed cropping.

Figure: 4.7: System of farming practised by yam farmers in the Krachi-East District

4.1.10 Quantity of Tubers Harvested in a Season

The table below showed the number of tubers harvested in a season, number of tubers loss in a season and the proportion of yam bruised in a season.

Table 4.6: Quantity of tubers harvested

		Frequency	Percentage
Number of tubers harvest in a season	Less than 500	56	28.0
	600 - 1000	17	8.5
	1100 - 1500	20	10.0
	1600 - 2000	15	7.5
	2500 - 3000	69	34.5
	3500 - 4000	23	11.5
Total		200	100
Number of tubers loss in a season	Less than 5 %	34	17.0
	10%	47	23.5
	15%	32	16.0
	20%	73	36.5
	25%	4	2.0
	30%	3	1.5
	More than 30%	7	3.5
Total		200	100
Proportion of yam bruised after harvest	Less than 5 %	30	15.0
	10%	58	29.0
	15%	12	6.0
	20%	45	22.5
	25%	21	10.5
	More than 25%	34	17.0
	Total	200	100

Out of the 200 yam farmers interviewed, it was recorded that 28% of the farmers harvested less than 500 tubers in a season, 8.5%, 10%, 7.5%, 34.5% harvested 600-1000, 1100 -1500, 1600 – 2000 and 2500 – 3000 tubers of yam respectively while 11.5% harvest 3500-400 in a season.

It was also found out that 17% of the farmers loss less than 5% of their produce before sale, 23.5%, 16%, 26.5%, 2%, 1.5% lost 10%, 15%, 20%, 25% and 30% of their produce respectively while 3.5% of them loss more than 30% of their produce in a season.

On the proportion of yam that bruises during harvesting, it was recorded that 5% of the farmers had less than 15% of their yam bruised, 10% of them had 29% of their produce bruised, 15% of them had 6% of their yam bruised, 20% of the farmers had 22.5% of the yam bruised, 25% had 10.5% of their yam bruised, while more than 25% of them had 17% of their produce bruised during harvesting.

4.1.11 Quantity of Yam Loss in a Season

The table below showed the quantity of yam loss in a season and this included: the percentage of yam loss at harvest, storage and percentage of yam that sprout at storage.

Table 4.7: Quantity of yam loss in a season

		Frequency	Percentage
Percentage of Yam loss at harvest	Less than 5%	60	30.0
	10%	50	25.0
	15%	40	20.0
	20%	25	12.5
	25%	20	10.0
	More than 25%	5	2.5
Total		200	100
Percentage of yam loss at storage	Less than 5%	14	7.0
	10%	46	23
	15%	46	23
	20%	54	32
	25%	19	9.5
	More than 25%	11	5.5
Total		200	100
Percentage of yam sprout at storage	Less than 5%	10	5
	10%	10	5
	15%	35	17.5
	20%	15	7.5
	25%	12	6
	30%	47	23.5
	More than 30%	71	35.5
Total		200	100

On the percentage of tubers loss during harvesting in table 4.7, it was realized that out of the 200 farmers interviewed, 30% had less than 5% of their produce lost during harvest, 25%, 20%, 12.5% and 10% had 10%, 15%, 20%, 25% of their tubers loss respectively during harvest.

Similarly, on the percentage of tubers loss during storage, it was recorded that 7% recorded less than 5% loss during storage, 23%, 23%, 32% and 9.5% had 10%, 15%, 20% and 25% loss respectively during storage of their produce while 5.5% had more than 25% of their tubers loss during storage,

On the percentage of yam tubers that sprout during storage, it was recorded that 5% of the farmers had less than 5% of their yam tubers sprout, 5% of them had 10% of their produce sprout, 17.5% of them had 15% of their yam sprout, 7.5% of the farmers had 20% of the yam tubers sprout, 6% had 25% of their yam tubers sprout, 23.5% of the farmers had 30% of their yam tubers sprout while 35.5% of them had more 30% of their yam tubers sprout during storage.

4.1.12 Storage Facilities Used by Yam Farmers in the Krachi-East District

On the storage facilities used by farmers in the Krachi- East district in table 4.8 below, it was recorded that 64% of the farmers stored their yams in barns, 18.5% stored their yams in cribs while 17.5% of the farmers stored their yams underground.

On the period in which yams are stored after harvest, it was found out that 36.5% stored their yams up to 2 months before they sell them, 45% stored their yams between 3-4 months while 18.5% stored their tubers from 4 – 6 months before sending them to the market.

Table 4.8: Storage facilities used by yam farmers

		Frequency	Percentage
Storage Facility	Barns	128	64.0
	Cribs	37	18.5
	Underground	35	17.5
Total		200	100
Period of Storage	Up to 2 months	72	36.0
	3 – 4 months	91	45.5
	4 – 6 months	37	18.5
Total		200	100

4.1.14 Reasons for Growing Yam in the Krachi-East District

Out of the 200 farmers interviewed, it was revealed that 49% of the farmers grew their tubers for sale, 40% of them grew their yams for the home while 11% grew their tubers for seed.

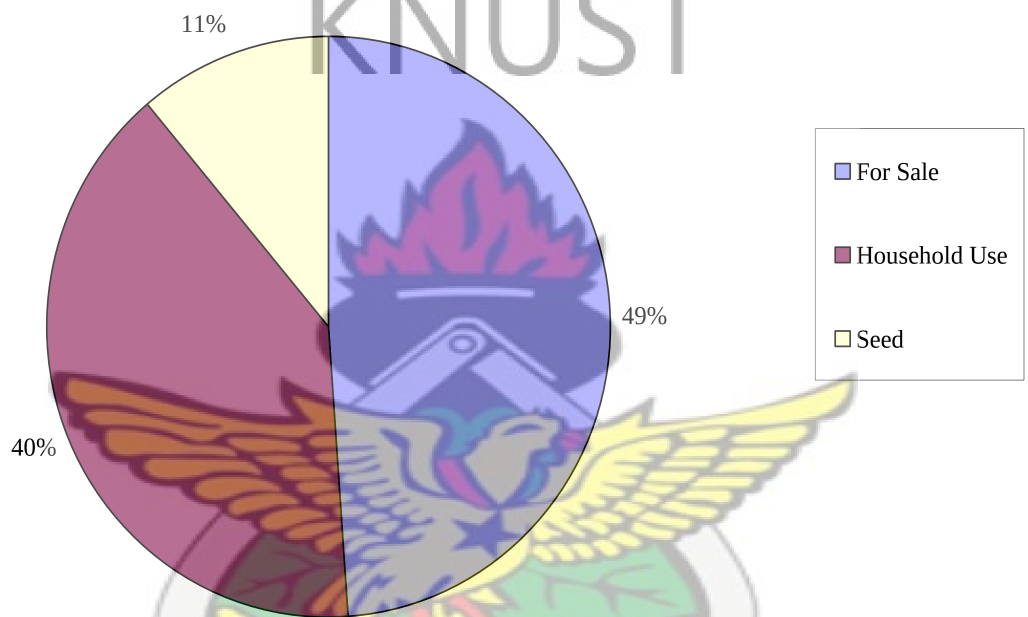

Figure 4.8: Reasons for growing yam

4.1.15 Quantity of Yam Tubers Sold by Farmers in the District

Table 4.9 below showed the quantity of yam tubers sold by farmers in the district and this included: the tubers sold in the district, tubers sold outside the district and tubers loss outside the district.

Table 4.9: Quantity of yam tubers sold by farmers in the district

	Range	Frequency	Percentage
Tubers sold in the District	Less than 500	76	38
	600 - 1000	20	10
	1100 – 1500	10	5
	1600 – 2000	94	47
Total		200	100
Tubers sold outside the District	1000 - 1500	14	7.0
	1600 – 2000	48	24.0
	2100 – 2500	23	11.5
	2600 – 3000	35	17.5
	More than 3000	77	38.5
	None of the above	3	1.5
Total		200	100
Tubers loss outside the District	Less than 5%	24	12.0
	10%	70	35.0
	15%	44	22.0
	20%	29	14.5
	25%	9	4.5
	30%	9	4.5
	35%	8	4.0
	40%	3	1.5
	None of the above	4	2.0
Total		200	100

In the local market within the district, it was recorded that 38% of the farmers sold less than 500 tubers, 10% of them sold 600 -1000 tubers of yam, 5% of the farmers sold 1100-1500 tubers while 47% of them sold 1600 – 2000 tubers of yam.

On the number of tubers of yam that were sold outside the district, it was recorded that 7% of the farmers sold 1000 – 1500 tubers outside the district, 24% sold 1600 – 2000 tubers, 11.5%, 17.5%, 38.5% sold between 2100 – 2500, 2600 – 3000 and more than 3000 tubers of yam respectively outside the district while 1.5% of them sold none of the above.

On tubers that were loss outside the district, it was recorded that 12% of the farmers loss less than 5% of their tubers, 35% of them loss 10% of their yams outside the district, 22%, 14.5%, 15% and 20% loss respectively outside the district while 5% of the farmers loss more than 30% of their yams.

4.1.15 Quantity of Yam Tubers Lost by Farmers in the Local Market

In order to determine the number of tubers that was loss within the local market in the district, it was recorded that 5.5% of the farmers loss less than 5% of their produce, 9% of them experienced 10% loss of yam tubers, 4.5%, 6%, 39%, 27.5%, 12.5%, 3% and 2% of the farmers experienced 10%, 15%, 20%, 25%, 30%, 35% and 40% loss in the local market.

Table 4.10: Quantity of yam lost by farmers in the local market

		Frequency	Percentage
Tubers lost in the local market	Less than 5%	11	5.5
	10%	9	4.5
	15%	12	6.0
	20%	78	39.0
	25%	55	27.5
	30%	25	12.5
	35%	6	3.0
	40%	4	2.0
Total		200	100

4.1.16 Vehicles for Transporting Yams to the Markets by Farmers

On the type of vehicles used by farmers in transporting their tubers to the market, it was realized that 25.5% of the farmers used closed/container trucks, 57% of them used open-closed trucks, 8.5% of them used salon cars and 9% of the farmers used mini vans to convey their yams to the market.

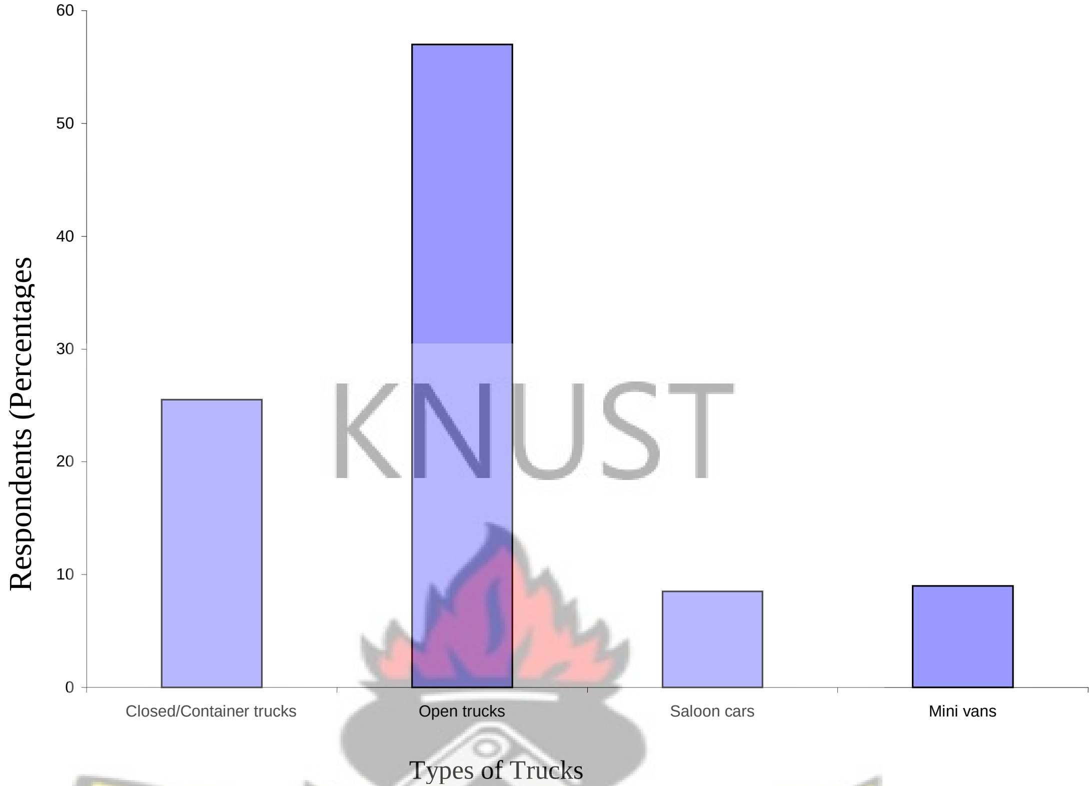

Figure 4.9: Vehicles for transporting yams to the markets by farmers

4.1.17 Challenges Faced by Yam Farmer in the Krachi-East District

Table 4.11 below showed the challenges faced by yam farmers in the Krachi-East District included: the type of pest that attack yam production, the major marketing problems and the storage problems of yam.

Table 4.11: Challenges faced by yam farmer in the Krachi-East District

	Causes	Frequency	Percentage
Pests	Yam beetles	66	33.0
	Aphids	18	9.0
	Crickets	11	5.5
	Termites	86	43.0
	Millipedes	9	4.5
	Centipedes	10	5.0
Total		200	100
Major marketing problem	Unstable market price	97	48.5
	Lack of transportation	77	38.5
	Exploitation by middle men	26	13.0
Total		200	100
Storage problems	Yam rot	172	86.0
	Change in taste	7	3.5
	Dehydration	11	5.5
	Sprouting	10	5.0
Total		200	100

On the challenges that yam farmers faced in their yam production, it was revealed that out of the 200 yam farmers interviewed, 33% of them had their yams infested with yam beetles, 9% of them had their tubers attacked by aphids, 5.5% of them had tubers eaten by crickets and 43% of them had their tubers attacked by termites while 9% and 5% of them had their yams attacked by millipedes and centipedes respectively.

On marketing problems faced by the farmers, it was clear that 48.5% of the farmers experienced unstable market prices, 38.5% of them complained of transportation problem while 13% of them also complained that sometimes they are being exploited by the middlemen in the market.

On storage problems, 86% of the farmers experienced yam rot, 3.5% complained of change of taste during storage, 5.5% of them complained that most of their yams dehydrated during storage while 5% also complained that their yams sprout during storage.

4.1.18 Regression Analyses of Factors that Contribute to Postharvest Losses at the Farm

The model summary from the regression analysis at the farmer level revealed that the model was 90.3% (Table 4.14) accurate in predicting changes or variations in the quantity of yam loss at the market ($R^2 = 0.903$). Factors that contributed to the quantity of yam tubers loss at the farm included pests attack, variety of yam cultivated, type of vehicles used in transportation and tools used in harvesting yams (Table 4.6). Other factors such as bruises on yam after harvest, which varieties of yam rot quickly after bruises, method of storage, storage duration, which variety of yam is prone to spoilage did not contribute to the quantity of yam tuber loss at the farm. However, the ANOVA table (Appendix 1.1) shows that the regression model is significant and can be used for future predictions ($P<0.05$).

Table 4.12: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.950[a]	.903	.901	.452

a. Predictors: Pests attack, Variety of yam cultivated, Type of vehicles used in transportation, Tools used in harvesting yam

4.1.19: An In-depth Study with Three Yam Farmers and Three marketers of Yam in the Krachi-East District to Assess the Level of Loss of Yam at the Farm Gate

The in-depth study showed that farmer A stored 450 tubers of yam and sold 300. There were losses of 150 tubers representing 33.3%. The study also showed that farmer B stored 2000 tubers and sold 1976 tubers. Twenty four (24) tubers of yam were lost representing 1.2%. Similarly, farmer C stored 400 tubers of yam and sold 354 tubers. 46 tubers were infested with bacteria soft rot, representing 11.5%. thus an average lost of 15.3%

Table 4.13: An in-depth study with three farmers and three marketers of yam at the farm gate to access losses of yam.

Farmers	Qty of Yam Stored at Farm	Qty of Yam Sold at Farm	Qty of Yam Lost at Farm	Percentage Lost	Causes of Lost at Farm
A	450	300	150	33.3%	Fungal infection
B	2000	1976	24	1.2%	Heat – tuber rot
C	400	354	46	11.5%	Bacteria soft rot
Average Loss				15.3%	

4.1.20: Temperature Reading of Yam at the Storage Facility (Yam Barn) at the Farm Gate

In order to determine the effect of temperature on yam at the storage facility, it was recorded that the morning, afternoon and evening temperatures were 25.3^0C, 39.4^0 C and 33.2^0C respectively.

Table 4.14: Temperature Reading of Yam at the Storage Facility at the Farm Gate

Farm gate	Morning	Afternoon	Evening	Average Temperature
Temperature	25.3^0C	39.4^0C	33.2^0C	32.6^0C

4.1.21: Pathological Analyses of Infested Tubers from the Storage facility

The pathological analyses of infested tubers in the storage facility showed that most of the organisms that affect tubers in the storage facility include the following: *Fusarium spp, Rhizopus oryzae* and *Botryodiplodia theobromae.*

Table 4.15: Pathological analyses of infested tubers from the storage facility

Isolates	Colony characters	Characters microscopy	Identified organisms
A	Aerial mycelium was sparse white grayish with tinge of bluish brown coloration	Many micro and macro conida present. Chlamydospores present, abundant and oval terminally positioned	*Fusarium solani*
B	Fast and rapid growth. Whitish with black spores and milky underneath	Coenocytic (non-sptate) has sporangial head, flat collumella and spore are single celled	*Rhizopus oryzea*
C	White to dirty white, black underneath	Mycilium are septate, Chlamydospores are inter calary and terminal conidia are celled	*Botryodiplodia theobromae*
D	Growth on PDA was rapid. White aerial mycelium tinged with pink purple colour	Micro and macro conidia are present. Macro conidia slightly sickled celled with epical cell and foot.	*Fusarium oxysoporium*

Plate 21: Rotten Yam infested by *Fusarium solani*

Plate 22: Rotten Yam infested by *Rhizopus oryzea*

Plate 23: Rotten Yam infested by *Botryodiplodia theobromae*

Plate 24: Rotten Yam infested by *Fusarium oxysoporium*

4.2 MARKETERS OF YAM IN THE KRACHI-EAST DISTRICT

4.2.1 Bio-data of the Marketers

4.2.1.1 Sex distribution of marketers

Out of the 100 marketers interviewed, 27% were males while 73% represents females.

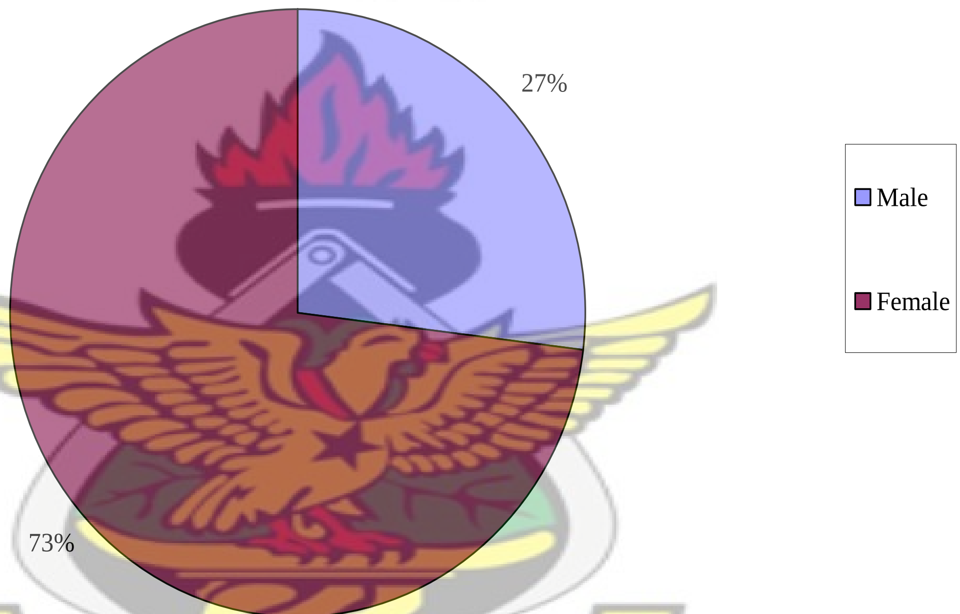

Figure 4.10: Sex distributions of marketers

4.2.1.2 Age distribution of marketers

On the ages of the marketers, two (2) people from each gender group had 1.0%, 22.0%, 12.0%, 10.0%, 29.0% and 23.0% fell within the age group of 18 – 21 years, 22 – 26 years, 27 – 31 years, 32 – 36 years, 37 – 40 years, 41 – 45 years and 46 – 50 years respectively while 2.0% were above 50 years.

Table 4.16: Age distribution of marketers

		Frequency	Percentage
Age of marketers	18 - 21	1	1
	22 – 26	1	1
	27 – 31	22	22
	32 – 36	12	12
	37 – 40	10	10
	41 – 45	29	29
	46 – 50	23	23
	Above 50	2	2
Total		100	100

4.2.1.3 Marital status of marketers

On the marital status of the marketers, the survey showed that 24% of them were singled, 73% married, 2% were divorced while 1.0% was widowed.

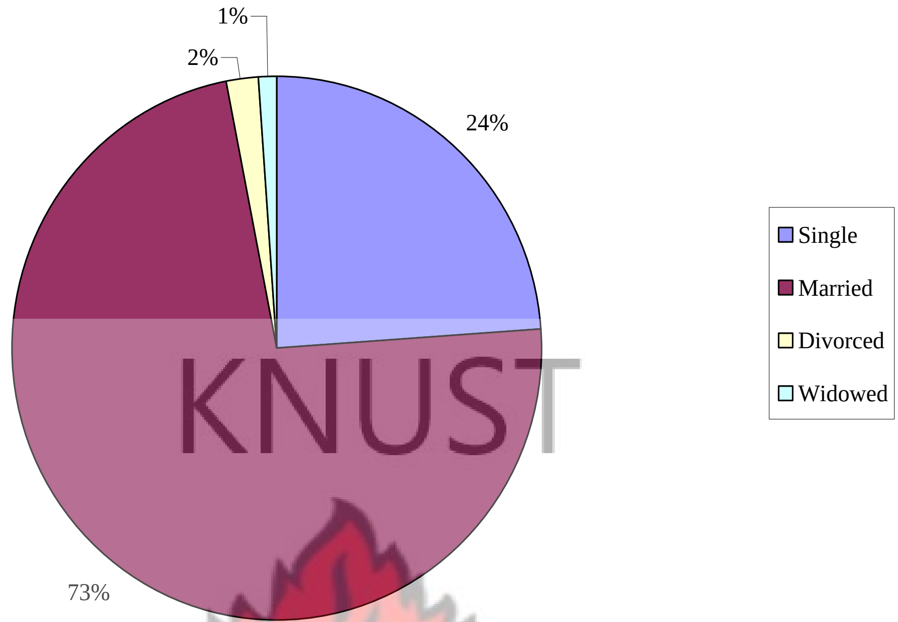

Figure 4.11: Marital status of marketers

4.2.1.4 Level of education of marketers

On the level of education of the marketers, it was reported that 19%, 31%, 15%, 9% and 6% had primary, Junior Secondary School (JSS), Senior Secondary School (SSS), Post-Secondary and tertiary education respectively but 20% of them had non-formal education.

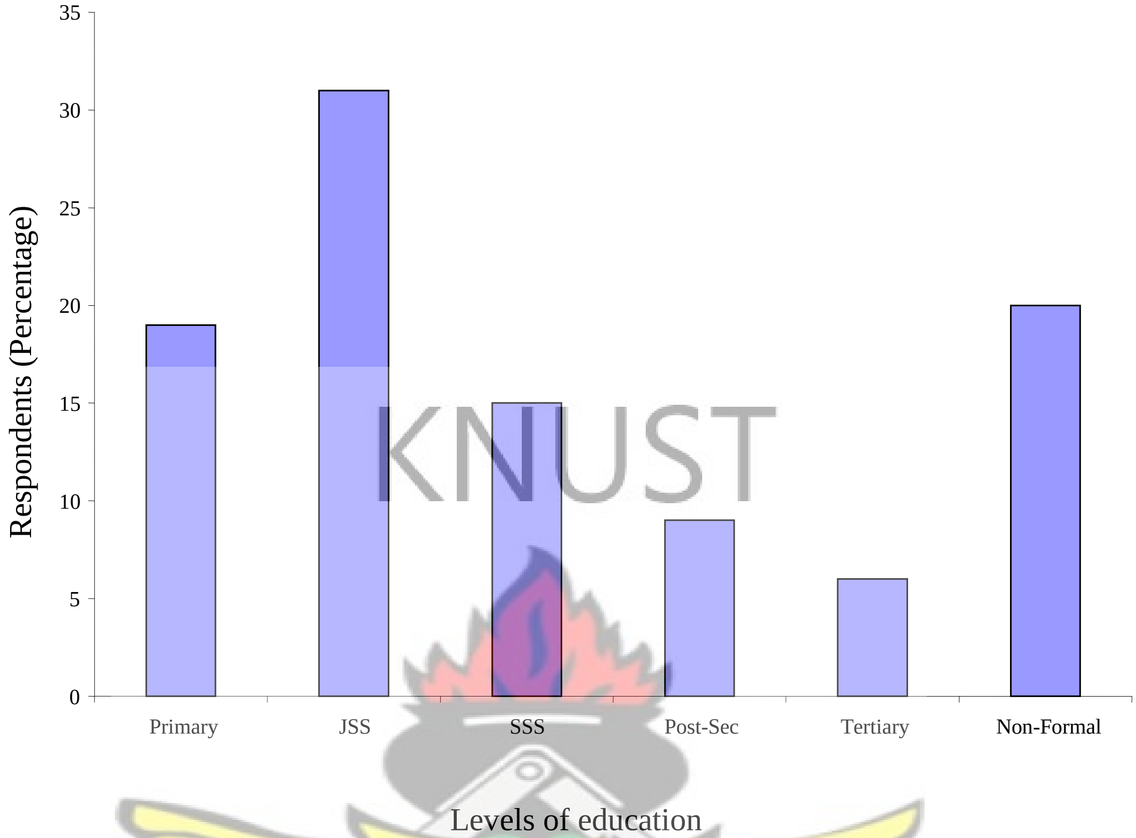

Figure 4.12: Levels of education of marketers

4.2.2 Number of Dependants of the Marketers

On the number of dependants as shown in Figure 4.13, it was recorded that 11 marketers had no dependants but 21%, 29%, 27% had 1 – 3, 4 – 6, and 7 – 9 dependants while 12% had 12 dependants respectively.

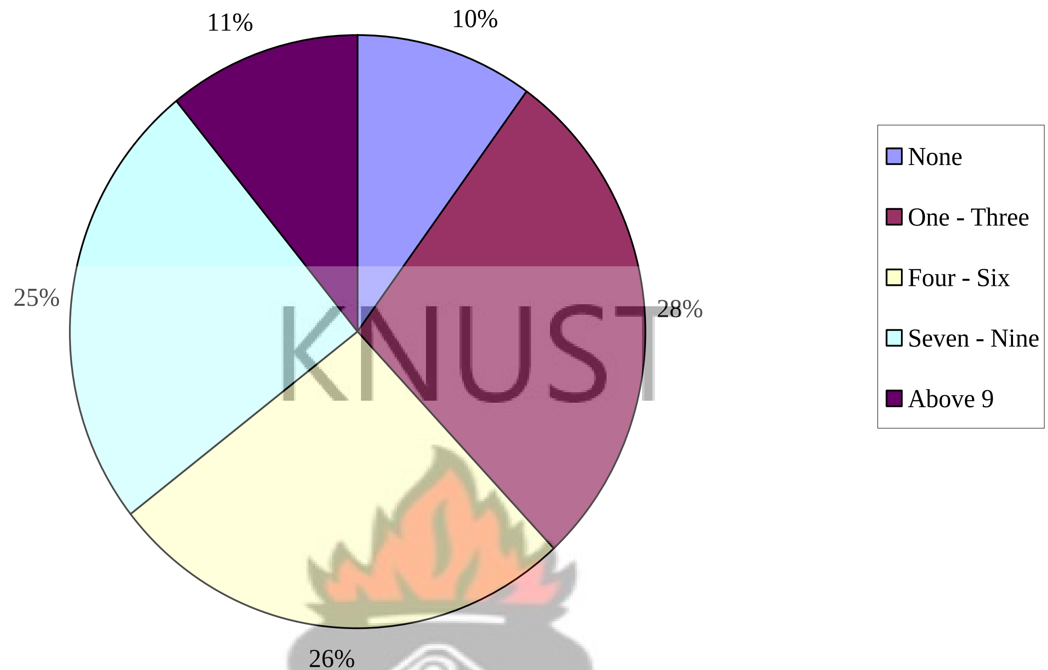

Figure 4.13: Number of dependants of the marketers

4.2.3 Marketing Practices of the Marketers in the Krachi-East District

The table below included the marketing practices of the marketers and these include the variety of yam sold at the market, proportion of yam loss during off-loading and the challenges the farmers faced during the selling of yams.

Table 4.17: Marketing practices of the marketers

		Frequency	Percentage
Variety of yam at market	Puna	49	49
	Lalbako	21	21
	Water yam	16	16
	White yam	14	14
Total		100	100
Quantity of yam lost at market	Less than 5%	52	52
	10%	13	13
	15%	8	8
	20%	11	11
	25%	8	8
	More than 25%	8	8
Total		100	100
Proportion of yam lost during off-loading	Less than 5%	53	53
	10%	24	24
	15%	8	8
	20%	9	9
	More than 20%	7	7
Total		100	100
Challenges during selling of yam	No storage facility	33	33
	Unstable market price	37	37
	Fatigue	18	18
	High transport fare	12	12
Total		100	100

From table 4.17 above on the marketing practices of the marketer, it was recorded that, out of the 100 marketers interviewed on the variety of yam bought from the market, 49%, 21%, 16%, and 14% bought puna, lalbako, water yam and white yam respectively.

On the quantity of yam that was lost in the market, less than 5% of the marketers had 52% of their tubers lost, 10%, 15%, 20% and 25% of the marketers had 13%, 8%,11% and 8% of their yam tuber lost while more than 25% of them had 8% loss of their tubers in the market.

On the proportion of yam that was lost in the market during off-loading; less than 5% of the marketers had 53% of their yam lost during off-loading, 10%, 15% and 20% of the marketers had 23%, 8% and 9% of their yams lost during off-loading while more than 20% of the marketers had 7% of their tubers lost during off-loading.

On the challenges that marketers face during the selling of yam in the market, it was recorded that 33% of them experienced storage problem, while 37%, 18% and 12% faced unstable market price, fatigue and high transport cost respectively.

4.2.4 Regression Analyses of Factors that Contribute to Postharvest Losses at the Market

The model summary from the regression analysis at the market level showed that the model was 95.6% (Table 4.15) (R^2=0.956) accurate in predicting changes or variations in the quantity of yam loss at the market. Factors that contributed to the quantity of yam loss at the market included the variety of yam sold and presence of cuts/bruises and rots (Table 4.14). Other factors such as packaging of yam to the market, transportation of yam to the market, postharvest handling of yam at the market, insect damage and microbial infection did not contribute to the quantity of yam loss at the market. However, the ANOVA table (Appendix 1.2) shows that the regression model is significant and can be used for future predictions ($P<0.05$).

Table 4.18: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.978[a]	.956	.955	.366

a. Predictors: (Constant), variety of yam sold, cuts / bruises, tuber rots

4.2.5: An In-Depth Study with Three Marketers of Yam to Assess the Level of Loss of Yam in the Market

The below showed the type of vehicles that marketers used to transport their yams to the market, percentage loss and the causes of loss yam in the market.

Table 4.19: An In-Depth Study with Three Marketers of Yam to Assess the Level of Loss of Yam in the Market

Marketers	Means of Transport	Qty of Yam off-loading at Market	Qty of Yam Lost at Market	Qty of Yam Sold at Market	% Lost	Causes of Lost of Yam at Market
A	KIA Truck	300	20	280	6.7%	• Careless handling during off-loading • Poor road network to the market • Theft cases at market
B	KIA Truck	1976	50	1926	2.5%	• Careless handling during off-loading • Poor road network to the market • Staging of tubers during loading and on transit
C	KIA Truck	354	25	329	7.1%	• Careless handling during off-loading • Poor road network to the market
Average Loss of Yam					5.4%	

The in-depth study showed that marketer A bought 300 tubers of yam and sold 280. There were 20 tubers lost, representing 6.7%. Similarly, marketer B brought 1976 tubers of yam into the market and sold 1926 tubers. Fifty (50) of them were lost, representing 2.5%. Marketer C brought 354 tubers of yam and sold 329 tubers. 25 tuber of yams were lost, representing 7.1%.

4.2.6: An In-depth Study with Six Retailers in the Market to Assess the Level of Loss of Yam

Table below showed the quantity of yam retailers brought to market, sold or lost at market, the percentage loss and the causes of the loss in the market

Table 4.20: An In-depth Study with Six Retailers in the Market to Assess the Level of Loss of Yam

Retailers	Qty of Yam Bought	Qty of Yam Loss at Market	Qty of Yam Sold at Market	Percentage Loss	Causes of Loss
A	300	22	278	7.3%	• Heat • Poor road network • Exposure of tubers to sun. • Lack of storage facilities
B	150	15	135	10%	• Heat • Poor road network • Exposure of tubers to sun. • Lack of storage facilities
C	250	20	230	8%	• Heat • Poor road network • Exposure of tubers to sun. • Lack of storage facilities
D	200	15	185	7.5%	• Heat • Poor road network • Exposure of tubers to sun. • Lack of storage facilities
E	300	11	289	3.7%	• Heat • Poor road network • Exposure of tubers to sun. • Lack of storage facilities
F	180	30	150	16.7%	• Heat • Poor road network • Exposure of tubers to sun. • Lack of storage facilities
Average Loss of Yam				8.9%	

The study showed that retailer A brought 300 tubers of yam into the market and lost 22 tubers, representing 7.3%. Similarly, retailer B brought 150 tubers and sold 135 of them. There was a loss of 15 tubers, which represent 10%. Retailer C brought 250 tubers of yam and sold 230 of them. There was a loss of 20 tubers, repressing 8%. Similarly, retailer D brought 200 tubers of yam and sold 185 of them, making a loss of 15, representing 7.5%. Retailer E brought 300 tubers of yam to the market and sold 289, there was a loss of 11 tubers, representing 3.7%. Retailer F also brought 180 tubers of yam and sold 150 of them, making a loss of 30 tubers representing 16.7%.

4.2.7: Temperature Reading of Yam at the Wholesale Level in the Market

To determine the temperature reading of yam at the wholesale level in the market, the following temperature readings were recorded in the morning, afternoon and evening as: 27.6^0C, 36.4^0C and 33.2^0C respectively.

Table 4.21: Temperature Reading of Yam at the Wholesale Level in the Market

Wholesale level	Morning	Afternoon	Evening	Av. Temp.
Temperature	27.6^0C	35.7^0C	32.2^0C	31.8^0C

4.2.8: Temperature Reading of Yam at the Retailers level in the Market

To determine the effect of temperature on yam tubers at the retailers' level in the market, the following temperature readings were recorded in the morning, afternoon and evening as 27.6^0C, 36.4^0C and 33.2^0C respectively.

Table 4.22: Temperature Reading of Yam at the Retailers Level in the Market

Wholesale level	Morning	Afternoon	Evening	Av. Temp.
Temperature	27.6^0C	36.4^0C	32.2^0C	32.1^0C

5.0 DISCUSSIONS

5.1 YAM FARMERS

5.1.1 Bio-data of Yam Farmers

The sex distribution of farmers in figure 4.1 showed that, out of the 200 yam farmers interviewed, 90% of them were males. The high percentage of males as compared to their female counterparts in the area of study could be attributed to the fact that males were the custodians of the land and had the opportunity to farm on large scale. Also, yam farming is generally energy-involving and is the men who can go into the production of such crops.

From table 4.1 on the age of the farmers, it was also realized that most of the farmers' age fell within the age group of 41 – 50 years, thus, as high as 28.5% as compared to the lowest percentage age group of 18% which fell within 60 years and above. The high percentage age group, thus, 41 – 50 years were the youth who were energetic enough to go into yam production in the district. Secondly, most of the youth in the area of study had no formal education and so had to go into the production of yam to make a living. This study is similar to FAO (1990) who reported that, a higher percentage of the active population of West African are engaged in farming.

The marital status of farmers as shown in figure 4.2 revealed that, out of the 200 yam farmers interviewed, as high as 52.5% of the farmers were married while 5% were widowed. The high percentage of marriage might be due to the fact that women helped their husbands on the farm to intercrop their farms. Secondly, women also help farmers in providing other services to laborers on their farms.

On the level of education of the farmers, in Figure 4.3 it was realized that as high as 37% of the farmers had non-formal education while 3% of them had tertiary education. The high percentage of illiteracy in the area of study might have contributed to the postharvest losses of farm produce in the area as most of the farmers may not like to adopt modern technology of preserving and storing yams due to their low illiteracy rate. Secondly, the high illiteracy rate in the area of study can contribute to poor method of farming and can consequently affect losses on farm produce.

The number of dependants of farmers as shown in figure 4.4 revealed that 72% of the dependents depended on the farmers and 28% of them are independent. The increase in the number of dependants could be attributed to the fact that these dependants serve as farm hands to the farmers on their farms. Secondly, most farmers in the area of study marry more than one wife to enable them to get more farm hands on their farms.

5.1.2 Pre-production Practices of the Farmer

From table 4.3 on pre-production practices of the farmer, it was revealed that out of the 200 yam farmers interviewed 95% of the farmers produced yam as their main occupation whilst others were involved in fishing and other services. The percentage increase in yam farming might be due to the fact that yam is the major crop grown in the area.

On the type of soil used in the cultivation of yam, it was revealed that farmers used well drained sandy loam soil, loamy soil and sandy soil in the cultivation of their yams. However, after the interview, it was found out that 50.5% of the farmers used well-drained sandy loam soil to cultivate their crops. The percentage increase in the use of well-drained sandy loam soil could be due to the fact that yams normally do well in these soils because of its rich nutrients. This study is similar to Tweneboah, (2000) who reported that most yams grown in Ghana do well in the well drained sandy loam soil.

Planting materials used by farmers on their farms as shown in table 4.3, revealed that most of the farmers get their sources of planting materials from renowned yam farmers, friends, extension agents and at the market but through the survey, it was reported that 60% of the farmers had their planting materials from friends as compared to 5% from extension agents. The percentage increase of planting materials from friends could be due to the fact that most of these farmers in the area do not have enough resources (e.g. money) to buy planting materials from the market as being done in other areas and therefore seek assistance from other renowned yam farmers (Tweneboah, 2000).

The period, in which farmers cleared their land before planting as shown in table 4.3, 38.5% of the yam farmers cleared their lands between September to October. The percentage increase within this period could be due to the fact that the farmer may have enough time to clear the land for the next season. Similarly during this period, the land is still moist enough to raise yam mounds for the next season.

On the farming experience that farmers had during their period of production, it was realized that out of the 200 yam farmers interviewed, 37% had as high as 21 – 25 years of farming experience as compared to 7% who had less than 1 year experience. The percentage increase in the farming experience may be due to the continuous adoption of yam production through the activities of the extension agents in the production area. Furthermore, this experience might also contribute to an increase in the production of yam in the area.

5.1.4 Planting Practices of the Farmer

From Table 4.5 on planting practices of the farmer, it was noted that on the varieties of yam setts that farmers plant during the planting season, it was revealed that out of the 200 yam farmers interviewed, most of them grew puna lalbako, water yam and white yam. But it was reported that there were percentage increase of 29%, 28.5% and 27.5% in water yam, lalbako and puna respectively during the time of planting. The increases in percentages of these varieties of yam could be due to the fact that puna and lalbako were the varieties of yam that was of good taste to consumers, had early maturity and consequently had good price in the market. Similarly, the increase in percentage of water yam in the area of study could be due to the fact that this variety is disease resistance and can be stored for a long time after harvest, have adaptability and availability of planting materials. This study is similar to Mignouna *et al*., (2003) who reported that, puna and lalbako have the sweet flavour and fragrant tuber and they are the most preferred cultivars by consumers in Ghana.

5.1.4 Weed Control Methods Practised by the Farmer

It was revealed in Table 4.5 that, out of the 200 yam farmers interviewed, 57.5% used the manual method to control weeds on their farms as compared to 10% who used the chemical method. The percentage rise in the use of manual method to control weeds in the farm could be due to the fact that most of the yam farmers do not have money to go into modern methods of controlling weeds on their farm. On the number of times that farmers weed their farms, it was revealed that about 42% of the farmers weeded their farms more than four times, the frequent weeding of the farms by the farmers might be attributed to the fact that weeds normally compete with other crops on the fields and if care is not taken, this could lead to loss of produce on the farm. Ofori and Nuttu (1991) also indicated that weeds reduced the yield of yam production and therefore regular weeding should be done with the use of hoe for a period of 3 – 4 times depending on the nature of weeds on the land.

On the system of farming, it was noted that out of the 200 yam farmers interviewed, 90% of them practiced mixed cropping while 10% practiced mono-cropping. The percentage increase in mixed cropping could be due to the fact that farmers grew other crops such as cassava, maize, tomatoes, okro or pepper in order to supplement their cost of production. This study is similar to Mignouna *et al*., 2003) who reported that, mixed farming provide the singular opportunity for the two crop to be harvested on the same piece of land during the same season and also serve as a security against total loss of yield due to pest or disease infestation of any one crop.

5.1.5 Harvesting Operations of the Farmer

On the period of harvesting yams, it was indicated that 63.5% of the farmers harvested their yam between 6 – 7 months as compared to 36% of them who harvest their yams between 8 – 9 months after planting. The increase in the percentage of the period of harvesting of yam might have resulted from the fact that most yam farmers cultivated puna and lalbako which take a shorter duration to mature. This study is similar to ICRA (1996) who reported that, there are two main harvesting methods. This includes the double and single harvesting. In the double harvesting, each plant is harvested twice. The first harvesting is about six months after sprouting and this involves the use of cutlass.

The implement that farmers used in harvesting their yam as shown in table 4.5, it was noted that most of the farmers use cutlasses; hoe and earth chisel to harvest their crops. However, it was reported in Table 4.5 that 45% of the farmers harvest their yams by the use of cutlasses and this is done mostly in the rainy season when the grounds are wet. ICRA (1996) also indicated that there are two main harvesting methods, thus double and single harvesting. The single harvesting is about 6 months after sprouting and this involves the use of cutlass in the period of harvesting where care is taken not to damage the root and the vines of the crops. However, the double harvesting is mainly practised when the leaves and vines are withered and this is normally done in the dry season by the use of earth chisel.

From table 4.6 on the number of tubers of yams that are lost before sale, it was noted that 20% of the farmers which represent 36.5% experienced lost of their tubers before they sold them. The percentage increase in this loss could be attributed to the fact that most of these tubers experienced cuts and bruises during harvesting (ICRA ,1996).

5.1.6 Storage Facilities used by the Yam Farmer

Percentage lost of the tubers during storage was indicated that, 20% of the farmers which represent 32% lost their yams during storage. The percentage increase in the lost of tubers during storage may be due to the fact that most of these yams experienced rot in the storage house as a result of cuts, abrasions and bruises and heat built up in these storage facilities.

Places where yams were stored, it was indicated that most of the farmers stored their yams in cribs, barns and undergrounds. In the survey, it was revealed that most of the yam farmers in the area of study stored their yams in barns and this represents 64%. The percentage increase in storage of yam in the barns could be due to the fact that the barn is the appropriate storage facility to store yams since the place is aerial and spacious for the circulation of air in the house. This will therefore reduce the rate of spoilage in the house. Degras (1993) and Bencini (1991) also indicated that yams are stored in the barns and should be covered with straw and enclosed within a fence for security. Inside the barn, the tubers may be tied individually to the vertical timbers or either arranged to allow maximum air circulation. They, therefore, stress that the maximum storage life of yams in the barn is six months. They indicated that losses are reported to be 10% to 15% during the first three months and up to 30% to 50% after six months

On the period in which yam tubers were stored after harvest, it was indicated that most of the farmers interviewed stored their yams between 1 – 2 months, 3 – 4 months and 4 - 5 months respectively. However, it was indicated that 45.5% of the farmers stored their tubers between 3 – 4 months before they sell them. The percentage increase could be attributed to the fact that most of the farmers want to keep their tubers for a long time in order to get good markets so that they can defray some of their cost of production (Bencini, 1991).

5.1.7 Temperature Reading of Yam in the Storage Facility at the Farm Gate

From table 4.14, it was indicated that there was a temperature reading of 25.3^{0}C, 39.4^{0}C and 33.2^{0}C respectively in the morning, afternoon and evening. The average temperature reading in the morning afternoon and evening was recorded as 32.6^{0}C and could affect the tubers as most of the yams stored in the barn cannot withstand this temperature for along time. FAO (1998) reported that tubers of yam could be stored at an optimal temperature of 13^{0}C.

5.1.8 Pathological Study of Samples of Yam from the Storage Facilities

The pathological study in Table 4.15 showed that the identified organism that affects postharvest losses of yam at the storage facility include *Fussarium solani, Fussarium oxysoporium, Rhizopus Orgzae, Botryodiplodia theobromae.* The study showed that the three organisms cause rot and diseases of yam during storage. This study was similar to what was reported by MOFA (2011) that most rot at storage were caused by *Fussarium solani, Fussarium oxysoporium Rhizopus. orgzae , Botryodiplodia theobromae.*

5.1.9 Marketing Practices of the Farmer

From table 4.11 on the marketing practices of the farmer, it was revealed that out of the 200 yam farmers interviewed 20% of them representing 39% lost their tubers in the local markets. The percentage increase in the tuber lost could be attributed to the fact that most of the tubers were exposed to the sunshine as yam farmers do not have appropriate place of storing their tubers. Also, the loss could be attributed to breakages and careless handling of the yams during off-loading by the loading boys. Maalekuu (2008) also indicated that most losses in agricultural goods lost directly in the market may be attributed to transport conditions. He estimated that postharvest losses of food grown in the developing countries were from mishandling, spoilage and pest infestations. And these were put at 25%.

Tubers lost outside the district as shown in table 4.11 revealed that, 10% of the farmer representing 35% experience tuber loss outside the district. The percentage loss outside the district may be due to the fact that most roads from the farms to the marketing centers are in poor conditions. Yam trucks are stuck on roads for a number of days before getting to the marketing centers. These often stem up heat leading to rot.

The type of vehicles that farmers used in transporting their tubers into the market showed that, most farmers use vehicles like: closed/container trucks, open trucks, saloon cars, and mini van and cargo trucks to convey their yams to the marketing centers. From the survey conducted, it was reported that out of the 200 yam farmers interviewed, 57% of them used open trucks as a means of conveying their tubers into the market. These could be due to the fact that these types of vehicles are covered during transit to avoid spoilage or rot of the tubers before they get to the marketing centres.

5.1.10 Challenges Faced by Yam Farmers

The challenges faced by yam farmers as shown in table 4.12 during yam production, it was noted that out of the 200 yam farmers interviewed, most of them experienced yam beetles, crickets', termites, millipedes and centipedes as some of the challenges that they faced in their farms. Out of these, 43% of the farmers experienced termite attack. The percentage increase in termite attack in the area of study could be due to the fact that most farmers in the area do not use the appropriate chemicals to treat these insects. This study is similar to Ogundaria (1998) who indicated that these insects damage the growing tubers by making unsightly tunnels in the tubers making them unattractive to customers and therefore reduce the price of tubers in the market.

On the major problem that yam farmers faced in the marketing of their produce, it was noted that unstable market price, lack of transportation and exploitation by middlemen were some of the problems that farmers experience in the market. Out of this, 48.5% of them experienced unstable market price. This study is similar to what is reported by (MOFA, 2011) that, the cultivation of yam is seasonal in nature in that, when the supply of yam is high in the market, prices of the produce falls. This often results to unstable market price making it difficult for yam producers to sell their produce in the market.

Storage of yam tubers as indicated in table 4.12 revealed that, yam rot, change of taste in the yam, dehydration and sprouting were some of the problems that were encountered during the period of storage. From the survey, it was revealed that 86% of the farmers interviewed experienced yam rots during storage. The percentage increase in the yam rot could be due to the fact that most farmers in the area use sharp objects and this sustains cuts and bruises on the tubers. This consequently leads to the rot of yam tubers during storage (MOFA, 2011).

The percentage increase of yam that sprouts, as noted in table 4.12 revealed that, more than 30% of the farmers interviewed representing 35.5% experienced sprouting of their yam during storage. The percentage increase in the sprouting of these tubers could be due to the fact that most of the farmers do not have any appropriate means of controlling the sprouting tubers.

5.1.11 Factor Contributing to Losses of Yam at the Farm

The model summary from the regression analysis at the farmer level revealed that the model was 90.3% (Table 4.14) accurate in predicting changes or variations in the quantity of yam loss at the market (R^2=0.903). Factors that contributed to the quantity of yam tubers loss at the farm included pests attack, variety of yam cultivated, type of vehicles used in transportation, tools used in harvesting yams (Table 4.6). Other factors such as bruises on yam after harvest, which varieties of yam rot quickly after bruises, method of storage, storage duration, which variety of yam is prone to spoilage did not contribute to the quantity of yam tubers loss at the farm.

5.1.12 An in-depth study with three yam farmers and three marketers at the farm gate to assess the level of loss of yam

From table 4.13 on the in-depth study with three farmers and three marketers of yam at the farm gate to assess the level of loss, it was found out that farmer A stored 450 tubers of yam and out of these 160 tubers were lost representing 35.6%. The percentage increase of the loss was attributed to fungal infection (*Fusarium solani*).This study was similar to a report by (MOFA, 2011), that most yam tubers at storage can be infested with fungal infection caused by *Fusarium spp.* Ogali *et al.*, (1991) also indicated that most of the pathogens of yam tubers are soil-borne but the manifestations of the tuber disease are observed during storage.

The study showed that farmer B stored 2000 tubers and 46 of them were lost, representing 2.3%. This study is similar to Ogundaria (1998) whose report stated that tuber rot affects white yam especially at storage. This study was also similar to Okigbo and Ikediegwu (2001) report which indicated that stored yams may suffer from fungal diseases, causing rot which spread quickly.

The results in table 4.13 showed that farmer C stored 400 tubers of yam in the barn and recorded 61 tubers lost representing 15.25%. The percentage increase of tuber loss was as a result of bacterial soft rot caused by *Fusarium spp*. This study is similar to Okigbo and Ikediegwu (2001) report stated that losses in storage are mostly diseases and rot on yam due to infections of micro organisms in the soil. The average loss of tubers in farmer A, B and C farm was recorded as 17.72%.

5.2 MARKETERS OF YAM

5.2.1 Bio-data of the Marketers

The sex distribution of the marketers as shown in figure 4.10 revealed that out of the 100 marketers interviewed, 73% of them were females and 27% were males. The increase in the percentage of females in the selling of yams in the market might be due to the fact that women in general are very good at selling of yams as compared to their male counterparts. This study was similar to what Godfred (2005) reported that women in general have the ability to give market information to consumers.

From Table 4.16 on age distribution of marketers, it was recorded that most of the marketers fell within the age group of 32- 50 years, representing 96%. The active age groups of 32 – 50 years were the energetic type who could go to the villages where yams are mostly produced for their businesses.

From figure 4.11 on the marital status of the marketers, it was recorded that about 73% of the marketers were married while 24% were single with 2% and 1% divorced and widowed respectively. The high percentages of marketers who are in marriage were as a result of the fact that marketers need support from their husbands or wives for their businesses.

The level of education of marketers as shown in figure 4.12 revealed that as high as 30% of the marketers were Junior high school holders while 5% had tertiary education. The high percentage of marketers who had Junior high school education could be that ,they had nobody to help them further their education and for that matter resort to the marketing of yam as their main source of occupation. Number of dependant of marketers as shown in table 4.16 revealed that as high as 29% of the marketers had 4 – 6 dependants while as low as 11% had no dependant. The high percentage of dependants could be that marketers need extra hands in their businesses.

5.2.2 Varieties of Yams Sold in the Market

The variety of yam that marketers buy from the farmers as shown in table 4.13 revealed that, 49% of them buy puna from the farmers while as low as 14% buy white yams. The percentage increase in puna could be due to the fact that this variety might be highly demanded by consumers, have good taste and stored for a long time. Mweeba (1993) also indicated that most varieties of crops are cultivated depending on the taste of preference of the consumer, early maturity of the crop and sometimes farmers' self sufficiency to enable them buy certain basic things.

5.2.3 Quantity of Yam Lost in the Market

On the quantity of yams that was loss in the market; it was found out that less than 5% of the marketers experienced 52% was of tubers in the market. The percentage increase in the loss of yam could be due to the fact that most of these yams might have experienced cuts, bruises and microbial infections during harvesting and these had consequently caused rot of yam in the market. This study is similar to what was reported by RIU (2003) that, the loss of yam quality is associated with certain pre-harvest tissues damage associated with the stacking of tubers and various rots. He stressed that such deterioration may lead to price discount of 25 – 63% and absolute biological losses of 10%.

The proportion of yam that was lost during off-loading revealed that less than 5% of the marketers experienced 53% loss during off-loading of their yams in the market. The high percentage of breakages during off-loading could be due to stacking during transportation and also the mishandling of tubers during off-loading by the loading boys in the market. Similarly, most of vehicles used in transporting these yams by the marketers to the marketing centers had bad shock absorbers. Also, most of these vehicles traveled in the hot sun and this often generates heat in the car and consequently leads to rot of tubers

5.2.4 Challenges Faced by Marketers

Challenges that marketers faced in the selling their yams in the market as shown in table 4.17 revealed that there were no storage facilities, unstable market prices, fatigue and high transport fare charged on their produce when transporting tubers to the market. It was also realized that 37% of the marketers complained of unstable market prices as one of their major challenges. The increase in the unstable market price by the marketers might be due to the fact that the supply of yam in the market could be more than the demand and hence individual marketers may decide to sell to customers at any price to either make profit or break-even. Similarly, since there are no storage facilities in the market, it makes it impossible for marketers to store their produce; the effect is that, the produce is exposed to sunshine which leads to rots.

5.2.5 Factor Contributing to Losses of Yam at the Market Level

The model summary from the regression analysis at the market level showed that the model was 95.6% (Table 4.15) (R^2=0.956) accurate in predicting changes or variations in the quantity of yam loss at the market. Factors that contributed to the quantity of yam loss at the market included the variety of yam sold, presence of cuts / bruises and rots (Table 4.14). Other factors such as packaging of yam to the market, transportation of yam to the market, postharvest handling of yam at the market, insect damage and microbial infection did not contribute to the quantity of yam loss at the market.

5.2.6: An In-depth Study with Three Marketers to Assess the Level of Loss of Yam in the Market

The in-depth study of marketers of yam to assess the level of loss of yam in the market as shown in table 4.19 revealed that, the average loss of marketer; A, B and C was 5.5%. This came about as a result of careless handling during off-loading, poor road network to the market centres and the stacking of tubers during loading and on transit. This study is similar to what was reported by Bencini (1991) who indicated that handling procedures are not fully recognized in less developed countries. Production is not linked with marketing. However with tuber crops such as yam, proper storage facilities, transport and handling technologies are practically non-existent hence considerable amounts of the product are lost. It is disheartening to note that so much time is devoted to the culture and the protection of the crop only to be wasted due to poor storage facilities, poor road network and poor handling methods adopted by the farmer from the production centre to the point of planting until the products reach the consuming public.

From table 4.21 on the temperature reading of yam at the wholesale level, it was realized that there was an average temperature reading of 31.8^{0}C and this could lead to loss of yam in the market because most of the yams are left in the open sun in the market. This study is similar to the study in table 4.16 which revealed that about 30% of the marketers sold their yam in the open sun; thus there were no storage facilities for marketers to store their yams.

5.1.7: An In-depth Study with Six Retailers in the Market to Assess the Level of Loss of Yam

The in-depth study on yam marketers to assess the level of loss of yam in the market as shown in table 4.20 revealed that, the average loss of retailer: A, B, C, D, E, and F was 8.9% and this came as a result of how retailers exposed their tubers of yam in the open sun in the market, poor road network leading to the market, poor shock absorbers and lack of storage facilities in the market.

From table 4.22 on the temperature reading of yam at the retailer's level in the market, it was recorded that there was an average temperature of $32.1^{0}C$. The high temperature could lead to loss of yam in the market.

6.0 SUMMARY, CONCLUSION AND R ECOMMENDATION

6.1 Summary and Conclusion

The study was to assess postharvest losses in yam production in the Krachi-East District of the Volta Region of Ghana. The need for the survey was because; yam is an important staple food crop in the area of study and Ghana as a whole. In all, 200 yam farmers and 100 yam marketers were selected from five``` (5) operational areas namely; Dambai, Kparekpare, Tokurano, Abrewanko and Katanga . The study examined the bio-data of the farmer, production practices of the farmer, the bio-data of the marketer and the marketing practices of the marketer.

From the survey, it was shown that 90% of the farmers interviewed were males and most of them fell in the age group of 41 – 50 years who happened to be active and productive in the cultivation of yam.

It was also revealed that the varieties of yam grown in the area of study included: puna, lalbako, water yam and white yam but there was a percentage increase in the production of puna (55%), lalbako (57%) and water yam (58%) and these might be due to the fact that these varieties mature early, have good taste to the consumer, good market and resistance to losses in the case of water yam.

In the survey, it was reported that 45% of the farmers interviewed, used sharp objects like cutlass to harvest their tubers of yam. This had affected the handling period of tubers, and stemed to rot of yam in the storage facilities as well as losses in the market. The survey revealed that about 86% of the farmers interviewed experienced yam rot as a result of poor handling methods adopted by the farmers, as most of the tubers were exposed to poor environmental conditions on the farm as well as produce transit points.

On the proportion of yam that was lost from harvesting till consumed or marketed, it was reported that 30% of the farmers lost their tubers after harvest as a result of cuts, 32% of them experienced storage losses. Similarly, 10% of the farmers experienced 29% of their tubers bruised after harvest while more than 30% of the farmers experienced 35.5% of their tubers sprout during storage.

Out of the 100 yam marketers interviewed, it was revealed that 73% of them were females who fell in the age group of 41 – 45 years. The varieties of yam that these women normally buy from the farmers included: puna (49%) and lalbako (29%) The reason might be that these varieties have good taste and are likened by the consumers.

On the handling methods adopted by the marketers, 77% of the marketers do not have appropriate place of storing their tubers of yam. They often heaped them and sold them in the open market and this often speed up the rate of rot of tubers in the market.

On the proportion of yam tubers lost from buying till marketed, it was reported that less than 5% of the marketers experienced less than 52% loss during the buying of yam. These losses came as a result of insect attack, microbial infection, rot, cuts and diseases sustained by the tubers in the farm. It was revealed that less than 5% of the marketers experienced 53% of their tubers lost in the market. Similarly, less than 5% of the marketers experienced 53% of their tubers lost during off-loading in the market due to careless handling by the loading boys.

The regression analysis showed that factors that contributed to the quantity of loss of tubers of yam at the farm gate included: pest attack, variety of yam cultivated, type of vehicles used in transportation and tools used in harvesting yam. Similarly, from the regression analysis, factors that contributed to the quantity of yam loss at the market included the variety of yam sold, presence of cuts, bruise and rot.

The in-depth study with three (3) yam farmers at the farm gate showed that the average loss of farmer A, B and C at storage was 17.72. The pathological study showed that *Fusarium solani, Fusarium oxysoporium, Botryodiplodia theobromae and Rhiyopus orayyea* affect tubers at storage.

The in-depth study with marketers in the market to access the level of loss of yam in the operational area indicated that: marketer D, E and F experienced an average loss of 5.4% in the market and these were caused by careless handling during off-loading, poor road network to the market centres, theft cases in the market and over- stacking of tubers during loading and on transit.

The in-depth study conducted with the retailers in the market to access the level of loss at the market indicated that, retailer A, B, C, D, E and F experienced an average loss of 8.9% and this came as result of heat (exposure of tubers to the open sun), lack of storage facilities, tuber rot and cuts sustained by tubers during harvesting.

The average temperature at the storage facility was as high as 32.6^0C . Similarly the average temperature range at the wholesale level in the market was 31.8^0C and the average temperature range at the retailers' level in the market was 32.1^0C.

6.2 Recommendations.

The survey showed that, most of the farmers grew puna (55%), lalbako (57%) and water yam (58%). However it is recommended that farmers in the area of study should go into the production of water yam as this variety is disease-resistance and had low tendency of rot during storage and on transit as compared to other varieties of yam.

It is recommended that farmers in the area should used local materials available which are airy and spacious enough to reduce storage losses. Also, tubers which have sustained cuts, injuries and bruises should be sorted from the lots before storage or marketed to reduce postharvest losses.

Farmers should be very careful when harvesting their tubers to reduce damages. Farmers should also sort out rot tubers, cut tubers and pest-infested tubers before sending them to the storage house or to the market.

On the marketing of yam in the area of study, marketers of yam in the area should go into the buying of puna and lalbako from the farmers as these varieties are preferred by the consumers in the market and often attract good prices.

With the handling method adopted by the marketers, they should be able to sort out the affected tubers in order to prolong storage of tubers in the market.

Marketers in the area can provide protection to yams in the markets to avoid exposure of tuber to harsh environmental conditions.

To reduce losses of yam during off-loading in the market, it is recommended that loading boys should be given training or education on how to off-load yam in the market to reduce losses in the market. Vehicles which are used to convey tubers from the farms to the market centres should have good shock absorbers to reduce losses and marketers must also be vigilant to reduce theft cases in the market.

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APPENDICES

APPENDIX 1

Appendix 1.1: ANOVA table for regression analysis for postharvest loss at the farm level

Model		Sum of Squares	df	Mean Square	F	Sig.
4	Regression	371.098	4	92.775	453.901	.000[a]
	Residual	39.857	195	.204		
	Total	410.955	199			

a. Predictors: Pests attack, Variety of yam cultivated, Type of vehicles used in transportation,

Tools used in harvesting yam

b. Dependent Variable: Quantity of yam tubers loss at the farm

Appendix 1.2: Table of Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.315	.086	-	3.661	.000
	Pests attack	.712	.057	.779	12.513	.000
	Variety of yam cultivated	.348	.090	.251	3.855	.000
	Type of vehicles used in transportation	.218	.053	.194	4.106	.000
	Tools used in harvesting yam	-.458	.130	-.235	-3.519	.001

a. Dependent Variable: Quantity of yam tubers loss at the farm

Appendix 1.3: Table of Excluded Variables[b]

	Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Bruises on yam after harvest	.157[b]	1.490	.138	.106	.045
	varieties of yam that rot quickly after bruises	-.162[b]	-1.339	.182	-.096	.034
	Method of storage	.081[b]	.944	.346	.068	.067
	Storage duration	-.154[b]	-2.431	.016	-.172	.121
	variety of yam prone to spoilage	-.218[b]	-2.512	.013	-.178	.064

a. Predictors: Pests attack, Variety of yam cultivated, Type of vehicles used in transportation, Tools used in harvesting yam

b. Dependent Variable: Quantity of yam tubers loss at the farm

Appendix 1.4: ANOVA table for regression analysis for postharvest losses at the market level

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	276.960	3	92.320	690.745	.000[a]
	Residual	12.697	95	.134		
	Total	289.657	98			

a. Predictors: variety of yam sold, cuts / bruises, tuber rots

b. Dependent Variable: Quantity of yam loss at market

Appendix 1.5: Table of Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	5.729	.844		6.787	.000
Variety of Yam Sold	.882	.087	.565	10.097	.000
Cuts / Bruises	-1.965	.250	-.433	-7.855	.000
Rots	-.862	.149	-.210	-5.798	.000

a. Dependent Variable: Quantity of yam loss at market

Appendix 1.6: Table of Excluded Variables[b]

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
					Tolerance
1 Package of yam to the market	-.017[a]	-.681	.498	-.070	.771
Transportation of yam to the market	-.052[a]	-1.080	.283	-.111	.195
Handling of yam at the market	.025[a]	.543	.588	.056	.220
insect damage	-.051[a]	-1.523	.131	-.155	.406
microbial infection	.042[a]	1.523	.131	.155	.607

a. Predictors variety of yam sold, cuts / bruises, tuber rots

b. Dependent Variable: Quantity of yam loss at market

APPENDIX 2:

QUESTIONNAIRE FOR DATA COLLECTION

ASSESSMENT OF POST-HARVEST LOSSES IN YAM PRODUCTION IN THE KRACHI- EAST DISTRICT OF THE VOLTA REGION

Preamble

The main purpose of the study is to assess postharvest losses of yam production in the Krachi- East District of the Volta Region. This questionnaire is designed to help the researcher to assess the postharvest losses of yam production in the Krachi -East District of the Volta Region. Please take sometime to respond to these items as truthfully as possible. Your answers will enable the researcher find solutions to the problems associated with yam production in the district. All answers will be treated with utmost confidentiality.

SECTION A – THE BIO-DATA OF THE FARMER

The following are statements about you. Please indicate by ticking the appropriate option against the number of the response to each item.

1. Gender: Male ☐ Female ☐
2. Age in years: Below 18 ☐ 21 – 30 ☐ 31 – 40 ☐ 41 – 50 ☐ 51 – 60 ☐ 60 above ☐
3. Marital Status: Single ☐ Married ☐ Divorced ☐ Widowed ☐
4. Number of dependents: None ☐ 1 – 3 ☐ 4 – 6 ☐ 7 – 9 ☐ 9 above ☐
5. What is your level of education? Primary ☐ M.S.L.C/JHS ☐ SSS ☐ Post-Secondary ☐ Tertiary level ☐ Non-formal ☐

SECTION B- PRODUCTION PRACTICES OF THE FARMER

6. What is your major occupation? Farming ☐ fishing ☐ civil servant ☐ others specify----------------------------

7. What is the major crop that you farm? Yam ☐ others (specify)………………………

8. What is your farm size? Less than five-acre ☐ five to ten acre ☐ fifteen to twenty acre ☐ more than twenty acre ☐ others (specify)……………………….

9. Which type of soil is used for yam cultivated? Sandy soil ☐ well – drained clayey loam soil ☐ loam soil ☐ silt soil ☐

10. Where do you get your planting materials before planting? From renowned yam ☐ farmer friends ☐ extension agents ☐ market ☐ others (specify)………………………

11. When do you clear the land for planting? The beginning of the dry season ☐ September to October ☐ middle of the year ☐ the beginning of the rainy season ☐

12. Which type of labour is used to clear the land? Family labour ☐ hired labour ☐ permanent labour ☐ casual labour ☐

13. What is your farming experience? Under one year ☐ 1 – 5yrs ☐ 6 – 10yrs ☐ 11 – 15yrs ☐ 16 – 20yrs ☐ 21 – 25yr ☐ more than 25yrs ☐ other (specify)……………

14. What variety of yam do you grow in you farm? "puna' ☐ 'lalbako' ☐ water yam ☐ white yam ☐ others (specify)………………………..

15. Why do you grow the variety you have chosen? Stores for a long time☐ high yielding ☐ not easily attacked by disease ☐ very much demanded by consumers☐ very palatable☐ others(specify)……………..

16. Which of these challenges do you face in your yam cultivation? Yam beetle ☐ aphids☐ crickets☐ termites☐ millipedes☐ centipedes ☐ others (specify)………………………………………………………………….

17. How do you control the pest in your farm? By hand – picking☐ use of resistant varieties ☐ use of insecticides ☐ no treatment ☐

18. How do you control weeds on your farm? Manual weeding ☐ hard – picking☐ use of weedicides ☐ use of chemicals ☐

19. How many times do you weed your farm before harvesting? Once ☐ twice ☐ four times ☐ more than 4times. ☐

20. What type of farming system do you adopt? Monocropping☐ mixed cropping ☐

21. From planting to harvesting takes how long? 4 - 5 months ☐ 6 – 7 months ☐ 8 – 9 months☐ 10 – 11 months☐

22. How do you know the crop is ready harvest..?

23. With what implements do you use to harvest you yam? Cutlass ☐ hoe ☐ earth chisel☐ others (specify)……………………………….

24. Why do you grow your yam? Fore sale ☐ for home/household ☐ export☐ seed yam☐ others (specify) ………………………………………….

25. If for sale, which market do you sell your yam? In the local, market within the district☐ out side the district☐ for export ☐

26. In the local market within the district how many tubes of yams is sold? Less than 500 tubers ☐ 600 – 2000 tubers ☐ 1100 – 1500 tubers ☐ 1600 – 2000 tubers ☐

27. In the local market within the district how many tubers of yam is lost? Less than 5% ☐ 10% ☐ 15 % ☐ 20 % ☐ 25% ☐ 30 % ☐ 35 % ☐ 40 % ☐ more than 40% ☐

28. How many tubers of yams are sold outside the district? 1000 – 1500 ☐ 1600 – 2000 ☐ 2100 – 2500 ☐ 2600 – 3000 ☐ more than 3000 ☐

29. In selling tubers outside the district how many tubers of yam are lost. Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ 25% ☐ 30% ☐ 35% ☐ 40% ☐ more than 40% ☐

30. How many quantity of yam is exported annually? 10m – 15m ☐ 16m – 20m ☐ 21m – 25m ☐ 26m – 30m ☐ 31m – 35m ☐ 36m - 40m ☐ more than ☐ 40m ☐

31. What percentage of yam is sold? Less than 10% ☐ 15% ☐ 20% ☐ 25% ☐ 30% ☐ 35% ☐ 40% ☐ more than 40% ☐

32. What percentage of the harvested yams is used for the household? Less than 5% ☐ 10% ☐ 15% ☐ more than 15% ☐

33. How many tubers of yams do you harvest in a season? Less than 500 ☐ 500-100 ☐ 1500 – 2000 ☐ 2500 – 3000 ☐ 3500 – 4000 ☐ more than 4000

34. How many tubers are lost before sale? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ 25% ☐ 30% ☐ more than 30% ☐

35. Mention the major causes of loss in yam production

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………

36. Which of the causes mentioned is common to domestic losses? Insect attack ☐ rots ☐ theft ☐ bruises ☐ others (specify)…………………………

37. Which of the causes is associated to local market? Unfavorable weather condition ☐ bruises ☐ cuts ☐ theft ☐ other (specify)……………………………

38. Which of the causes is associated to the export market? Rots ☐ bruises ☐ cuts ☐ insect attack ☐ others (specify)………………………

39. After harvest what proportion of yam is bruised? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ 25% ☐ more than 25% ☐

40. Mention the major causes of losses during harvest

……………………………………………………………………………………………

…………………………………………………………………………………………....

41. Which of them is common/most important to losses? Cut ☐ pest infection ☐ theft ☐ insect attack ☐ others (specify)……………………………….

42. What percentage is lost during harvest? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ 25% ☐ more than 25% ☐

43. Mention the major causes of lost during storage.

…………………………………………………………………………………………

……………………………………………………………………..

44. Which of them are common storage losses? Sprouting ☐ rots ☐ cuts ☐ theft ☐ pest attack ☐ other specify……………………………………….

45. What percentage is lost during storage? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ 25% ☐ more than 25% ☐

46. What do you do with such bruised tubers? Sell immediately ☐ eat at home store for sometime ☐ others (specify)………………………………….

47. Which varieties of yam rot quickly after bruises? "puna" ☐ "lalbako" ☐ water yam ☐ white yam ☐ others (specify)………………………

48. Where do you store your harvested yams? Barns ☐ cribs ☐ underground ☐
other (specify)……………………

49. How long do you store your yams harvested before sale / use.

Up to 2 months ☐ 3- 4 months ☐ 4 -6 months ☐ 7- 8 months ☐
Others…(specify)……………………

50. What are some of the problems you experience in your storage? Yam rot ☐
change of taste ☐ dehydration ☐ sprouting of yam ☐ other
specify…………

51. If you store your yam for a long time, what method do you use to reduce sprouting?

(i) ………………………………………………………………………………

(ii) ………………………………………………………………………………

52. In your estimation, what percentage of yam sprouts? Up to 5% ☐ 10% ☐
15% ☐ 20% ☐ 25% ☐ 30% ☐ more than 30% ☐

53. Which variety of yam is prone to spoilage? "puna" ☐ "lalbako" ☐
water yam ☐ white yam ☐ other specify………………….

54. Why the spoilage? Cannot withstand heat ☐ insect infection ☐
bruised ☐ cuts ☐ others (specify)……………………………………..

55. Which vehicle is used to transport your yam from the farm to the market center?
Container ☐ open close truck ☐ salon car ☐ articulator truck ☐
refrigerator truck ☐ other specify…………………………………….

56. State two major problems you encounter in the marketing of your yam.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………….

SECTION C – BIO – DATA OF THE MARKETER

57. Gender male ☐ female ☐

58. Age in years 18 – 21 ☐ 22 – 26 ☐ 27 – 31 ☐ 32 – 36 ☐
37 – 40 ☐ 41 – 45 ☐ 46 -50 ☐ above 50 ☐

59. Marital status single ☐ married ☐ divorced ☐ widowed ☐

60. Number of dependants: 1 – 3 ☐ 4 – 6 ☐ 7 – 9 ☐ 9 above ☐ none ☐

61 What is your level of education? Primary ☐ M.S.L.C/JHS ☐ SSS ☐ Post-Secondary ☐ Tertiary level ☐ Non-formal ☐

SECTION D – MARKETING PRACTICES OF THE MARKETER

62. Which variety of yam do you normally buy from the farmers? "puna" ☐ "lalbako ☐ water yam ☐ white yam ☐ other specify ………………….

63. Why do you choose that variety? Good taste ☐ liked by consumers ☐ store better ☐ can sell better ☐ other specify……………………………..

64. How did you package your yam? In a basket ☐ in containers ☐ others, (specify)…………..

65. What quantity of yam do you often buy from the farmers? 1000 – 1500 ☐ 1600 – 2000 ☐ 2100 – 2500 ☐ 2500 – 3000 ☐ more than 3000 ☐

66. What quantity is lost during buying? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ 25% ☐ more than 25% ☐

67. What are the causes of these losses? Insect attack ☐ microbial infection ☐ rots ☐ cuts ☐ other specify…………………………………………………..

68. What percentage is cause by cuts? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ more than 20% ☐

69. What percentage is cause by rots? Less than 5% ☐ 10% ☐ 15% ☐ 20% ☐ more than 20% ☐

70. During off loading of yam, what proportion of yam is lost? Less then 5% ☐ 10% ☐ 15% ☐ 20% ☐ more than 20% ☐

71. Any treatment before you loads the yam into vehicles...

……………………………………………………………………………………..

…………………………………………………………………………………….

72. If yes how did you do it?...

…………………………………………………………………………………

73. Which type of vehicles do you normally use to convey you yam to the market center? Long vehicles ☐ cargo ☐ articulated truck ☐ mini van ☐ others (specify)…………………………………………………………………………..

74. How do you prevent loss of yam after off loading? Sorting ☐ removing infested yam from the lot ☐ by removing bruised yam ☐ other (specify)………

75. Mention some of the challenges that you encounter during the selling of yam in the market. No storage facility to store the yam ☐ unstable market price ☐ fatigue ☐ high transport cost ☐ others (specify)………………………………..

76. Which of the challenges impede the selling of yam in the market? Lack of storage facilities ☐ lack of capital ☐ others (specify)……………………………

77. Any other challenges that you face in the marketing of yam?..