Assessment of post-harvest loses of cocoa from the harvesting point to the Deport

Dissertation Submitted to the Faculty of Regional Development and International Studies, Mendel University in Brno, Czech Republic in Partial Fulfilment of the Requirements for the Award of a Master Degree in International Territorial Studies.

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This work is dictated to my brothers, Alexander Ennin Kennedy, and Bismark Adzakpa and my children Theodore Kenross Asamoah and Evangeline Anohemaa Asamoah.

ACKNOWLEDGEMENT

Thanks be to the Almighty God for His protection and guidance throughout my studies. Special thanks also go to my brothers Alexander Ennin and Bisamark Adzakpa for their support both financially and spiritually; God richly bless you. To my supervisor Dr. Samuel Darkwah, God richly bless you for your support, encouragement, directions, corrections and advice. I am also indebted to the various farmers and to my mother Rose Affukaah who gave me the opportunity to use their farms for the various research that were conducted.

To my wife Bertha KorangGyimah, I say a big thank you for your support and encouragement. Also my sincere gratitude goes to Dr, EboTawiah Quartey and Beatrice OforiAmoakoh Mensah for their assistance and also being by my side in difficult times.

Finally, to all my course mates and everybody who helped in diverse ways for the success of this work, I say God richly bless you.

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ABSTRAKT

Stanovení ztrát u sklizně kakaa (Theobroma cacao) od okamžiku sběru až po uložení do skladiště včetně stanovení preventivních opatření

Produkce kakaa (Theobroma cacao) je relativně malý sektor v zemědělství s celosvětovou produkcí, která dosahuje v průměru 4,5 milionu tun ročně. Produkce kakaa je však prvořadá pro ekonomiku mnoha západoafrických zemí, kde je vyrobeno okolo 80% celosvětového kakaa. Milióny drobných zemědělců produkují tuto plodinu jako prostředek k udržení jejich živobytí. Taktéž je hlavním zdrojem příjmu miliardářů. Produkce kakaa významně přispívá k ekonomice Ghany, HDP a slouží jako prostředek pro kurzové výnosy. I když je Ghana uznána za nejlepší a hlavní stát v kakaovém průmyslu, její výroba čelí problémům, které se týkají ztrát před a během sklizně. Tyto ztráty jsou hlavním důvodem znepokojení vlády, zemědělců a dalších zainteresovaných stran. Bohužel dostupné informace o těchto ztrátách jsou velmi malé. Tím je teoreticky i prakticky nemožné provádět účinné preventivní opatření na omezení těchto ztrát.

Cílem této práce je posoudit příčiny a identifikovat hlavní oblasti v rámci výrobního řetězce, kde dochází ke ztrátám kakaa. Ghana, která je jedním z nejlepších výrobců kakaa ve světě, stále postrádá opatření, metody a postupy, které by zamezili ztrátám kakaa od producentů (farmářů) do skladiště, kde probíhá následně nalodění a přeprava do marketingových center (export). Vzhledem k tomu, že nejsou zaznamenány ztráty ze stran zemědělců a vlády, celková ztráta není známa.

Výzkum je veden k tomu, aby zjistil množství ztrát při sběru a s tím i související peněžní ztráty. Výsledky výzkumu snad zaujmou pozornost vlády i zemědělců, i když nelze vyloučit, že se nepodaří danou situaci vyřešit. Dalším cílem této práce je zjistit a ověřit vliv fermentačních metod, počet dnů fermentace a způsobů sušení kakaa na kvalitu a chemické vlastnosti sušených kakaových bobů.

Na shromažďování primárních údajů od zemědělců, vedoucích pracovníků vybraných výzkumných farem a skladišť v obou hlavních přístavech v zemi, budou využity správně strukturované a metodicky zpracované dotazníky, díky kterým se zjistí jejich vnímání na rozsah škod během sklizně. Prohlídky v terénu budou prováděny na kakaových farmách ve vybraných regionech, včetně zemědělských podniků Institutu pro výzkum kakaa v Ghaně (CRIG) a kakaových stanic Sefwi Boako, Goaso, Bunnso a Brong Ahafo. Dále různé kakaové depa ve vybraných oblastech a hlavní sklad kakaa v obou přístavech v zemi, aby se kvalitativně i kvantitativně určily ztráty v řetězci. Odpovědi vedoucích pracovníků ve výzkumných farmách a skladech budou shromážděny, analyzovány a vyhodnoceny a tím nalezeny hlavní příčiny ztrát kakaa v průběhu sklizně.

ABSTRACT

Assessing the causes of postharvest losses of cocoa (Theobroma cacao) from harvest to the depot

Cocoa (Theobroma cacao) production is a relatively small sector in agriculture with a global production that averages about 4.5 million tons a year but the cocoa industry is paramount for the economies of many West-African nations, where about 80% of the world cocoa is produced and millions of small scale or peasant farmers produce the crop as a means to sustain their livelihoods. Cocoa production is a major source of income that helps to sustain the livelihood of billions of farmers and their households, cocoa contributes significantly and tremendously to the Ghanaian economy, GDP and avenue for foreign exchange earnings. Even though Ghana is recognized as the best and the leader in the cocoa industry, its cocoa production faces problems such as pre-harvest and postharvest losses which are major cause of concern to the government, farmers and other stakeholders. Unfortunately, available and accessible information on pre-harvest and postharvest losses in cocoa in Ghana is very meagre or sparse. This makes it virtually and practically difficult to carry out effective prevention measures. This study will therefore, be conducted to assess causes, nature and identify major areas along the production chain where losses occur. Since records are not kept for the losses on the side of both the farmers and the government the total amount of losses is not known. The research was conducted to at least find the causes of loses, quantify it and relate it to monetary terms and bring both the government and farmers attention to the situation and even if cannot completely eliminated it will manage the situation. The research was conducted to seek and to examine the effect of the methods of fermentation, number of days of fermentation and the drying methods of cocoa to find out if it will have any effect on the quality and chemical properties of dried cocoa beans. A well-structured questionnaires was used to collect primary data from farmers, managers of the selected research farms and the depots in the two main harbours in the country to ascertain their perception on extent of postharvest losses on their farms. Field visits will be carried out on cocoa farms in the selected Regions across the cocoa growing regions in the country including farms of Cocoa Research Institute of Ghana at SefwiBoako, Goaso and Bunnso all in the Western, Eastern and Brong Ahafo region and the various cocoa depots in the selected regions and the main.

Key words: Cocoa; Post –harvest loses; Ghana.

1. Introduction

Encouraging the connection and the empathy for the sustenance of Security and Economic growth and development should be part of the paramount goal and ambition for developing regions and countries in Africa and other parts of the globe. My work to be embarked on, will be designed to come out with what are the primary causes of post-harvest loses of cocoa and future research will be designed to show how to increase the productivity of cocoa to increase productivity and help improve the livelihood of the people especially cocoa farmers at the community based and how it can be linked more integrally into regional and international market domain or system.

Post- harvest losses cause one of the primary problems not only in the line of production system but also along the line of the marketing chain. Post-production losses and deterioration of food or crop quality are areas of major concern and has to be looking at, as it has immediate impacts and effects on household earnings and incomes and the duration of the regular food shortage which affects the earnings of the farmers and results in income reduction on that part of farmers and end up affecting the improvement of livelihood of the people. The benefits of such systems for crops that contribute to household income and food security or are of export importance cannot be overstressed particularly as CORAD's strategy is for the increment of productivity and strengthened household resilience through increased incomes. A post-harvest system implies of a number of operations and functions from the production point (producer) to the consumer of any agricultural commodity or product. Farm produce from the farm to the consumers must pass through this system of post- harvest. During this process or transition, there are losses that may and can occur due to spatial and time lapse between the production point and the consumption point. The total food loss experienced is as result of all the various activities that take place along the system and which are prevalent the physical and biological factors operating at each phase. Transitional process or Phases like harvesting, transporting, pre-processing, storage, processing and marketing, can either add or subtract value from the end product.

Loss is defined as any change in the availability, edibility, wholesomeness or quality of food that prevents it from being consumed by people. Food losses may be direct or indirect. Direct loss results from spillage or damage by insects, rodents and birds. Indirect loss on the other hand refers to the lowering of quality to the point where food cannot be utilized.

1.1. Justification

Even though Ghana is a recognized leader in the cocoa industry, the industry faces myriads of problems. Important problems confronting the industry include diseases and post-harvest concerns such as bad beans (i.e. caked beans, mouldy beans, purple beans, germinated beans and wet beans). Information on post-harvest handling and losses are important in charting and informing policy direction for stakeholders in the cocoa industry. Although, extensive reports are available on postharvest handling practices of cocoa in Ghana there is insufficient information on the postharvest losses in the cocoa industry. Post-harvest losses along the cocoa production chain could be addressed if they are empirically estimated. This study will therefore seek to bridge the knowledge gap by providing empirical data on post-harvest losses of cocoa in Ghana. In addition, it will enable government and stakeholders to plan and to mitigate these losses by putting in place strategic interventions that will help reduce the losses and enhance the production target for cocoa.

1.2. Research Objectives

The main objective of the research is to find out the causes of post-harvest losses of cocoa and how it is affecting the country.

Other areas that will be looking at are the preventive measures that can be put in place to manage the situation and the liberalization of the cocoa marketing sector to bring more firms on board in order to come out with fair price to farmers

1.3. Research questions

1. What are the causes of post-harvest losses of cocoa?
2. Is there any way it can be prevented or managed?
3. Is there any way the cocoa trade can be liberalised?

1.4. Limitations of the study

The study has two key limitations. First, since the survey was conducted in 8 districts out of sixty-seven cocoa districts in Ghana, one should exercise some kind of care and caution when generalizing the results of the study for the entire country. Secondly, the time frame given for the study was rather short, and that presented challenges to the research team at various stages of the work. Nevertheless, much effort has been expended on both the data collection

and the subsequent analysis and discussion, and a lot of caution exercised at every stage of the process to ensure the accuracy and reliability of the results obtained.

2. Literature Review

2.1. Origin of Cocoa

Researchers and historians have the believe that Olmecs first discovered that, the cocoa fruit as edible by observing some rodents especially rats eating it with excessively greedy and vigour. It was later realized that, the cocoa tree produced a fruit with differentflavours and nearly as many different uses (World agroforestry centre, 2014).The Olmecs (1500-400 BC) were certainly the first humans to taste and consume cocoa in a form of chocolate, and originally in the form of a beverage. They crushed and milled the cocoa beans, add water, spices, chillies and other herbs. They realised that the beans were very nutritious began growing cocoa in some part of Mexico. Over some period of time, the some groups in the southern America called the Mayans (600 BC) and the Aztecs (400 AD) developed successful methods for growing coca as well and started with farms in small scale. The cocoa bean was used as a monetary unit and as a measuring unit, 400 beans equalling a Zontli and 8000 equalling a Xiquipilli. During their time of wars with the Aztecs and the Mayans, the Chimimeken group preferred to take cocoa from their conquered region as taxes of taxing in conquered regions. For these civilizations, cocoa was a symbol of abundance. Cocoa was used for religious and ritual pacifications. It was believed to Quetzalcoatl, the Aztec god is responsible for bringing the cocoa tree to man, to ChakekChuah, the Mayan patron saint of cocoa and as an offering at the funerals of noblemen. Amazon and Orinoco basins of South America and cultivated in the tropical regions of the world (Ardhana and Fleet, 2003). Cocoa production advanced as people moved or migrated throughout Meso-America but consumption of the drink remained a privilege for the rich and upper classes and for soldiers during battle. By this time, the re-invigorating and fortifying virtues of cocoa were becoming widely recognized and embraced worldwide.

The **cacao tree** is a small tree which originated from tropical South America. It is small, and only grows to 4 to 8 meters in height. Its seeds are called cocoa and are used for products like cocoa butter, the chocolate drink, Milo which is one of the oldest cocoa products in Ghana as well as chocolate.

Cocoa (Theobroma cacao) is one of the most important perennial crops world-wide, with an estimated world production of 2.8 million tons in 2002 (FAO, 2003). Although the body of

cocoa research is very large (e.g.,Ahenkorah et al.,1974; Alvim, 1977; Wood and Lass, 1985; Somarriba et al., 2001), the results of cocoa studies have never been integrated into a physiological production model. The cocoa production models that have been established so far are either regression-based models with limited applicability for locations other than the ones for which data were collected (e.g.,Fassbender et al., 1991;Beer et al., 1990), or are conceptual models which are not suitable for yield simulations (e.g.,Hutcheon, 1976; Alvim,1977; Balashima, 1991; Yapp and Hadley, 1994). For cocoa, physiological simulation models may be valuable to compare attainable cocoa production between locations, soil types and cropping systems, to obtain insight in the main factors determining yield and to identify gaps in knowledge on cocoa production.

2.2. History of Ghana

Ghana is known officially as the Republic of Ghana, is a presidential constitutional democracy, which is located along the Gulf of Guinea and Atlantic Ocean, in the sub region of western part of West Africa. Ghana has a land mass of 238,535 km², Ghana share it bordered with the Ivory Coast currently known as Cote d'Ivoire in the west, Burkina Faso in the north, Togo in the east and the Gulf of Guinea and Atlantic Ocean in the south. Ghana has been inhabited for millennia, with the first permanent state dating back to the 11th century. Ghana is considered as a multicultural nation, Ghana has a population of approximately 27 million, consisting of a different of ethnic, with different languages and religious groups. Five percent of the population are considered to practices traditional faiths, 71.2% belongs to Christianity and 17.6% are Muslim. It has a diverse geography and ecology which ranges from coastal savannahs to tropical forest. Ghana is a democratic country led by a president who is both head of state and head of the government. Ghana's economy is one of the strongest and most diversified in Africa, following a quarter century of relative stability and good governance. Ghana's growing economic prosperity and democratic political system have made it a regional power in West Africa. It is a member of the Non-Aligned Movement, the African Union, the Economic Community of West African States (ECOWAS), Group of 24 (G24) and the Commonwealth of Nations.

Map of Ghana showing growing areas.

Figure 1. Map of Ghana showing cocoa growing areas in Ghana.

Source: National Gender and socio economic Research chocolate and cocoa making.

2.3. How cocoa came to Ghana

The Cocoa plant originated from the southern part of America around the tributary or the headwater of the Amazon in. Its cultivation with its value spread widely and faster in olden times all over the Central and Eastern Amazonian and northwards to Central America. Cocoa beans were used by the Native Americans to prepare a chocolate beverages or chocolate and also as a form of currency for trading purposes and payment of tribute to the king.

After the conquest of Central America in 1521, Hernan Cortez and his entourage took sizeable quantity of cocoa beans in a form of cargo to Spain in 1528, together with accoutrements that will be used preparing some chocolate to serve as beverage. By 1580 the

beverage had been made known and popularised in the country and consignments of cocoa were regularly sent through sail to Spain. Large-scale of farms and plantations or cultivation of cocoa were started by the Spanish in the 16th century in some part of the Central America when the emerged to colonised some of the countries in the continent. This farming and plantation of coca diffused rapidly to other European countries like the British, French, the Dutch and West Indies (Jamaica, Martinique and Surinam) in the 17th century and to Brazil in the 18th century.

The cocoa fruit was taken from Brazil and was set to SÃO Tome and Fernando Po a small Island in the western part of Africa in 1840; and from there to other parts of West Africa, notably the Gold Coast (now Ghana), Nigeria and the Ivory Coast. The available data and information clearly indicates that Dutch missionaries first planted cocoa in the coastal areas of the then Gold Coast as early as 1815, whilst in 1857 Basel missionaries also planted cocoa at Aburi. However, these did not catalysed and facilitated in the spread of cocoa cultivation in the Gold coast until a man called TettehQuarshie, a Ghanaian and native of Osu, Accra, who had travelled to Fernando Po for job at Fernando Po he worked as a blacksmith, and he returned to Ghana in 1879 with Amelonado cocoa pods and planted it in his farm at AkwapimMampong in the Eastern Region. Other people (farmers) showed interest in the crop and came to buy the pods from his farm from his farm to plant and cultivation spread from the Akwapim area to other parts of the Eastern Region.

In 1886, Sir William Bradford Griffith, the Governor during the Gold coast era, also showed interest and arranged for cocoa pods to be brought in from Sao Tome, from which seedlings were nursed and raised at Aburi Botanical Garden and distributed to farmers who showed interest in the cocoa plant. In recognition of the tremendous contribution of the god tree in other words cocoa to the development of Ghana, in 1947 the government in introduce the establishment of the Ghana Cocoa Board (COCOBOD) as the main government agency responsible for the development of the industry. Currently there are seven cocoa growing regions namely Ashanti, Brong Ahafo, Eastern, Volta, Central and Western North and Western South regions.

2.4. Cocoa Farming in Ghana

There are various activities and steps that the farmer goes through in the cocoa farming. In Ghana all lands are sold as leasehold and it has a maximum of one hundred years for the expiration of the lease agreement. Lands are owned by the family, family heads chiefs and government. Some land are sold whiles others are given to farmers in the share cropping system locally known as Abunu or do ma yen kye. Cocoa lands are burnt and slashed and from there planting is done. There are two methods of planting. The local method and the modern one. In the local methods planting is mostly done in a haphazard way without a distance rule which is intercropped with other staple food like plantain cassava cocoa yam etc. With this methods farmers get the pods from their own farm and sow them.

Considering the modern method the farmers ensures accurate spacing between the trees that is 3mx3m without overcrowding and easier to estimate the number of seedlings or trees per hectare. The estimated seedlings per hectare is 1200 and after thinning the estimated trees is 111. The differences between the two methods are, with the local methods it is difficult to estimate the number of trees per hectare while with the modern method is the opposite.

The ideal range of temperatures for cocoa is between 18 - 32°C with an annual rainfall in the range of 1250-3000 mm per year. The rainfall must be well distributed and any dry period should be no longer than three months. Cocoa is grown on a wide range of soil types which has at least 1.5 m depth of free draining soil good moisture holding capacity with pH range from 4.5 to 7.0, preferably close to 6.5.

2.5. Cocoa Production trend in Ghana

Cocoa is the main cash crop produced in Ghana and it's produced in the following areas seven cocoa growing regions namely Ashanti, Brong Ahafo, Eastern, Volta, Central and Western North and Western South regions. See map figure.1. According to Anang Tawiah, 2010, Cocoa is one of the important export crops, which accounted for 8.2 percent of the country's GDP and 30 percent of total export earnings in 2010. Total production of cocoa rose up from 450,000 tons in 2000 to 900,000 tons in 2010 see figure 2.

Ninety percent of total production is grown by smallholder farms. In the Cocoa marketing, all cocoa beans are solely sold to Licensed Buying Companies (LBCs), which in turn sell to the only authorized exporter in Ghana, the COCOBOD which is the government body or

government agency or to domestic industries for local processing. Cocoa is mainly exported to the following destinations, European Union, Japan and the United States.

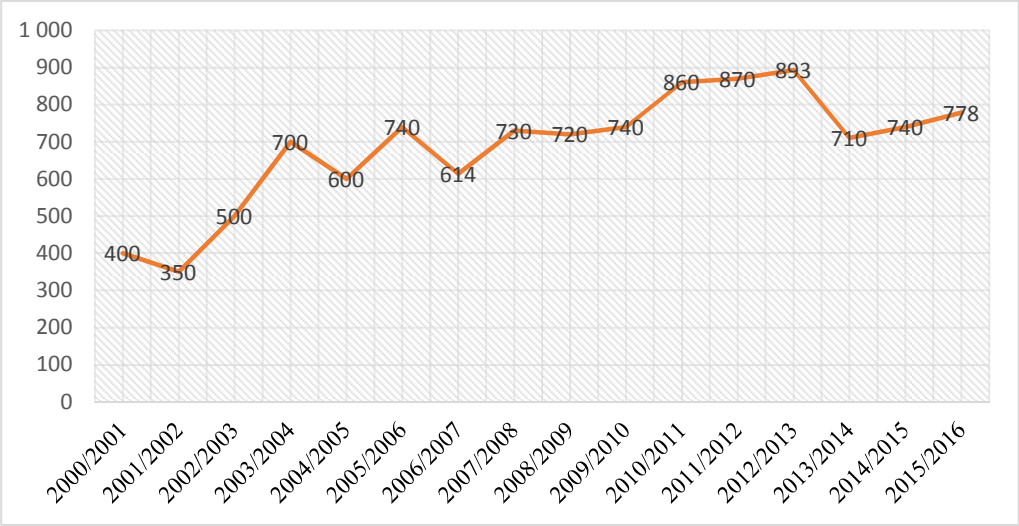

Figure 2. Cocoa production trend in Ghana (2000-2016)

Source: ICCO (2006)

Considering the figure above it can observed there low production of cocoa in the year 2000 2003 due to high infestation of pest and diseases and high price of farm inputs. In 2004-2006 there was a sharp increase of production due to the implementation of free mass spraying the government. It really helped to improve production in the subsequent years.

2.6.West African and world production of cocoa beans (thousand tons).

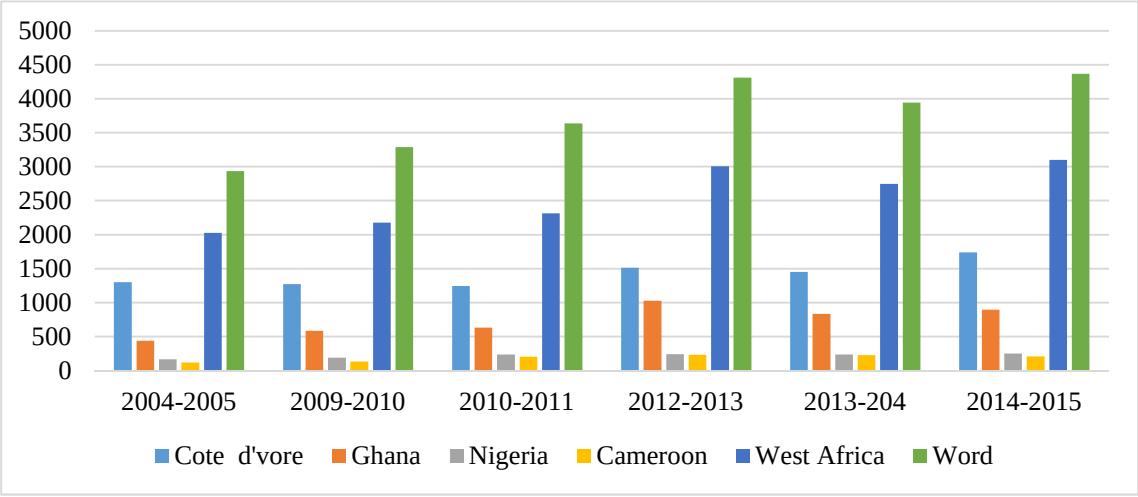

Figure 3. West African and world production of cocoa beans (thousand tons).

Source: ICCO (2006)

From the figure above it can be observed that Cote d'Ivoire has been the leading producer of cocoa in West Africa and the word in General followed by Ghana. Nigeria and Cameroun are producers but not as large Cote d'Ivoire and Ghana.

2.7.Cocoa Marketing liberalisation in Ghana

Market sharing, price fixing, and fluctuating domestic prices motivated Ghana's colonial government to establish the Cocoa Marketing Board (CMB) in 1947 (Stryker et al. 1990). Before each season, CMB was made and announced the official producer of price, and it gave licensed to buying agents (LBAs), now known as licensed buying companies (LBCs), a fixed allowance per ton to cover procurement and transportation costs, and a profit margin that varied with the price.

The left over or surpluses that the cocoa marketing board generated during periods of high world prices were to be used to finance the board deficits when prices were is reduced at the world market. In addition, the surpluses were to be used for other purposes like national development, general benefit and motivation to the cocoa farmers and the industry,' including research, control of crop diseases, credits, cooperatives, and provision of other amenities and facilities to the producers" (Stryker 2011, 88).

According to IFPRI 2012, the cocoa in the Ghana is one of few examples of an export commodity sector in an African country that has withstood the pressure to fully liberalize. In spite of the government taken the total control over internal and external marketing issues by the Ghana Cocoa Board (COCOBOD), the present time institutional arrangement is able to pass on a significant amount of export prices to the producers or the farmers, a key objective of the liberalization of commodity markets in Africa. As Ghana continues to capitalize on its recent discovery of off-shore oil reserves, the government and donating agencies have shown concerned that the serious competitiveness of the cocoa sector may be threatened.

As the second largest producer of cocoa in the world after Côte d'Ivoire but first quality beans provider, Ghana remains the only country where the state retains control of the entire volume of exports, and an overwhelming presence in the internal market. Some elements of competition were bought up in 1993, there new private buying companies which rose up to 25 private licensed buying companies (LBCs) buying the crop in all regions where cocoa is grown. Despite this partial liberalisation, the Cocoa Board called continues to announce the farm gate price to farmers without any negotiation with the farmers and that is, effectively,

the price paid to all farmers everywhere in the cocoa growing belts. The Ghana Cocoa Farmers Survey (GCFS), in which one of which one prominent researcher of this Brief (Marcella Vigneri) was involved, surveyed 497 farmers about their experience with partial liberalisation, asking them about choices they have in selling their produce.

African taxation policies have particularly targeted perennials like cocoa, coffee, and vanilla. These crops are especially prone to government actions that are inconsistent over time because they tend to have a longer time gap between planting and harvest, which locks in the initial capital investment made by farmers (McMillan 2001). Consequently, governments may announce a price that covers sunk and harvest costs. After harvest, however, farmers can be cheated out of their sunk costs, receiving a price that covers only harvesting costs. Data support this theory and show that tax rates vary directly with the ratio of sunk to total costs and expected future earnings (McMillan 2001).

Cocoa, coffee, and vanilla have historically been taxed more heavily than crops with lower fixed costs like cotton, groundnuts, and tobacco. Several studies (Besley 1997; McMillan 2001) have demonstrated that in the long term it is disadvantageous for governments to pursue high-tax policies. Once repeatedly cheated, producers will revise their choices, stop planting new trees, and revert to parallel markets where available. Ultimately, a high-tax-regime strategy is self-defeating and will successively require the implementation of both price and non-price policy measures to restore farmers' trust and production investments in perennials. Significant examples can be drawn from the politics of cocoa in both.

Ghana and Côte d'Ivoire (Woods 2004; Kolavalli and Vigneri 2010). The initial expansion phases in both countries allowed ruling elites to tax cocoa producers heavily, taking advantage of high world prices and of farmer willingness to be buffered from world price swings through the operation of marketing boards. Through the bust cycles that characterized the economics of cocoa production, as well as dips in international prices, farmers were squeezed by higher production costs and declining shares of export prices. In Ghana, production fell by 74 percent over the course of 20 years. It did not increase until the government enacted policies that provided farmers with a higher percentage of world market prices. The boards that controlled trade prior to liberalization, in addition to serving as convenient instruments to tax producers, also added to marketing costs because of their inefficiencies.

Marketing margins the spread between producer and world prices were reduced substantially after market reforms, reflecting the lower processing and marketing costs of a competitive private sector (Kherallah et al. 2002). This, in turn, has improved the transmission of world prices to farmers. As in most African countries, Ghana heavily taxed its major exports such as cocoa to finance its public expenditures (Herbst 1993). The revenue extraction had a varying effect on production, depending on global prices, marketing costs, explicit taxes on the sector, and macro conditions such as inflation and overvaluation of exchange rates.

ACCRA Jan 24 (Reuters) - Ghana's new government is pondering full liberalization of the cocoa sector in renewed efforts to significantly lift production above 1 million tonnes yearly, a minister designate said on Tuesday. The world's second largest cocoa producer with an average annual output of around 750,000 tons, only permits internal marketing of its beans with state-run regulator Cocobod as sole exporter. Liberalization is something that we'd look at as part of the measures that we'd want to take in order to increase cocoa production, OwusuAfriyieAkoto, nominated as agriculture minister told a parliamentary committee vetting him for the job.

Under the existing policy, Cocobod provides seed fund or money to the licensed private buyers to purchase cocoa from farmers on its behalf. It's a very conservative arrangement that we have for cocoa ... but definitely (liberalizing) it is something that is worth considering in our efforts to increase production," he said. Akoto, a former economic advisor at the London-based International Coffee Organization, said government would also invest heavily in cocoa pest control and fertilisation under a hi-tech programme.

2.8.Pre-harvest

Pre-harvest can be considered as the various activities on the farm or ranch that occur before crop or livestock products are harvested and sent to the market. Lack of good pre-harvest or cultural practices like diseases and pest control and farm sensitization can lead to great loss of post-harvest in cocoa and not only in cocoa but in the crop production. Pest and disease infestation is a primary causes of the major post-harvest losses of cocoa in the cocoa production or cocoa industry in Ghana.

A disease can be considered as a disorder that generally affects the functions and activities of a normal living thing. Some of these functions could be production, flowering, excretion and

other functions. Diseases can cause malfunctions to cocoa which can causes a lot of losses to the cocoa production. One renowned agriculturist Yaw Sarbeng brought to the notice of Agric Department some swellings on cocoa chupons (further upright suckers) of the trees. Some time being on, Dr Posnette in 1938's proved that the causal agent of the disease is virus. It usually affects the tree which result to the defoliation for the cocoa tree, reduction of yield and end up to the death of the plant.

The Virus of swollen shoot disease is very infectious and devastating which can easily diffuse in a very faster rate in the cocoa farm if not controlled and managed in the very early stage. If proper measured and care is not taken into consideration it can infest and destroy a whole farm within a short possible time within 18-24 months. The already mentioned diseases and activities in the pre-harvest stage contribute to pre-harvest losses and extends it to Post-harvest losses. There are two primary insect and pests of pre-harvest of cocoa, these are Capsid (Akate) and Bathycoeliathalassina (Atee) and Minor pest are stem borers and termites. These insect and pest suck the sap of the cocoa pods and sap of the stem of the cocoa plant which result in great deficiency of the cocoa beans and the cocoa plants.

2.9. Major causes of Post-harvest - losses of cocoa

Some of the major causes of the post- harvest are bad cultural practices in the pre-harvest stage like pest and disease control. Mirids, also known as capsids, are major pests that affect cocoa in Ghana which results in great post-harvest losses. These insects pierce the surface of cocoa stems, branches and pods using their needle-like mouthpart and also suck the sap of the cocoa tree. In the process of sucking, they inject toxic spit into the plant and this causes the dying of internal cocoa tissues. (Boateng, 2011).There are four species found on cocoa but the most common types found in Ghana are Distantiellatheobroma (black capsid) and Sahlbergellasingularis (brown capsid). Helopeltis species (cocoa mosquito) and Bryocoropsis species are less important, except in instances of occasional localized outbreaks. They attack crops from the establishment stage.Stem borers are now a very seriously and widespread pest in Ghana (Adu-Acheampong et al; 2001). They are considered to be an emerging pest of cocoa in Ghana. Losses from this insect are usually low but a high number can seriously affect yield and tree health. The shield bugs (Bathycoeliathalassina) are insects that feed on cocoa pods. They pierce the pod husk with their mouth parts and suck out the sap of the beans. As a result young pods turn yellow and then black, large pods stop growing and becomes yellow (Boateng, 2011). Seating in its sixteenth meeting of cocoa in Berlin in 2008,

Consultative Board on the World Cocoa Economy agreed that cocoa of merchant quality must be fermented, thoroughly dry, and free from smoky or broken beans, abnormal or foreign odours and any evidence of adulteration, reasonably uniform in size, reasonably free from broken beans, fragments and pieces of shell, and be virtually free from foreign matter. In Ghana, because of financial pressure on the farmers which force farmers to sell their produce and the fact that quality is not usually considered when buying and selling is done, usually end up post-harvest loss of coca in the country.

2.10. Post-harvest of other Agricultural crops in Ghana

Farmers that provide Seeds that have poor quality, inadequate farming practices, or insect attacks in the field can provoke losses of products even before their harvest. But we are concerned here only with prevention of losses after the harvest. From the harvest onward, then, the grain undergoes a series of operations during the course of which quantitative and qualitative losses can occur. The sequence of these operations and the conditions in which they take place can, furthermore, create physical and biochemical phenomena that will bring about an alteration of the grain at later stages in the post-harvest system. A late harvest, for example, can bring about losses from attacks by birds and other pests. Insufficient drying of grain can cause losses from the development of moulds and insects. Threshing can cause losses from broken grains and encourage the development of insects. Poor storage conditions can bring about losses caused by the combined action of moulds, insects, rodents and other pests. Transport conditions or defective packaging of grain can lead to quantitative losses of product. Finally, in addition to these factors, there are others which can often be partly responsible for post-harvest losses, such as, for example: marketing practices, sectoral policies and other socio-economic aspects.

Current world population is expected to reach 10.5 billion by 2050 (UN March, 2013), further adding to global food security concerns. This increase translates into 33% more human mouths to feed, with the greatest demand growth in the poor communities of the world. According to Alexandratos and Bruinsma (2012), food supplies would need to increase by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security. Post-harvest Food Loss (PHL) is

defined as measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest till its consumption or other end uses (De Lucia and Assennato,1994; Hodges, Buzby and Bennett, 2011). PHLs can occur either due to food waste or due to inadvertent losses along the way. Thus, food waste is the loss of edible food due to human action or inaction such as throwing away wilted produce, not 3 consuming available food before its expiry date, or taking serving sizes beyond one's ability to consume. Food loss on the other hand, is the inadvertent loss in food quantity because of infrastructure and management limitations of a given food value chain.

2.11. Post -harvest loses of cocoa in Neighbouring countries (cote D'ivore)

It is recorded that more than 80% of the contracts of cocoa purchased by Ivory Coasts' local cocoa shippers will not be executed due to failed speculations that prices would rise (IFC Markets, 2016). Local exporters also told industry regulator Le Conseil du Cafe-Cacao that they can't honour commercial agreements for about 350,000 metric tons of beans because after prices plunged due poor standard of beans, exporters can only ship about 50,000 tons. This resulted in serious decline of income generated for the country. Ivory Coast usually sells 80 percent of the bigger of two seasonal harvest before the season starts in October. Local exporters that purchased the cocoa while expecting getting on higher prices in future are now facing massive losses, due to the sharp decline of the price of cocoa and rejection of the cocoa beans prompting some of them to default on deals. Cocoa futures traded in London tumbled by more than one-third since reaching a six-year high in July, partly as traders forecast the global market would return to surplus. The defaults have meant that the regulator already had to re-auction 180,000 tons of cocoa, the person said. Because beans have to be re-sold ad different and at a very lower price, the CCC is now seeking compensation from exporters who couldn't fulfil their commercial agreements, according to a copy of a letter obtained by Bloomberg that was sent by the CCC to a buyer in recent weeks. Ivory Coast who is the current top producer faced a lot of post- harvest due to poor fermenting and drying method that are used. Ghana uses the natural sun drying method for drying beans but Ivory Coast uses fire drying method this really have some effects on the cocoa of the beans.

The controller needs to recuperate harms for as much as 100 billion CFA francs roughly USD162 million in misfortunes as beans are re-sold at lower costs. The misfortunes mean the CCC may need to tap an adjustment reserve that is put away in Ivorian financial balances and that is intended to alleviate value perils from the bartering. The sharp drop in costs could

likewise drive the controller to utilize cash kept at the Reserve Fund, put away with the Central Bank of West African States.

2.12. Post -harvest loses of cocoa in Brazil

According to the press release on August, 2014 about Brazil suffering from post-harvest losses, With all the plans, strategies and effort it takes to grow a food crop from seed for sale, it may be surprising that some farms in Brazil lose 10 to 12 percent of their yield at various points along the postharvest route. According to a University of Illinois agricultural economist, when it comes to meeting the needs of the world's growing population that's a lot of food falling through the cracks. Interestingly, farm managers who are aware of the factors that contribute to postharvest loses of cocoa are able to manage the situation. This was one of the findings in a study that examined how managers of large farms in the Brazilian state of Mato Grosso may be negatively affecting the efficiency of their own operations.

Clearly stated there are things that you can do to reduce loss–you can adopt good cultural practices, good harvesting methods and good fermenting and bagging methods. It appears that farm managers in Brazil actually allow loss to happen because the cost of reducing loss is greater than the benefits. Goldsmith said that one of the basic research questions of the ADM Institute for the Prevention of Postharvest Loss, which funded this study, is about why loss occurs. He said that although there are hundreds of articles about postharvest loss, no one is working with the farm managers to find out, from a managerial and organizational perspective, what drives this loss. There is a discrepancy between the reality of the postharvest loss and what the managers believe to be acceptable loss.

2.13. Post –harvest losses of cocoa and its Effects in Ghana

Ghanaian exports are being rejected at the European Union (EU) and United States (US) borders, due to non-compliance with international standards. The Swiss Ambassador to Ghana, H.E Mr. Andrea Semadeni, has revealed. (Masahudu, 2013). To address these, he called on the Ghanaian government to take swift pragmatic steps to remedy the situation, in order to be well-placed in the competitive international market. The Swiss Diplomat made this known at the signing of an agreement on improving sustainable value chains for exports from Ghana under the trade capacity building programme in Accra. How do the key actors in Ghana's cocoa sector define quality? (2)What is the state of cocoa bean quality in Ghana? (3) What are the institutional and socio-technical reasons underlying the cocoa bean quality

problem? (4) What institutional or policy options are likely to address the quality problem in Ghana's cocoa?

The study was based on two assumptions: (1) the quality of cocoa beans produced and exported depends on the actions and interactions of all the actors in the cocoa sector and (2) institutions shape the incentives for these actions and interactions.

Institutions are "he set of common habits, routines, established practices, rules or laws that regulate the relations and interactions between individuals and groups''. (NJAS, 2012).

The agriculture sector contributed 21 per cent to the country`s GDP in 2014, declining by one per cent from the 22 per cent of 2013 (Ghana business and finance, 2014).

The pattern of growth for each sub-sector under agriculture over the last five years suggests a gradual decline of the Crops and Cocoa sub-sector. This comes against the backdrop that the Crops sub-sector, which includes cocoa, was the largest contributor (74 per cent) to the agriculture sector's output in 2014. The sub-sector grew by 3.6 per cent last year against a targeted output of 5.8 per cent. Also, out of a total agricultural land area of about 14,038,224 hectares, only 7,847,300 hectares were recorded to be under cultivation as at 2012. (Ghana business and finance, 2014).

Generally, farming activities that deal with tilling and clearing of lands with ordinary implements and mechanised tools form the Crops and Cocoa sub-sector. The sub-sector is further sub-divided into Food Crops and Industrial or Cash Crops. Ghana`s Ministry of Food and Agriculture (MOFA) classifies the following as Food crops: (1) Starchy Roots and Tubers, including cassava, yam, cocoyam sweet potato, plantain; (2) Cereal, Staples and Legumes, including maize, rice (milled), millet, sorghum, wheat, beans; and (3) Fruits and Vegetables, including pineapple, citrus (orange, tangerine, etc.), banana, cashew, pawpaw, mangoes, tomato, pepper, okro, egg plants, onion, shallots, cabbage, carrot, cucumber, spinach, cauliflower, etc. (Ghana business and finance, 2014).

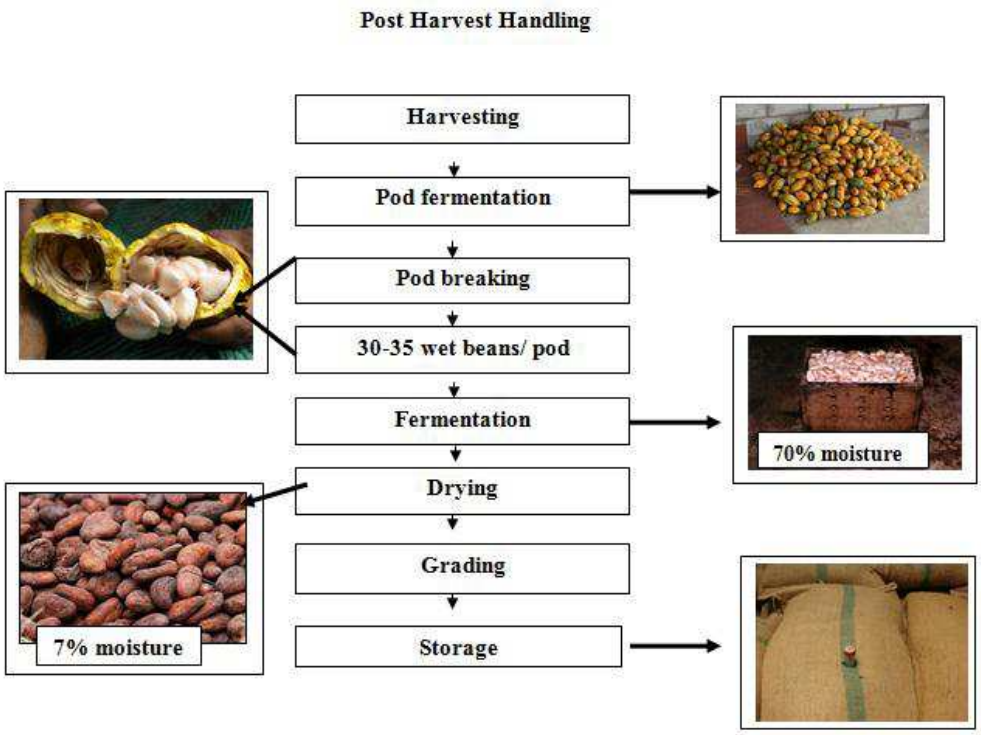

Figure 4. Post-harvest handling of cocoa

Sources: Cocoa production passes through various stages.

2.14. Occurrence of loses of in the Post- harvest handling process of cocoa

There are various activities and processes that the farmer goes through before the cocoa beans are sold to the government. The process is discussed as below.

2.14.1. Harvesting and gathering.

Pods containing cocoa beans grow from the trunk and branches of the cocoa tree. Harvesting involves manually removing or plucking ripe pods from the trees and opening. The pods are harvested manually by making a clean cut through the stalk with a well sharpened blade. For pods high on the tree, a pruning hook type of tool can be used, with a handle on the end of a long pole. By pushing or pulling according to the position of the fruit, the upper and lower blades of the tool enable the stalk to be cut cleanly without damaging the branch that bears it. (ICC, 2012). Cocoa pods are harvested regularly to prevent pods from becoming over-ripe. During harvesting, only ripe and matured pods are picked. Unripe pods cannot undergo the fermentation process, and over ripe pods also often become dry (Barclays Bank 1970).

Diseased and damaged pods are also discarded and not included in the harvest. The ripe pods are judged by their colour and are harvested using harvesting hooks. It is necessary to use sharp harvesting tools, in order not to cause damage to the cushions of the tree (Mikkelsen, 2010). Damaging the cushions serve as a potential point of entry for fungi. Care is taken when cutting the stem of the pod to avoid injuring the junction of the stem with the tree, as this is where future flowers and pods will emerge (Dand, 1999; wood and lass, 2001). While harvesting, the farmer may spread fungal diseases from 15 contamination by the hook or knife (Vos*et al.*, 2003). Also when pods are left too long on trees, beans start to germinate and this affects the quality and flavour of the cocoa after fermenting and drying. During this time farmer leaves some of the pods in the canopy of the trees due to oversight and sometimes difficult for plucking. Plucked pods are gathered a particular place where breaking of the pods can be done. In the process of gathering a number of pods are lost due to an oversight on the famers.

2.14.2. Pod breaking

Pods should not be opened more than six days after harvesting (Are and Gwynne-Jones, 1974; Mossu, 1992). Harvested pods should be kept for about three days before breaking. Pods are usually opened using a cutlass, however, care is taken in order not to cut beans since this affects their quality after fermenting and drying. During pod breaking, beans that are caked in pods, germinated beans and wet beans are sorted out and dried separately. Also placental materials are also removed.

Figure 5. Cracking pf pods.

Source: Chocolate and cacao cultivation and harvesting

The best way of opening the pods is to use a wooden club which, if it strikes the central area of the pod, causes it to split into two halves; it is then easy to remove the wet beans by hand. A cutting tool, such as a machete, is often used to split the pod, though this can damage the beans. Some machinery has been developed for pod opening, but smallholders in general carry out the process manually. After extraction from the pod, the beans undergo a fermentation and drying process before being bagged for delivery. (ICC, 2012). Sometimes some of the beans are not picked by the farmers from where the cracking is done and some of the beans are damaged from the cut of the machete that is used for braking of the pods.

2.14.3. Fermentation

Fermentation can be carried out in a variety of ways, but all methods depend on removing the beans from the pods and piling them together or in a box to allow micro-organisms to develop and initiate the fermentation of the pulp surrounding the beans. The piles are covered by banana leaves. (ICC, 2012)

The fermentation process begins with the growth of micro-organisms. In particular, yeasts grow on the pulp surrounding the beans. Insects, such as the *Drosophila melanogaster* or vinegar-fly, are probably responsible for the transfer of micro-organisms to the heaps of beans. The yeasts convert the sugars in the pulp surrounding the beans to ethanol. Bacteria then start to oxidise the ethanol to acetic acid and then to carbon dioxide and water, producing more heat and raising the temperature.

The pulp starts to break down and drain away during the second day. In anaerobic conditions, the alcohol converts to lactic acid but, as the acetic acid more actively oxidises the alcohol to acetic acid, conditions become more aerobic and halt the activity of lactic acid. The temperature is raised to 40ºC - 45ºC during the first 48 hours of fermentation.

In the remaining days, bacterial activity continues under increasing aeration conditions, as the pulp drains away and the temperature is maintained. The process of turning or mixing the beans increases aeration and consequently bacterial activity. The acetic acid and high temperatures kill the cocoa bean by the second day. The death of the bean causes cell walls to break down and previously segregated substances to mix. This allows complex chemical changes to take place in the bean such as enzyme activity, oxidation and the breakdown of proteins into amino acids. These chemical reactions cause the chocolate flavour and colour to

develop. The length of fermentation varies depending on the bean type, Forastero beans require about 5 days and Criollo beans 2-3 days (ICC, 2012).

Basket fermentation is usually used when beans are in smaller volumes. Before the fermentation begins, the sides of the basket are lined with banana leaves, but the bottom remains uncovered to let the sweating drain away easily. The basket is mounted on a board. Beans are then poured into the basket and covered with banana leaves. Short sticks are placed on the leaves to support them and hold them in place.

Heap fermentation is mostly used by farmers because it is a cheap method that produces well fermented beans, when it is done properly (Are & Gwynne-Jones, 1974). With this method, short sticks are arranged in a circular form on the ground with banana leaves placed on them to overlap each other. The sticks are used to raise the centre to enhance easy drainage of the sweating. Beans are poured in the centre and covered with banana leaves. This is supported by placing short sticks on them from behind. Tray fermentation is done by arranging the trays in stack on a slab.

The bottom tray is placed on a slab to avoid the ground absorbing the produced heat, to allow the sweating to drain away, and to promote air circulation. The trays are stacked in piles, 3 - 12 trays high since less than three trays will not produce enough heat. The top tray is covered with banana leaves and supported with short sticks placed on them. No turning is done with this fermentation method and beans are fermented for five days. 17

Finally, with the box fermentation method, boxes are arranged in a form of tiers (3 tiers). The beans to be fermented is put in the uppermost box and covered with banana leaves with pieces of wood placed on them to hold them in place. After two days of fermentation, the beans is scraped into the second box in a horizontal pattern and covered again with banana leaves. On the fourth day, beans are scraped again into the third box which is the last box in a vertical pattern and covered. On the sixth day, beans are sun dried.

Figure 6. Heaped fresh Bean before fermentation

Figure 7.Heap Fermentation

Figure 8. Box fermentation.

Source:we are running out of chocolate byJuliet Bray

2.14.4. Drying

Cocoa beans are dried after fermentation in order to reduce the moisture content from about 60% to about 7.5%. Drying must be carried out carefully to ensure that off-flavorous are not developed. Drying should take place slowly. If the beans are dried too quickly some of the chemical reactions started in the fermentation process are not allowed to complete their work and the beans are acidic, with a bitter flavour. However, if the drying is too slow, moulds and off flavours can develop. Various research studies indicate that bean temperatures during drying should not exceed 65ºC.

There are two methods for drying beans - sun drying and artificial drying.

Figure 9. Farmer drying cocoa using the sun drying method

Source: European commission, Villagers drying cocoa

Well dried beans will crack easily when squeezed between the fingers and can easily be cut with a knife (Amoa-Awua*et al*., 2006). Methods of drying cocoa beans are usually either by sun-drying or artificial drying. Sun drying is the natural means of drying beans in the sun on raffia mats. It is simple and cheap but it is also labour-intensive and there is much concern for a stable weather condition. The mats are placed on a raised platform to protect the cocoa beans against animals and foreign materials. There is also the frequent stirring of beans on mat to facilitate drying. At night and whenever the rain comes, the mats should be rolled up (Areand Gwynne-Jones, 1974: Mossu, 1992). Artificial dryers include the use of ovens in drying cocoa beans. The beans are spread in trays, allowing the air to permeate through a ladder system (Mossu, 1992). Using this method, it is very important that the cocoa beans are not contaminated with smoke fromthe fire, since dry beans easily absorb flavours and aromas from the environment (Barclays Bank, 1970). During the drying process most of the famers uses old and loose drying mat which the beans drain and most farmers do not pic them

2.14.5. Bagging

After cocoa is tried and before it can be transported the cocoa should be bagged. Transport of bagged cargo in ventilated containers (cocoa containers) is possible subject to compliance with lower limits for the water content of goods, packaging and flooring. The wooden flooring of the containers must be absolutely clean and dry. If it has been washed, it must

have dried completely. Water content should be 12%, corresponding to a lumber equilibrium moisture content of 70%, so that the flooring does not constitute an additional source of water vapour to dampen the cocoa cargo and container atmosphere. The cargo may be covered with paper which readily absorbs any moisture to provide protection from moisture damage. Given the high value of a fully loaded cocoa container, a two-layer anti-condensation film or nonwoven should be used to provide protection against dripping sweat. (TIS, 2017).

Figure 10. Bagging and packaging.

Figure 11. Bagging and loading of cocoa at the Port

Sources: Travel in the Ghanaian Cocoa bagging. Pictured by Umberto.

Some of the beans are left up picked during the backing process and this contribute to the loss of the cocoa.

2.14.6. Storage

After the beans have been completely and well dried, they are bagged and stored in jute sacks under favourable weather conditions. Old sacks are usually not used because of the weevil attack. Beans are then transported to individual buyers or buying companies.

Quality of dry cocoa beans in international trade is assessed on the percentage level of total mould, slaty, purple, insect infested, flat, and germinated beans. Recent cocoa trade has assumed a scientific dimension and emphasis is placed on the content of free fatty acids (FFA) which is influenced by many factors such as humidity, oxygen and insect infestation. For these reasons hermetic storage has been considered as a successful storage method for the management of FFA, insect control and quality preservation. Ghana is the world's second biggest producer of cocoa *Theobroma cacao* L. after neighbouring Côte d'Ivoire (Sarpong, 2002). Under the climatic conditions of these countries, output is sometimes affected

significantly by infestation. Infestation of dry cocoa beans in the post –harvest sector starts from the drying mats and continues during storage. At the farm, insects in drying mats are an important source of infestation. At the end of the season they are usually rolled up and stored under the eaves but they often carry pupae from which *Ephestiacautella* (Walker) may emerge to infest the new crop. Similarly, the area around mechanical dryers can provide a breeding ground for pests (Wood and Lass 1985, Jonfia-Essien, 2004). This incidence of pests is a worldwide phenomenon which cannot be completely eradicated but can be curbed through pragmatic measures. Unless storage is properly carried out there is a risk of dry cocoa beans becoming damaged from insect infestation, mould and foreign odours (Jonfia-Essien, 200).

3. Research methods

The study has been designed to provide empirical evidence that will form the basis of a certification system for Ghana's cocoa sector. The survey shall conducted with a relatively in some of the cocoa growing districts in the country. A quantitative (statistical) survey was designed to enable the estimation of the post-harvest loses in the cocoa production in Ghana. The data requirements for the above tasks were obtained from both primary and secondary sources. Descriptive statistics were used to explain the data collected, and data analysis was done using excel.

The research was carried in carried out in the Ghana and the survey was conducted in selected growing farm areas in the Western, Eastern, Ashanti and part of the BrongAhafo where the large portion of the cocoa is grown.

The farmer fields selected included fields from SefwiDebiso, SefwiAsawinso cocoa District, Goaso Cococa District Nyinahin Cocoa district, Kwasiaku, Bosomponso No.1 Mampong-Akuapem and Adonkwanta.

Cocoa stations or cocoa seed production farms at SefwiBoako, Goaso, Bunso were visited. Different forms field work was to find out some of the causes of post-harvest loses on the farm and in the cocoa sheds, physical, chemical, biochemical and physicochemical analysis were also performed on the dried cocoa beans. The various experiments conducted will described in this chapter and discussed in the next chapter. Various farms site of the selected areas will be visited and the process and ways of gathering information will be described as bellow. A total number of thirty (30) questionnaires were administered to farmers in selected which includes fields from SefwiDebiso, SefwiAsawinso cocoa District, GoasoCococa District Nyinahin Cocoa district, Kwasiaku, Bosomponso No.1 Mampong-Akuapem and Adonkwanta. Cocoa stations and cocoa seed production units at SefwiBoako, Goaso, Bunso were visited for information of seed production and good cocoa farm cultural practices

The questionnaires administered were to find out the causes of postharvest losses in cocoa production sector. Field work and experiments were conducted to find out the causes of loses cocoa of cocoa beans in the farm and outside the farm (Shed and deport).

3.1. Determination of postharvest losses in cocoa from harvest point (farm)

3.1.1. Determination of postharvest losses of cocoa

Determination of postharvest losses of cocoa caused by inadequate practicing of good agricultural practices. Spraying to insects and pest, Control of black pods fungi disease and control mistletoe.

Three farms were selected at SefwiAsawinso, One of the farms is a farm that the farmer follows the cultural practices very well, the other farm is a farm that the farmer do follow the good cultural practices but do not control and manage mistletoe and do not apply fertilizer. The last farm, the farmer does not do most of the cultural practices.

The farms were named in alphabetical order.

Farm A,B,C.

Farmers were informed about this experiment and observations.

On the day of cracking of pods, in each of the farms, 100 pods were selected from the total pods ready for cracking. The 100 pods were cracked and observations were made.

Observations

It was observed that,

- ✓ Farm (A) of which the farmer follows all the good cultural practices, had a healthy cocoa pods and beans and cracking of the beans was easy.
- ✓ It was observed again that Farm (A) cocoa beans has a lot of moisture and fresh beans which indicates healthy cocoa beans.
- ✓ Farm (B) which the farmer practice most of the cultural practice but not all, it was observed that most of the beans were healthy and cracking of the pods was easy but not as easy as that if the Farm (A).
- ✓ It was observed that about 10 pods were have flat beans and some stacked beans in the pods.
- ✓ Farm C of which the farmer do not practice most of the cultural practices, Out of the 100 pods only 25 pods were healthy pods as compared to the healthy pods of Farm A and B.
- ✓ Remaining 75 pods were unhealthy pods and beans. Most of the beans were stacked in the pods, and flat.

500 pods at each harvest on each farm were selected, recorded and the quantity of good and healthy cocoa pods were separated from the bad pods (Fungi infected or black pods, capsid infected pods, rodents eaten or damaged pods). 500 hundreds healthy pods were selected and another 500 hundred unhealthy pods were also selected. Both healthy and unhealthy pods

were cracked separately. The good beans obtained from the good pods were weighed and the wet weight determined (50.8kg) same thing as that of the unhealthy and damaged pods (43.3kg). Beans were fermented for six days by using the heap method of fermentation. After the six days beans were taking the mat for sun dried. The cocoa beans were sun dried for about 10 days since the experiment was conducted in December and it was in the dry season we had enough sunshine for the dryness of the cocoa. The dried beans of both healthy beans and unhealthy beans were weighed separately and the dry weight determined after which beans were bagged and sold. The healthy cocoa beans weighed 25'24 kg whiles the unhealthy weighed 12.7kg.

Observation

- ✓ Healthy dried cocoa beans weighed 25.24 kg
- ✓ Unhealthy dried cocoa beans weighed 12.7 kg
- ✓ Wet healthy cocoa beans weighed 50.8kg
- ✓ Wet unhealthy cocoa beans weighed 43.3kg.

3.1.2. Determination of postharvest losses in cocoa based on gathering after harvesting

Five farms were selected due to how close they were. These five farms were visited after harvesting and gathering were done. Myself and a friend walk through these farms and each farm cocoa pods there picked were tabulated, see table 3.

3.1.3. Determination of postharvest losses in cocoa based on the number of days of fermentation

Activity

This experiment was performed in my mother's cocoa farm.

The total weight of beans used was 100kg each and the specimen were labelled A, B, C and D accordingly. The heaping method of fermentation was used. Each heap was created by arranging leaves of banana on the ground closely in a circular pattern. Short sticks were also arranged underneath the banana leaves but in the centre to raise the heap to facilitate easy drainage of the sweating. Each heap was filled with cocoa beans which weighed 100kg and beans were poured in the centre of each heap and covered very well to prevent the entry of air. The heaps were covered with banana leaves and short sticks were also placed on the heap after covering to prevent the heap from opening up thereby allowing the entry of air. In order to maintain the temperature and also to enable beans ferment properly, beans were turned on

the second day of fermentation and covered again. Fermentation was done for 3, 4, 6 and 7 days and on each of these days, a heap of beans was sun dried on a raffia mat.

Observations

- ✓ Cocoa beans with three (3) days of fermentation were having deep violet colour.
- ✓ Cocoa beans with four (4) days of fermentation were having light deep violet colour.

3.1.4. Determination of Post -harvest based on the drying of cocoa beans

Same five farms were selected as done in field work.3. Six (6) different farmers were visited during drying period. Drying mat of the age of 5-10 years were selected from farms. During the time of drying inspections were made. Beans that fell from each mat were collected in each day of drying. Drying mat were labelled A- F. All the fallen beans from each mat were kept in a sack and labelled with the respect with letters A-F from where it was collected. This experiment was done in four different farms.

Three days visit were made to the farmer in the drying process after the muddy or the juicy part of the beans were gone and as the beans started talking on the mat. At the end of every evening after the cocoa beans on the drying mat is covered, Cocoa beans that falls under the mat is gathered and kept. At the end of the drying period when all the beans gathered were weighed and the recorded weight in each farm are tabulated see table 3.

3.1.5. Physical Cut Test

Activity

The cut test was performed by collecting dried cocoa beans, 50 fifty dried cocoa beans were randomly taken form 6 farmers' fields, the farms were labelled A-F and farm F was farm selected that the farmer intensively practice all the cultural practices and based on the modern system of cocoa farming.. For the cut test determination 300 beans were used. The beans were cut lengthwise through the middle in order to show the cut surface of cotyledons. Halves of each bean were visually examined in daylight. Beans were categorized into the following: mouldy, germinated, slaty, purple, weevil, other defects, total mouldy, total slaty, total purple, all other defects and tolerance level. Each defective bean was counted separately, and the result for each kind of defect was expressed as a percentage of the 300 beans examined.

3.1.6. PH determination

The pH of the number of day's fermented cocoa was determined by taking samples on dried cocoa beans and these included samples from sample obtained from the dried cocoa beans from day 3, 4, 6, and 7. About 70g of dried cocoa beans was weighed from each sample. Each of these beans was peeled, blended and bagged using different sample bags. Ten grams (10g) of each blended sample was put in different conical flasks and 90ml of boiling distilled water added. Samples were allowed to cool in a cold room to a temperature of about 20ºC and the pH readings were taken using the pH meter. Each sample was replicated three times.

3.1.6.1.Free fatty acids determination

Fat was extracted from the cocoa bean samples with petroleum ether (60ºC -80 ºC) using a Soxhlet apparatus. Melted fat samples (5g) were weighed into a 250ml conical flask and 25ml of Diethyl Ether added to the weighed sample. The sample was swirled to mix and titrated against 0.1M KOH with phenolphthalein as indicator till a faint pink colour was obtained.

3.1.6.2.Proteins determination

This determination was done using the Kjeldahl method. Three stages were involved: digestion, neutralization and titration stage. Each of the blended cocoa samples (0.5g) to be analysed was weighed into a digestion flask and 0.5g of the catalyst (a mixture of 0.2g Selenium + 5g K2SO4 + 1g Cuso4) added. Sulphuric acid (12ml) was added to the sample and digested in a digester at a temperature of 350ºC for at least two hours under a fume chamber until a clear solution is obtained. The solution was allowed to cool and the digested sample was transferred into a conical flask and 5ml of 40% sodium hydroxide
34 added. The ammonia in the resulting solution is distilled off into a conical flask containing 20ml of 2% boric acid solution. The resulting solution was then titrated against sulphuric acid using methylene blue and methyl red as indicators until a purple colour was obtained.

3.2.Determination of postharvest losses in cocoa from purchasing point

Activity

Five (5) towns were randomly selected in the selected districts each. Four (4) cocoa purchasing clerk depot were randomly selected in each of the five (5) towns selected. The depots were visited immediately after cocoa were loaded to the district depot. Cocoa left over that are not picked are gathered and weighed and kept in a conducive place. This activity was performed repeatedly in each time cocoa was loaded to the depot for one month.

Observations

It was observed that at the end of the one month period the cocoa gathered in each of the depot are stated as follows.

Table 1. Results of cocoa lose at the shed

Town	Depot	Cocoa weighed First week(kg)	Cocoa weighed Second week (kg)	Total (Kg)
Adabokrom	**Depot A**	2.8	3.72	**6.52**
	Depot B	5.33	2. 31	**7.64**
	Depot C	4.21	4.54	**8.75**
	Depot D	4.13	5.14	**9.27**
			Total	***32.18***
Nyinahin	**Depot A**	3.12	3.11	**6.23**
	Depot B	3.10	4.00	**7.10**
	Depot C	2.11	3.00	**5.11**
	Depot D	3.09	3.232	**6.23**
			Total	**24.67**
Bunso	**Depot A**	5.00	4.81	**9.81**
	Depot B	3.61	2.21	**5.82**
	Depot C	3.11	2.20	**5.33**
	Depot D	3.23	3.22	**6.45**
			Total	**27.41**
Sefwiwiawso				
	Depot A	2.31	6.30	**8.61**
	Depot B	5.00	5.23	**10.23**
	Depot C	4.11	2.34	**6.45**
	Depot D	3.11	5.21	**8.32**
			Total	**33.52**
SefwiBoako	**Depot A**	4.07	7.23	**11.30**
	Depot B	3.22	3.23	**6.45**
	Depot C	4.77	4.21	**8.98**
	Depot D	2.11	2.03	**4.14**
			Total	**30.87**
			Total	**143.38.**

3.3.Determination of postharvest losses in cocoa at the shipping depot point

Activity

Two (2) depots were randomly selected in the selected depot in the Tama main port in Ghana each. The depots were visited immediately after cocoa were loaded to the ship for export. Cocoa beans left over in the depot are not picked, are gathered and weighed and kept in a conducive place. This activity was performed repeatedly in each cocoa depot for two months.

Table 2. Results of loss of cocoa beans at the Harbour

Month	Depot A (Weighed in Kg)	Depot B (Weighed in Kg)
1	73.4	68.3
2	54.92	67.44
Total	128.32	135.74

4. Analysis and Discussion

This chapter presents results and the discussion of the responses given by the farmers in the selected districts in the Western, Eastern, Ashante and BrongAhafo region on the sources, causes and extent of postharvest losses in the cocoa production system. It also presents results obtained from the field to depot on the determination of postharvest losses in cocoa (in both CRIG and farmer fields) after harvest to the depot. Results of the various experiments conducted were discussed in this chapter. Cut test results on the quality of beans produced are also presented.

4.1.Determination of postharvest losses of cocoa from harvest point (farm)

Observation

From the experiment conducted these results were recorded and explained as below.

- ✓ Healthy dried cocoa beans weighed 25.24 kg
- ✓ Unhealthy dried cocoa beans weighed 12.7 kg
- ✓ Wet healthy cocoa beans weighed 50.8kg
- ✓ Wet unhealthy cocoa beans weighed 43.3kg.

It was observed that the healthy pods weighed twice more than that of the unhealthy pods, which is a clear indication that farmers are losing twice of each bag of cocoa they get from the farm with their unhealthy beans.

After the drying of the 500 pods of healthy cocoa pods it weighed 25’24 kg whiles the unhealthy weighed 12.7kg. It is getting twice that of the healthy ones.

If it happens the farmers get all the pods to be healthy, every single bag of cocoa that they (farmers) harvest will be doubled for them. This really indicates that the farmers are losing a lot of bags of cocoa within the harvesting period which is caused by not following the good cultural practises. Famers harvest most of their pods in not healthy condition. It can be estimated that if the country produce 77000 tonnes in a year, half of this number of tones is lost by the country because of not following good cultural practices. Ghana farmers, are losing high tons of cocoa within a production year. Famers loose most of their beans to black pods and capsid.

4.2.Determination of postharvest losses in cocoa based on gathering after harvesting

Five farms were selected due to how close they were. These five farms were visited after harvesting and gathering were done. I and a friend walk through these farms and each farm cocoa pods there selected and recorded as shown in the table 3.

Table 3. Postharvest losses in cocoa based on gathering after harvesting

FARM	PODS PICKED
A	202
B	178
C	300
D	415
C	314
TOTAL	**1409**

It was observed that most farmers leave most of the pods on their farm due to oversight when picking pods in the farm. This kind of oversight causes a lot of post-harvest loses in the farm. At the end of the field work conducted the total number of pods gathered was 1409 which can be more that a bag of cocoa beans when dried. This shows that farmers lose some quantity of cocoa during the harvest. Farms that have high level of dead leaves on the floor, the cocoa pods hide in the dead leaves and farmers find it difficult to see them to handpick them. Farmers should be extra vigilant when it comes to gathering of pods in the farm.

According to the Ghana cocoa cocobod 1000 healthy pods of cocoa should provide a bag of cocoa. So if only five farms can provide 1409 pods without picking them in their farms and the district consist of about five thousand farmers and if averagely every farmer leaves 150 pods in his farm without picking them due to oversight it means in every harvest cocoa pods that are left on the farm without picking them is 750000 pods which is equal to 750 bags of cocoa are left in the farms of farmers only at the SefwiWawso district and this kind of lost is only at one harvest. This really shows that farmer’s government and the world in generals is losing high volumes of cocoa every season.

4.3.Determination of postharvest losses effects of days on fermentation

It was observed that after drying of the cocoa for four days, the flat and caked beans were weighed. The weight obtained was 10.7kg and that of the healthy beans was also weighed. The weight for the healthy beans 35.73kg. Even though the number of pods selected was almost the same but the weight difference was too huge. This is an indication that cocoa that are flat, caked lose a lot of weight.

Table 4. Determination of postharvest losses effects of days on fermentation

Time	Protein (%)	FFA (%)	Polyphenol(mg/g)	Carbohydrate(mg/g)	pH
Day 3	15.56	0.51	36.64	54.3	4.75
Day 4	15.33	0.50	50.61	33.32	5.10
Day 6	15.21	0.49	52.33	31.42	5.22
Day 7	15.10	0.87	38.34	30.34	5.62

Effect of time (days) of fermentation on various quality parameters of cocoa. From Table 2, as the days of fermentation increased, the protein content reduced. Fermenting beans for 7 days produced higher (0.96%) free fatty acids (FFA) and less (28.07mg/g) carbohydrate content. Comparing the days of fermentation, fermenting beans for 6 days had the highest (52.97 mg/g) polyphenol content. There were significant differences in pH between all the days of fermentation.

From the results obtained from the experiment conducted to find the effect of number of days of fermentation on the cocoa beans. The results indicated that there was not a significance difference in the protein content and the number of days of fermentation.

According to Biehl*et al.,* (1982); and Spencer and Hodge (1992), who reported Protein content of ranges between 15-20% in dried cocoa beans. Protein content in the caked beans was significantly higher than that of the healthy beans. Although caked beans are considered bad beans, some farmers tend to mix their good cocoa beans with caked beans to increase weight and increase their income. Caked and flat beans are considered as bad beans at the world market so farmers are encouraged to produce quality beans.

This result corroborates with earlier works that as fermentation time increased, total protein concentration decreased (Adeyeye*et al.,* (2010); De Brito *et al*., (2000); Hashim, *et al.,* (1998)). In the experiment conducted, the protein content in beans ranged between 13.5% - 20%. Even though caked beans are considered bad beans, they fell within this range.

However, contrary to the results obtained in this study, Aremu*et al*. (1995) reported a significant increase in bean protein content by the sixth day of fermentation. The number of days can have changes on the pH, the carbohydrate, free fatty acids and other important ingredient in the cocoa beans which can effects on the quality of the cocoa, but the approved and required days for fermentation by the Ghana cocobod is five (5) to Six (6) days. Despite these approved days some farmer cannot endure for that six days due to economic reason within three (3) days they take the beans from the fermentation site and send it for drying and same way they do not dry the cocoa and send it to the purchasing clerk and sell.

This result high content of cocoa beans being moulded what it stored for some few days at the cocoa shed which sometimes the government rejects this type of beans and it is not sent to the shed. In this way some buying companies pre-finance the farmers to go by the approved number of days for fermentation and drying to help get quality cocoa beans for sale.

4.4.Determination of Post –harvest loses based on the drying of cocoa beans

Same 6 farms were selected as done in experiment 3.Three days visit were made to the farmer in the drying process after the muddy or the juicy part of the beans were gone and as the beans started talking on the mat. At the end of every evening after the cocoa beans on the drying mat is covered, Cocoa beans that falls under the mat is gathered and kept.

At the end of the drying period when all the beans gathered were weighed and the recorded weight in each farm are tabulated as below. When days visit was made for three days after the cocoa start talking on the drying mat, cocoa gathered under the mat was 24.2kg which was too high for farmers to recorded that number just for drying. Some farmers have time to hand pick the drained beans whiles others do not have time to pick them they see the drained beans as not being much. Farmers should be educated about all these lose and how much it is costing them.

Table 5. Determination of Post –harvest loses based on the drying of cocoa beans

FARM	GATHERED BEANS (KG)
A	6
B	4.8
C	5.5
D	4.5
C	3.4
TOTAL	24.2

Only six farmers contacted, the total loss of beans recorded was 24.4kg and if thousands of farmers do not take drained beans into consideration, farmers and the state is losing thousand and tons of cocoa every year. It can be estimated 1000 of bags of cocoa can be lost only at the drying point of cocoa post-harvest process.

4.5.Physical Cut Test

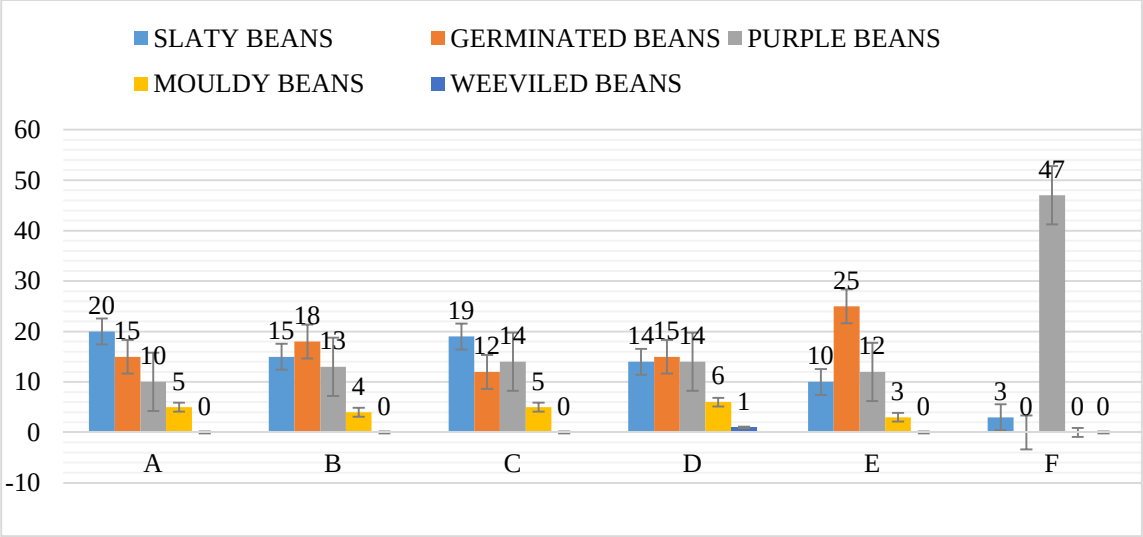

Figure 12. Physical Cut Test

From the results obtained from the experiment of the physical test of dried cocoa beans, it was observed that in farm A where the farmer use to apply some chemicals but in the adequate level recorded 20 seeds to be slaty beans, 15 beans germinated 10 being purple beans 5 beans being mouldy beans and no weevil beans was recorded. Farm E recorded the highest number of germinated beans this indicated the farmer lacked good and appropriate good cultural practices in the farm. Farm F recorded only 3 weevil beans and 47 purple which is indication of healthy beans and no recordings for slaty, germinated and mouldy beans. This is clear indication that when farmers follow and pay heed to all the good cultural practices it will be very helpful to farmers and the state in general.

Results obtained from the experiment clearly indicate that old drying mat causes post-harvest loses of cocoa in the farm. It was observed that drying mats that has the old age recorded the highest loss of cocoa beans, old drying mats develop large holes or spaces in them due the weakening of the string that is used for the waving of the drying mat. In Farm .A. 10.3kg of cocoa beans were picked gathered for the total number of days after the cocoa started talking on the mat, 8.9kg of beans was recorded in farm .B. as the lost beans, 11.1kg of beans was recorded in farm C.9.3kg in farm .D. 7.4kg in farm .E. and 7.3kg in farm .F. with the mat is eight (8) years old. It was observed that the higher the age of the mate the higher the loss

recorded. There was an indication that most farmers were using old type of mat which really shows that the farmers are losing high volumes of cocoa at the drying point. Since in Ghana, farmers use the natural heat from the sun for the drying cocoa beans the farmers have no option but the option is the farmers should be educated to maintain their drying mat to manage the situation.

4.6.PH determination

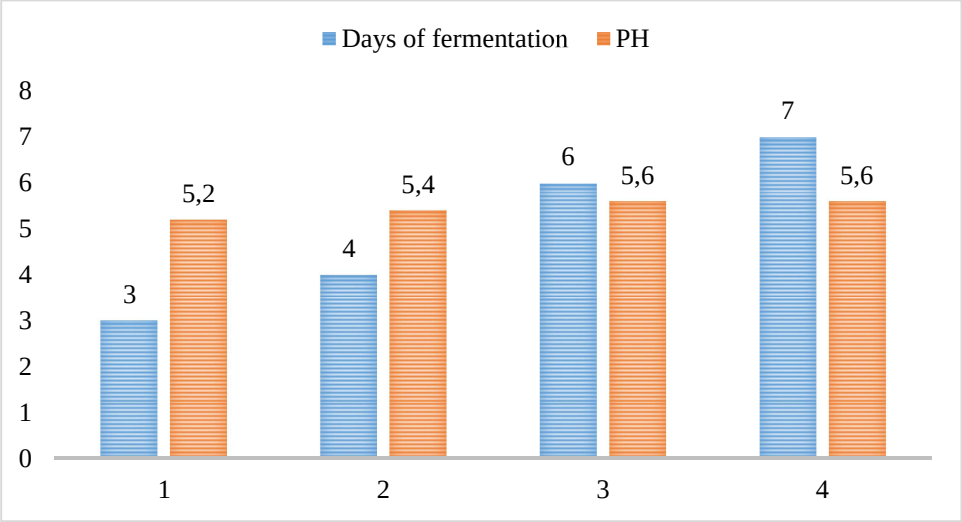

Figure 13. PH determination.

It was observed there was not a sharp or significance differences between the PH of cocoa beans and the number of days of fermentation.

4.7.Determination of postharvest losses in cocoa from purchasing point

This experiment was conducted to look at the lost post-harvest loses that occur at the purchasing clerk centres. It was observed that high amount or volumes of is left at the depot without taking it into consideration. It was observed that, at Adabokrom after the first loading of cocoa from the purchasing clerk centre to the district cocoa depot, total amount 32.18 kg was gathered and that was cocoa lost in the five selected centres within a month. Those beans were considered as lost beans. At Nyinahin which was the second town visited total amount of cocoa gathered was 24.67kg meaning this amount of cocoa was not sent to the depot and is considered lost. At SefwiWiawsototal cocoa gathered after loading was 33.52 kg.

At SefwiBoako total cocoa gathered was 30.87 kg. At the end of the experiment the total amount of cocoa gathered was 143.38 kg which is 2 bags and20 kg. Total number of purchasing clerks recorded in these selected towns were 700 purchasing depot.

Mathematically,

25 centres---------- 143.38 kg

700 centres ----------x kg

$$\frac{700 \times 143.38}{25}$$

= 4014.64 kg.

4014.64 kg is equal to 64.752 bags and equivalent to 4.425 tons of cocoa within one single month only on left overs that occurred at the purchasing clerks centres. It was recorded that there are about 28 licensed cocoa buying companies in Ghana.

The table below show the shows the list of the buying

Table 6. List of the of cocoa buying companies

S/N	Company	Society /Purchasing Centre (Estimation)	Districts (Estimated)
1	Produce Buying Company Ltd.	5000	97
2	Olam Ghana Ltd	4000	90
3	AkuafoAdamfo Marketing Co. Ltd	4500	90
4	Adwumapa Buyers Limite	4500	89
5	KuapaKokoo Ltd	4000	87
6	Federated Commodities Ltd.	4200	94
7	Armajaro Ghana Limited	4200	94
8	Transroyal Ghana Ltd	4100	93
9	Cocoa Merchants Ghana Ltd	3500	87
10	Dio Jean Company Ltd	3300	79
11	SompaKokoo Company Ltd	2300	80
12	Royal Commodities Ltd	3200	80
13	Sika Aba Buyers Ltd	3100	87
14	Fereday Company Ltd	3000	87
15	Diaby Company Ltd	3400	90
16	Ghana Co-operative Marketing Ltd	2800	81
17	Evadox Ltd	2700	80
18	Allied Commodities Ltd	3000	83
19	Farmers Alliance Ltd.	2000	78
20	Duapa Buyers Company Ltd	3700	89
21	Mapie Enterprise	2300	82
22	Yayra Glover Limited	2300	82
23	Abapa Golden Ltd	3200	83
24	CDH Commodities Ltd	3200	83
25	Aboafo Buyers Company Ltd	2800	80
26	Universal	2800	80
27	Blossom Export Co. Ltd	2800	80
28	Alhaji Sulemana	2800	80
	Total.	**92700**	

Source: Ghana cocoabod.

This indicates that there are high tons of cocoa beans that get lost only at the purchasing centres which is also known as societies.

Mathematically,

If 700 societies or centres ---------- 4014.64 kg

92700 societies or centres ----------x?

$$= \frac{92700 \times 4014.64}{700}$$

==531653.04 kg.

It means we lose Eight thousand five hundred and seventy five point Zero five (8575.05) bags of cocoa every month at only the purchasing centres. This number of bags is equivalent to 586.04 tons of cocoa. This is the estimated number of cocoa that will be lost within a single month of loading when proper checks are not done. Relating it into monetary terms Ghana lose four million two hundred and eighty seven thousand, five hundred and twenty five Ghana cedis (GhȻ 4,287,525) which is equivalent to one hundred and seven million, one hundred and eighty eight thousand and one point 25 dollars. ($107,1881,25).

Key.

62 Kg ---------- I bag of cocoa.

907.185 kg…… 1 Tonnes.

The amount of cocoa that is lost at the point of purchasing is also huge. Purchasing clerks do not take into consideration the beans that is left at their shed, from the experiment that was conducted, it was estimated that at the end of the season 586 tons of cocoa is lost in that season which is huge volume of cocoa lost. Purchasing clerks do not know the amount of cocoa that they are losing just because they are not taking into consideration. It was observed that the purchasing clerks has no idea about what they lose whenever load trucks of cocoa to be sent to the district offices depot. When the purchasing clerks were asked why they are not managing this losses, the response that was made was that we cannot send cocoa control

100% manage all the lost at least some of the beans will be remained at the shed. We see it to be time wasting for us to sweep all these beans all the time. The Ghana cocoa bod should made it clear to the various licensing companies to educate their purchasing clerks to curb the situation.

It was estimated ninety two thousand seven hundred (92700) purchasing clerks are in Ghana, if all these people are educated to know that none of the beans should be considered small non important and they have to treat every single with equal importance, Ghana is going to regain about tens of thousands tons of cocoa every year. This should be applied to the various district offices and the various depots at the port. If the managers are educated, to manage and treat every single with equal importance Ghana can increase about 2% of its cocoa production with a year.

4.8.Determination of postharvest losses in cocoa at the shipping depot point

Two (2) depots were selected at Tema harbour where the shipment of cocoa is done. The two depot that were selected were named A and B respectively.

At the end of the first gathering that was made, total of 73.2 kg at the Depot A after all the cocoa was evacuated for shipment. At Depot B total of 68.3 kg was gathered. So in one loading trench total amount of 141.7 kg of cocoa is lost. I was informed that there are about 75 of such depot in Ghana and if two is giving us this figure of 141.7 kg of cocoa that is lost after loading cocoa then averagely the estimated cocoa of lost after each loading is 5315.75 kg which is equivalent to 85 bags of cocoa which is equivalent to 5.856 tonnes of cocoa is lost by the government in each trench of loading made at the various depot at the harbours.

If 10 loadings are made at the cocoa season it means the government loses 50.56 tonnes of cocoa within a single season this really indicates that Ghana is losing a lot of cocoa at the various depots.

4.9.Type of labour used for postharvest activities in the cocoa production of the farmer

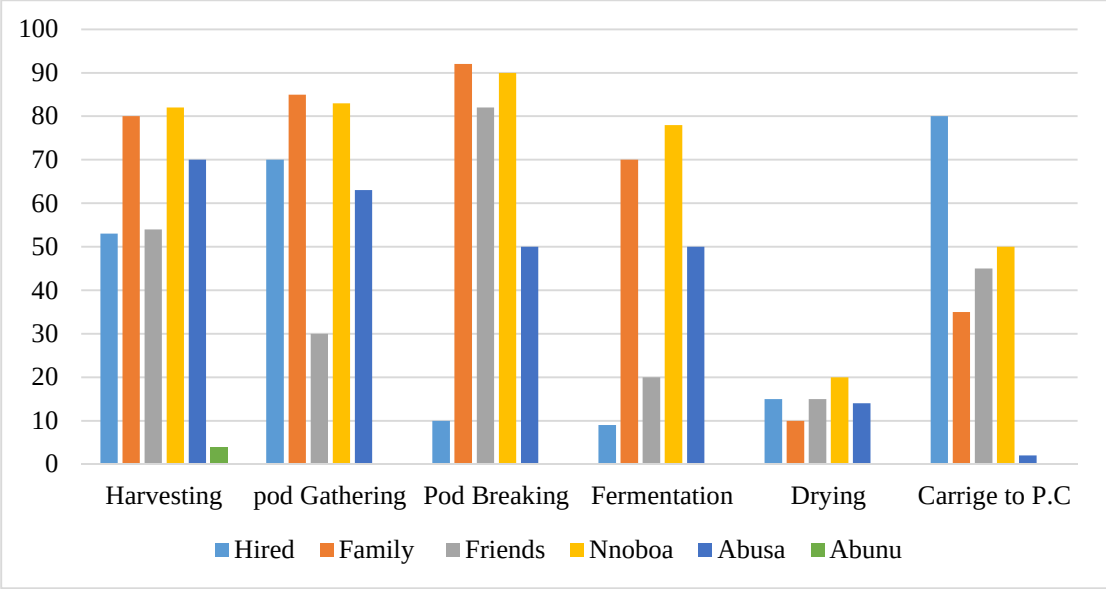

Figure 14. Type of labour used for postharvest activities in the cocoa production chain.

Results presented in Figure showed that most of the farmers used hired labour for their postharvest activities (harvesting; 53%, pod gathering; 70 %, pod breaking; 10%, fermentation; 8%, Carriage; 80%) with the exception of drying of the beans, which is done mostly by the family members (58%). It was observed Abunu was what is not practiced by most of the farmers, farmers see it to be a cheat and has no benefits to the part of the farmers.

It was observed that Nnoboa and family were the main sources of labour that are used in the cocoa production. The reason is that there no cost involve in these type labour.

Cocoa production, particularly under the smallholder system as occurs in Ghana, is highly labour intensive. The kind of labour that is mostly used by farmer are families, friends, and associations that are formed by farmers which is also known as “nnobua’’. Farmers cannot afford to hire labour in all the activities that all the stages of post-harvest in the farm.

According to the labour practices in cocoa production in Ghana 2006 which was conducted by the ministry of employment of Ghana in 2006,farmers use a combination of family, hired and communal (nnoboa) labour in cocoa production. In general, the farmer’s household is the main source of labour for the cocoa farm, contributing almost 60 percent of the total labour requirement. The children of the farm household provide about 14 percent of the labour on the farm. It is against the labour law for parents to use their children for cocoa farming activities but parents have not option due financial constraints, parents cannot afford to pay for hired labour and with the children parents will not be able to get funds to pay for their

fees and other bills to keep the house. Due this is very difficult for government to fight 100% child labour in the cocoa growing area.

4.10. Number of years a farmer has practice cocoa Farming.

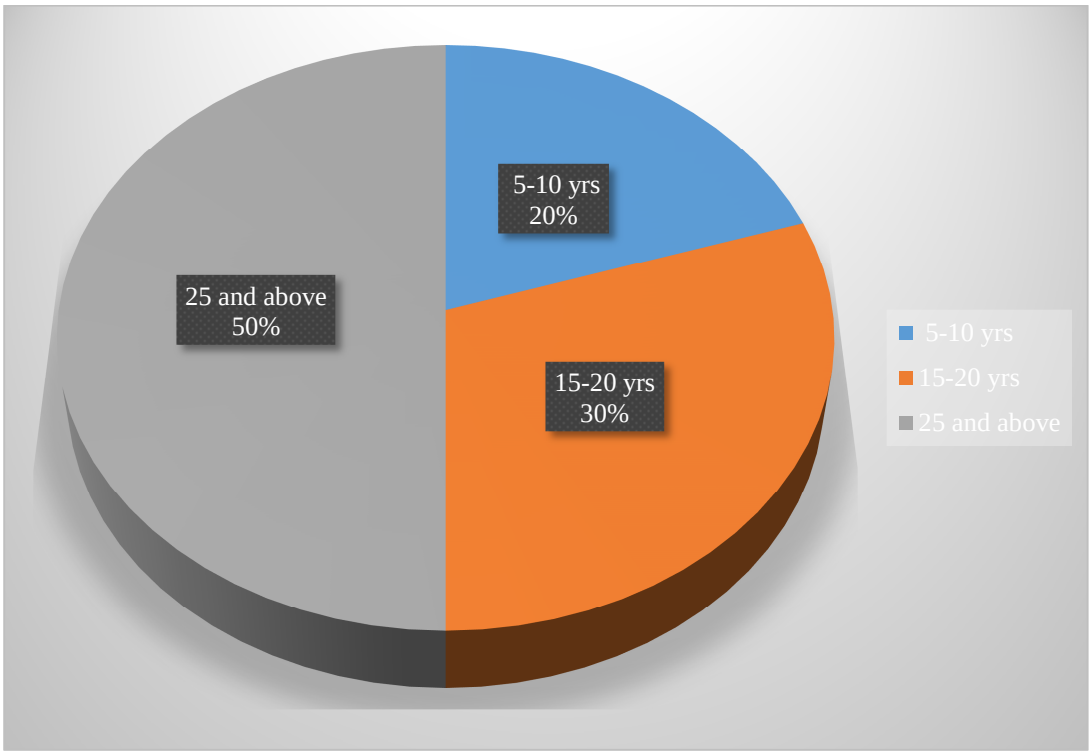

Figure 15. Number of years a farmer has practice cocoa Farming.

From the results obtained from the respondents it was observed that half of the farmers (respondents) entered into the cocoa farming sector from 25 years and above (50%), 15-20 years being second with 30% and 5-10 years being last with 20%. Youngsters sees that going into the cocoa farming industry is just waste of time and waste of resources. It was observed that the welfare of the farmers is not taking into consideration and most of the farmers do not want their children to be farmers but rather go to school for formal education go for white colour jobs. Other farmers also find it that the government is not making the cocoa farming attractive so they are switching to oil palm plantations and Para rubber plantations. The government has made the cocoa farming industry not attractive because people look at the conditions of the cocoa farmers and see it not to be pleasant.

Farmers who been into the cocoa farming industry from 25 years and above were 50% of the total respondent of farmers, 20% for famers who have been into the cocoa farming for 5-10 years and 30% for farmers between 15-20 years. This is a clear indication youth have no

interest in the cocoa farming. Most of the farmers do not also encourage their children to come and practice the cocoa farming due to the worst situation of the cocoa famers in Ghana.

4.11. Level of Education of Farmers

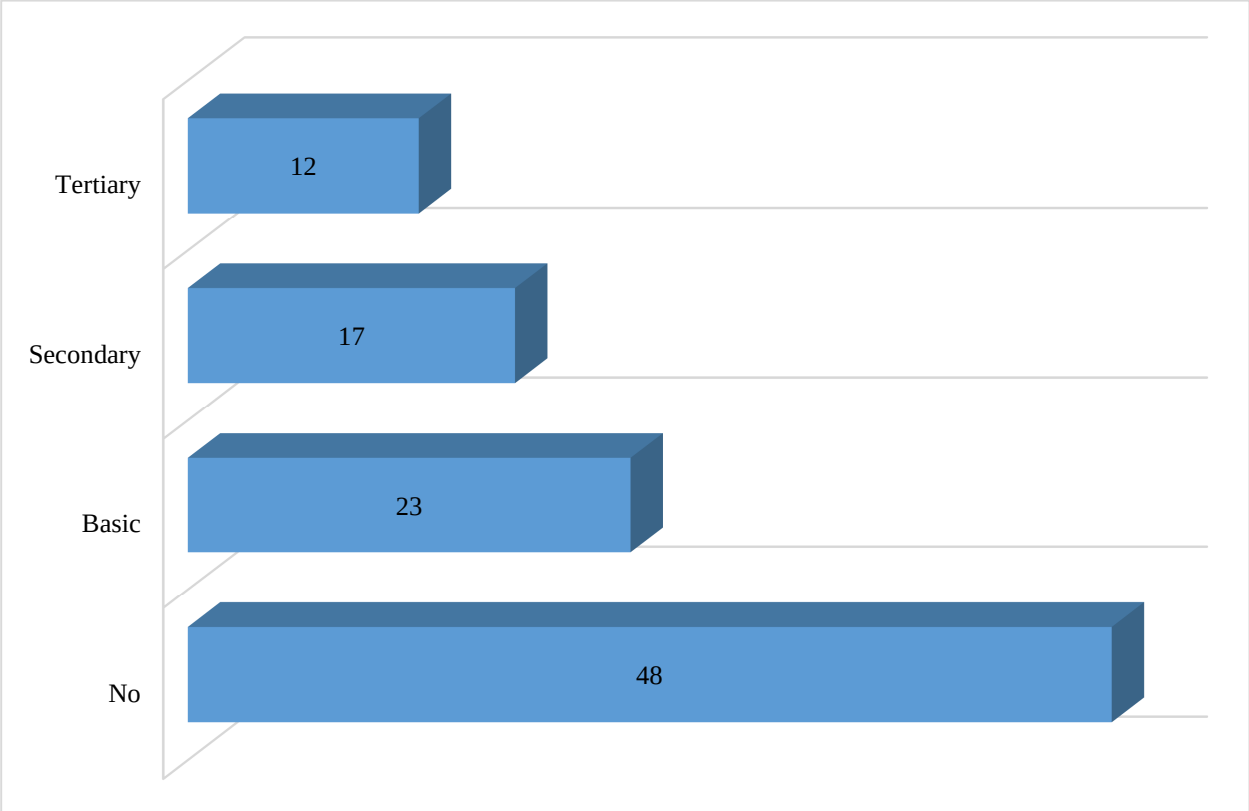

Figure 16. Level of Education of Farmers

The results indicated that almost half of the farmers are not educated, they do not have formal education. 48% of the farmers were not educated in other words they are illiterate, 23% of the farmers have Basic Education, 17% have Secondary Education and 12% have tertiary education. Most of the farmers gave the reason why they were not educated being that their fathers were reach cocoa farmers in the olden days and their parents wanted them to inherit their cocoa farms and maintain it in their absence so their parents took them to the farm instead of school.

Lack of education is not helping farmers to use the prescribed and the standard method application of insecticides and pesticides and how to control other parasite like mistletoe. It is difficult for some farmers to read the instructions of the pesticide or the dosage and other important information that should be known by the farmers in the process of the application. Since farmers do not know the exact thing to do they either under dose or overdose.

Due to the lack of education on the part of the famers, it makes it very difficult for famers to keep records with the reason being that they cannot read and write. Most of the farmers contacted do not know the size of their farm let alone the number of bags they get at the end of the harvesting season.

4.12. Knowledge of famers on their farm size

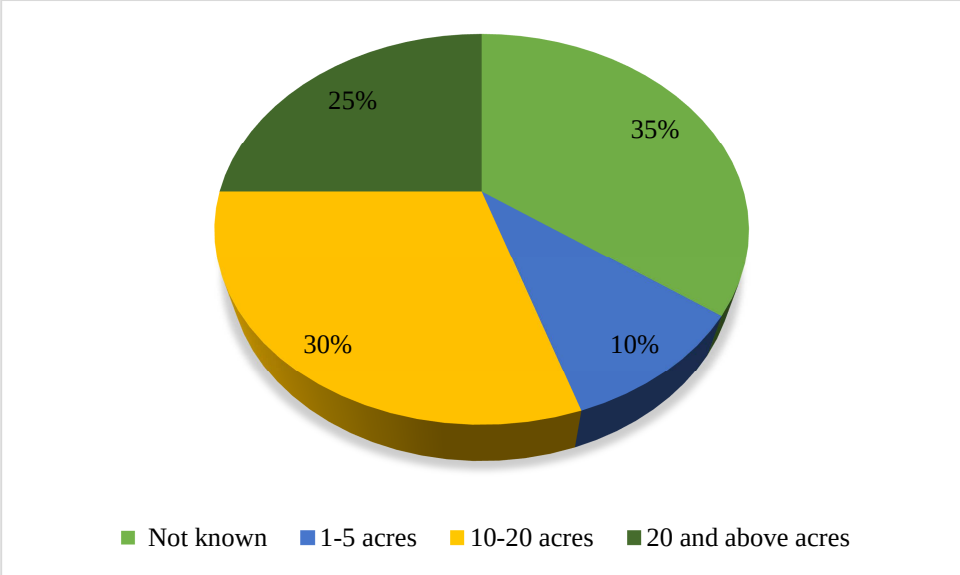

Figure 17. Farm Size of Farmers

According to the farmers, 35% do not know the size of their farm, 25% of the farmers have the farm size that ranges between 25 hectares and above, 30% of farmers have their farm size between 10-20 hectares and 10% of the farmers have the farm size between1-5 hectares. This really indicates that most of the farmers have small size farms.

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4.13. Response on record keeping of farmers

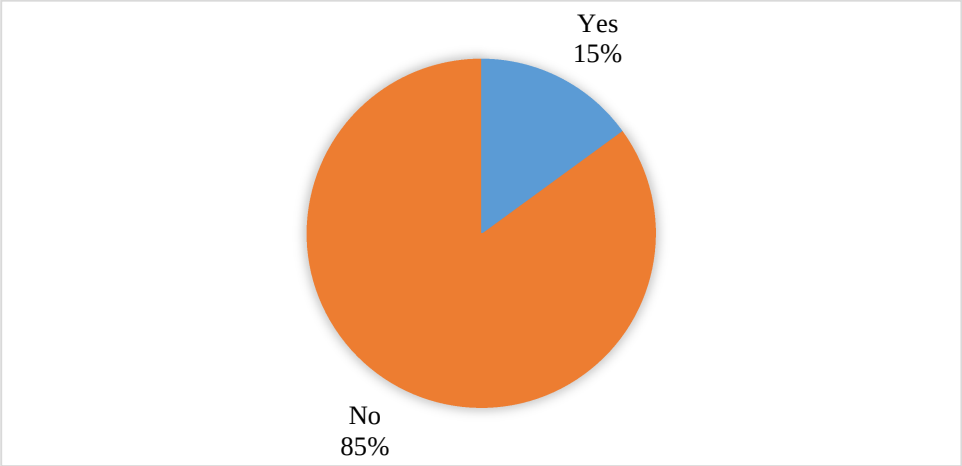

Figure 18. Farmers that keep records

Based on the results of farmers it was recorded that out of the total number contacted only 15% keep records while the other 85% do not keep records.

There are farmers who are educated but still have not inculcated the habit of record keeping.

4.14. Response on number of bags of cocoa harvested within a year

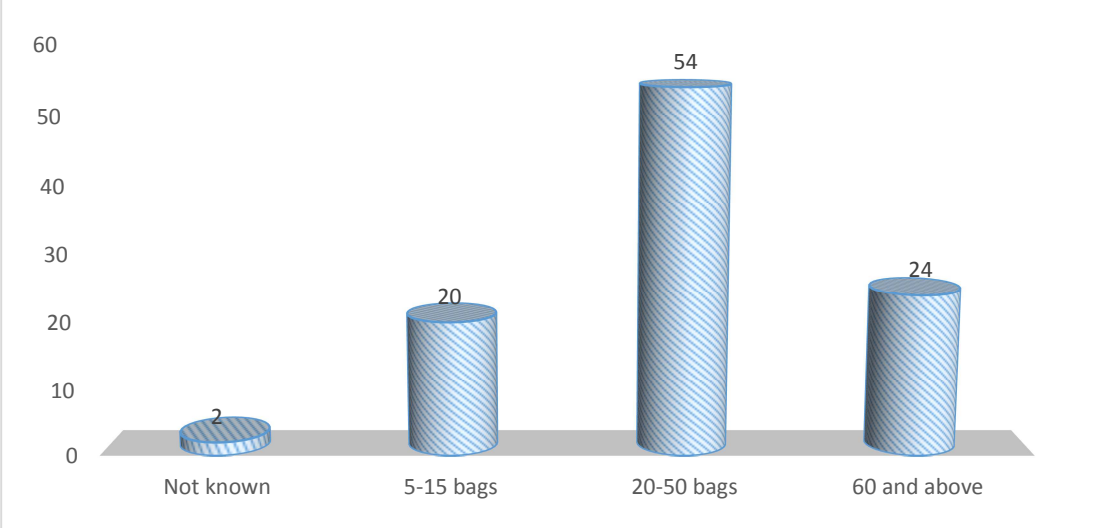

Figure 19. Number of bags of cocoa harvested within a year.

According to the response from the farmers only 2% of the total farmers contacted do not know the amount of bags of cocoa that they harvest within a year, 20% of the farmers harvest within the range of 5-15 bags of cocoa within the year whiles 54 % harvest 20-50 bag and

lastly 24% harvest 60 and above. This really indicates that the total numbers of farmers that harvest great number of bags of cocoa are few.

This les number of bags harvested within a year is due to the factors of post -harvest which farmers cannot manage. If farmers are able to manage the factors that contribute to pre and post- harvest loses it is going to help farmers increase their harvest.

4.15. Response on the knowledge on the amount of cocoa farmers lost in a year

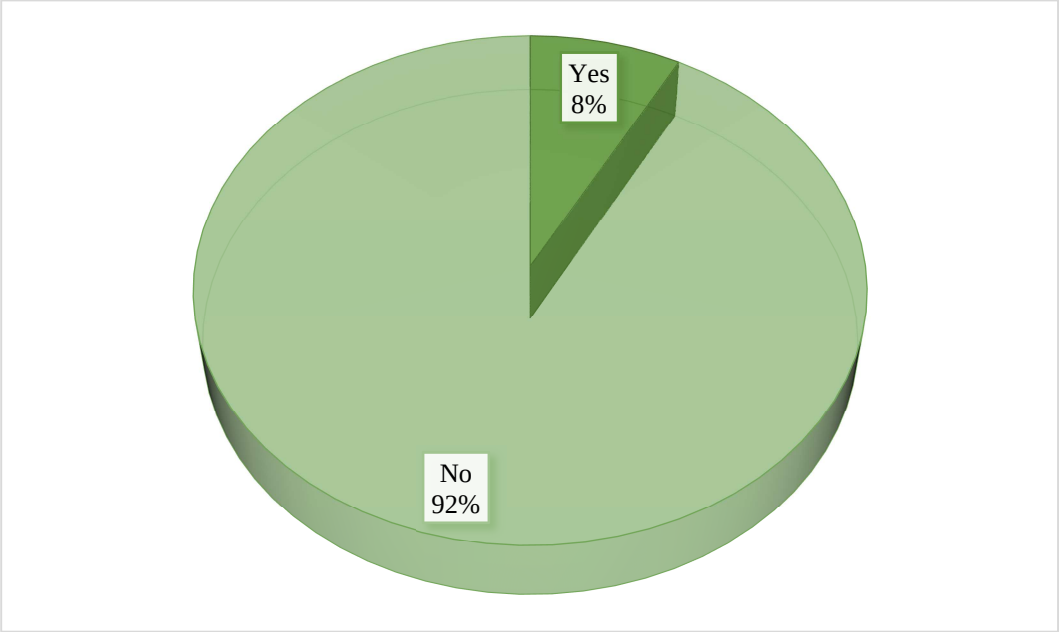

Figure 20. Knowing the Amount of cocoa farmers loose in a year in a year.

According to the farmers response it was observed that only 8% farmers have the idea about the amount of lost cocoa within the year of harvest and 98% of the farmers contacted have no idea about what they lost within the year in the process of harvesting. Most the farmers contacted stated that there is no way some of the cocoa will not get lost in the harvesting to the drying process. So they have the idea that no matter what this issue cannot be controlled.

Due to the low level of education and lack of keeping records on the side of farmers, famer cannot observe and determine the amount of cocoa they lose within a year. This makes it makes it difficult to put up good measures to curb the situation.

According to the farmers response it was observed that only 8% of farmers have the idea about the amount of lost cocoa within the year of harvest and 98% of the farmers contacted have no idea about what they lost within the year in the process of harvesting. Most the farmers contacted stated that there is no way some of the cocoa will not get lost in the

harvesting to the drying process. So they have the idea that no matter what this issue cannot be controlled.

Since the farmers do not know the total amount of cocoa that is lost every farming season it is going to be very difficult to quantify them.

4.16. Quantifying total cocoa lost within the harvesting season

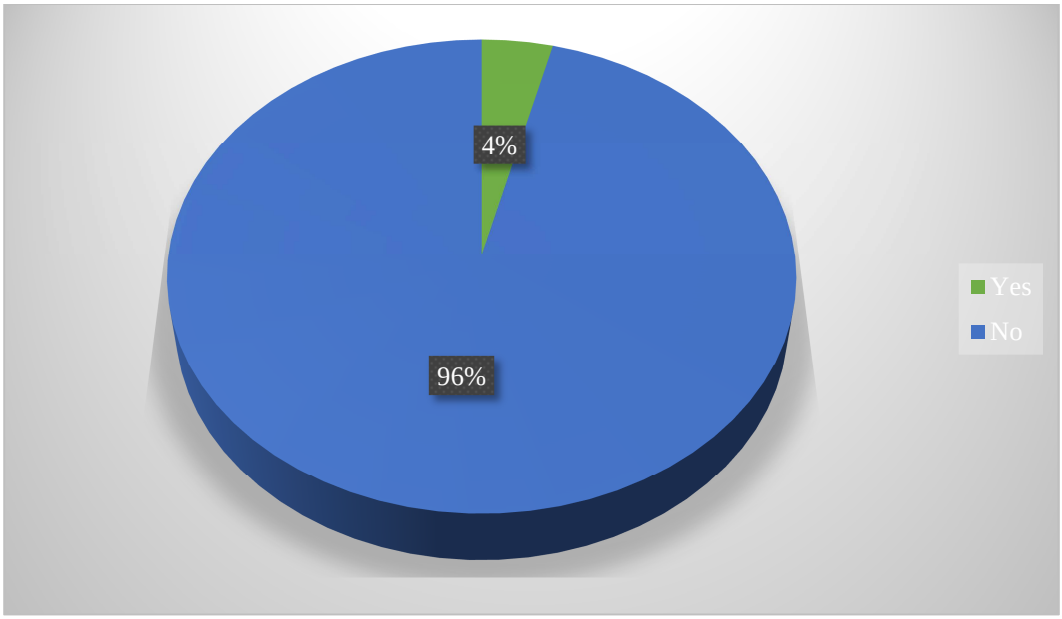

Figure 21. Quantifying total cocoa lost within the harvesting season

It was observed that out of the total respondents 96% have no idea about the quantifying of the cocoa lost in the harvesting process and they see it to be very complicated to quantify the lost. In the first 8% that they responded that they have the idea about amount that is lost only 4% can quantifying the amount of cocoa that they lost within a year and even with that they are not sure they estimate.

Quantifying the amount of cocoa that is lost every farming season is even very difficult for the Ghana cocoabod and very difficult for anyone to get data regarding the amount of cocoa that is lost during the post-harvest process.

4.17. Farmer's response to Post Harvest

The figure below depicts the farmer's response to post –harvest loses. 5% responded that they have an idea about causes and management of post-harvest loses on the farm, while 95% of the farmers have responded that, they have no idea about the causes post-harvest loses of

cocoa on the farm. This really indicates most of the farmers have no idea about post -harvest loses not to talk of the causes and how to prevent or management it.

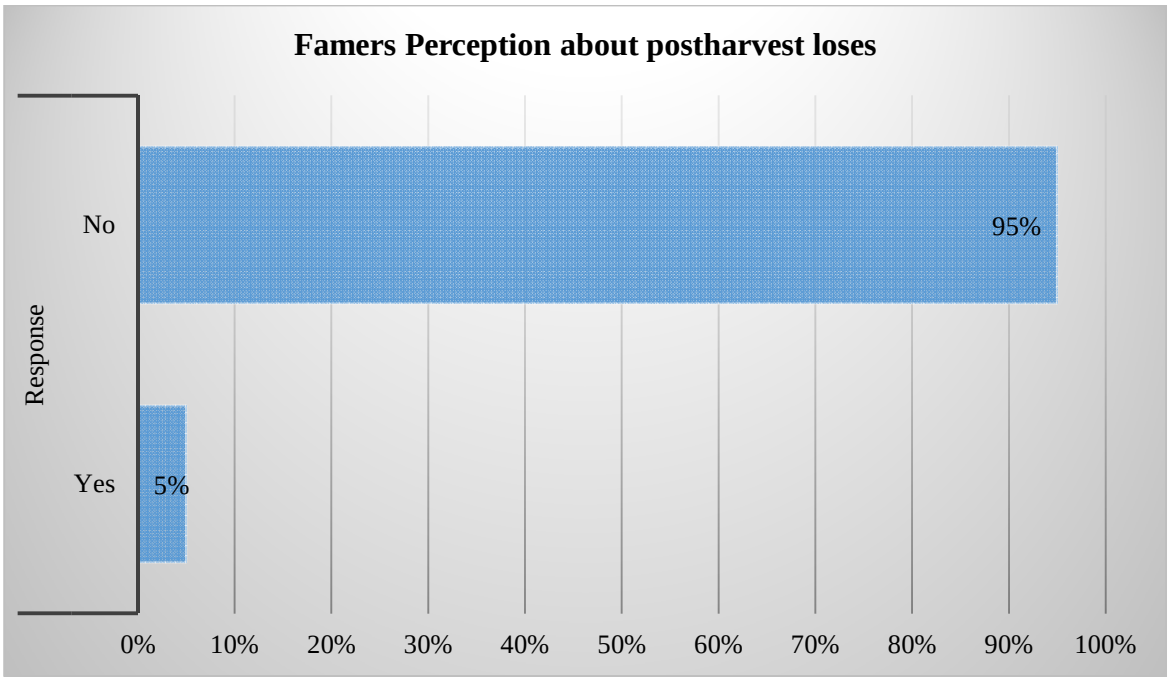

Figure 22. Farmer's response to Post Harvest

5% of the farmers responded that they have an idea about causes and management of post-harvest loses on the farm, while 95% of the farmers responded that, they have no idea about the causes post-harvest loses of cocoa on the farm. This really indicates most of the farmers have no idea about post -harvest loses not to talk of the causes and how to prevent or management it.

4.18. Number of times farmers spray their farm

According to the response of the farmers 10% do not apply chemicals or do not spray their farms, 42% of the respondents spray their farm to control pest and diseases ones in the whole farming season. 35% of the farmers spray 2-3 times for the whole farming season. 13% of the respondents spray their farms 4 and more times within the year to control pest and diseases. Looking at the habit of pest and disease control of farmers it is observed that most of the farmers do not control pest and diseases in their farm and this is one of the major causes of post-harvest losses.

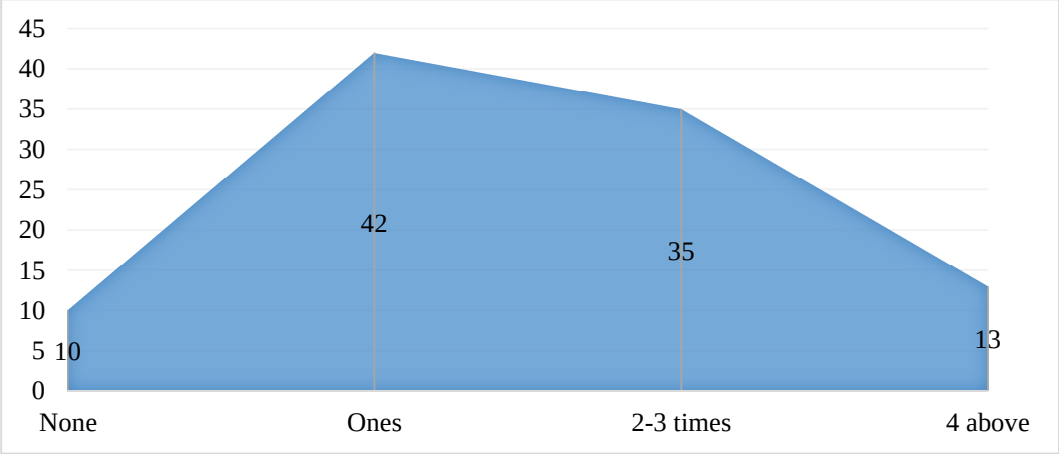

Figure 23. Number of times farmers spray their farm

According to the response of the farmers 10% do not apply chemicals or do not spray their farms, 42% of the respondents spray their farm to control pest and diseases ones in the whole farming season. 35% of the farmers spray 2-3 times for the whole farming season. 13% of the respondents spray their farms 4 and more times within the year to control pest and diseases. Looking at the habit of pest and disease control of farmers it is observed that most of the farmers do not control pest and diseases in their farm and this is one of the major causes of post-harvest losses. It is good and should a good practice for farmers to spray their farms all the time to control the pest, Insect and diseases in the farm increase production. Most of the causes of post- harvest loses that result to the flat, caked and germinated beans is caused not controlling pest and disease. From the survey and the experiment conducted, it was observed farmers who do not spray their farms recorded the highest amount of germinated, flat and caked beans. The few farmers who were practicing the good cultural practices, who were spraying their farms to control the diseases on the farm produce healthy and quality beans. It was observed that most of the farmers cannot spray their farm due to the cost of the chemicals, the labour cost and even the gadget that will be needed for the spraying on the farm. Government was doing well previously to help farmers in the mass spraying policy which was helping the farmers. The government was providing assistance to farmers, when the cocoa mass spraying exercise began, COCOBOD was providing insecticides and machines for the mass spraying six times within a year. The mass spraying in exercise which was started around 2004 to 2008 increases productivity so some level.

4.19. What prevent farmers from spraying

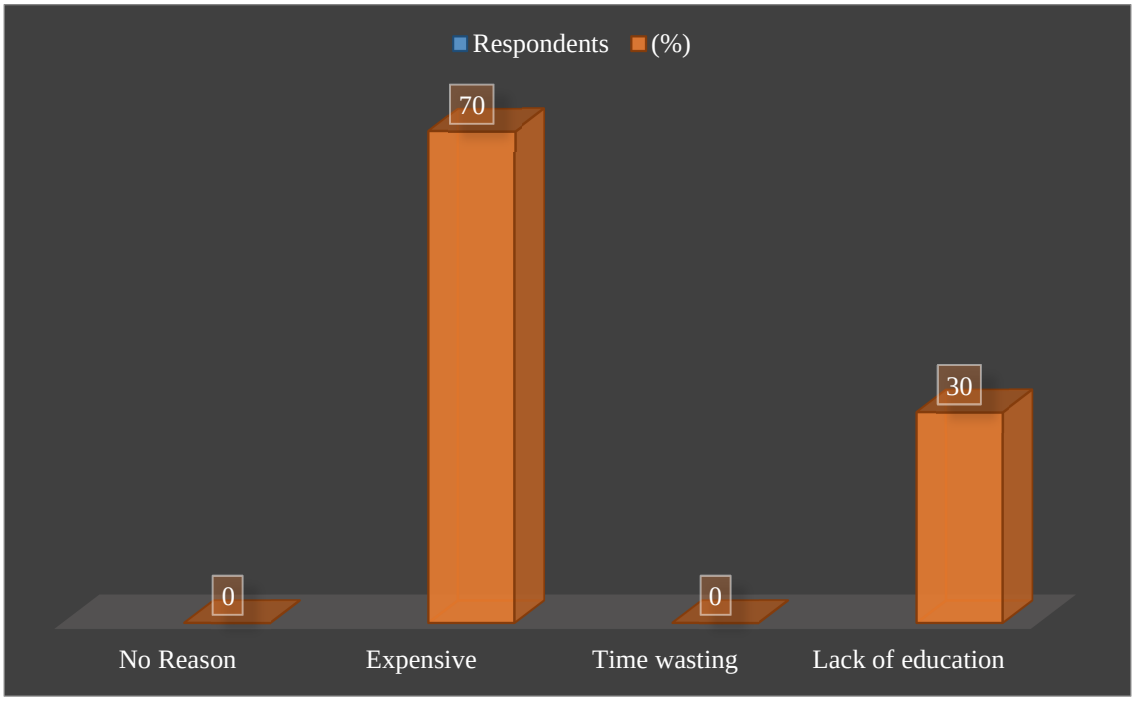

Figure 24. What prevent farmers from spraying

The total farmers contacted, none of them think that it is time wasting for them to spray their farm to control pest and disease and none of them have no idea about not to spray their farm. 70% of the farmers contacted responded the chemicals and the labour involve in the spraying of the farm to control the pest and the diseases is very expensive. 30% of the farmers responded that they have no idea as to which chemical is good to control the pest and the diseases and how to use these chemicals the concentration for a hectare or acre.

4.20. Farmers support from government

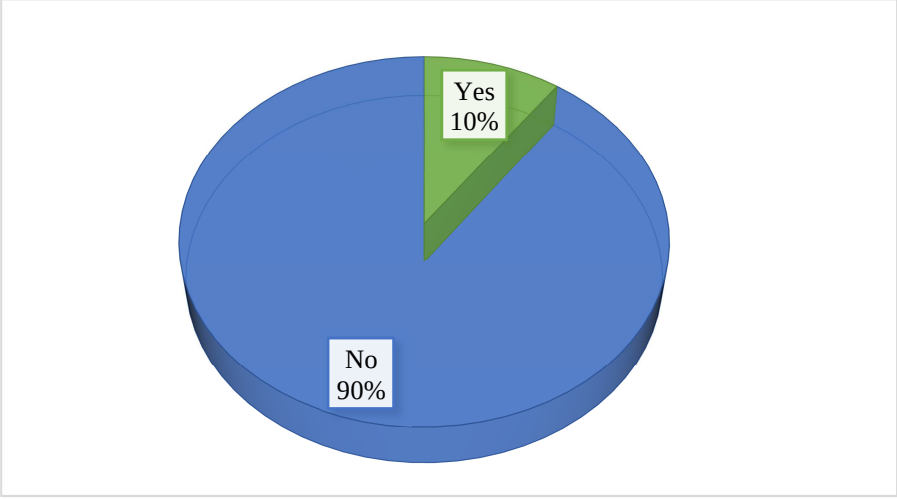

Figure 25. Farmers' response to government support of inputs

According to the farmers contacted only 10% responded that they get support from the government in terms of inputs to help control pest and diseases in their farms and 90% responded that they do not receive any support from the government. Due to lack of support on the side of the farmers from the government the farmers find it very problematic when it comes to the purchase of the inputs which prevent most of the farmers when it comes to the control of pest and diseases in the farm. The supply of inputs to producers continues to be carried out by COCOBOD. Although inputs were subsidized until 1993 (Shepherd and Farolfi, 1999), it usually did not reach remote regions. In 1996, the subsidies were however withdrawn. Following pressure from farmer-based organizations, the government intervened by subsidizing the price of insecticides and fungicides. In 2002/2003 growing season, COCOBOD introduced the "Cocoa High-Tech" programme. In the programme, fertilizers were supplied to farmers on credit so as to encourage farmers apply a minimum of two fertilizer bags per acre of land cultivated (COCOBOD, 2012). The programme however failed due to the low repayment rate by farmers.

4.21. Stages that causes more Post-harvest losses on the side of the farmer

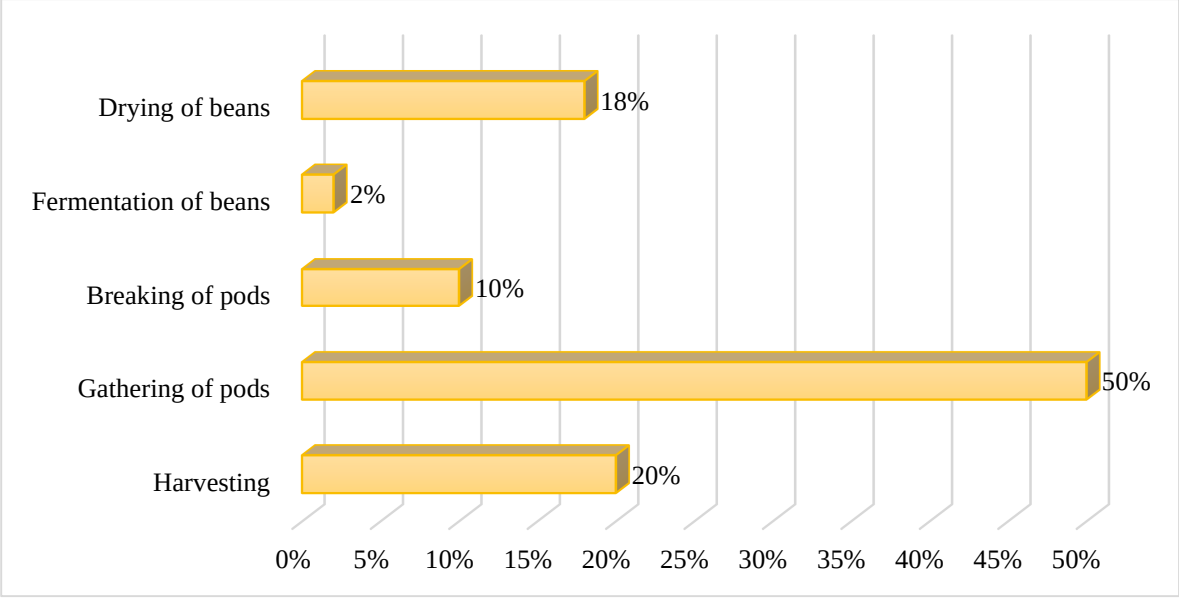

Figure 26. Stages that causes more Post-harvest losses on the side of the farmer

According to the survey conducted, farmers who were sure about some of the causes of post-harvest losses of cocoa on the side of the farmers responded this way. They stated that gathering of the pods result to the most post-harvest loses on the farm %50 of the farmers agreed to that followed by harvesting of the cocoa pods where most of the cocoa pods are

hidden in the canopy of the cocoa tree, 20% of the farmers responded to that. 18% of the farmers agreed to it that drying of the beans is the third highest causes of post -harvest loses on the farm. Gathering of the pods is in the fourth position of the causes of post-harvest loses of cocoa in the farm 10% of the farmers contacted attested to that and lastly the most least causes of post-harvest loses is fermentation of which 10% of the farmers contacted responded to that. Based on the response of farmers it was seen that fermentation is not among the major factors or process that contribute to the post-harvest losses of cocoa in the farm.

From the first experiment conducted It was observed that the healthy pods weighed more than that of the unhealthy pods, which is a clear indication that farmers are losing twice of each bag of cocoa they get from the farm.

After the drying of the 500 pods of healthy cocoa pods and when weighed 25'24 kg was recorded whiles the unhealthy when weighed recorded 12.7kg. It is getting twice below that of the healthy ones. It can be assumed that if it happens the farmers get all the pods to be healthy, every single bag of cocoa that they (farmers) harvest will be doubled for them. This really indicates that the farmers are losing a lot of bags of cocoa with the harvesting period which is caused by not following the good cultural practises. It can be estimated that if the country produce 7700 tonnes in a year, half of that number of tonnes is lost due not observing the correct farm practice. To curb this situation farmers should be educated as to follow correct and accurate cultural practices that should be observe in the farm. The government should also employ more extension officers to help educate farmer on the good cultural practices that should be observed on the farm that will really help farmers to get high number of produce that will help to improve the lives of the farmers and improve the nation's economy.

This is what a farmer said testified to me during the survey, "Before I started applying fertilizer in my farm, applying insecticides, pesticides and fungicides to control pest, insect and black pods on my farm, I only harvested one bag of cocoa per acre, but after I started applying fertilizer, I now harvest five bags of cocoa from the same area," says Mrs Rose Affukah, a cocoa farmer with 26 years of experience at Sefwi Asawinso. Flat and caked beans are caused by pest, insects, and black pods diseases so if all these are controlled Ghana is going to see positive trend it its cocoa industry.

4.22. Causes pest and disease on the farm

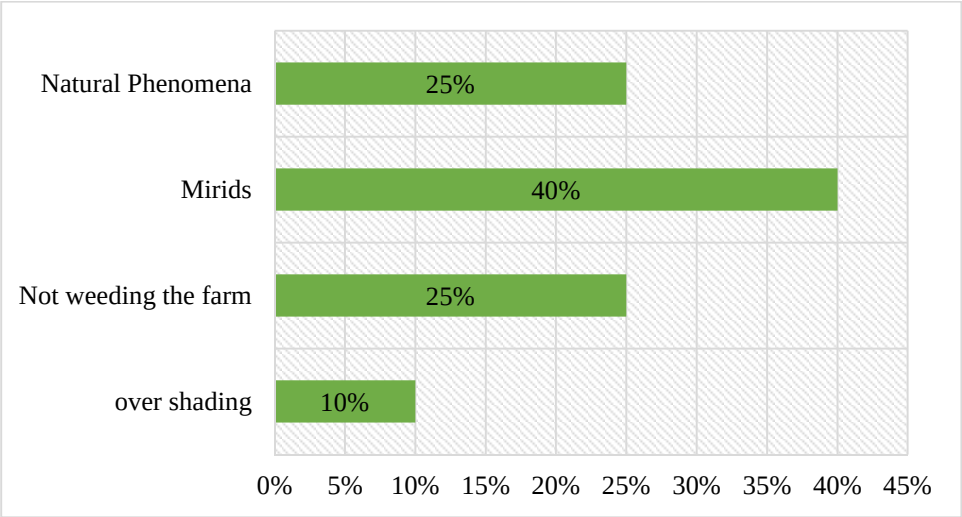

Figure 27. Causes pest and disease on the farm

The farmers contacted responded that diseases on their farm are caused by over shading, Mirid, not weeding the farm and over shading and other see it to be natural phenomena and cannot be prevented. 25% out of the total farmer contacted responded that diseases in the cocoa farm are caused by natural phenomenon it cannot be prevented but can be managed, 40% of the famers stated that Mirids are also the causes of diseases in the farm, whiles 25% agreed to it that diseases are caused by not weeding the farm and lastly 10% stated that diseases are caused by over shading in the farm not pruning the disease affected branches of the cocoa plant.

4.23. Effects of Capsid

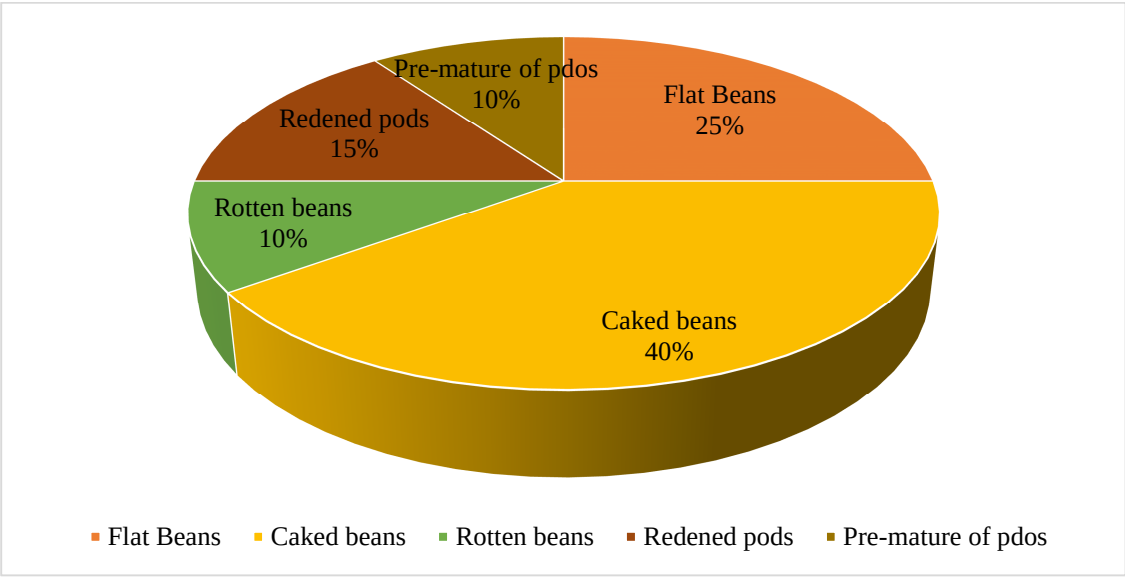

Figure 28. Effects of Capsid

The effects of capsid which is considered as the most serious pest that causes bad effects to the cocoa pods that results to some of the post loses of cocoa to farmers. Famers were contacted to find out if the farmers have any idea about the effect of capsid if not controlled in their farms.

Among the farmers contacted it was observed that 40% responded that capsid causes caked beans of cocoa and this contribute to post-harvest loses of cocoa, 25% stated that capsid causes flattened of cocoa beans, while 15% stated capsid causes to the reddened of the pods whiles they are not matured, 10% of the farmers responded that capsid can also cause rotten of cocoa beans and lastly 10% of the famers stated that capsid causes the pre-mature of pods which result to a high loss of cocoa beans. Effects of Capsid.

From the results obtained from the farmers Capsid attack was reported by the farmers to be the major cause of pre-harvest losses which result to caked, flat and germinated beans.

The major cause of the capsid attack was the mirids (capsids) which are major pests that affect cocoa in Ghana. According to Boateng (2011), mirids pierce the surface of cocoa stems, branches and pods using their needle-like mouthpart and also suck the sap of the cocoa tree. In the process of sucking, they inject their poisonous or toxic spit into the pod and this causes the dying of internal cocoa pod tissues.

Also, neighbouring farms which are not culturally maintained and are left weedy and bushy result to these losses since the cocoa farms are unable to attain the suitable environmental condition that are needed to promote proper growth and development. The weedy and bushy farms serve as the breeding grounds for the mirids (capsids) and also reduce aeration required by the cocoa trees. Black pod disease is one of the dangerous and very difficult disease of cocoa .The disease is caused by fungus and it not well controlled can rot the whole pods in a farm, it is causing the loss of 30-90 percent of the cocoa pods annually. This is the worst of all and the deteriorating of the diseases that can deteriorate a whole farm.

In the study, the farmers reported black pod incidence as a major cause of pre-harvest loss in cocoa. The incidence of black pod attack is brought about when there is high humidity (as a result of excessive rainfall) within the farm. High humidity increases fungal activities. Over shading the cocoa trees also facilitate heat accumulation thereby increasing humidity as well as fungal activities. Farmers also found rodents to be a cause of pre-harvest losses on their farms. The rodents mainly found on their farms were squirrels and this could be as a result of poor maintenance of the farms. Farmer needs

4.24. Effects of Black pods Disease

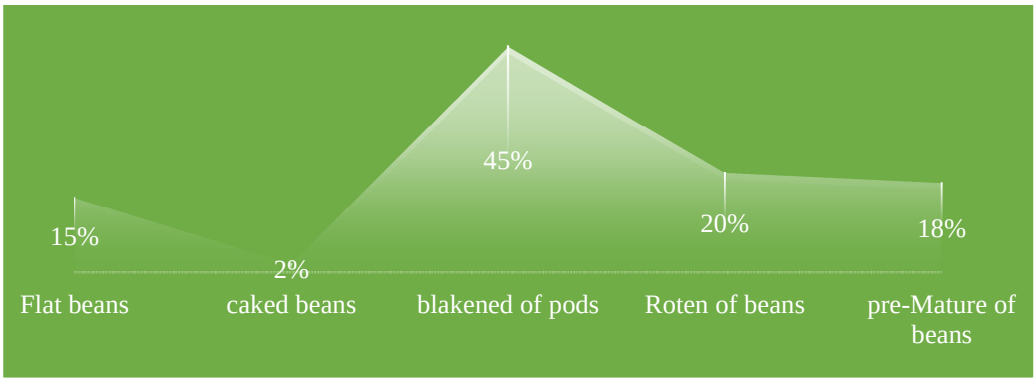

Figure 29. Effects of Black pods Disease.

Black pods disease which is caused by fungus is one of the most serious and destructive cocoa disease which causes major post-harvest loses in the cocoa industry. Views of farmers were solicited and these were the response of the farmers.

45% of the farmers contacted responded that black pods causes the blackening of the pods which causes great loss of cocoa to farmers. 20% of the farmers responded that back pods causes rotten of beans which cause great loss to them, 18% responded that black pods causes pre-mature of pods which result to pre-mature of beans and causes loss to farmers and the government. Lastly 15% of the farmers contacted responded that black pods results in the flattened of the beans.

4.25. Response of purchasing clerk about the amount of cocoa they lose

The figure below depict the purchasing clerks contacted and their responses, 70% declared that they have no idea about the amount of beans they lose during the purchasing process and 30% responded that they know the amount that get lost in the process and because they run through the process with care.

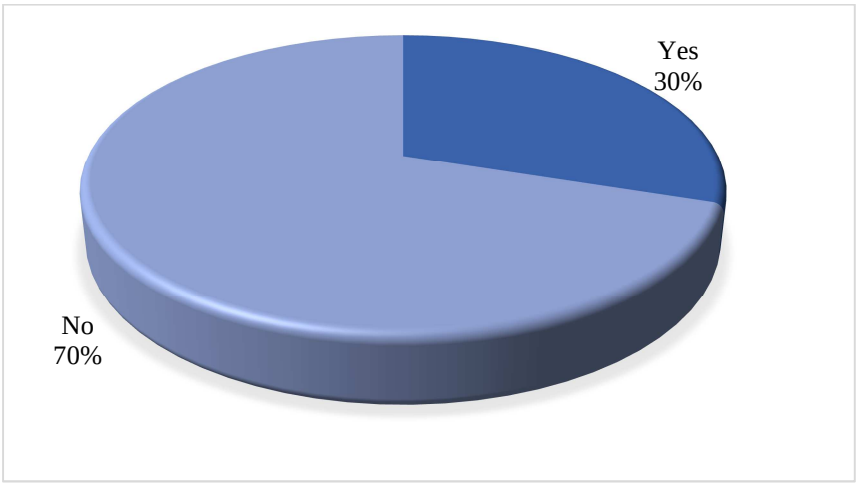

Figure 30. Response of purchasing clerk about the amount of cocoa they lose.

5. Conclusion and recommendation

From the results obtained from farmers it revealed one of the major causes of post-harvest lose on the farm is the invasion of pest and diseases, black pods disease is one of the most destructive disease on the farm that causes major post-harvest loses to farmers. There were other causes that were noted in the research process of which most of the farmers were not aware of and some that were noted were harvesting, gathering and drying of the cocoa.

As regards post-harvest losses the farmers indicated that most postharvest losses occurred at the pod-breaking stage where diseased, caked, wet and germinated beans were removed prior to fermentation. Rodent damage to cocoa pods and beans were identified by the farmers as some of causes to loss of cocoa.

There were serious recordings of high volumes of cocoa beans that were lost in the shed of the purchasing clerks and the depot of the shipping harbours where export is made.

It was also noted that, most these causes of post-harvest loses on the farm occur as a result of the low educational level of famers, high price level of inputs which farmers find it very difficult to purchase these inputs and low farm gate price. An of the major factors that result to the post-harvest on the farm are the farmer's inability to keep records to know how much is put and how much is expected for harvest.

According to the results obtained from the farmers about the number of years that farmers have being in the cocoa production industry it was observed that majority of the farmers are being aged and a time will come where by the youth do not have the zeal to enter the cocoa farming industry because they see it not be pleasant to them.

Due to the low level of the price of the cocoa farmers most farmers do have zeal to spend much time in the process of the cocoa from the harvest to the sale. They see that the cocoa may help them but cannot change their lives.

5.1.Recommendation

This study has dug the ground deeply and clearly identified the potential causes post-harvest loses of cocoa from the farm to where cocoa is being exported. Most of the causes of post-harvest loses of cocoa in Ghana can be controlled and manage by famers but due to the loss of the cocoa farming appetite by the farmers due to the low price of the government and the monopolistic nature of the cocoa purchasing the cocoa this makes most farmers not to waste their time in the cocoa industry,

The Ministry of agriculture and the cocobod should come together to formulate policies that will help improve the cocoa industry, they should invest in researchers and scientist to come out with new and modernised method of farming to help improve the cocoa production. The cocobod should work hard to get enough data about the quantum of cocoa that is lost every year to help the board to come out with appropriate resolutions. The government should educate and employ more extension and technical officers to help educate farmers on how to manage post-harvest loses.

The government should take into consideration the welfare of the farmers to come out with pension schemes bonuses to motivate farmers.

Farm inputs should be subsidizes by the government to make it affordable to the government and reachable to the farmer.

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Appendix

Questionnaire

Name……..

Location……..

District……..

Region……..

1. How long have you been in cocoa farm?
    a. 5-10 yrs
    b. 15-20 yrs
    c. 25 and above.
2. What is your level of Education?
    a. None
    b. Basic Education
    c. Secondary Education
    d. Tertiary Education.
3. What is the size of farm?
    a. Not known
    b. 1-5 hectares
    c. 10-20 hectares
    d. 25 and above.
4. Do you keep records for your farming activities?
    a. Yes
    b. No
5. How many bags of cocoa do you get in a year?
    a. Not known
    b. 10-15 bags
    c. 20-50 bags
    d. 60 and above.
6. Do you know the amount of cocoa you lose every year?
    a. Yes
    b. No

7. Can you quantify the amount you lose?
    a. Yes
    b. No
8. Do you practice all the cultural practices that are prescribed by the extension services?
    a. Yes
    b. No
9. How many times do you spray your farm?
    a. None
    b. Ones
    c. 2-3 times
    d. 4 and above.
10. How many times do you apply fungicide to control black pod.
    a. Non
    b. Ones
    c. 2-3 times
    d. 4 and above.
11. What prevent you from spraying?
    a. None
    b. Expensive
    c. Time wasting
12. Do you get support from anywhere for input?
    a. Yes
    b. No
13. Do you know post-harvest loses?
    a. Yes
    b. No
14. Do the government support you in purchasing the farm inputs?
    a. Yes
    b. No
15. Do you get education from the extension service?
    a. Yes
    b. No
16. If yes

17. If yes do you know the causes of Post-harvest?
    a. Yes
    b. No
18. Which of the following stages do you think causes more lost in the production chain?
    a. Gathering of pods
    b. Braking of pods
    c. Fermentation
    d. Drying.
19. What are the causes of loss of cocoa at the harvesting?
    a. No reason
    b. Hiding in canopy
    c. Oversight.
20. What are the causes of loss of cocoa at the gathering?
    a. No reason
    b. Hiding on leaves
    c. Oversight.

21. Do you know the causes of Capsid in your farm?
    a. Yes
    b. No
22. If yes what is the cause among the following.
    a. Over shading
    b. Not weeding your farm
    c. Mirids
23. Do you know the effects of capsid on your farm?
    a. Yes
    b. No
24. If yes which of the following will be your response.
    a. Flat beans
    b. Cake beans
    c. Germinated beans
25. Do you know the effects of the black pod disease?
    a. Yes

b. No

26. If yes which of the following will be your response.
    a. Flat beans
    b. Rotten beans
    c. Flat beans.
27. Do you know the causes of Black pod disease?
    a. Yes
    b. No
28. If yes which of the following is your response.
    a. Over shading
    b. Over raining
    c. Lack of sunshine
    d. Stagnant waters in farm
29. What are some of the factors that prevent you from application of chemicals to prevent?
    a. Expensive
    b. No time
    c. No labour
30. Type of labour used for postharvest activities in the cocoa production chain.
    a. Hired
    b. Family
    c. Nnoboa
    d. Abusa
    e. Abunu.