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BACTERIAL BLACK SPOT DISEASE AND ITS EFFECT ON AGRO-PROCESSING FIRMS: EVIDENCE FROM BLUE SKIES LIMITED IN NSAWAM ADOAGYIRI MUNICIPALITY

BY

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DECLARATION

I do hereby declare that except, for citations to other authors' works that have been properly acknowledged, this dissertation is the result of my own research carried out at the Institute of Statistical, Social, and Economic Research, University of Ghana, under the supervision of Dr. Ralph Armah**.**

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Dr. Ralph Armah Date

29 February 2024

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(SUPERVISOR)

DEDICATION

I dedicate this dissertation to my parents, my supervisor, and my relatives for the immense role they have played throughout my entire education. May God Almighty reward them abundantly for their support and love.

ACKNOWLEDGEMENT

With my kindest gratitude, would like to acknowledge the encouragement, time, direction, and effort bestowed on me to execute this task. To fully perform this task, I met my supervisor, Dr. Ralph Armah, for his wonderful guidance and strict surveillance in making sure that the right work was done. May the Almighty God bless you, Dr. Armah!

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ABSTRACT

Bacterial black spot disease is an incurable disease posing many challenges to stakeholders in the mango industry, and for fear it might collapse if appropriate measures are not taken. The study was conducted to determine the relationship between the BBS disease and its effect on agro-processing firms in terms of adaptability and survival. The data for the study was collected based on interview guides and in-depth knowledge from external stakeholders in the Nsawam Municipality and key informant interviews with internal stakeholders at Blue Skies Limited, which employed purposive and convenience sampling techniques. A qualitative approach was used in providing the findings, where data collected through interview guides and audio recordings were transcribed, coded, analyzed, and errors corrected for validity. For the statistical purposes of the descriptive study of demographic characteristics, frequency tables were made available. Results were presented using the content analysis method, and the researcher directly cited comments from the voice recordings of in-depth and key informants under the thematic areas. The findings indicated that the BBS disease had a major negative influence on the natural fruit flavor during product production, and processing, that the quantity of fruit disease causes production schedule delays, that insufficient tonnage from infected stored mangoes is produced due to delayed disease discovery, and that periods of intense rainfall had a significant influence on the fruit-bearing flowering stage.

Based on the study's findings, research and development, extension services, and information dissemination which would pave the way for the concepts of sustainable farming systems in the mango industry, adopted measures that both out-grower farmers and agro-processing firms can implement to reduce the prevalence and severity of the BBS disease.

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LIST OF ABBREVIATIONS

BBS	Bacterial Black Spot
CABI	Centre for Agriculture and Bioscience International
CBPBBE	Composite Budget Programme-Based Budget Estimate
CSIR	Council for Scientific and Industrial Research
CSSVD	Cocoa Swollen Shoot Virus Disease
GIZ	German Corporation for International Corporation
GEPA	Ghana Exports Promotion Authority
MoFA	Ministry of Food and Agriculture
MFA	Mango Farmer's Association
NAM	Nsawam Adoagyiri Municipality
PHC	Population and Housing Census
PPRSD	Plant Protection and Regulatory Services Directorate
KII's	Key Informant Interviews

CHAPTER ONE

INTRODUCTION

1.1: Background of the Study

Ghana's agriculture is predominantly small-scale, traditional, and rainfed, where farming systems vary across agro-ecological enclaves. The agricultural sector is made up of four subsectors: crop farming (including cocoa), livestock, forestry, and fishing.

Mango fruit, which is under cash crop farming, is reported to have originated in India in the Indo-Burma Region (Crane, 2020) and has spread to all tropical fruit-producing regions across the world. In the last two decades, Ghana has developed its fruit production industry by exporting assorted fresh and processed tropical fruits like mango, banana, pineapples, and other fruits to the European market.

Mango farming, which is an important activity in the agricultural sector, is done mostly in the northern and south-eastern regions of Ghana. Somanya in the Yilo Krobo district and parts of the Lower Manya Krobo district in the Eastern Region are the biggest hubs for mango cultivation in Ghana. Mango farmers in this region can harvest twice a year as compared to the northern parts of Ghana. The mango fruit in Ghana has increased its annual trade on the domestic market, mainly in the form of whole, fresh cuts, and juice.

According to the Ghana Exports Promotions Center (GEPA), Ghana's exports of mangoes grew by 28% between 2020 and 2021, with the total value of exports reaching $64.6 million in 2021, compared to $50.3 million in 2020. This growth in exports demonstrates the rising significance of Ghana as a supplier of mangoes to international markets (GEPA, 2021).

Considering this, multinational fruit corporations, including Golden Exotics, Bio Exotica, and Britain's Blue Skies, have established fruit processing plants and export businesses in Ghana due to the abundance of mango fruit grown here. These companies have also supported local farmers in various capacities to expand their production. Some of the mango varieties grown in Ghana are Haden, Keitt, Kent, Tommy Atkins, Palmer, Francine, and Irvin. These mango fruit varieties are usually exported to Europe, and this has increased export earnings for the country. The various varieties of mangoes grown in Ghana have their own distinct oval-shaped sizes, sweet taste, and colour, giving them a competitive advantage over other mango-producing countries on the continent.

Mango contains nutrients such as protein, vitamin A, C, E, K, B6, potassium, sugar, and others. It helps in protecting the body against diseases such as diabetes and heart disease while improving eye health, digestion, and reducing the risk of cancer (Bagchi, 2018).

Bacterial black spot, known to agrarian farmers as BBS, is caused by the pathogen *Xanthomonas campestris pv. mangiferae indica*. It first appeared in the Northern Region (Tamale) and was later found in the Manya Krobo enclaves. The disease was named after the black spot marks that developed first on the leaves and then spread onto the fruits.

It attacks leaves, twigs, flowers, and fruits, thereby reducing the mango tree's yield and quality of fruit produced, resulting in a loss of market value for the fruit and subsequently lowering the revenues of farmers (Kibira et al., 2015). Most of these farmers get their revenues from the tons of mangoes sold to agro-processing firms both home and abroad, who patronize them for mass processing, and the remaining feed local households in Ghana.

1.2: Problem Statement

In recent years, Mango Farmers Associations (MFA) in Ghana, formed by small-scale farmers, have called on the government, and all stakeholders to help in the fight against BBS disease for fear it would collapse the mango industry. The disease, which is airborne, occurs when strong, heavy winds blowing during the rainy season carry the bacterium, which spreads quickly from one farm to another. Within a few minutes, it affects the fruits, flowers, leaves, and branches of the plant. The disease attacks mango trees by weakening their branches, causing premature fruit droppings and cankers on fruit.

Mango Farmer's Associations across the regions of Ghana have tried to tackle the problem over the years together with the MoFA and other stakeholders, but this has not yielded many results because it keeps occurring each year. There are fears that the disease could significantly reduce fruit quality, and marketability (Crane, 2017). This could affect employment in the mango agrarian sector as well as in agro-processing firms. Due to the important role mango plays as a food security crop in the livelihood of the farmers, the economy of Ghana could be under threat from the disease (Al-Adawi et al, 2013).

The gap identified is that there is not much information about the economic impact of BBS disease on mango production and processing. This study seeks to look at the relationship between the disease and its effect on agro-processing firms in terms of adaptability, and survival in the industry. Enterprises that grow mangoes in Africa and elsewhere face a serious threat from BBS disease.

1.3: Research Questions

The following research questions were addressed:

1. What is the perception, and knowledge of stakeholders on the prevalence, and spread of the BBS disease?
2. What are the Economic Costs of BBS disease in Mango Production, and Processing?
3. What measures can Out-grower farmers, and Agro-processing firms adopt to prevent the prevalence BBS disease?

1.4: Research Objectives

The specific objectives are as follows:

1. To assess the perception, and knowledge of stakeholders on the prevalence and spread of the BBS disease.
2. To examine the Economic Costs of BBS disease in Mango Production, and Processing.
3. To determine measures Out-grower farmers, and Agro-processing firms can adapt to prevent the prevalence of the BBS disease.

1.5: Justification of the Study

The negative impact of the bacteria black spot disease on mango was detected in 2011 in the northern parts of Ghana; it spread down to the south-eastern zones (Pruvost et al., 2011) and resulted in a reduction in market value and fruit yields. This has been the bane of the woes of mango farmers, argo-processing firms, and other stakeholders.

Based on this, the study examined the effects of BBS disease on argo-processing firms, in terms of adaptability, and survival.

A few studies that were conducted concentrated on the origin and severity of the disease in the mango industry, but this study was relevant because of its contribution to national agriculture emergency research undertaken and how argo-processing firms can adapt and survive based on the topic.

The research would offer first-hand knowledge regarding how the prevalence of BBS disease affects the economic costs associated with survival for agro-processing firms. The results of the study will contribute to our understanding of how appropriate sustainable farming systems can support farmers and agro-processing firms in making informed decisions about appropriate policy implications, modifications, and countermeasures to the disease's spread within the mango industry. Furthermore, the study would shed light on how losses in mango production affect both domestic and foreign markets.

Also, it is expected that this study will help the Government of Ghana through the MoFA, in collaboration with Municipal Agric officers, the MFA, the Agriculture Department under the CSIR, local and international agencies, and other stakeholders, come on board to provide lasting measures and solutions as soon as possible.

1.6: Scope and Limitation

This study focused on the relationship between the BBS disease and its effect on Blue Skies Limited adoption strategies, and survival. The research encountered some limitations, such as high transport fares in data collection from stakeholders at Blue Skies Limited and the Agric Municipal Assembly, time constraints, power outages, and a lack of funds. However, despite the challenges that were faced with this dissertation, I produced an authentic and dependable original work that will be valuable for future research.

1.7: Organization of the Study

This study was organized into five chapters. Chapter one examined the study by looking at the background. Chapter two dealt with the conceptual and theoretical frameworks. Chapter three looked at the methodology of the research understudied. Chapter four dealt with the presentation of findings, discussions, and analysis of the data collected, while Chapter five dealt with the summary, conclusion, recommendations, and suggestions.

CHAPTER TWO

LITERATURE REVIEW

2.0: Introduction

This study reviewed extensively the overall impact of mango bacterial black spot disease and its effect on farmers as well as argo-processing firms. It further compared literature work and findings from research on other diseases and how they affected the mango industry.

2.1: Conceptual Review

This section demonstrates a clear understanding of the concepts used in the research. These include a basic understanding of mealybugs, fruit flies, and anthracnose; the origination of BBS disease; its causes and economic impact on agro-processing firms; the disease's impact on mango yields; the role of mango production in the domestic and global markets; and the socioeconomic implications of mango production on farmers' livelihoods.

2.2: Brief Knowledge of Mealybugs, Fruit Flies and Anthracnose in the Mango Industry

Micah et al. (2016) opined that the constraints on mango production in the Yilo Krobo Municipality in Ghana have reduced productivity, which has adversely affected the mango farmers in the area. Studies show that access to skilled labour, credit facilities, the incidence of fruit droppings, and pests and diseases had a significant effect on the production of mango in the locality.

Mango pests and diseases that are severe in the industry but have been brought under control are mealybugs, anthracnose, and fruit flies. Mango mealybugs are the primary pests of mangoes that significantly reduce the value of mango fruit (Bokonon-Ganta et al. 2016).

Mealybugs are transmitted by various means, such as ant movements, airborne movements, labourer movements on farms, and contaminated farm equipment. They caused damage to a wide range of crops and posed a grave threat to agriculture in the area.

Preventive measures adopted to stop their spread include pruning trees to remove highly infested branches and removing weeds from field borders during cropping periods to avoid alternative hosts for the bugs. Control measures adopted were brushing off mealybugs on small-scale farms, spraying with a mixture of dishwashing liquid and water, and blasting bugs off with a strong stream of water, often effective in the early stages of infestation (Asante, 2015).

Photo 1: An infested mango fruit with mealybugs by Nebie et al. (2016).

A complex tropical fruit fly called Bactrocera invades is also known as a fruit fly (Acheampong, 2013). These pests seriously hindered the production and marketing of mango fruits, to the point where imports from Ghana were banned.

According to the cultivar and season, losses from fruit flies in Ghana were predicted to range from 60% to 85% of the harvest (Acheampong, 2013). They caused severe damage to both unripe and ripped fruits on the tree by laying eggs within the fruit. When the fruit falls from the tree, the maggot stays and grows inside the mango. Then it comes out of the fruit, pupates in the soil, becomes a fly, and goes up again into the tree (GIZ, 2015).

The traditional management methods used included gathering rotten falling fruit into black plastic bags and using parasitic wasps or weaver ants, which are known to feed on fruit fly larvae and are natural predators of these insects (GIZ, 2015).

Photo 2: Infested fruit flies and the damage they cause to mango fruit by Gyaan (2019) & Naadi (2016).

The pathogen *Colletotrichum gloeosporioides,* which causes anthracnose in Ghana (Offei et al., 2015), prefers humid, hot, and wet weather (Nelson, 2015). The pathogens are comparatively inactive in dry weather (Tovar-Pedraza, 2020). Darkened sunken lesions that may or may not be accompanied by brilliant orange-coloured acrevuli of the causative agent are the disease's primary symptoms (Admasu, 2014).

Mango trees should be planted in areas with a definite dry season to allow fruit to develop in conditions that are unfavourable for disease development. Other cultural control measures include ensuring field and general tree sanitation and wrapping developing fruit in paper bags (Mureithi et al. 2017).

Photo 3: Anthracnose on mango fruit and leaves by Shutterstock (2022).

2.3: Origination of Bacterial Black Spot Diseases

Bacterial black spot-on mango emerged in 2011 in the Northern Region (Tamale) and then spread down to the Eastern and Volta parts of the country in 2012 (Pruvost, 2014). Bacterial black spot is one of the most important diseases of mango fruit, and a major challenge in the mango industry worldwide (Pruvost, 2015). Later, it was discovered in an orchard in the Manya Krobo in the Eastern Region (Adiku, 2014) which is close to Somanya and where large plantations of mango are cultivated for exports, local production, and household consumption.

It happens during windy or rainy seasons where there are strong, heavy blowing winds, irrigation water, and insects transporting the disease from one fruit to another by carrying spores of the pathogen to immune plant tissues, and then spreading the disease throughout the whole mango plantation. It's an airborne disease that settles on farms and can spread very rapidly to other farms in neighbouring towns. It affects leaves first, then moves to the fruit, where the BBS disease only needs either water on the leaves or extremely high humidity for a prolonged period of about twelve to fourteen hours to start the infection. The bacteria are caused by numerous tiny, black-soaked water spots on the leaves, fruit, flowers, and branches.

Photo 4: Bacterial black spot disease on mango leaves, flowers, and branches by (Alam, 2019) & GIZ (2015).

2.4: Causes of Bacterial Black Spot Disease on Mango

The main areas where bacterial spots appear on mangoes are the leaves and fruits, but twigs and branches can also be affected. On the leaves, which are connected by veins and have chlorotic margins, there are tiny, black, water-soaked sores. As BBS disease progresses, the spots might get dry, and the leaves may fall off, which can result in defoliation (Carolyn, 2020).

The BBS disease on mango fruit sometimes has a dip or shallow black spot with a crack on the epicarp, that is, the outermost layer of the mango, but when the rotten spot gets serious, it enters the endocarp, thus the inner layer enclosing the seed damages the whole fruit, as shown in the diagram below.

Photo 5: Rain or irrigation water on the mango and rotten spots caused by BBS in the mango by John (2018).

Particles of wind-driven rain or irrigation water left on the mango fruit for some time develop soaked, rotten black spots, which in some cases become gummy or sticky on the fruit. It can also be caused during grove maintenance operations, where a strike of the farmer's equipment on the fruit generates a liquid fluid that encounters bacterial disease.

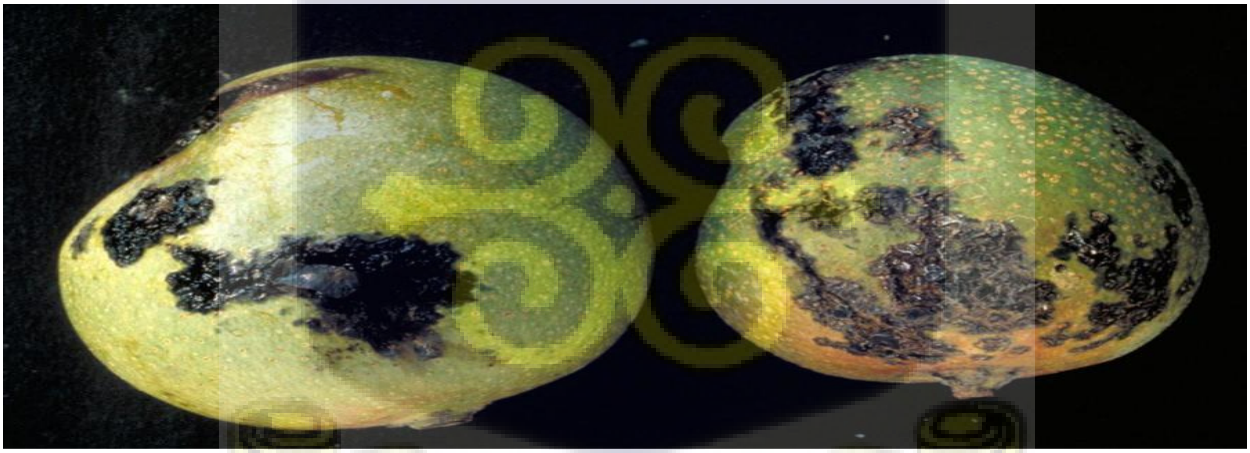


Photo 6: Black irregular-shaped spots (right), and gummy spots (left) on mango fruit caused by BBS by (Alam, 2019).

As shown in the photo above, at the early stages, the water-soaked light spots appear in the infected fruits, and then they later evolve into dark star- shaped craters, oozing infectious gum that attracts the pathogen. Minimal infections cause immaturity, and a reduction in fruit quality, while frequent fruit dropping occurs when the disease is extremely serious. Wounds can result in black, cracked branches and stems, which weaken the stability of the mango plant (Prusky, 2023).

2.5: Economic Cost on Agro-Processing Firms

Fruit processing firms such as Blue Skies Limited, Healthilife Beverages Limited, and Ekumfi Juice Factory, among others, have contributed immensely to the economic development of the country in terms of job creation, export earnings, and revenue. The linkage between local mango farmers and argo-processing firms has enhanced over the years in providing quality fruits, which generate huge incomes for these farmers.

The inception of the mango BBS has not only affected local farmers but also agro-processing firms that rely on these fruits for the production and processing of their products. This has been the headache of most agro-processing firms since they are unable to get enough raw materials from the mango farms for manufacturing purposes. This has affected the economic costs of their business operations in relation to production.

Due to the prevalence of the BBS disease, which affects the quality of mangoes and yield losses, agro-processing firms were unable to get sufficient mangoes from their out-grower farmers to manufacture their products. However, chemical pesticide use, and misuse are frequently linked to serious health and environmental concerns (Bertrand, 2019).

Professionals should thoroughly examine mangoes for chemical residues and disease severity before manufacturing to prevent production issues and impact quality costs. This would result in low product quality in terms of taste and longevity, revenue losses, and a high percentage of

product rejections from customers who feel that the product does not live up to their expectations. Furthermore, if some farmers employed antibacterial agents to combat the BBS disease, this would pose a health risk to the public.

Consuming the antibacterial ingredient in mangoes may reduce the human immune system's capacity to combat the numerous microorganisms that humans encounter daily. The BBS outbreak emergency will make it difficult for agro-processing firms to obtain the raw materials they need, which will force them to lay off employees due to the financial burden of unpaid salaries and other overheads that will eventually force the company to shut down. This will have an impact on employment factors.

In other words, while labor would not be accessible, workers would remain idle due to a shortage of raw materials (mangoes). Additionally, the company would incur additional costs if idle machinery were utilized for processing and manufacturing items with low efficiency.

Long lead times have an impact on agro-processing firms since they force them to import mangoes from neighboring countries and European markets, where the price of the product increases relative to what is paid locally for the fruit grown on the farms. Additionally, delays in the procurement of the product could result in irrational production timelines for the product as well as disruptions to the supply chain, which could spread the BBS disease through the vehicles, equipment, and mango crates used to transport the fruit from farms to factories' storage facilities. The sustainability of agro-processing firms' production is impacted by each of these elements.

These are some of the production-related issues that influence the product and affect consumers' perceptions of the company's brand, which is a challenge for Blue Skies Limited.

2.6: Impact of Bacterial Black Spot Disease on Mango Yields

Bacterial black spot disease has a significant impact on mango yields, which can lead to an increased reduction in fruit production, making it a limiting factor for the mango industry. BBS disease is very difficult to control, and it usually becomes a limiting factor for mango industries when fungal diseases and other pests can occur together with it. In infected orchards, chemical control is challenging, and on some farms, up to 90% of the fruit has had to be discarded due to the disease, making them unacceptable for sale and exports (Mossie, 2023). The impact of bacterial black spot disease on mango yields underscores the need for effective disease management strategies to ensure food security and promote the livelihood of farmers as well as the survival of agro-processing firms.

2.7: The Role of Mango in the Local and International Markets

Mangoes play a significant role in both the local and international markets where mangoes are popular fruits, with global demand increasing due to their nutritional value and unique taste. The global mango market is expected to grow at an active compound annual growth rate (CAGR) of 4.9% by 2030, with Asia-Pacific being the region with the largest market share (Data Bridge Research Market, 2022).

Ghana's mangoes play a significant role in both the local and international markets. The major varieties exported from Ghana include Haden, Kent, Palmer, and Keitt. Ghana's mango exports grew by 28% between 2020 and 2021, with the total value of exports in 2021 standing at $64.6 million compared to $50.3 million in 2020. Ghana ranked 11th in the order of countries that exported mangoes to the world in 2021 (CABI, 2011). Despite these challenges, Ghana is importing more than 3,000 metric tons of fresh mangoes, with a third of the imports coming from Brazil.

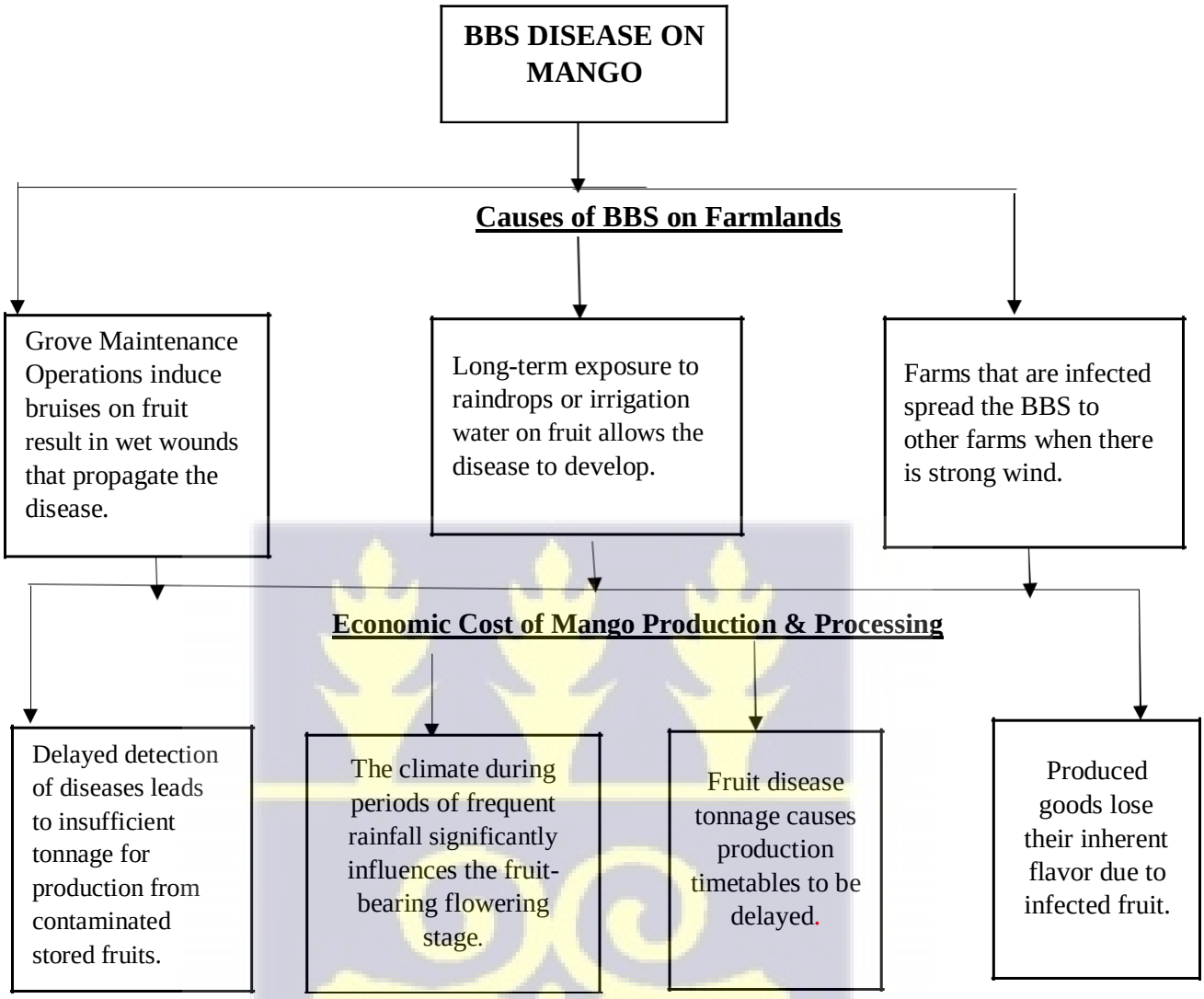
The importance of Ghana's mango in the local and international markets underscores the need for effective disease management strategies to ensure food security and promote the livelihood of farmers as well as the survival of agro-processing firms that depend on raw materials. Additionally, improving production practices, enterprise development, and marketing are essential to increasing the competitiveness of Ghana's mango industry in the global market (Ridolfi, 2018).

2.8: Socio-Economic Implications of Mango Production on the Livelihood of Farmers

Mango production has significant socio-economic implications for farmers and agro-processing firms, where mango farming has a higher cost of harvesting, sorting, and grading than other crops, making it a profitable venture for farmers in some areas. In Ghana, it has been estimated that the average loss following harvest is between 20 and 50%, accounting for a significant reduction in farmers' incomes (Mossie, 2023).

The high level of importation of fresh mangoes in Ghana is partially attributed to the need for juice processors to have a constant supply to meet their year-round demand. Mango production also has significant implications for agro-processing firms, with mangoes being a popular fruit in the international market. The socio-economic implications of mango production underscore the need for effective disease management strategies to ensure food security and promote the livelihood of farmers.

2.9: Conceptual Framework



Source: Author's Construct

Figure 1: The diagram below illustrates the progression of the causes of BBS disease and how equipment bruising, prolonged rain/irrigation water droplets breeding, and extremely windy conditions spread the disease on farms, resulting in economic costs for agro-processing firms.

2.10: Theoretical Framework

The Integrated Disease Management Strategies, which include the Germ Theory and the Integrated Pest Management Theory, provide the theoretical framework for the research on the bacterial black spot (BBS) disease and its effects on agro-processing firms.

2.11: Germ Theory

A scientific theory known as the "germ theory" contends that microbes, particularly germs, are the root cause of numerous diseases. The germ theory's fundamental principle is that germs, including bacteria, viruses, fungi, and parasites, can enter the body and cause disease. These microorganisms can spread from person to person through contaminated food, water, or items, or they can be found in the environment (Yen-Nien, 2018).

By identifying the bacterium Xanthomonas axonopodis pv. mangiferaeindicae as the disease's causal agent, the germ theory of disease explains how the bacterial black spot disease spreads among mangoes. The germ theory states that certain bacteria cause diseases; in the instance of BBS, the bacterium enters the mango plant and results in the fruit's peculiar black, oval, or unevenly elevated spots. The bacteria are hidden in cankers, or stem lesions, on seedlings and bud wood, from which they may spread to fruit and leaves. Initial infection occurs through natural openings in stems and leaves, and fruit injuries from wind damage can provide additional entry opportunities. Transmission and spread are driven by wind and rain and are favored by warm, humid conditions (Rickles, 2011).

In the case of BBS, the bacteria can be isolated from diseased mango plants and grown in workshop labs. This enables the creation of focused control measures as well as the identification of the precise bacteria causing the disease. Prevention is key to reducing the incidence and spread of

bacterial black spot disease. Some of these strategies include finding disease-free trees, planting in safe areas, properly pruning, sterilizing pruning equipment, removing fruit carefully, and keeping an eye out for symptoms.

2.12: Integrated Pest Management Theory

The Integrated Pest Management Theory is a theory that aims to integrate multiple strategies, such as biological control, cultural practices, the use of resistant varieties, and judicious use of pesticides, to manage pests and diseases. It emphasizes the reduction of pesticide use and the promotion of sustainable and environmentally friendly disease management practices (Baumgart-Getz, 2012).

The use of extension services is essential where farmers may be aware of the harm their management practices bring to the environment, but without the right information, and direction, it can be challenging for them to change their practices. Farmers adopt the modifications after they are aware of the benefits of new goods and methods. Thus, local research facilities and demonstration farms play a crucial part in disseminating this knowledge.

Additionally, with improved varieties and chemical inputs, agricultural extension can greatly boost its effectiveness in advancing agricultural development, empowering farmers, and disseminating knowledge by incorporating technology. This allows for a more comprehensive understanding of how technology is adopted in the agricultural sector.

Despite these significant achievements by previous researchers, a careful examination of the literature on BBS disease and its effect on agro-processing firms in developing countries, particularly Ghana, reveals an unexpected gap in the literature regarding the economic cost of mango production and processing, particularly in Ghana.

However, based on the literature reviewed and lessons learned from other developed countries that have adopted the germ theory and the integrated pest management theory, to adapt to the prevalence of the BBS disease, research and development, dissemination of information, and the use of extension services have helped in the adoption of strategies in sustainable farming systems.

CHAPTER THREE

METHODOLOGY

3.0: Introduction

The study consisted only of qualitative techniques. This chapter includes a profile of the study area, study design, study type, study variables, sample size and techniques, data source, data collection and instrument, data analysis, and ethical considerations.

3.1: Profile of the Study Area

Considering Blue Skies Limited, an agro-processing firm, is based in the Nsawam Adoagyiri Municipality and is the main subject of the study, the municipality was selected for the study. A summary of the company is provided below.

3.2: Overview of Nsawam Adoagyiri Municipality

According to the Composite Budget Programme-Based Budget Estimate (2021), the Nsawam Adoagyiri Municipal Assembly was established due to the Legislative Instrument's division of the previous Akwapim South Municipal Assembly into two (L.I. 2047) in 2012 as part of deepening the process of decentralization to enhance effective governance. The Nsawam Adoagyiri Municipality is in the Southeast of the Eastern Region between latitudes 5.45'N and 5.58'N and longitudes 0.07'W and 0.27'W. It occupies a land area of around 175 square kilometers and is situated about 23 kilometers from Accra, the nation's capital (CBPBBE, 2021).

According to the Population and Housing Census (2021), the population of the municipality was 155,597. With an annual population growth rate of 1.6%, of which 76,417 are males and 79,180 are females (PHC, 2021). The municipality shares borders with Ga West Municipality to the South, Suhum Municipality to the North and West and Akwapim South District to the East (PHC, 2021). The municipal chief executive is the political and administrative head of the NAM.

Agriculture is the municipality's main source of employment and revenue, employing roughly 37% of the workforce. Major crops grown there include maize, cassava, plantains, cocoa, oil palm, citrus, cola, pineapple, pawpaw, cashew, papaya, and both exotic and local vegetables. Also, they engage in livestock such as cattle, sheep, goats, pigs, and poultry. Nsawam Adoagyiri Municipality is dominated by the Akan ethnic group, followed by the Ga's, and then the Ewe people (CBPBBE, 2022).

3.3: Profile of Blue Skies Limited

Anthony Pile, the chairman and founder of the industry leader in fresh-cut fruit, freshly squeezed juice, and dairy-free ice cream, founded Blue Skies Holdings Limited. It has eleven operations in seven countries, including Egypt, South Africa, Senegal, Ivory Coast, and Ghana. The company, which is in the food and beverage industry, began in 1997, operated for profit, and is in Pitsford, Cumbria, in the United Kingdom. The company's main concentration is producing high-quality, just-harvested fruit products. Blue Skies Limited supplies leading retailers around the world, including Sainsbury's and Waitrose in the United Kingdom, Albert Heijn in the Netherlands, and Carrefour in France (MacGillivray, 2020).

Blue Skies Limited's main raw material is mango fruit, which is sourced from Ghana and Brazil, and other fruits used in the production and processing of products are pineapple, passion fruit, papaya, and coconut, as well as melon and pomegranate from Egypt (Blue Skies Holdings, 2021).

DISTRICT MAP OF NSAWAM ADOAGYIRI MUNICIPALITY

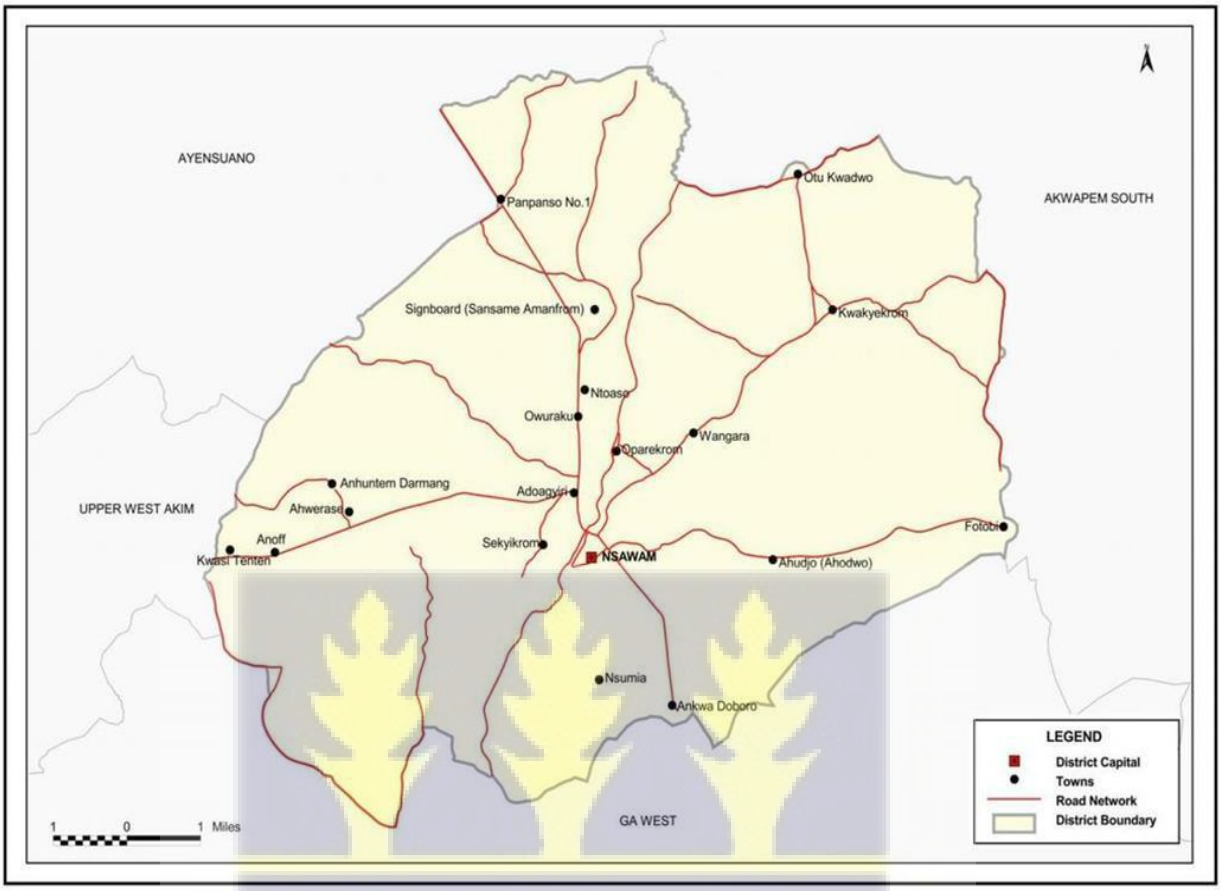


Figure 2: Map of Nsawam Adoagyiri Municipality (NAM)

Source: Ghana Statistical Service (2014).

3.4: Qualitative Research Design

Data was gathered at Blue Skies Limited and the Agric Municipal Office using a qualitative, descriptive technique that was based on sample size and interview guides. Stakeholders in NAM, including Blue Skies Limited employees, agricultural officers, and agrochemists at the Municipal Assembly, were the focus of a case study methodology. The choice of the case study design was based on its ability to facilitate the provision of proven, in-depth information to stakeholders, thereby addressing the primary objective of the research, which was to examine and understand

mango BBS diseases and agro-processing firms' adaptability and survival. The method assisted in gaining an in-depth understanding of the subject matter understudied.

The agricultural extension officer, municipal officers, out-grower farmer, and input dealer (agro-chemist) were the subjects of in-depth interviews. They offered appropriate responses for assessing their understanding of the BBS disease in the industry and some cultural control initiatives implemented. Agro-processing firm chief agronomist, fruit intake officer, production/processing staff, factory technical manager, factory technical staff, and suppliers were among the chosen respondents who participated in KII's. These individuals were chosen based on their specialization and understanding of the ways in which the disease impacted production-related concerns.

3.5: Study Type

Narrative research was the study's type, which focused on understanding and inquiring into human experiences through the collection and analysis of stories and lived experiences (Adedoyin, 2020) on BBS disease and its economic cost to agro-processing firms.

3.6: Study Variables

The study variables included the respondent's awareness of the BBS disease and its spread, their knowledge of the production's economic costs, and their ability to process and identify the steps stakeholders took to reduce the disease's prevalence. Demographic characteristics of respondents were sex, age, and educational level which constitute other variables.

3.7: Study Population

The target population refers to the entire group of individuals or objects to which researchers are interested in generalizing the conclusions (Stratton, 2021). The target population of the research was key to stakeholders at Blue Skies Limited and Agric Municipal office.

3.8: Sample Size and Technique

In carrying out this study, purposive sampling and convenience sampling techniques were used. Purposive sampling is a sampling technique in which the researcher relies on his or her own judgments when choosing members of the population to participate in the study (Campbell, 2020). This type of sample is frequently used to provide evidence for sample-based generalizations when working with extremely small, informative samples. Convenience sampling was used because the respondents were readily available for data collection (Stratton, 2021).

The research employed convenience and purposeful sampling approaches with a sample size of 14 stakeholders, as they possessed the necessary information for the investigation. Their absence from the scheduled discussion for various reasons hindered the completion of the focus group discussion, which was the study's restriction. It was advantageous to use in-depth interviews and KII's from Blue Skies Limited due to time constraints, a smaller labor force, and the fact that municipal officials had hectic schedules. During extensive interactions with the stakeholders, the perception and transmission of the disease were evaluated, along with the actions taken by the stakeholders to lower the prevalence of BBS disease. To study the economic costs of BBS, key informant interviews were conducted with stakeholders who possessed special information.

3.9: Data Source

An original data source is one in which the researcher gathers the data directly from the source for a particular project or purpose (Sudarmin, 2020). The primary data sources were Blue Skies Limited employees, including the factory technical manager, production/processing staff, chief agronomist, factory technical staff, suppliers, and fruit-intake officer, using interview guidelines tailored to the research area.

External data sources included municipal agricultural officers, crop officer, input dealers (agro-chemists), out-grower farmers, and agricultural extension officers. In-depth interviews with external stakeholders at the Agric Municipal office and KII's with internal stakeholders at Blue Skies Limited and its surroundings were used in this study to gather primary data from the sampling population.

3.10: Data Collection and Instrument

The population for the survey consisted of stakeholders and employees of Blue Skies Limited, and at the Agric Municipal office in the NAM. The instruments used to gather the data were interview guides and audio voice recordings from the stakeholders.

Section A consisted of demographic characteristics of respondents, such as sex, age range, and educational levels, from stakeholders.

Section B consisted of in-depth interviews with stakeholders based on the knowledge and spread of the BBS disease's origin, causes, effects, and control.

Section C consisted of the KII's and collected data from internal employees of Blue Skies Limited on the economic cost of BBS disease in mango production and processing.

Section D consisted of in-depth interviews that collected data from both internal and external stakeholders in the municipality to determine the measures that stakeholders adopted to reduce the prevalence of the disease.

3.11: Data Analysis

Structured, open-ended interview guide questions were utilized to collect field data for the three study objectives. These questions guided both in-depth and KII's and provided opportunities for follow-up and probing questions. The real data from these interviews was recorded using an audio

recorder for analysis. After that, the data was carefully transcribed by paying close attention to the stakeholder comments that addressed the given study questions. The content could be efficiently organized and examined because it was written through verbatim transcription. Filler words and repetitions were eliminated with the aid of verbatim transcription.

This helped the field data to be coded, edited, and analyzed. Coding was done by transcribing the audio recording into written text to identify stakeholder themes under headings that the researcher deemed pertinent to the study's goals and connected to the subject under discussion. Results were presented using the content analysis method, and the researcher directly cited comments from the voice recordings of both in-depth and key informants under the thematic areas. To help explain the findings, the content analysis technique was employed to cite, and extract conclusive evidence from the stakeholder replies.

The data findings of variables such as sex, age range, and educational levels of the stakeholders were represented with only frequency tables, and descriptive analysis was applied.

3.12: Ethical Consideration

For qualitative researchers, ethical practice is defined as a moral stance that involves respect and protection for people actively consenting to be studied (Suri, 2020). Before any respondents participated in the study, the research protocols were explained to them, and their informed consent was obtained. This is to say, the study adhered to the privacy of the participant if he or she refused to participate in the research out of fear of exposing their organizational operations.

Based on the interview guide, stakeholders were not obliged to give their names or contact information but only the job positions they occupied. The interview guide was given to my

supervisor for his opinions and review, and further literature research was done. These helped achieve content validity.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSION

4.0 Introduction

This chapter presented data collected from stakeholders at Blue Skies Limited and the Agric Municipal office, which focused on discussions with stakeholders on KII's and in-depth interviews. Using purposive and convenience sampling techniques, a total of 14 stakeholders participated; thus, the data collected were thoroughly analyzed to present the results accordingly.

4.1 SECTION A: Demographic Characteristics of Stakeholders

Respondents included in the study were asked about their sex, age range, and level of education. Findings regarding this information are shown in the frequency tables below.

Table 1

Construct	**Categories**	**Frequency**	**Percentage**
Sex	Male	10	71.4
	Female	4	28.6
	Total	**14**	**100.0**
Age Range	15-30 years	4	28.6
	30-45 years	7	50.0
	45-60years	3	21.4
	Total	**14**	**100.0**
Educational Range	JHS	6	42.9
	SHS	1	7.1
	Vocational/Technical	2	14.3

	University	5	35.7
	Total	**14**	**100.0**

Source: Fieldwork, 2022

In terms of sex, table 4.1 indicates the number of stakeholders who participated in the study; thus, 71.4% represented males, and 28.4% represented females. This suggests that there are more men than women, indicating that men predominate in the NAM.

When asked what age group they represented, 50.0% of the stakeholders said they were between the ages of 30 and 45, while 28.6% said they were between the ages of 15 and 30. The age group of 45 to 60 years old constituted 21.4% of the total stakeholders. This indicated that Blue Skies Limited and the municipality had employed energetic and youthful people within the agriculture and industrial sectors.

Regarding the respondents' educational backgrounds, it was found that 6 out of 14 respondents, or 42.9%, had completed their high school education, 5 out of 14 respondents, or 35.7%, had completed their university education, 2 out of 14 respondents, or 14.3%, had completed their vocational or technical education, and 1 out of 14 respondents, or 7.1%, had completed their SHS education.

4.2 SECTION B: Perception of BBS from Stakeholders

Construct	Categories	Frequency	Percentage
Years Stakeholders Spent in the Mango Industry	1-5 years	3	21.4
	5-10 years	3	21.4
	15-20 years	1	7.1
	20 & above	7	50.0

	Total	**14**	**100.0**
Industry Revenue Statistics for Mango	Production	7	50.0
	Export Earnings	2	14.3
	Income	5	35.7
	Total	**14**	**100.0**
Major Mango Diseases that Influence Farms	BBS Disease	11	78.6
	Mealybugs	1	7.1
	Anthracnose	1	7.1
	Fruit Flies	1	7.1
	Total	**14**	**100.0**

Source: Fieldwork, 2022

When asked about the number of years spent in the mango industry, 7.1% of stakeholders were between the ages of 15 and 20 and over, while 50% of stakeholders were over the age of 20. The remaining respondents, who ranged in age from 1 to 5 years and from 5 to 10 years, each accounted for 21.4% of the sample.

In addition, the study discovered that most mangos cultivated contributed 50% to production purposes, 14.3% represented export earnings derived from the industry, and 35.7% represented income generated from the industry.

Lastly, the study revealed that 79% of respondents stated that the BBS disease was the most common one in the industry, with a high severity. The remaining responses, which included 7% each for the diseases of fruit flies, mealybugs, and anthracnose, suggested that these diseases existed but were of low severity.

4.3: Perception of the Prevalence of BBS Disease

The municipal agriculture officer at the municipal assembly shared his view about their knowledge of the BBS disease.

"The BBS disease started in Burkina Faso, and entered the northern regions of Ghana, then *Kintampo, before it came into the Krobo enclave. Manya Krobo off season coincides with the season of the northern parts and the middle belt, which is Kintampo. So, when there is a shortage of mangoes in Krobo, mango traders' resort to Kintampo. Well, the disease began to spread by physical contact through the transmission of infested material, mango crates, and vehicles transporting mangoes to and from the farms". [Municipal Agric Officer, In-depth interview, November 4th, 2022].*

4.4: Perception of the Transmission and Spread of the BBS Disease

Supplier (A) at Blue Skies Limited shared his opinion about the spread of the disease.

> *"BBS is one of the diseases in mango production and can cause total loss of the fruit. Most of the disease came from Cote d'Ivoire and entered the country through the importation of plant materials, which affected mango fruits, leaves, and branches. The disease is transmitted using infested pruning tools, and equipment. Also, infested nursey seedlings of the mango picked up from affected farms when planted on a new farm breed the disease". [Supplier (A), In-depth interview, 22nd November 2022].*

4.5: Causes of the BBS Disease

An out-grower farmer said these about the causes of the disease.

> *"The symptoms on the fruit sort of include black spots that are being raised from the fruits, water-soaked cracks shaped like stars, and gummy substances coming from the fruit. On the leaves, one would see the black spots where water is soaked with yellow hallow*

around them. The disease is favoured by high winds, and frequently humid cool conditions with rains that promote the development of the disease, as well as irrigation water on the farms that can cause the disease". [Out-Grower Farmer, In-depth interview, 28th October 2022].

4.6: Effect of the BBS Disease

The chief agronomist reported these about the effect of the disease to the farmer and not Blue Skies Ltd.

"To us, it's the farmer who loses, not Blue Skies, when it comes to BBS because we don't send infested fruits to the factory. Before you supply fruits to the factory, the farmer takes out all the infested fruits. When the company is receiving the fruits, there are guys that check to see any spots on the fruit, pick them out before they weigh the fruits. But Blue Skies suffers losses on the field, which reduces tonnage." [Chief Agronomist, KII's, 22nd November 2022].

To buttress this point, the out-grower farmer said these about the use and effect of chemicals on the mango plant on humans.

"The bactericide, you know, is very expensive, and they don't use a bacterium chemical in treating a bacterial disease because of its harmful nature. Application of anti-bacterium to the plant, which makes us humans when we consume the fruit, take in the residues of the anti-bacterium, and when infected with a bacterial disease, it becomes difficult to fight them. You know, poultry manures containing ant-bacterium residues are not recommended to be used on mango farms for the same reason as the bactericide does, when the plant absorbs them, the residues get into the mango fruit, which when consumed, renders our immune system weak. So, less harmful chemicals to use are the copper-based fungicides

that are used in fighting the BBS disease". [Out-Grower Farmer, In-depth interview, 4th November 2022].

4.7: Control of the BBS Disease

The factory technical manager said this about the control of the disease:

"You don't wait till you detect the disease on the fruit, you begin spraying before flowering, and after flowering, you continue with your treatment. The bacterium moves about 250 meters and covers almost ten acres in heavy windstorms. There are prerequisite measures where some farmers don't care, and others care when controlling the disease on the farm. When the fruit starts to develop into a 'tennis ball size', and it's affected by the disease, one needs to cut them, and burn them as soon as possible before it spreads." [Factory Technical Manager, KII's, 22nd November 2022].

An agro-chemist added his contribution to the control measures farmers adopted for disease severity.

"When the mango starts fruiting, the farmer must spray using the copper-based fungicides, which come in two varieties: Copper Hydroxide, and Copper Sulfate. This is done through alternation, where the farmer sprays one agro-chemical in one season, and then sprays the other chemical in the next season so that the disease is not familiar with one agro-chemical." [Agro-Chemist, In-depth interview, 31st October 2022].

In addition to the above response, the crop officer shared his view about control measures in terms of spraying the fungicides.

"You know, researchers have been brought in to solve the problem, but to no avail. That there is no cure for the BBS disease but only a management practice for it. There is no collective way of spraying where Farmer A sprays today, and tomorrow Farmer B sprays,

which has not been an effective way of controlling the disease. Farmers who cannot afford the fungicides during the incidence of the disease also chance other farmers who have sprayed their farmers to be infected again even after spraying. Again, if the farmer has sprayed using copper-based fungicides, when it heavily rains it washes them away which makes them prone to the disease again." [Crops Officer, In-depth interview, 4th November 2022].

Lastly, the out-grower farmer said this in his response to control measures farmers can adopt to prevent the spread of the disease.

"The BBS disease can be controlled if farmers sanitize their farm tools, such as pruning tools that are borrowed by neighbour farmers to go and use on their farms. These are channels through which the disease can be transmitted from one farm to another." [Out-Grower Farmer, In-depth interview, 28th October 2022].

SECTION C: Overview of Economic Costs at Blue Skies Ltd.

4.8: Output Issues Impacted by the Economic Costs of Production and Processing.

A production/processing employee (A) said the BBS disease affected product output through high inventory, delayed production schedules, and supply chain interruptions.

"When a lot of farms are affected, a lot of fruits are lost, and the yield will be reduced. The quantity of fruits in a particular year that an agro-processing firm would want to buy from local farmers, will not be available, and they must import most of their fruits from other countries such as South Africa, and Cote d'Ivoire because the ones grown in Ghana cannot sustain their demand. Disease transmission through infested mango crates, and cargo

trucks transporting the fruits from farms to factories influences supply, and demand in the business operation." [Production/processing employee (A), KII's, 22nd November 2022].

4.9: Fruit Flavor Naturality Lost in Production and Processing

The science department, headed by the factory technical manager stated why the BBS disease affected the quality of fruits in production and processing.

"The gateway of the BBS disease to the mango fruit, is through its stake, which makes penetration of the disease into the fruit easier. When the fruit is brought from the farms to the factory, it goes through an acceleration test. This test is done to check whether the conversion of the starches to sugar is affected, whether the process of fruit ripening is affected and whether the texture, and taste of the fruits are affected before production or processing takes off." [Factory Technical Manager, KII's, 22nd November 2022].

Another production/processing employee (B) said:

"When one or two diseased fruits are transported to the factory, it must be reported to the Factory Technical Manager before it affects the other fruit in the storage houses. When the detection is not done earlier, it affects the tonnage of other fruits in terms of quantity, and quality. Since one must peel the fruit and scoop the BBS infected side out, the left-over tonnage to add up in producing a product is reduced as compared to the ones not infected." [Production/processing employee (B), KII's, 22nd November 2022].

The chief agronomist reported this about not getting quality, which affects production.

"This year, climate change, which is greatly impacting production, and has caused severe losses because flowering was really good but with the continuous rains, we had all flowers

falling off, was going to be a test for this season." [Chief Agronomist, KII's, 22nd November 2022].

4.10: The Effect of BBS Disease on Employment Productivity

The labour force of the company was very large, which was done according to working shifts daily, ranging from the inspection team, product (fruit) carriers, warehouse, and factory, accounts department, human resource department, factory technicians, production/processing employees, security services, cleaners, salespersons of the product, and so on. All these jobs are interrelated, which makes the business operation a very safe and conducive environment to work in.

The chief agronomist shared his view about the effect of the BBS disease on employment productivity.

"The disease does not affect the company's labour issues, because we are a company that produces mango every day and supplies all our retailers with fruits every day. We can't afford to stay a day without producing mangoes, and we are the only processor r in the world that produces mangoes all year round from January to December. We have our own sourcing strategy to make sure that we have mangoes every time. Even though Ghana produces mangoes only sixteen weeks out of the year, we produce mangoes every day. So, we make sure there is always a plan B to carry out a good forecast of the season and alert our head office quickly. Sometimes we are even forced to fly mangoes by air to Ghana to fill a gap because we don't want to disappoint our customers. Since he joined the company about 20 years ago, there has not been a single day we have not produced mango every day." [Chief Agronomist, KII's, 22nd November 2022].

4.11: Testing for Chemical Residues and Disease Severity

The office of the agronomist deals hand in hand with farmers and suppliers in terms of delivery to the factory. They all worked to ensure that the fungicides used in controlling the disease were well regulated to reduce the chemical residues in the fruit.

A fruit-intake officer at Blue Skies Limited said that:

> *"Alright, every pesticide is poison, but there are some that are very toxic, some moderately toxic, and some lightly toxic, depending on the chemical residues that have been rated. The rating of the pesticide tells you that we have a preharvest interval. The preharvest interval is accepted period between the spraying, and eating the fruits that would get the residues to a very low to acceptable level. So, for any farmer that supplies, we check the records to see the last time you sprayed. There are pesticides that last for a seven day preharvest interval, and others last for twenty-one days, and the caution we give to our farmers is that, if you know your fruit will be ready in December, make sure your spraying is done by October. This is to give a one-month gap so that the fruits would be free of pesticides, and we are very strict on pesticide residues; samples are taken from our farmers, and sent to UK labs before they are harvested, and so yes, we are very mindful of residue levels." [Fruit-Intake Officer, KII's, 22nd November 2022].*

A factory technical employee (B) contributed his knowledge to buttress the response above about the cost incurred in testing fruits.

> *"Fruits brought from the farms by the suppliers always follow the right procedures in the Global Gap Certification in farming practices to ensure quality fruits are produced. The company does not incur costs in testing for chemical residues in the fruit because fruit*

harvested and brought to the factory is shipped back to the UK laboratory for testing, and reports are given before they are brought back into the country for production, and processing." [Factory Technical employee (B), KII's, 22nd November 2022].

SECTION D: Adoptive Policy Recommendations from Stakeholders

4.12: Organize Workshops and Forums for Stakeholders

The crop officer said this about training and workshop programmes by the Assembly.

"We run a plant clinic as, and when there is need, the Agric Municipal Assembly does publicity before going into the communities, for farmers to bring their disease samples, and the Municipal Agric Officers diagnose, and give the farmers recommendations." [Crops Officer, KII's, 4th November 2022].

The municipal agricultural officer had stated why training, and workshops were organized by the Assembly for the mango farmers.

"Training programmes are organized in collaboration with the Mango Farmers Association and other state agencies to address the current issues facing mango farmers and to promote their interests. Forums are held to discuss best practices for producing mangoes, which helps generate revenues for the industry. Also, agricultural extension officers are sent by the Municipal Assembly to go around and educate farmers in the locality". [Municipal Agric Officer, KII's, 4th November 2022].

4.13: Agricultural Initiatives from Government and International Agencies

From the responses of key informant interviews organized, both the municipal officer and crop officer made it clear that there were no agriculture initiatives from the government to support them

in their production because the government of Ghana has no hand in the operations of the mango industry as compared to cocoa farmers, where the government played a monopolistic role for cocoa farmers in Ghana.

The municipal officer stated why there were no agricultural initiatives from the government for mango farmers.

> *"The MFA has been pushing over the years for the government's involvement in the industry; thus, the government does not have direct control over the sales of mango as compared to cocoa. This makes it difficult for the government to come in with the same initiatives or interventions as cocoa farmers in terms of mass spraying exercises which have not been successful for mango farmers." [Municipal Agric Officer, KII's, 4th November 2022].*

Also, the crop officer reported why there were no agriculture initiatives from the government for mango farmers.

> *"There are no programmes, or assistance from the MoFA in terms of providing equipment, and agro-chemicals to mango farmers, but the government only supports maize farmers in the provision of forearmyworm agro-chemicals to them, but apart from that, there is no initiative at all." [Crops Officer, KII's, 4th November 2022].*

4.14: Best Modern Agricultural Practices Adopted to Control the Disease

The municipal officer of the municipal assembly stated some ways grower farmers adapted to the prevalence of the BBS disease during a key informant interview session with him.

> *"The Plant Protection Regulatory Services Directorate (PPRSD) in Accra came up with a management plan that had to do with all the mango farmers, engaging in regulatory services, just like the cocoa farmers do in mass spraying exercises, which was the only*

effective way of controlling the disease." [Municipal Agric Officer, KII's, November 4th 2022].

A supplier (B) at Blue Skies Limited had provided some effective agriculture practices that helped in minimizing the disease on mango farms.

"Weeding in between the grove when it gets bushy to allow for enough sunlight penetration through the plants and pruning should be done more often where all disease parts on the tree are removed to prevent further transmission of the disease to other plants." [Supplier (B), In-depth interview, 22nd November 2022].

The agricultural extension officer had shared some best agriculture practices that mango farmers should adopt considering the prevalence of the disease.

"To help control the disease on mango farms, one had to plant certain trees that served as windbreaks between the mango plants, and also, to add that farmers must disinfect, and sanitize their farming tools to prevent the spread of the disease to other farms." [Agric Extension Officer, In-depth interview, 28th October 2022].

A factory technical employee (A) stated a few best cultural practices to adopt in the spraying regime to reduce the incidence of the BBS disease.

"Spraying should commence after pruning when the first flush is seen. Alternate copper at a one-month interval because this helped with disease incidence before flowering. You know the application should be done at a two week interval from fruit development to maturity. Canopy, stem, and branches must be thoroughly wet in the application of copper-

based fungicides, which are highly effective." [Factory Technical Employee (A), KII's, 22nd November 2022].

DISCUSSIONS

4.15: Objective One: Perception of the BBS Disease, Causes, Effects, and Control.

According to the findings of in-depth interviews conducted, the BBS disease entered the country in 2012 from neighbouring countries such as Burkina Faso and Cote d'Ivoire to the northern enclaves of Ghana and then spread down to the south -eastern parts, that's Yilo Krobo to the Lower Manya Krobo enclaves. The disease, being a bacterium, spreads through heavily wind-driven rains, which could cover about 250 meters on the farms. The disease started affecting the leaves, then progressed to the flowering stage, and then proceeded to the fruiting stage.

Most of the stakeholders held the view that the disease was transmitted through physical contacts on the farms; thus, infested mango leaves were used as a cushion in the mango crates, vehicles, and infested pruning equipment used in transporting the fruits from one farm to another. Most of the stakeholders related the spread of the disease to grove maintenance operations on the farm, where pruning materials that strike the fruits generate liquid fluid from the mango and start the process of the BBS disease. Also, some made the assertion that prolonging droplets of irrigation water on farms helped generate black spots on the fruit.

Many interested parties thought that irrigation water droplets, heavy rains, and grove maintenance activities were to blame for the fruit disease, which starts with soaking water and turns black on the fruit with a gummy, sticky texture. This then turns into a star with deep or shallow cracks, and it affects both the fruit's inner and outer layers as well as having a significant impact on the seed.

Most responses cited how it affected the farmer's overall yield losses on the farm, as most of the fruits fell off the mango tree, resulting in the farmer losing money when selling the mangoes to agro-processing firms. Many stakeholders believed that, due to the hazardous nature of several pesticides used to treat the disease, farmers who do not follow the proper preharvest interval in their pesticide application could induce respiratory disorders in humans.

Most of the stakeholders stated in their responses that they could control the disease on the farms and subsequently produce high-quality, healthy fruits, provided they implemented effective control measures and appropriate cultural farming practices. This was done to make sure that agricultural equipment was cleaned of dirt and infected materials, that the proper fungicides were used to combat the bacteria, that healthy, nurtured seedlings free of the disease were planted, that weeds were removed, and so on.

Based on the results of the in-depth interviews, the following deductions about the bacterial black spot (BBS) disease that is harming Ghana's mango sector can be drawn from objective one:

- **Origin and Spread**: The disease entered Ghana in 2012 from neighboring countries such as Burkina Faso and Cote d'Ivoire and spread from the northern enclaves of Ghana to the south -eastern parts, including the Yilo Krobo and Lower Manya Krobo enclaves. Physical contact, including the use of infected pruning tools, equipment, and nursery seedlings, is how the disease spreads, and it is caused by a bacterium. The disease spreads through heavily wind-driven rains, which can cover about 250 meters on the farms.
- **Impact on Mango Industry:** The BBS disease has had a significant impact on the mango industry in Ghana, causing total yield losses on the farm to the farmer, leading to a loss of revenues in the sale of mangoes to agro-processing firms. The disease affects the leaves,

flowering stage, and fruiting stages of the mango tree, leading to a significant reduction in mango production and exports.

- **Transmission and Control Measures:** The disease is transmitted through physical contact, including the use of infested pruning tools, equipment, and nursery seedlings. The spread of the disease is a result of the movement of infested materials and plants from affected farms to new areas. To manage the situation, the use of disease-free seedlings, good hygiene, proper pruning of affected branches, and the use of copper-based fungicides have been recommended as preventive measures. The droplets of irrigation water, heavy rains, and grove maintenance operations are also identified as factors that cause the disease on the fruit.
- **Call for Government Intervention:** Mango farmers and industry stakeholders have called for urgent government intervention to address the BBS disease, emphasizing the need for a national approach, mass spraying, and the introduction of bactericides to prevent the total collapse of the mango industry.

These deductions highlight the severity of the BBS disease, its widespread impact on mango production, and the urgent need for coordinated efforts and government support to mitigate its effects and prevent the collapse of the mango industry in Ghana.

4.16: Objective Two: Economic Cost of BBS Disease in Mango Production and Processing

According to the findings of KII's conducted at Blue Skies Limited, the BBS disease had a negative impact on the cost of production and processing. Most employees who responded to the survey acknowledged that the disease's severity on farms makes it challenging for the processing firms to obtain the quantity of mangoes needed for production. Processing also caused issues with

output, such as production schedule delays. To make up for the difference, the firm had to import fruits from countries nearby, which impacted the timeliness of manufacturing.

Most of the employees stated that the presence of a disease in a fruit can hinder its ability to convert starch to sugar, affecting the firm's ability to produce high-quality products. Due to this, it is challenging to obtain the fruit's original flavor. In cases where the fruit disease was severe, it caused the fruit to ripen too quickly, which prevented the firm from obtaining the necessary texture for processing and production. To obtain the desired flavor, preservatives may also be used.

Furthermore, climatic conditions made it more difficult for the firm to harvest enough high-quality products because of their effects on the flowering stage, which makes fruit tougher to collect. Frequent rainfall and strong, powerful winds blow on the mango flowers.

When most of the employees conducted field checks prior to the fruits being carried to the storage facility, they found that there could have been one or two infected fruits, which, if not found in the storage houses early on, could have resulted in significant losses in yield. They also acknowledged that the fruits underwent post-harvest treatment, which involved the application of chlorine to lessen or eradicate the bacteria on the fruit to prevent production losses, even though those fruits showed early symptoms of the disease.

According to the results of the responses, it was discovered that although fruit-intake officers are not paid to test for chemical residues or the severity of the disease, the firm does have a policy of checking for them prior to the start of manufacturing and processing. This was done to determine the fruit's level of toxicity or the rate at which pesticides were absorbed, protecting consumers' health.

Finally, the chief agronomist's key informant interview revealed that the severity of the BBS disease had no economic impact on production in terms of industrial job losses.

Many important conclusions on the impact of the Bacterial Black Spot (BBS) disease on Ghana's mango industry may be drawn from the findings of Key Informant Interviews (KIIs) carried out at Blue Skies Limited and the accessible search results.

- **Economic Impact:** The severity of the BBS disease has had a significant negative economic impact on mango production and processing. The disease has made it difficult for the factory to obtain the planned tonnage of mangoes for production and processing, leading to delayed production schedules and the need to import fruits from neighboring countries to fill the production gap, affecting production timelines and output. Additionally, the BBS disease results in decreased crop yields, which would necessitate adding extra labor to make up for the lost output. Since most out-grower farmers could not afford the pesticides, Blue Skies Limited bears the cost of purchasing pesticides and other farm equipment for the farmers they work with to combat the disease. The management of Blue Skies Limited sends out fruit-intake officers to farms to monitor the mango fruit, how out-grower farmers apply the chemical treatments, and repurchase health seedlings to replace diseased ones, which adds to labor expenses.
- **Quality and Taste:** The prevalence of the BBS disease has affected the quality and taste of the mango fruits, leading to the loss of some fruits. The conversion of starch in the fruit to sugar is affected, making it difficult to achieve the natural taste of the fruit. Additionally, the disease has led to the quick ripening of fruits, affecting the required texture for production and processing, necessitating the addition of preservatives to maintain the taste.

- **Post-Harvest and Processing:** The disease has also impacted post-harvest and processing operations. Delayed detection of the BBS disease can lead to the loss of some fruits in storage facilities. Even with post-harvest treatment using chlorine to reduce or eliminate the bacteria on the fruit, the disease has led to economic yield losses. The disease has affected the ability to get quality fruits for production, and the need to check for chemical residues and disease severity before processing has become a critical part of the firm's policy.
- **Climate Change**: The consequences of climate change have contributed to the challenges associated with BBS disease. The availability of high-quality fruits for production and processing has further decreased due to changes in the flowering stage brought on by climate change, which causes strong winds and frequent rainfall to blow the mango blossoms.

In Rutten's (2014) article "The Impacts of Reducing Food Loss in Ghana", the evidence of food losses in Sub-Saharan Africa is relatively high in agricultural production, post-harvest handling and storage, processing, and packaging stages. Dinko's, (2017) article, "Climate Change and Changing Food Security Risk in Ghana," revealed that the most important factor in the fight to feed Ghana is a seasonal variation in rainfall. The frequency and intensity of climatic extremes such as dry spells and droughts, as well as floods, cause substantial losses in yields and, consequently, affect household income and overall national growth. Due to its reliance on rain-fed agriculture, food production is vulnerable and very sensitive to climate change and variability. The recommendations provided were that an adaptation method should take into consideration the knowledge of residents and farmers and elicit a grassroots approach instead of a top-down approach from the government.

These deductions underscore the serious and multifaceted impact of the BBS disease on the mango industry in Ghana, affecting economic, quality, and processing aspects, and the urgent need for coordinated efforts and government support to mitigate its effects and prevent the collapse of the industry.

4.17: Objective Three: Adaption Strategies for Stakeholders

Most stakeholders acknowledged in their responses that setting up forums, workshops, and training programs aided in educating people, fostering idea sharing, and working together to address and analyze critical challenges facing the mango industry.

Most stakeholders acknowledged in their responses that the government did not directly participate in the industry's decision-making process; instead, they relied on the MFA and foreign organizations for money and assistance with their farming endeavors.

The best modern agricultural practices used to control the disease, according to all the stakeholders whose responses were received, were planting windbreaks like mahogany and acacia, which protected the mango plants and should be planted in the middle or on the farms' borders; adhering to cultural practices and sanitation, like weeding, pruning, and spacious planting to allow sunlight penetration; using disease-free planting materials; sanitizing farming equipment; and using certified pesticides on the farm.

Based on the given statement and the search results, the following deductions about Ghana's mango industry can be drawn:

- **Stakeholder Collaboration:** The stakeholders in the mango industry have emphasized the importance of organizing training programs, workshops, and forums to educate, share

ideas, collaborate, and address relevant issues in the industry. This highlights the value of knowledge sharing and collaborative efforts in addressing challenges and improving practice.

- **Government Involvement:** The stakeholders have expressed that there is limited direct involvement of the government in their decision-making processes within the industry. Instead, they rely on the Ministry of Food and Agriculture (MoFA) and international agencies for funding and support in their farming activities. This suggests a need for increased government engagement and support within the mango industry.
- **Adoption of Modern Agricultural Practices:** The stakeholders have acknowledged the importance of modern agricultural practices in controlling diseases such as the Bacterial Black Spot (BBS) disease. These practices include the planting of windbreaks, adherence to cultural practices and sanitation, usage of disease-free planting materials, sanitization of farming equipment, and the usage of certified pesticides on the farm. This underscores the significance of adopting and implementing best practices to manage and prevent the spread of diseases within the mango industry.

An article published by Andres et al. (2018) showed how social networks informed and helped in preventing the spread of swollen shoot disease in Ghana. The findings showed that the information flow among stakeholders in the cocoa value chain of Ghana is a key factor affecting knowledge spread and thus the adoption of Cocoa Swollen Shoot Virus Disease (CSSVD) prevention measures. Future research should explore knowledge transfer methods that capitalize on social networks as a key vehicle to increase the effectiveness of extension services and technology adoption.

To tackle and reduce the effects of diseases like the Bacterial Black Spot (BBS) within Ghana's mango industry, these deductions together highlight the importance of stakeholder collaboration, the necessity of increased government involvement and support, and the adoption of modern agricultural practices.

CHAPTER FIVE

SUMMARY, DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

5.0: Introduction

A summary of the key findings, a discussion of the study's findings in relation to its objectives, conclusions, and recommendations for additional research were given to the mango industry's stakeholders in this chapter.

The report's first and second sections provided an overview of the key results and information regarding the impact of the BBS disease on Blue Skies Limited's production-related problems. The last portion featured conclusions, ideas, and recommendations from the findings, as well as strategies that agro-processing firms and out-grower farmers used to adapt to the severity of the disease in the mango industry.

5.1: Summary

Mango black spot disease is detrimental because it produces yield losses that affect agro-processing firms' ability to meet their production needs and because the demand from local farmers does not match the severity of the disease. The goal of the study was to comprehend BBS disease, how it affected agro-processing firms (based on data from Blue Skies Limited), and how the industry tries to adapt and survive in the face of the disease's widespread presence. The investigation's findings from the firm's data collection are as follows:

- The study revealed that the prevalence of BBS disease affects the quality and quantity of mangoes, resulting in decreased tonnage and lower consumer expectations.
- Delayed detection can lead to economic yield losses in storage facilities and production losses.

- Grove care activities contributed to black spots on fruits, causing diseases on farms.
- Farmers' incomes are impacted by sales to agro-processing firms, affecting supply and production schedules.
- Windbreaks, weeding, trimming, and burning damaged leaves and fruits have been successful in reducing BBS disease.
- The agro-processing firms bear the costs of checking for chemical residues in the field.
- Training programs for farmers and international assistance are also provided.

5.2 Implications of Key Findings

Mango production is seriously threatened by the Bacterial Black Spot (BBS) disease, which may lead to a greater decrease in fruit yield and have a substantial impact on agro-processing firms. The disease can cause a drop in fruit quality and marketability, which might affect the availability of premium mangoes for processing. It is known to be particularly severe in exposed, humid circumstances. Moreover, BBS can be particularly difficult to treat because its symptoms might be mistaken for those of other prevalent viruses, which could result in improper treatment.

BBS disease has a significant effect on agro-processing firms since it can cause supply chain disruptions and raise expenses associated with disease management. All these elements may result in decreased revenue and diminished competitiveness for agro-processing firms, which would ultimately affect the mango industry.

Effective disease management plans and regulations are crucial, considering these difficulties, to lessen the effects of BBS on agro-processing firms. Effective management of BBS requires integrated disease management, which includes cultural, biological, and chemical control approaches. The creation of mango varieties resistant to disease and the enforcement of strict

regulations can also help manage BBS in the long run and its consequences on agro-processing firms.

Overall, the management of BBS disease and its implications for agro-processing firms require a multi-faceted approach, integrating scientific, regulatory, and industry-specific measures to ensure the continued supply of high-quality mangoes for processing and the sustainability of the agro-processing sector.

5.3 Policy Recommendations

This study suggests the following adoption strategies to reduce the spread of the BBS disease in the mango industry, based on its analysis of the research findings and discussion section:

- It is essential to consider the broader policy and market implications of BBS disease, including regulatory measures, market access, and consumer perceptions. However, the impact of BBS disease on mango production and the agro-processing industry can have significant policy and market implications. For example, BBS disease can lead to a reduction in fruit yield, quality, and marketability, resulting in revenue losses for farmers and agro-processing firms.
- The government should put nursey operators under serious control by registering them, training them, and creating a nursey bank for nursing mango seedlings, where they could be picked from one place and not everywhere, and which is free from the grafting disease on the farms.
- Regulations are necessary to guarantee the safe use of pesticides since, according to policy recommendations, using chemical control measures to manage BBS diseases may have negative effects on the environment and human health.

- The market implications of BBS disease can also be significant, as it can affect the supply and quality of mangoes available for processing, potentially leading to higher prices for consumers and reduced competitiveness for agro-processing firms.
- Various solutions have been proposed to control the spread of the BBS disease, including the planting of windbreaks such as mahogany and acacia, adherence to cultural practices and sanitation such as weeding and pruning, spacious planting to allow penetration of sunlight, the usage of disease-free planting materials, sanitization of farming equipment, and the usage of certified pesticides on the farm.
- Overall, the policy and market implications of BBS disease highlight the need for effective disease management strategies and policies that promote sustainable agriculture and protect the environment and public health.

5.4 Areas for further Research

Although the study was limited to Blue Skies Limited and its surrounding area, it was unclear how much the findings would have been applicable to other agro-processing firms in Ghana whose principal product is mango fruit. Thus, more investigation in other Ghanaian enclaves is needed. To guarantee the study's validity, a mixed-methods approach and a larger sample size should be used in subsequent reviews.

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APPENDIX I: Interview Guide

IN-DEPTH INTERVIEWS ADMINISTERED TO EXTERNAL STAKEHLODERS: OUT-GROWER FARMER, MUNICIPAL AGRIC OFFICERS, INPUT DEALERS AND AGRIC EXTENSION OFFICER

SECTION A: Introduction of Respondents

a) Sex :……..

b) Age range: 15-30 years [ ] 30-45 years [ ] 45-60years [ ] 60 & above [ ]

c) Educational level: Primary [ ] JHS[ ] SHS[ ] Vocation/Technical [ ] Uni. [ ]

SECTION B: Perception of BBS from Stakeholders

1. How long have you been in the mango industry?
    a) 1-5 years [ ] b)5-10 years [ ] c)15- 20 years [ ] d)20 years & above [ ]
2. What are the revenue statistics in growing and patronizing mangos in terms of the following:
    a) Income[ ] b) Export earnings[ ] c) Local consumption[ ] d) Production[ ]
3. Have you noticed some of the major mango diseases that have an effect on your farms? **Yes/No,** then **List** ……...
4. Have you heard about the BBS disease currently, and in your opinion, what is your knowledge about the **BBS** disease?

5. How does the BBS disease spread on the farms? Is it through insect transmission, grove maintenance operations, weather conditions or irrigation practices?
6. How is the BBS disease caused by the fruit? Does it affect the quality of the fruit and yield losses?
7. What are the effects of the disease on farms? Does it lead farmer's income losses, the sale of farmlands, and farmers not being able to afford agro-chemicals?
8. What control measures do mango farmers adopt to reduce the prevalence of the disease?

APPENDIX II: KEY INFORMANT INTERVIEW FOR INTERNAL STAKEHOLDERS IN BLUE SKIES LIMITED

SECTION C: Overview of Economic Costs at Blue Skies Ltd

1. In your opinion, does the prevalence of the BBS disease affect firms output problems in terms of high inventory, delayed production schedules and supply chain interruptions (the transmission of disease)?
2. How does the BBS disease on the fruit lead to quality problems that affect the cost of production and processing?
3. Do you think the BBS disease influences employment in terms of people getting laid off and non-usage of machinery, which leads to low efficiency in productivity?
4. In light of the prevalence of the **BBS** disease, do the quality control officers incur costs in testing for chemical residues and disease severity in the fruit?

APPENDIX III: KEY INFORMANT INTERVIEW FOR BOTH EXTERNAL AND INTERNAL STAKEHOLDERS

SECTION D: Adoptive Policy Recommendations from Stakeholders

1. Have training and workshop programmes been organized by the stakeholders to control the spread of the disease in the mango industry?

2. What agriculture initiatives, through funding and equipment, have government/international agencies through the Municipal Assembly provided to mango farmers in the locality?
3. In your opinion, what are the best modern agriculture methods that can be adopted to control disease?