Pre-harvest losses of *Musa* spp. and Food Security Situation of Households in Sub-Sahara Africa: A Review

Abstract

Musa spp. generally known as bananas and plantains are staples to many in Africa. However, pre-harvest losses of these crops for the past two decades are alarming. The paper reveals that pre-harvest losses of bananas and plantains since 2002 ranges from 20.7-100% in Sub-Sahara Africa with most countries recording 50% losses and above. The paper further categorised the causes of pre-harvest losses of *Musa* spp. into natural, agronomic, biotic and human-induced constraints. Among these categories, human-induced constraints were seen to cause the highest pre-harvest losses as they influence the occurrence of other constraints. Some of the primary natural and agronomic constraints are storm, drought, and irregular/mixed cropping and over dependent on sward suckers and rainfall respectively. *Fusarium* wilt, Banana *Xanthomonas* wilt (BXW), banana bunchy top disease, black sigatoka and cigar-end rot are some of the biotic constraints reported in most producing countries in the region. Pests such as banana weevils, nematodes, mealy-bugs and white grubs are equally identified as potential causes of *Musa* pre-harvest losses while some human-induced constraints are farmer-grazier conflicts, weak extension system and poor inputs. The paper revealed that in Rwanda, pre-harvest losses of bananas led to an increase (14-64%) of the number of households who were unable to eat their preferred meal in all the months of the year while in Tanzania, the food situation of 53.8% of the households were reported to be very bad. Meanwhile in Cameroon, insufficient food was reported in 81% of the producing households in Boyo Division. It is therefore, concluded that in order to minimise pre-harvest losses and enhance the food security status of the producers and consumers in the region, proper propping, pruning, crop rotation and above all integrated pest and disease management techniques should be practiced while *Musa* research centres should be decentralising, extension delivery systems revisited and disease-free planting materials provided to the farmers.

Key words: *Musa* spp., Pre-harvest losses, Food security and Sub-Sahara Africa

1.0 Introduction

Musa spp. generally known as bananas and plantains are staple food crops to many people in Africa (Ajambo *et al.*, 2018; Food and Agricultural Organisation (FAO), 2019). They are also considered as cash crops in many producing countries (FAO, 2018; Olumba & Onunka, 2020). *Musa spp* are perennial crops which originated from Southeast Asia and New Guinea and were introduced in Africa before 2500 years ago (Mbide *et al*., 2005). In this continent, *Musa* production is carry out predominantly in Sub-Sahara African countries with plantains production concentrated in the West and covers 32% of the world production (Cauthen *et al.*, 2013; Ayanwale *et al*., 2016). Reports shows that Africa cultivates four over (4) million hectares of bananas and produces 25% of the world banana volume (Lorenzen *et al.*, 2010; UNCTAD, 2016). Most banana production is centred in Central Africa followed by West and East Africa with some of the primary producers in the region being Cameroon and Côte d'Ivoire (FAO, 2018). Cameroon remains the prime producer of plantains in the region followed by Ghana and Nigeria respectively (Tenkouano *et al*., 2019). Meanwhile, East

Africa is noted for the production of East African Highland Bananas (EAHB) (Nemecková *et al*., 2018).

Over 90% of *Musa* producers in Africa are smallholder farmers who produce for consumption and income (Alabi, 2013; FAO, 2020a). Bananas and plantains are consumed across Africa in different forms by people of all age groups. Food and Agricultural Organisation (FAO) (2019) reported that in Rwanda, Uganda and Cameroon, the per capita consumption of banana stands at 200kgs. They are generally eaten raw as fruits (bananas), cooked and fried as in the case of plantains. In Central Africa especially in Cameroon, banana (*Achu*) is pounded into *achu* while plantains are processed mostly into chips and flour and used for baking. East Africa countries especially Rwanda and Uganda are noted for the processing of banana beer (*tonto*), wine and juice (Whitney *et al*., 2016; Rwubatse, 2018) while in the West Africa, bananas and plantains are used in making *dodo* as well as processed into chips, and floor which is used for baking and preparing of *fufu* (Akinvemi *et al*., 2010; Cauthen *et al*., 2013).

Producers are unable to meet the needs of their increasing households and consumers in the region due to production constraints ranging from natural, agronomic, biotic to human-induced factors. According to Ayanwale *et al*. (2016), over the past 20 years' research works on bananas and plantains have tilted towards socio-economic and post-harvest studies, with little emphasis on the agronomy and pre-harvest losses. It is important to note that due to the morphology of these crops, in most producing countries, pre-harvest losses are far more than Post-harvest losses. According to Cauthen *et al.* (2013), in West and Central Africa, particularly in Nigeria, Ghana and Cameroon, 30-50% and sometimes up to 80% of plantains and bananas are lost at pre-harvest stages. This, in addition to the losses recorded by other producing countries reduces yields and renders millions of people who depend on banana or banana and plantain products food insecure in the continent. In 2019/2020, 81% of banana producing households in Boyo Division in Cameroon were food insecure because of pre-harvest losses of bananas (Nkwain, 2022). Meanwhile in Tanzania, the food situation of 38.3% of the producing households was reported bad while 53.8% was very bad (Muchuruza & Melchior, 2013).

Future food insecurity situations in the region can partly be reverted by revisiting and encouraging certain crops that farmers have the capacity to produce at a lesser cost especially bananas and plantains. According to Tchango *et al.* (1999) and Cauthen *et al.* (2013), the cost of producing a hectare of bananas and plantains is relatively cheaper than that of cassava, maize and rice. This therefore, means that if there is an increment in investment in this sector, yields will increase as farmers will be able to minimise or prevent losses. Therefore, this study is aimed at highlighting the extent of pre-harvest losses of *Musa* spp., causes and effect on food security as well as highlighting possible ways of minimising the losses to enhance the future food security situation of the consumers in the region towards the achievement of the second Sustainable Development Goals (SDGs) in 2030.

2.0 Clarification of Concepts

The *Musa* crop

Generally, *Musa spp* (bananas and plantains) are made up of a corm, pseudo-stem, leaves and the fruits. The corm, held by the roots, makes up the underground part of the plant where the mother plant and the suckers are connected and jointly form the mat. According to Scot *et al*. (2006), and Okolle *et al.* (2009), all *Musa* species ranges between 2- 9m (6.6–30 ft) in height. After fruiting, *Musa* fruits mature from three to four months depending on the cultivar,

season and climate of the locality (Scot *et a*l., 2006; Nayar, 2010). Scot *et al.,* (2006) ascertained that matured *Musa* fruits are generally 3–40 cm (1.2–16 inch) long, and 2–8 cm (0.8–3 inch) in diameter with some having an elongated, cylindrical and strongly curve shape and are seedless (parthenocarpic).

There are several views on the typology and grouping of *Musa* spp. Some studies distinguish two groups of bananas (Desert and Cooking banana) while some present four groups *vis*: desert bananas (Musa AA and AAA), cooking bananas (Musa AAB, and ABB), plantains (Musa AAB), and East African Highland Bananas (Musa AAA-EA). Irrespective of the groups, different varieties/cultivars of bananas and plantains can be classified based on the height (as dwarf, medium and tall/giant varieties). The dwarf varieties range from 1.5-2m and are very stable and less sensitive to wind thus, minimises pre-harvest losses resulting from toppling or folding. The medium varieties range from 2.5-4m in height and are sensitive to wind thus, prune to pre-harvest losses. Meanwhile, the tall varieties range from 4m and above and are very sensitive to wind thus, records most pre-harvest losses resulting from folding and toppling. One common feature of this group especially in the case of plantain cultivars is that the pseudo-stems are smaller and sometimes outweighed by the size of the bunches they carry resulting to folding or toppling of the fruited plants. Apart of the height, the perennial nature of *Musa* spp. made them to easily accumulate pests (weevil, nematodes etc.) and diseases (panama, sigatoka, *Xanthosomonas* wilt etc.) which in turn contribute to pre-harvest losses.

Pre-harvest losses (PrHL)

Pre-harvest losses occur before the harvesting process begins and may be due to factors such as insects, weed and or diseases (Global Strategic Working Papers (GSWP), 2015; Oino *et al*., 2017). In banana and plantain, observation shows that losses at this stage are sometimes due to poor site selection, storm, poor stalking, and the variety of seedlings cultivated. Similarly, Verma *et al*. (2019), argues that the absence or inadequate participation of regional agricultural research institutes and extension services can lead to lack of adequate information and unavailability of crop varieties suitable to local conditions which is believed to affect the growth and maturity of crops. Other factors such as poor farm equipment, insufficient labour, and limited finances also contribute to pre-harvest losses. This study considers pre-harvest losses of banana as losses that occur during the life span of the crop in the field which reduces the quality and the quantity of harvest. These losses begin with site/seedlings/sucker selection and ends when harvesting begins. In a study on banana losses conducted in Cameroon by Nkwain (2022), farmers insisted that pre-harvest losses pose a higher effect on their social wellbeing most especially food availability. Chief among their rationale was that strong wind, pest and diseases as well as fire devastate their crops living them with little or nothing to harvest and consume on daily, weekly and monthly bases hence, threaten their food security status.

Food security

In 1996 World Food Summit, it was adopted that 'Food security exists when all people at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (FAO, 2008). Four dimensions of food security are identified in this definition. These are; availability (food available through local production or importation), accessibility (consumers able to access and pay for the food), utilisation (consumers able to consume the quality (nutritional quality) and quantity needed for a healthy life) and stability (being able to have the food at all times

irrespective of shocks) (Maetz, 2011; Peng & Berry, 2019). It important to note that even if all these dimensions are fulfilling without the food being culturally accepted by the consumers, food security will still not be attained (Maetz, 2011). Therefore, cultural acceptability of food maybe regarded as the fifth dimension of food security. Equally, some scholars emphasised on the long term attainment of food security therefore, suggesting another dimension referred to as sustainability with attention focused on achieving the food needs of the present consumers without degrading the environment for the future generation to harness and meet their food needs (Peng & Berry, 2019). Attaining just two out of these dimensions has been a challenge in Africa over the years (Food and Agricultural Organisation (FAO), United Nations Economic Commission for Africa (ECA) and Africa Union Commission (AUC), 2020). The continent is still battling to attain food availability which is one of the fundamental dimensions of food security. This is in part because of the incident of pests and diseases, insufficient improved technologies, climate change and conflicts. Therefore, food security is considered in this paper in terms of availability of food to all people at all times of the year.

3.0 The extent of pre-harvest losses of *Musa spp*. in Africa from 2002-2021

For over 20 years, few studies have been published on pre-harvest losses of *Musa* spp. in Africa to inform the stakeholders. However, the losses from the few published studies vary from one country to another and are alarming. In Central Africa, Pierrot *et al*. (2002) documents an average loss of 30% before harvest of total plantain plants initially planted by smallholders in the South West region of Cameroon while Hauser and Amougou (2010), reported 50% losses of plantains in Southern parts of Cameroon as a result of poor agronomic practices and pests and diseases. According to Dépigny *et al.* (2019), 50% of plantains are lost at pre-harvest stage in the Littoral region of Cameroon. These losses are experienced through damages to non-fruited and fruited stems and theft which, contribute to 20-30% of plantains losses. In every 100 stems of plantains planted, farmers only harvest an average of 30 bunches. Meanwhile, in Western/Central Africa, Cauthen *et al*., (2013) reported 30-50% and sometimes up to 80% bananas and plantains pre-harvest losses in Nigeria, Cameroon and Ghana caused by black sigatoka.

In East Africa, African Agricultural Technology Foundation (AATF), (2009) reported that 100% of banana especially the brewing type were lost in Rubavu Nyamyumba District in Rwanda caused by banana bacterial wilt while in Tanzania in the Lake Zone region, close to 42,000 infected plants were destroyed. According to Whitney *et al*. (2016), close to 50% of bananas are lost in the field in Southwest Uganda during growth and maturity due to diseases and bad weather. Bantayehu *et al.* (2018), reported pre-harvest losses of fruits (banana inclusive) in North-western Ethiopia to be 20.7% due to improper activities. According to Okonya *et al*. (2019), in Rwanda and Burundi, banana pre-harvest losses due pest and diseases are estimated at 29% and 48% respectively. Black sigatoka has equally been reported to cause banana yield losses of more than 50% in Kenya (SHEP PLUS, 2019). Nematodes on their own part also poses serious threat to banana cultivation in Kenya, contributing to about 70% pre-harvest losses (SHEP PLUS, 2019).

4.0 Causes of pre-harvest losses of *Musa spp*. in the region

Natural causes

Some of the natural constraints to *Musa* yields in the region are drought, flood and strong wind (storm). In West Africa, drought, wind and flood are some of the external or natural constraints to bananas and plantains production in Nigeria, Benin and Ghana (Cauthen *et al.*,

2013; Chabi *et al.*, 2018; Faïnou *et al*., 2018). During the months of April and May, these crops are dehydrated due to the five-months-dry season experience in this region thus, reducing the quality of yields. Equally, Ayanwale *et al*. (2016), reported that the poor production and pre-harvest losses of bananas and plantains in this zone are caused by farmers' over dependence on rain-fed system. Farmers do not practice irrigation. They depend mostly on rain for the growth of their crops which, is irregular thus, frequent drought and poor quality of fruits produced. Flood causes oxygen shortages to the roots distorting the uptake of water and other essential elements resulting to leaf yellowing. Also, the strong winds above 40km/hour experienced in this region at the onset of the rainy season leads to the folding and toppling of bananas and plantains resulting to yield losses which further translate to shortages during the months of May to August (Kainga, 2013; Olumba & Onunka, 2020).

In East Africa, especially in Rwanda, according to Rwubatse *et al*. (2018), heavy wind does not only cause *Musa* plants to fold or completely fall-off, it also scatters the leaves of standing plants thus, reducing the rate of photosynthesis and therefore, resulting to poor quality of the fruits produced. Drought and flood have equally been reported to cause yield losses in Rwanda and Burundi (Okonya *et al*., 2019). Banana and plantain toppling due to strong wind has also been reported by Jacobsen *et al*. (2004) and Depigney *et al*. (2019) as one of the main causes of pre-harvest losses in Central Africa specifically in Cameroon.

Agronomic causes

Poor agronomic practices pose serious threat to banana and plantain yields. Many *Musa* small and medium scale farmers in Sub-Sahara Africa especially in the West and Central Africa practiced predominantly *Musa*-cocoa/coffee intercrop where cocoa and coffee are common. These crops are intercropped irregularly. According to Hailu *et al*. (2013), one of the important factors determining the quality of *Musa* fruits is row spacing and the associated plant population. The number of plants on a hectare usually known as plant density matters a lot especially in the case of *Musa* plants with so many leaves. Irregular and so many banana plants in a field increases plant competition and reduces the exposure of the fruits to sunlight thus, reducing the fruit quality. Also, allowing dry and yellow leaves on the plants reduces air circulation which affect the quality of bunches and fruits.

Majority of farmers in the region do not carry out de-suckering. They believe that the more the number of plants per stool, the more the anticipated bunches to be harvested. Therefore, they accumulate non-vibrant plants with weak pseudo-stems that are sensitive to the least wind. These plants end up producing small bunches and slender fingers. Equally, dry leaves, leaf sheaths and stumps are accumulated in farms which harbours weevils, insects, birds and rodents that ends up affecting *Musa* corms, pseudo-stem, fresh leaves and fruits. Leave pruning is practiced while wounding the leave petioles of some leaves thus, exposing them to diseases and folding. Some farmers reduce the number of green leaves to 4-6 thus, reducing the rate of photosynthesis and the quality of fruits produced.

Equally, almost all the small farmers in the region depend on sword suckers of which majority are less productive and resistant to pests and diseases. These suckers are not always treated before or after planting resulting to stunted growth and poor yields. In addition to the less use of insecticides and nematicides, there is little or no used of fertilizers to maintain soil fertility and boost yields.

Biotic causes

Pest

Some of the predominant *Musa* pests reported in the region are nematodes, weevils, white grubs and mealy bugs. Majority of farmers in the region have been cultivating bananas and plantains in the same farm for more than 10 years without crop rotation. Most farms are old. In some localities like in the Western Highlands of Cameroon especially in the banana-coffee intercrop, *Musa* stools stays for 10-15 years and even more while producing suckers and extending the stools. This has resulted to accumulation of pests like nematodes and weevils which in turn prey on banana roots and corms reducing yields. The movement of infected plant material in the region is also a contributing factor of the spread of pests as well as diseases (Lorenzen *et al.*, 2010). The seasonal climatic changes have equally brought about different varieties of insects (e.g. the outbreak of desert locust in East Africa in 2020) (FAO, 2020b) which either prey on the corms, leaves or fruits of *Musa* spp. causing losses. In West Africa, banana weevils and nematodes have been reported to devastate *Musa* corms in Nigeria, South Benin, Ghana and Côte d'Ivoire (Dimelu, 2015; Chabi *et al*., 2018; Cauthen *et al.*, 2013; Traoré *et al.*, 2010) while in Central Africa, in addition to weevils and nematodes, Okolle *et al*, (2009) linked the poor yield of bananas and plantains in Cameroon to Mealy-bugs and white grubs. Meanwhile, in East Africa, banana weevils have equally been reported in Rwanda and Burundi (Okonya *et al*., 2019).

Banana weevils, nematodes and white grubs are reported to feed on banana and plantain roots and corms while distorting the nutrients uptake and causing poor anchorage to the plants as they create tunnels on the corms and destroy the roots. This leads to stunted growth and toppling as the plants become very sensitive to wind. On the other hand, according to Okolle *et al*. (2009), Mealy bugs feed on the leaves, bud and fruits of bananas and plantains while secreting honey dews which in turn form mould fungus (black soot) after fermentation. This black soot changes the green colour of the fruits to black resulting to quality reduction and refusal of the fruits in the market.

Diseases

Several diseases have been identified to affect banana and plantain output in the region. These diseases affect different parts of *Musa* plants especially the pseudo-stem, leaves and fruits causing pre-harvest losses. Among these diseases are Banana Bacteria Wilt (BXW), *Fusarium* wilt (panama), black leaf streak (black sigatoka), Banana Bunchy Top Disease (BBTD) and cigar-end rot. Other diseases are Cucumber mosaic virus, banana thrips disease and root necrosis. Banana Bacteria Wilt first discovered in African continent in Uganda in 2001, has continue to play a significant role in reducing banana losses in the region especially in East Africa (AATF, 2009). This disease which cause the wilting and drying-off of banana leaves as well as premature ripening of fruits of affected plants, wilting of the bracts of the male bud, blackening or staining of the fruit pulp and stony fruit has equally been identified to ravished farms in Tanzania, Rwanda and Burundi (AATF, 2009; Muchuruza & Melchior, 2013; Okonya *et al*., 2019). Little has been documented about this disease in West and Central Africa. The disease seems to be common mostly in East Africa.

Reports showed that *Fusarium* wilt, a disease that is predominant in Gros Michel banana varieties affect banana plants in Cameroon, Nigeria, Rwanda and Burundi causing the drying-off of the leaves starting from the older ones to the shoot and eventually the whole plant (Nkwain, 2022; Okonya *et al*., 2019). Once a plant is affected with this disease, the leaves turn yellow and collapses. This continue until all the leaves hang around the plant like a skirt and eventually dry-off. Meanwhile, black sigatoka has been reported to cause significant

losses to both bananas and plantains in most of the producing countries across the region (Cauthen *et al.,* 2013; SHEP PLUS, 2019). This disease cause the development of black spots on edges of the leaves which eventually covers the surface area of the leave thus, causing a drastic reduction in the rate of photosynthesis resulting to the poor quality of the fruits produce.

Another serious threat to banana and plantain yields in the region is the Banana Bunchy Top disease. This disease is a serious threat because ones it attacks a plant, the leaves grow upright in a bundle hindering fruits production. The disease has been reported in Burundi, Rwanda, DRC, Congo Brazzaville, Malawi, Nigeria, Gabon, Benin and Cameroon (Ajambo *et al.,* 2018; Chabi *et al.,* 2018; Mikwamba, 2019; Okonya *et al*., 2019). Among the diseases that attack bananas and plantains in the field, cigar-end rots and banana thrips disease have been identified to attack directly the fruits during development and maturation. Cigar-end rot is a fungus that invade the pistils (flowering part) of the fruits causing the fruits to starting rotting from the tip forming a black soot that look like a cigar (AAFT, 2009). This infection continues down to the pulp of the fruit causing it to rot as well. In the Western Highlands of Cameroon, the disease is common in Cavendish varieties. On the other hand, according to SHEP PLUS, banana thrips disease cause silvery patches on fruits which turns brown with time and eventually lead to cracks and rotting of the fruits. Cucumber mosaic virus transmitted by aphid, causes leave narrowing and fruit distortion (Cauthen *et al*., 2013).

Human-induced causes

Human practices and quest for limited resources in their environment influence pre-harvest losses of bananas and plantains. Farmer-grazer conflicts are common in the region especially in the West and Central Africa. There are repeated cattle invasion of crops (bananas and plantains inclusive) in the Southern States of Nigeria and the Western highlands of Cameroon (Brottem, 2021; Bobbo & Tsi, 2020). These invasions lead to the destruction of banana and plantain suckers, fruited and non-fruited plants resulting to huge pre-harvest losses and a reduction in yields. In addition to crop destruction, farmers are equally chased out of their farms in some situations like in the case of herdsmen in Nigeria resulting to the abandonment of plants in the field (Brottem, 2021). Goats and sheep on their own part contribute to losses as they move around freely in the dry season while eating and destroying crops. *Musa* spp. are most vulnerable because they are among the few crops that remains evergreen throughout the dry season and these animals are attracted to green plants.

Equally, the extension system in the region is weak and lack specialisation. According to the Growing Africa's Agriculture (AGRA) (2019), farmers-extension ratio in the continent varies between 1:3000 and 1: 10,000. This means that the chances of a farmer meeting an extension agent or an extension agent visiting a farmer in a month or a year are slim. This literally means that farmers are on their own because before extension packages ever reach some farmers, their crops must have been ravished. Equally, there are limited specialised extension agents in the domain of bananas and plantains production in the region to better educate and train the farmers on improved practices to improve their yields. Farmers therefore, suffer from limited and adulterated information from their colleagues thus, poor output. Farmers therefore, continue to use their indigenous strategies which are equally limited. Ayanwale *et al*. (2016) blamed poor banana and plantain yields in Nigeria to little or no change in cultural practices of these crops in the past 20 years due to inadequate knowledge of production, inefficient extension service system and research.

Insufficient input/poor farm tools are also contributing factors to poor *Musa* yields in the region. Insufficient inputs are in part because of high prices of (herbicides, insecticides, nematocides, fungicides, seedlings, fertilizers, knapsack sprayers, cutlasses etc.) and insufficient finances. Due to poor output, farmers are unable to raise enough revenue to sustain their household and still maintain the farms or buy inputs. These have led to farmers continue dependent on artisanal tools for cultivation which contribute to pre-harvest losses and poor yields.

5.0 Effect on food security

Bananas and plantains are part of the daily diet of many people in Africa especially in rural areas where small and medium scale productions are mostly concentrated. Consumers are unable to meet up with the quality and quantity needed for daily, weekly, and monthly consumption because of pre-harvest losses. Even the quantity produced is expensive due to unusual scarcity in some seasons. This has reduces/stops the affordability of many consumers especially the vulnerable households thus, affecting their nutrients intake. In East Africa, according to Muchuruza and Melchior (2013), Banana *Xanthomonas* Wilt (BXW) reduces the quantity of banana bunches harvested by 16.6% in Tanzania thus, reducing the daily number of meals of several households who depended on banana from 3-2. This further resulted to the food situation of 53.8% of the producers to be very bad while 38.3% was said to be bad. Banana contribute more than 50% to the diets of 32% households in Rwanda (Nkuba *et al*., 2015). Nkuba *et al*. (2015) reported that in 2009 and 2011, BXW reduces the bunches of banana harvested per household from 35-25% causing 14.4% of farmers to regulate their daily meals to one meal per day. This further led to a significant increase (14-64%) of households who were unable to consume their preferred meals throughout the year.

Equally in East Africa, Okonya *et al.* (2019) reported the aggregated perceived effect of pests and diseases on Roots, Tubers and Bananas (RTB) losses on households in Rwanda and Burundi. According to these authors, insufficient food to feed families throughout the year were reported by 80% and 29% of the households in Burundi and Rwanda respectively. Equally, these authors added that in Burundi, 90% of the households attributed the high prices of these food items to pests and diseases. This high food prices further exacerbated the food insecurity situation of the consumers.

In Central Africa, according to Nkwain (2022), in 2019 and 2020, bush fire, hailstones and storm reduces the quantity of banana bunches harvested by 31.6% in Boyo Division in the North West Region of Cameroon. This resulted to food insufficiency to 81% of the producing households. Bananas in this part of the region were complemented with beans, cocoyams and potatoes to economise the consumption of these food items. It was also consumed solely especially during the lean season of beans and maize (*Zea mays*). It was equally exchange for other food crops not produce by the farmers' households in order to balance their diet. All these practices drastically reduce because of the drop in the quality and quantity of banana produced (Nkwain, 2022).

6.1 Possible ways of curbing losses caused by natural factors

a. Proper propping

Farmers should be practicing proper propping of fruited as well as non-fruited plants to minimise the effect of the storm. Propping can be done in three ways (1) supporting the tilted plants at the level of the leaf crown or under the bunch in the case of fruited plants with two

criss-cross dry bamboos or poles to form a tripod, (2) staking by pinning a healthy pole (2-4m of length depending on the height of the plant) 50cm-1m away from the tilted plant or in between oppositely tilted plants and fastening a twine above the mid part of the plants to the poles and (3) fastening a twine on a stick of 15-20cm and passing it in between the leaf crown to hock on the transitional peduncle (spike) and then pulling the extended part of the twine and fastening it on a stump or tree. These methods can be applied individually or two on the same plant depending on the size of the bunch and intensity of wind in a locality.

b. Development of dwarf and resistant varieties

Banana and plantain research institutions should develop more dwarf and medium varieties/cultivars with emphasis on larger pseudo-stems and strong root systems that are less sensitive to wind. Equally, farmers cultivating on slopes like in the case of the Western highlands of Cameroon should be advised to be cultivating short and medium varieties to minimise toppling.

c. Avoid the use of systemic herbicides

Farmers should avoid the use of systemic herbicides on their fields especially those on slopes. This is because these chemicals go right down to the roots of herbs and in the course of killing the herbs, they cause the soils to loss the cohesive bond holding its particles together. This result to lose soils contributing to easy toppling of banana plants as well as erosion which exposes banana corms and equally contribute to toppling.

d. Pruning at the onset of the seasons and speculative planting

During the onset of the dry and rainy season, *Musa* plants should be pruned. This will create spaces for free circulation of air as well as the strong wind that usually occurs during these periods thus, minimising the toppling and folding of the plants and leaves as a result of the wind unable to pass. Since mostly fruited plants are highly sensitive to wind, speculative transplanting should be practiced. That is, transplanting suckers in periods such that fruiting of those suckers will not coincide with the periods of strong wind.

6.2 Possible ways of curbing losses caused by agronomic factors

a. Planting spacing

In the *Musa* coffee/cocoa intercrop, the *Musa* planting spacing should be at least 4m x 5m and a stool should contain at most four (4) plants, that is, the mother plant that is fruited or about to fruit, 1-2 daughter plants that are halfway or almost close to the mother plant, and a young sucker (SHEP PLUS, 2019). This will maintain the plant density and the production of healthy bunches. This spacing will equally reduce the spread of pests and diseases especially sigatoka. In a newly opened farm or in a forest system, a spacing of 3m x 4m or 4m x 4m can be adopted but should be increased as soon as other crops like cocoa, coffee and palms among others starts gaining cover.

b. De-suckering

The number of suckers in a stool should be controlled because they increase competition for nutrients and thus, reduces the fruit quality. De-suckering should be practiced in situations where the number of plants per stool exceed the recommended amount. This can be done by carefully cutting-off or off-rooting extra suckers or unhealthy plants. Off-rooting is better

because it stops the regeneration of the plant but should not be carried out on plants that are about to fruit or have fruited to avoid exposing the plants to toppling.

c. Pruning and removal of leaf sheaths

Leaf pruning and sheath removal increases the exposure of fruits, stems, suckers and the floor of the farm to sunlight hence better quality of the fruits produce. It also reduces the accumulation of aphids, fruits flies, spiders and mealy bugs among others which are either vectors of disease or direct consumers of plant parts. The pruned leaves equally act as mulch reducing the growth of grass as well as water evaporation especially during the dry season. Pruning should be done carefully in order not to wound the petioles of the remaining leaves and expose them to infections or folding. The leaves should be pruned 10-15cm away from the pseudo-stem to avoid infections easily getting to the pseudo-stem from the cuts. At least 7 green leaves should be allowed per plant. Only dry leaf sheaths and those that are no longer attached to the pseudo-stem should be carefully removed at the ground level while making sure that the remaining ones are not wounded as this will create avenue for pests and diseases.

6.3 Possible ways for minimizing losses caused by biotic factors

a. Crop rotation

Crop rotation should be practiced to reduce the accumulated population of nematodes, weevils and other pests in *Musa* farms. This can be achieved by clearing-off *Musa* farms that have been existing for five or more years or farms whose yields have started dropping. Some of the ways to know that a farm is infested is when suckers are no healthier, fruits and bunch sizes have reduced and when there is frequent toppling of plants with the least wind. The cleared farm should be allowed to fallow for at least 1-2 years or planted with crops that are not in the family of bananas and plantains. This will reduce the population of the pests as they will have no identical substrate or what to feed on.

b. Provision of improved/disease-free plantlets.

The continue spread of *Musa* diseases in the region is partly because of over dependent of farmers on sward suckers which most often are infested. Therefore, improved and disease-free planting material should be made available to farmers via extension agents so that farmers can revamp their farms. This can be achieved by decentralising or creating and funding propagation centres in every Division/State or District involved in *Musa* production. The availability of these centres and plantlets closer to the farmers will influence adoption. This will therefore, minimises the spread of pests and diseases and improved yields. Equally, disease resistant varieties especially those resistant to BXW, panama and sigatoka should be developed and recommended to farmers to plant in between their existing plants. This will help in curbing the spread of these diseases and reduce losses.

c. Cutting and throwing away of the infected leaves and plants

Infected leaves especially in the case of sigatoka should be carefully cut-off and gathered in between the plants. While plants detected with BXW, banana bunchy top disease and panama should be carefully cut-off or better still off-rooted and thrown away from the farm or chop-off and burn. Wood ash and or hot water can equally be poured on the pits to neutralise the disease. Equally, during pruning, there should be a separate cutlass and sickle or 'banana spear' reserve for the pruning of infected plants. This will minimise the spread of diseases.

d. Cleaning of farm tools

After every pruning or cutting of infected plants, the tools should be properly washed or hot water should be pour on them in the case of metal tools for disinfection. Tools begged or rented should equally be washed before any utilisation because they may have been contaminated.

e. Use of wood ash and pesticides

Three handful of sieved wood ash should be added to 15 litres of water in a bold and stir thoroughly. A tin tomato-can (40-50g) of *mocap* (nematicide) and 80-100ml of *comfu* (insecticide) should be added to the water and equally stir thoroughly (Nkwain, 2022). Corms of suckers should be clean while exposing the whitish part. The cleaned corms should be immersed in this mixture for 10-20 minutes and kept to dry before planting. This will reduce the population of nematodes and weevils. The mixture can equally be sprayed in suckers' pits before transplanting for better performance. It can also be spray round existing stools for the same purpose. In a locality where these chemicals are not available, any nematicide and insecticide can be used.

f. Integrated Pest Management (IPM)

In general, it is necessary to be practicing Integrated Pest Management (IPM) techniques for sustainable production. That is, applying multiple techniques to prevent or minimise pest and disease attacks on plants. For instant, planting of resistant *Musa* varieties, practicing crop rotation, field sanitation, regular trimming of the leaves, early removal of infected plants and leaves, de-suckering and proper spacing of the plants should be practiced. This will reduce pests and diseases and therefore, the rate of utilisation of synthetic pesticides which are expensive and less friendly to humans and the environment will be reduced. It will equally reduce cost of production and enhance farmers' income and the sustainable production of healthy fruits.

6.4 Possible ways of minimising losses caused by human-induced factors

a. Providing long lasting solutions to farmer-grazer conflicts

A long lasting solution can be provided to farmer-grazer conflicts by demarcating grazing land in every community where grazers are found and banning open grazing as in the case of Southern States of Nigeria. Equally, grazers should be trained on improved grazing systems to avoid them from moving with cattle from one place to another and causing problems. Grazing policies should be revisited, revised and properly implemented while making sure that defaulters are handled by law accordingly.

b. Improvement of extension delivery system and training of farmers on improved practices

There is a need to revisit extension information delivery systems in Africa. In the 90s, farmers use to have radio-listening groups in communities where radio sets given by agricultural funding organisations (e.g. World Bank) were used by these groups to follow extension programs (mass method of information delivery). By then handsets (mobile phones) as well as radio sets were not common. Today, 50-70% of farmers especially banana and plantain (cash crops) farmers or someone in their households are having at least a mobile phone which receive radio signals. This improved communication tool can be harnessed by

extension systems in the continent to disseminate agricultural packages to banana and plantain farmers to make up for field absences and late visits resulting from insufficient resources and high extension-farmers' ratio (Nkwain & Fatty, 2019). Agricultural information dissemination through radio and newspapers should be reinforced. Imagine the level of agricultural development in Africa if agriculture, the so call backbone of Africa's development was preached the same way politics is being preached in radio channels and newspapers in the continent.

In addition to this, bananas and plantains being some of the cheapest produced crops and among the most farmers-dependent food and cash crop in the continent, need more specialise extension agents to enhance the production of these crop. These specialists should be able to sensitise and train farmers on improved production practices. That is, methods of suckers' selection, treatment, planting and maintenance as well as common pests and diseases affecting these crops, the signs and symptoms of these diseases, possible seasons when they are common and ways of minimising them. Trainings should equally be given on fertilisers and pesticides application to avoid the application of 'less or over dose.'

c. Subsidisation of farm inputs and equipment

The inadequate/non-use of improved inputs and farm tools in the continent is partly as a result of high prices. Therefore, if farm inputs and equipment are subsidised, farmers will be encouraging to purchase and use insecticides, herbicides, nematicides and fertilisers when needed hence, minimising pre-harvest losses. Equally, farm tools like cutlasses, spades, dig-axes as well as knapsack and engine sprayers that can be used for chemical weeding and pesticides application will easily be afforded and used.

7. Conclusion

The study has shown that pre-harvest losses of *Musa* varieties are high in East Africa especially in Uganda, Tanzania and Kenya, followed by Cameroon in Central Africa. Few studies have reported pre-harvest losses of *Musa spp*. in West Africa with Nigeria and Ghana being on the lead. Pre-harvest losses have been increasing over the years due to the incidents of new pest and diseases, conflicts and climate change. These losses rendered thousands of household's food insecure. The principal causes of pre-harvest losses in the Region are pests and diseases, strong wing, over depended on sward suckers and rainfall, poor input/farm tools, and weak extension system. It is therefore, recommended that proper propping, pruning and crop rotation should be practiced while *Musa* research centres should be decentralising, extension delivery systems revisited and disease-free planting materials provided to the farmers.

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