Determinants of Successful Trading of Outbound Oranges Produced in the Limpopo Province, South Africa

By

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DEDICATION

The thesis is hereby dedicated to the “Bjang family”, my mother Mrs. Lekwapa Joyce Bjang, my sisters Miss Dimakatso Byang, Miss Masokolle Byang, my brothers Mr. Motshabi Byang, Mr. Tebogo Byang and my wife Mrs. Lerato Thandy Bjang as well as my three children Miss Khomotso Bjang, Miss Katlego Bjang and Mr. Nkgodišeng Bjang for their love and support to me.

DECLARATION

I, Mr. Mafadi Abram Bjang student number 53398084, hereby declare that the thesis titled Determinants of Successful Trading of Outbound Oranges Produced in the Limpopo Province, South Africa, is my own work. I further declare that all sources of information like pictures, tables and data used in this thesis were referenced and acknowledged. I also declare that the thesis which I hereby submit for the degree of Doctor of Philosophy in Agriculture at the University of South Africa, does not contain any written work submitted by other persons nor previously been submitted by me for a degree at this or any other institution.

Student signature: ……………………………………… Date: November 2023

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ABSTRACT

Success in international trade of oranges for the Limpopo province's citrus farmers remains a difficult task as phytosanitary constraints and other cultural practices continue to pose serious threats within the citrus supply chain. Based on the said backdrop, a pragmatic study was conducted from September 2020 to September 2021 to identify the determinants of successful trading of outbound oranges produced from the citrus farms in the Limpopo province of South Africa. The study used the mixed methods research design which includes both quantitative and qualitative methods. The first part of the study employed the positivism philosophy, deductive approach, quantitative methodological choice, the survey strategy with cross-sectional time horizon to collect data from the respondents. A standardized questionnaire was administered to 215 sample of citrus producers who were randomly selected from the four production regions (Groblersdal, Hoedspruit, Letsitele and Vhembe) in the study area. The qualitative aspect was in the form of a workshop for further inputs from farmers in developing the framework for increased outbound orange export. The software computer programme used to analyse the data of the study was the Statistical Package for Social Sciences (Version 28.0.). The descriptive statistics, the Multinomial Logistics Regression Model, the Poisson Regression Model, and the Tobit Regression Model were used for the statistical analyses of the study. The study employed Descriptive Statistics to identify the general (demographic and socio-economic) characteristics of farms/farmers. The Poisson Regression Model was used to assess the determinants of orange losses with respect to cultural practices, the multinomial logistic regression model was used to analyse the determinants of modes of disease control used by the citrus farmers, and the Tobit regression model was used to analyse the main factors associated with the successfully traded export oranges produced from citrus farms in the study area. The results of the descriptive statistics of the respondents showed that gender, age group, and education were the most influential factors in the study area. The results of the multinomial regression model indicated that factors such as age group, education, and transport modes were statistically significant. The Poisson Regression Model results indicated that factors such as storage mode, transport mode, farm age and the type of labour used by the respondents were statistically significant. The results of the Tobit regression model showed that factors such as age group, farm ownership, type of labour and transport mode were statistically significant. Overall, the results of this study disagree with the hypothesis that the demographic and socio-economic characteristics of citrus farms do not influence the level of losses of orange outputs with respect to cultural practices. The study results also disagree with the notion that the demographic and socio-economic characteristics of farmers/farms and cultural modes do not significantly influence successful traded outbound oranges from farms in the Limpopo province. Based on the outcome of this study, a framework for the successful trade of export oranges has been developed to serve as a guide to export orange producers in the Limpopo province and provide the basis for informed policy decisions by the government and relevant stakeholders. Overall, this study recommends that the Limpopo province citrus industry can trade successfully if they can consider using the developed framework of this study.

Keywords: Phytosanitary constraints, outbound oranges, cultural practices, multinomial, poisson, tobit regression model, South Africa.

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LIST OF ABBREVIATIONS

AGBIZ	Agricultural Business Chamber
AgriBEE	Agricultural Broad-Based Black Economic Empowerment
APPPC	Asia and Pacific Plant Protection Commission
B. dorsalis	Bactrocera dorsalis
BEE	Black Economic Empowerment
BFAP	Bureau for Food and Agriculture Policy
BIO:	Biological control
CA:	Citrus Academy
CABI	Centre for Agriculture and Biosciences International
CBS:	Citrus Black Spot
CF:	Citrus Farmers
CGA:	Citrus Growers' Association of Southern Africa
CH:	Chemical
COEF:	Coefficient
COSAV	Comité de Sanidad Vegetal del Sur
COVID-19	Coronavirus disease 2019
CPPC	Caribbean Plant Protection Commission
CT:	Cold Treatment
CRI:	Citrus Research International
CRT:	Citrus Research Trust
D:	Degree of accuracy
DAFF	Department of Agriculture, Forestry and Fisheries
DALRRD:	Department of Agriculture, Land Reform and Rural Development
EC:	Eastern Cape

EEU:	Eurassian Economic Union
EPPO:	European Plant Protection Organisation
EFSA	European Food Safety Authority
ET:	Economic Threshold
EU:	European Union
FAO	Food and Agriculture Organisation
FCM:	False Codling Moth
FLW	Food Loss and Waste
FPEF:	Fresh Produce Exporters' Forum
FUM:	Fumigation
FS	Free State
FSA:	Fruit South Africa
FSCs	Food Supply Chains
GP:	Gauteng Province
GVP	Gross Value of Production
HIV/AIDS	Human ImmunoDeficiency Virus/Acquired Immunodeficiency syndrome
HLB	Huang Long Bing
IAPSC	Inter-African Phytosanitary Council
IPM	Intergared Pest Management
IPPC	International Plant Protection Organization
IRT	Ionizing Radiation Treatment
ISPM:	International Standards on Phytosanitary Measures
IT	Information Technology
KZN	KwaZulu-Natal
LEWC	Land Expropriation Without Compensation
LP	Limpopo Province

MLE	Maximum Likelihood Estimation
MP	Mpumalanga Province
MT	Metric Ton
MY	Marketing Year
N	Population size
NAMC	National Agricultural Marketing Council
NC	Northern Cape
NFPMs	National Fresh Produce Markets
NPPOZA	National Plant Production Organization of South Africa
OIRSA	Organismo Internacional Regional de Sanidad Agropecuaria
OLS	Ordinary Least Square
P	Population Proportion
PE	Port Elizabeth
PHT	Post-Harvest Treatment
PPECB	Perishable Products Export Control Board
ROS	Rind-Oil-Spot
RS	Rind Staining
RSA	Republic of South Africa
S	Required Sample Size
SERB	Stem-End Ring Breakdown
SOPP	Sodium Orthophenylphenate
SPS:	Sanitary and Phytosanitary Measures
SPSS	Statistical Package for the Social Sciences
SAHC	South African High Commission
STASSA	Statistics South Africa

TTB	Technical Trade Barriers
TBZ	Thiabendazole
UK	United Kingdom
UNISA	University of South Africa
USA	United States of America
USDAFAS	United States Department of Agriculture Foreign Agricultural Service
VIF	Variance Inflation Factors
WC	Western Cape
WCO	World Citrus Organisation
WTO	World Trade Organisation
WTO-SPS	Agreement on the Application of Sanitary and Phytosanitary Measures

CHAPTER ONE
GENERAL INTRODUCTION

1.1 Introduction

South African export of citrus fruit, particularly oranges, is generally regulated by international phytosanitary requirements/protocols especially at the point of exit for the international market. As a citrus exporting country, South Africa continues to face numerous phytosanitary constraints in the global markets which amongst others include Citrus Black Spot (CBS), *Phyllostica citricarpa* (formerly known as *Guinardia citricarpa*), Oriental fruit fly, *Bactrocera dorsalis* (Hendel), and False Codling Moth (FCM), *Thaumatotibia leucotreta* respectively (Citrus Growers Association of Southern Africa (CGA), 2020). During the citrus marketing season 2021/2022, the European Union market introduced a new False Codling Moth (FCM) regulations requiring all South African citrus to be precooled to below two degrees celsius for a period of 20 days before reaching European Union (EU) markets (Moore and Manrakhan, 2022). To comply with the citrus export markets, this study explored orange export phytosanitary compliance of citrus growers at selected farms in Groblersdal, Hoedspruit, Letsitele and Vhembe areas of the Limpopo province in South Africa. The study further investigated the main determinants of successful trading of outbound oranges produced from citrus farms in the aforementioned areas, which contributed 48 percent (%) of the total citrus production in the marketing year (MY) 2021/2022 (Esterhuizen and Caldwell, 2022). This chapter provides an overview of the entire study including the general introduction, background of the study, problem statement, aim and objectives of the study, research questions, hypothesis of the study, significance of the study, conceptual framework of the study, arrangement of the chapters and chapter summary. This study also investigates the most relevant determinants of successful trading of outbound oranges in the Limpopo province’s citrus industry which may serve as guide for export-bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders.

1.2 Background

The presence of technical trade barriers (TTB) within the South African citrus industry and world-wide did not have any devastating impact on the Limpopo province's citrus industry as it had been able to achieve 48% of the total citrus production in the marketing year 2021/2022 (Department of Agriculture, Land Reform and Rural Development (DALRRD), 2022). The country's citrus industry of late undergoes serious citrus export trade challenges in the international markets particularly the CBS regulations and the newly introduced EU FCM regulations requiring all citrus fruits from South Africa to be precooled to below two (2) degrees celsius for a period of 20 days before reaching the EU markets. Irrespective of the existing circumstances, South Africa had been able to export a total record of 2.7 million tons of citrus in the marketing year 2021/2022, which thus means that South Africa's position of being the second largest exporter of citrus after Spain remains unchanged (DALRRD, 2022). There was also a positive contribution being achieved by the South African citrus industry when both the CGA (2022) and DALRRD (2022) revealed that an estimated total of more than 100,000 hectares (ha) of the country's land was planted to citrus in the marketing year 2021/2022, which constituted an increase of two percent to 47,750 hectares (ha) from 46, 809 hectares being achieved in the marketing year 2020/2021.

As it is considered the largest citrus producing area country-wide, the Limpopo province is naturally a subtropical area located in the Northern part of South Africa and characterized by low rainfall. The climate in Limpopo (LP), Mpumalanga (MP) and KwaZulu-Natal (KZN) provinces is warmer and suitable for the production of Grapefruit and Valencia oranges whereas the Western Cape (WC) and Eastern Cape (EC) are considered cooler citrus growing areas and production is mainly focused on navels and lemons (DALRRD 2022; CGA, 2022). According to DALRRD (2022) citrus annual report, most citrus production (48%) in South Africa took place in Limpopo, followed by the Eastern Cape (23%) and Western Cape (14%) respectively. As one of the most important foreign exchange earners, the industry's biggest contributor to the total gross value of citrus is oranges, which accounted for 48% in 2021/2022 followed by soft citrus (26%), lemons and limes (18%) respectively. In the Limpopo province, the main citrus production areas include Groblersdal, Letsitele, Hoedspruit and Vhembe. It is however estimated that the citrus industry already employed more than 140 000 people with large number of workers in the orchards and packing houses (Meintjies 2023; DALRRD, 2022).

In South Africa, citrus industry is extensive and unchanging, well-structured, and categorized into four sub-industries which include oranges, grapefruits, soft citrus, lemons, and limes. The citrus industry is presently older than 300 years and considered the third largest horticultural industry after deciduous fruits and vegetables (Meintjies 2023; DALRRD, 2022). The country presently has an estimated total number of 1 300 orange export farmers of which 490 of them come from the Limpopo province, 810 from other provinces and 250 000 small farmers who supply the local market (DALRRD, 2019). The main outbound orange markets for South Africa are 33 countries which include Europe (EU) as separate states, United Kingdom (UK), China, Russia, India, Middle East Countries (Saudi Arabia, United Arab Emirates and Kuwait) who are said to consume between 20% and 25% of South Africa's fresh orange exports making the region the second biggest consumer of South African oranges after Europe (DALRRD, 2021).

Based on the recent global citrus market conditions, the international trade of outbound oranges has become increasingly challenging, labour-intensive, costly, and export-oriented involving a very long and complex supply value chain which requires a wide range of skills (DALRRD, 2021; Ni *et al*.,2020). Additionally, the revelations of the studies by both Ni *et al*. (2020) and Meintjies (2023) concur with the afore-mentioned notion that export orange trade is costlier and labour- intensive and further recommends that success in the export orange trade is mostly determined by the supply of good quality fruit and compliance with the citrus export market requirements. In summary, a good quality orange is a highly nutritious fruit containing vitamins A, B, C, and other essential elements. Moreover, orange is mostly considered to be an economic product produced and consumed as fresh fruit, orange juice, used as fragrance and medicine to cure diseases in the human body (Ni *et al*., 2020: DALRRD, 2021). Orange fruit is reported to consist of 1300 species and is naturally produced in subtropical and tropical areas worldwide primarily to generate farmers' income and create jobs for rural communities (Meintjies, 2022; CGA 2022). It has also been alluded by Yun and Liu (2022) that the annual production of citrus has presently reached about 157 million tons world-wide. Notwithstanding the fact that the marketing year 2022 was a tough season for the South African citrus industry, the CGA (2022) reported that growers packed 164.8 million 15-kg cartons for shipment to global markets, representing an increase of 3.2 million cartons when compared to 2021, but some 5.7m cartons below the pre-season forecast. According to the CGA (2022) Annual Report, there was a decrease in the number of cartons of Valencias packed for export, with 53.8 million cartons compared to 55 million in 2021. In the marketing year 2021/2022, the South African Citrus industry's contribution was R30 billion to the Total Gross Value of South African agricultural production (GVP) (Meintjies 2023; DALRRD, 2022). Based on the status of the Limpopo Citrus Industry, this research therefore sought to examine all the existing determinants of successful trading of outbound oranges produced in the province and suggest solutions to underlying challenges.

In South Africa, citrus production is mainly aimed at the export market (DALRRD, 2020). Due to phytosanitary effects faced in the EU market, the country is estimated to have spent R4 billion (US$232 million) to comply with the EU market requirements (Esterhuizen and Caldwell, 2022). Some of the strategies the country is using to address these current challenges include pre-export inspections, strict spraying protocols, field surveillance programs, adherence to shipping protocols and comprehensive CBS risk management systems (DALRRD, 2021). As it has long been discovered that most citrus production takes place in the Limpopo province, and so far, little or no study has evaluated the determinants of successful trading of outbound oranges produced in the province and its impact on the economy of the country. This study aims at improving the citrus industry in the study area as it was found that most export orange shipments from the study area get detained every citrus marketing year due to its non-compliance with International Standards on Phytosanitary Measures (ISPMs), regulations and guidelines set by these international bodies in terms of management of phytosanitary pests and diseases. As a result of the said backdrop, this study therefore examined the most relevant determinants and developed a framework for successful trading of export oranges in the study area to avoid export orange ban and rejection notifications from the international special markets every citrus marketing year.

1.3 Problem statement

As a signatory member of the World Trade Organization Agreement on Application of Sanitary and Phytosanitary measures (WTO SPS Agreement) and the International Plant Protection Convention (IPPC), South Africa has an obligation to comply with all the international standards called International Standards on Phytosanitary Measures (ISPMs), regulations and guidelines set by these international bodies in terms of management of phytosanitary pests and diseases (National Plant Protection Organization of South Africa (NPPOZA), 2019). As part of the affected areas in the country, the Limpopo province's citrus industry is believed to experience numerous phytosanitary constraints on its export volumes and returns in respect of cultural practices such as pests and diseases control, harvesting, packaging, storage, and transportation. However, some of the phytosanitary constraints hampering success of citrus farmers in orange export markets include False Codling Moth (FCM), Citrus Black Spot (CBS), and *Bactrocera dorsalis* (*B. dorsalis*) which citrus farmers ought to effectively deal with to trade successfully in the global citrus markets. Based on this backdrop, the Limpopo citrus industry finds it difficult to comply with the citrus export market requirements which is a problem that necessitates research to determine the main factors affecting successful trading of outbound orange produced in the study area.

However, export orange spoilage is deemed to occur and appear in many forms which amongst others include fruit-rot, fruit puncture, fruit greening, fruit blemishes and bruises and differ in terms of forms of spoilage caused by cultural practices, natural factors, and climatic factors. It is therefore believed that identifying orange spoilage symptoms and laying down effective control measures requires adequate knowledge on citrus export market requirements, international standards on phytosanitary control measures, and attendance of annual citrus growers' organisation workshops. It is further postulated that the climatic factors such as floods, drought, hails, tropical storms, and high heat together with the economic factors such as market prices, supply and demand also have negative impact on the production volumes of export oranges if they are not effectively managed or controlled. Additionally, South Africa together with other citrus exporting countries often receive export orange ban and rejection notifications from the international special markets about detection records of CBS, FCM, *B. dorsalis*, Fruit flies, mealy bugs, chinch bugs and others almost every marketing year. The primary aim of this research is to identify and analyze the most relevant determinants of successful trading of outbound oranges in the Limpopo province's citrus industry which may serve as guide for export bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders.

1.4 Aim and objectives of the study

1.4.1 Aim of the study

The primary aim of this research is to identify and analyze the most relevant determinants of successful trading of outbound oranges in the Limpopo province's citrus industry which may serve as a guide for export bound orange producers and to provide the basis for informed policy decisions by the government and relevant stakeholders.

1.4.2 Objectives of the study

The study will focus on the following specific objectives:

i. To identify and analyze the general (demographic and socio-economic) characteristics of the citrus farms/farmers involved in the study.

ii. To analyze determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges, type of storage, and transportation used among the export bound orange farms in the study area.

iii. To analyse factors influencing the level of orange losses among target growers in the study area.

iv. To analyze factors influencing successfully traded outbound oranges from export orange farms in the study area.

v. To develop a framework for successfully trading outbound oranges from orange farms in the study area.

1.5 Research questions

From the foregoing, the following research questions are formulated for the study:

i. What are the general (demographic and socio-economic) characteristics of the citrus farmers/farms in the study area?

ii. What are the factors affecting the losses of oranges in respect of cultural modes (plant pest and disease control especially of Citrus Black Spot (CBS), *Bactrocera dorsalis* (*B. dorsalis*), and False Codling Moth (FCM), harvesting, packaging, storage, and transportation) applied on each of the 215 randomly selected outbound orange farms in the Limpopo province?

iii. What are the significant factors which inform the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of storage and transportation used among the export bound orange farms in the study area?

iv. What are the determinants of successful trading of outbound oranges of farmers in the study area?

v. Which framework should be developed suitable for successfully trading outbound oranges from orange farms in the study area?

1.6 Hypothesis

It may be hypothesized that:

i. Ho: Demographic and socio-economic characteristics of farmers/farms and cultural modes do not influence the level of losses of orange outputs in the study area.

ii. Ho: Demographic and socio-economic characteristics of farmers/farms and cultural modes do not significantly influence successful traded outbound oranges from farms in the Limpopo province.

iii. Ho: Demographic and socio-economic characteristics of farmers/farms are not the main determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the province.

1.7 Significance of the study

The primary justification of this study is to identity and analyze the most relevant determinants of successful trading of outbound oranges produced in the Limpopo province of South Africa. As this study identified phytosanitary constraints such as FCM, CBS and *B*. *dorsalis* to be key citrus industry's phytosanitary constraints, its core value is to examine the underlying challenges and help the citrus farmers in the study area to meet the global market requirements and trade successfully. The core contribution of this study is mainly to provide citrus farmers in the study area with more information regarding international trade challenges and understanding factors influencing the level of losses of orange outputs in respect of cultural practices and also the main determinants of the modes of plant pests and disease control, types of packaging and harvesting used, and types of storage and transportation of export oranges used by citrus farmers in the study area.

The outcome of this study may serve as a guiding instrument for export orange producers and provide the basis for informed policy decisions by government and relevant stakeholders. Moreover, the study results may add more value to the existing body of knowledge in respect of proper and effective marketing strategies necessary for international trade of oranges. Based on the afore-mentioned rationale, the researcher thus believes that the outcome of this study, if adopted, may enable citrus farmers to cope with the existing technological changes occurring within the citrus industry, be able to avoid orange spoilage and export ban notification challenges, improve farm sizes and productivities, generate more farm-income, increase the country's gross domestic production and revenue, and lastly to reduce hunger and poverty through creation of more jobs for the rural communities in the study area and the country at large. Under the literature review section/chapter, a far-reaching analysis of the available literature had been conducted to demonstrate the contribution of this study to knowledge in this field.

1.8 Conceptual framework of the study

It is assumed that to avoid outbound orange spoilage and export rejection notifications from export orange markets, citrus producers ought to strengthen their cultural practices such as pest and disease control, harvesting, packaging, storage and transportation modes, improve fruit quality and size, and also manage the climatic factors such as high heat, drought and hails and lastly the economic factors such as market prices, supply and demand occurring every citrus marketing year. Figure 1.1 shows the determinants of successful trading of outbound oranges or a conceptual framework of the study.

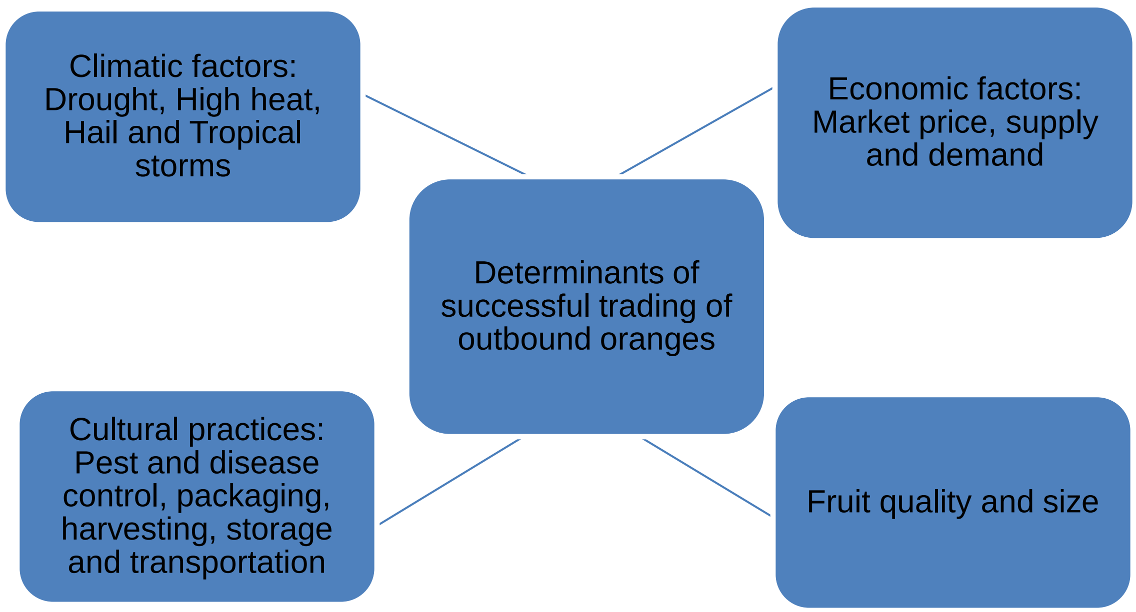

Figure 1.1 Conceptual Framework of the study
Source: Used data from the study

Based on the above conceptual framework of the study, phytosanitary measures (pest and disease control, packaging, harvesting, storage, and transportation), climatic factors (drought, high heat, hail and tropical storms), and economic factors (market price, supply and demand) prove to have an influence on the quality and size of the fruit. Since orange export ban and rejection notifications come because of poor management of the aforesaid factors, it is therefore the responsibility of every citrus farmer in the study area to work hard and produce good quality oranges that can meet the export orange market standards. In their study, Balfagon et., *al* (2022) found that because of climate change, plant growth often decreases under low temperature or freezing conditions. It was further highlighted that high temperatures may lead to high evapotranspiration and eventually increase irrigation needs for citrus trees. In their research conducted in the United States of America (USA), Luckstead and Devados (2021) discovered that amongst economic factors faced by the country included import competition, dwindling farm-retail price spread and labour shortages. It was also revealed that because of competition with other foreign countries, the total supply of fresh oranges fluctuated to a point that 72% of the country's fresh oranges went to domestic consumption whereas the remaining 28% of the supply was exported. According to the CGA (2022), phytosanitary constraints such as *B. dorsalis*, FCM and the CBS can hamper success of the South African citrus industry if they are not effectively controlled. Additionally, climatic factors such as high heat and floods can also cause damage to citrus orchards, even though it has been noted that such damage is occasional than the one caused by phytosanitary constraints in respect of cultural practices.

In this study, all factors influencing successful trading of export oranges in export markets have been identified, analyzed, and presented in the form of a framework for citrus farmers in the study area to make use of it. The primary focus of this study is to examine the cultural practices and control measures applied on export orange farms in the Limpopo Province and finally develop an effective framework that may serve as a guiding instrument for export orange producers and provide basis for informed policy decisions by government and relevant stakeholders. The above framework is deemed necessary to citrus farmers in the study area as it is believed that effective management of cultural practices can enable citrus farmers to meet export orange market requirements. This picture evidently illustrates that if citrus farmers can take note of all the necessary factors included in this framework, they can successfully deal with these cultural practices by means of avoiding orange spoilage and export rejection or ban, complying with the international markets and ultimately trading successfully. In summary, to obtain the required data, one on one meetings with all relevant stakeholders took place during 2019/2020 citrus marketing year in ensuring that a framework for successfully traded outbound oranges in the Limpopo Province is finally developed.

1.9 Arrangement of chapters

The chapters in the thesis are arranged as follows:

Chapter 1: Provides the introduction and background of the citrus farms, and farmers. It also provides the problem statement, aim, and objectives of the study, research questions, hypothesis, significance of the study, conceptual framework of the study, arrangement of chapters, and chapter summary.

Chapter 2: Provides for the literature review, introduction, citrus industry structure and overview of the citrus production in South Africa, the citrus market structure, citrus fruit export performance, European Union (EU) demand for citrus from South Africa and the world, EU market requirements for imported oranges, influence of Oriental fruit fly, *Bactrocera dorsalis* and False codling moth, *Thaumatotibia leucotreta* on botany and physiology of outbound orange, Oriental fruit fly, False codling moth, effects of Citrus Black Spot, *Phyllostica citricarpa* disease on botany and physiology of outbound orange. It further provides for the impact of harvesting mode related injuries on outbound orange, influence of packaging mode-related injuries on outbound orange, influence of storage and transportation mode on outbound orange and a chapter summary.

Chapter 3: Covers the introduction, study area, map of the study area, research design, sampling techniques, data collection, validity and reliability of the data collection instrument, data analysis, ethical consideration, and summary of the chapter.

Chapter 4: Focuses on the results and discussions regarding the demographic and socio-economic characteristics of citrus farms/farmers, identification, and analysis of effectiveness of cultural practices (plant pest and disease control, harvesting, packaging, storage, and transportation) applied on each of the selected outbound farms in the study area and summary of the chapter.

Chapter 5: Provides for the results and discussions regarding analysis of the determinants of the modes of plant disease control, used in the study area using the multinomial regression model which provided the results for case processing summary, model fitting, goodness of fit, Pseudo-R-square, likelihood ratio tests, parameters estimate, and summary of the chapter.

Chapter 6: Focuses on the results and discussions of the analysis of main factors influencing orange losses on the citrus farms in respect of cultural practices using the Poisson regression model, and summary of the chapter.

Chapter 7: Focuses on the results and discussions of the analysis of the main factors influencing successful traded outbound orange from export bound orange farms in the study area using the Tobit Regression model and the Ordinary Least Squares regression model, and the chapter summary.

Chapter 8: Provides for the results and discussions regarding the development of a framework for successfully traded outbound orange from orange farms in the study area, and summary of the chapter.

Chapter 9: Provides a summary of the findings, conclusions and recommendations of the study, and future prospect.

1.10 Chapter summary

This chapter provided an overview of the entire study including background of the study, problem statement, aim and objectives of the study, research questions, significance of the study, hypothesis of the study, conceptual framework of the study, arrangement of the chapters and chapters' summary. This chapter identified cultural practices as major challenges hampering success in the international trade of oranges. The chapter further hypothesized that the demographic and socio-economic characteristics of farmers/farms do not influence the level of losses of orange outputs in respect of cultural practices; the demographic and socio-economic characteristics of farmers/farms and cultural modes do not significantly influence successful traded outbound oranges from farms in the Limpopo province; and the demographic and socio-economic characteristics of farmers/farms are not the main determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges, storage and transportation modes among the export bound orange farms in the province. A conceptual framework of the study was also developed with chapters well arranged. This study gave a brief outline of all the items included in it.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The preceding chapter provides a background of the study, its problem statement and justification as well as its research questions, hypothesis, aim and objectives. This chapter reviews relevant literature that was conducted to generate a picture of what is known and not known about relevant determinants of successful trading of outbound oranges as postulated to be cultural practices (plant pest and disease control, harvest, package, storage, and transportation modes). The study used the mixed methods research design which include both quantitative and qualitative methods to understand the research problem. The major aim of the literature review is to assist the researcher to gain insight into the problem under study, verify the significance of the problem, and put the research problem into context. The chapter provides the scope of literature reviewed including the citrus industry structure, citrus production regions, citrus market structure, citrus fruit export performance, European Union (EU) demand for citrus from the world and EU market requirements for imported oranges, cultural practices related to the influence of insect pests/diseases, harvesting, packaging, storage, and transportation modes of outbound oranges produced in the Limpopo farms of South Africa.

2.2 Citrus industry structure in South Africa

South African citrus industry's organizational structure comprises various stakeholders such as the Department of Agriculture, Land Reform and Rural Development (DALRRD), Citrus Growers' Association of Southern Africa (CGA), Fruit South Africa (FSA), Perishable Products Export Control Board (PPECB), Fresh Produce Exporters' Forum (FPEF), Citrus Farmers (CF), Citrus Academy (CA), Citrus Research Trust (CRT) and Citrus Research International (CRI). The industry contains about 1400 citrus fruit producers throughout South Africa, Zimbabwe, and Swaziland with predominantly South African producers (Potelwa, 2017; CGA, 2021). The citrus industry structure is shown in figure 2.1.

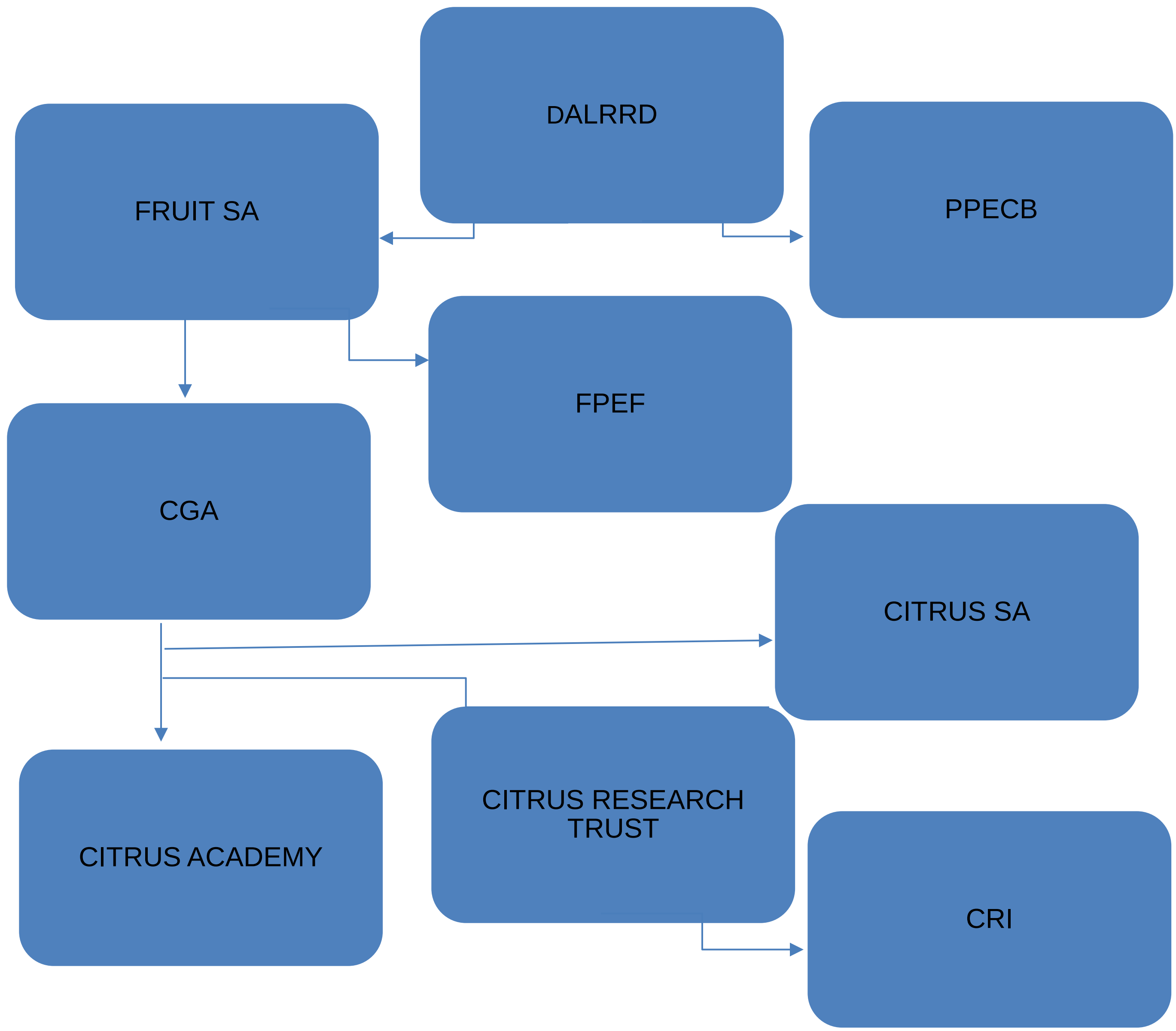

Figure 2.1: Citrus industry structure
Source: CGA (2022)

DALRRD is responsible for policy regulation and implementation based on production, exchange, and distribution. It also ensures policy implementation through private and public entities, for example, PPECB which provides quality inspection, handling, storage, and maintenance of cold chain services to the perishable produce industry under the auspices of DALRRD. On one hand, PPECB provides food safety, quality, and quarantine services to encourage and create confidence in South African agricultural products preferred at the international level (Potelwa, 2017; DALRRD, 2022). Fruit SA is a non-profit organization and the umbrella body of the South African fruit industry. This entity's mandate is to create and facilitate a competitive, equitable, and sustainable environment for fresh fruit marketing and promotion for its members. The CGA is also a body that represents farmers' interests in terms of the provision of marketing and technical support services whilst other organizations such as CRI, PPECB, FPEF and DALRRD also provide significant support to the industry (CGA, 2018; Potelwa, 2017).

The Fresh Produce Exporters Forum (FPEF) has, as its primary role, the provision of leadership and information services to its members and the international buying community. This body ensures that only competent and reliable marketing agents and growing exporters are part of the forum. The marketing campaigns carried out by the FPEF are geared towards creating awareness and differentiation of South African products among consumers. The Citrus SA is a body responsible for enhancing the position of citrus farmers whilst citrus farmers' mandate is to provide food and fiber to meet basic human needs by increasing productivity (CGA, 2017; Potelwa, 2017). The Citrus Research Trust (CRT) is a body that is responsible for the coordination of funding distribution in support of identified research proposals. The CRI is the sub-body of CRT responsible for executing research and development in the industry. The institution collaborates with various universities in the country on research and development in the industry (Chisoro-Dube and Roberts, 2021; CGA, 2022). The CRI also works with the Citrus Academy in providing bursary funding. The Citrus Academy aims to support previously disadvantaged learners to access higher education and provides skills and knowledge development among producers on citrus pest monitoring, which is in collaboration with the CRI and CGA (CGA, 2018; Potelwa, 2017).

2.3 Overview of citrus production in South Africa

Considering that for every country to develop economically, there is always a significant need to strengthen its ability to export agricultural products, South Africa also plays a dynamic role in the global citrus markets. In total, the South African production of oranges was estimated to reach approximately 1.6 million metric tons (a growth of 6 percent compared to the previous season) in the 2021/2022 season, but irrespective of the existing circumstances, the country had also been able to export a total record of 2.7 million tons of citrus during in the marketing year 2021/2022 (Rambau, 2023; CGA, 2022). In South Africa, citrus fruit is persistently produced in six different provinces across the country including Limpopo (LP), Eastern Cape (EC), Free State (FS), the Western Cape (WC), KwaZulu-Natal (KZN), Mpumalanga (MP), and Northern Cape (NC) respectively. Many registered citrus exporters are based in the Western Cape Province which serves as the exit point for citrus exports through the Cape Town harbour. Nevertheless, the major citrus exporting regions in the Limpopo province include Hoedspruit, Groblersdal, Letsitele and Vhembe areas where this study was conducted. Approximately 40% of the hectares of the Limpopo citrus industry's land was utilized for citrus fruit production during the marketing year 2020/2021 (CGA, 2021). The major Valencia orange production areas in the country include the Limpopo province (59%), followed by Eastern Cape (15%), Western Cape (9%), Mpumalanga (5%), Zimbabwe (5%), and other (4%). The diverse climatic conditions ranging from winter rainfall in the South of the country to summer rainfall in the North, allow farmers to produce a variety of citrus fruits, including oranges, lemons, soft citrus, and grapefruits. Besides, this diversity allows growers to produce fruit with different attributes such as quality and taste, which meet different consumer preferences (CGA, 2021; Meintjies, 2023).

The major orange cultivars or varieties produced in South Africa include Valencia oranges and Navel oranges. Valencia cultivars planted in the production year 2020/2021 per hectare include: Midnight (39%), Valencia late (16%), Delta (14%), Turkey (10%), Bennie (10%), and others (11%), whereas Navel cultivars planted in the production year 2020/2021 per hectare include: Cambria (16%), Palmer (15%), Bahianinha (13%), Washington (11%), Witkrans (8%), Cara Cara (5%), Robyn (4%), Navelina (4%), and others (24%). The most planted citrus variety in 2021 was Valencia/midseason at 30 926 ha with the Limpopo Province contributing 59% of all Valencia oranges planted in 2021. Another citrus variety planted the most in the production year 2021 was Navel oranges at

27% or 15 883 ha with the Eastern Cape Province contributing 41% of all Navel oranges planted in 2021. The South African climatic conditions do however pose a threat to the production of citrus fruit through the occurrence of pests and diseases. Approximately 80% of citrus fruit originates from Citrus Black Spot (CBS)-affected areas while others come from non-affected areas which include the Western Cape, Northern Cape, and Free State (CGA, 2021; Arnoldi, 2023). Considering the effects of phytosanitary constraints within the South African citrus industry, this study identified and analyzed the most relevant determinants of successful trading of export oranges and developed a framework for successful international trade of oranges.

2.4 The citrus market structure

Considering that South African citrus production is destined for export market, citrus farmers in the country therefore produce and supply their citrus produce to different citrus markets across the globe. In South Africa, the market structure is very much broad and enormous, comprising citrus markets such as the European Union (EU), United Kingdom (UK), China, Korea, Japan, United States of America (USA), Indonesia, Eurasian Economic Union (EEU) (Russia, Armenia, Belarus, Kyrgyz, and Kazakhstan), and India. Whilst these citrus farmers send their citrus produce to the global citrus markets, they thus face numerous challenges in respect of trading of their citrus produce worldwide. Developing countries across the globe have in place the market structures to assist citrus farmers particularly the small-scale or rural farmers with directions, channels, requirements, and procedures to cope with high global competition and high tariffs placed on their exported products or goods. According to Dlikilili (2018), Van Rooyen (2018), and the CGA (2022), EU and UK are considered the most important markets for South African citrus, absorbing more than 30% of South Africa’s citrus even though EU still applies full phytosanitary control regulations to combat CBS and FCM.

However, the South African citrus industry continues to dispatch its citrus to all these markets based on compliance with their standards as others are deemed to be special markets due to their unique export requirements. In South Africa, the citrus market structure is categorized into three groups, namely, bilateral countries (Protocol markets), Import permit markets and directive markets. The bilateral countries consist of countries such as the China, United States of America (USA), Thailand, Korea, and Japan; Import permit markets include Mauritius, Bangladesh, Malaysia, Jordan, and most African countries; and directive markets comprise the EU Countries, India, and Reunion (DALRRD, 2018; CGA, 2020). Approximately 70% of the South African citrus is exported to the global market and the remainder is thus sold on the local market (6%) or processed. In South Africa, citrus products are locally sold at National Fresh Produce Markets (NFPMs), informal markets and processors (Rambau, 2023; DALRRD, 2020).

2.5 Citrus fruit export performance

From a global perspective, South Africa is ranked the second largest exporter of citrus after Spain (DALRRD, 2022). Despite the country's citrus trade challenges, particularly the CBS regulations and the newly introduced EU FCM regulations requiring all citrus fruits from South Africa to be precooled to below two (2) degrees Celsius for a period of 20 days before reaching the EU markets, the industry remains stable. Besides, South Africa had been able to export a total record of 2.7 million tons of citrus in the marketing year 2021/2022 (Bulbulia, 2022; DALRRD, 2022). Out of the said figure, the EU and UK received 42% of 155 million cartons of the Southern African citrus crop during the 2021/2022 citrus season. According to annual reports by both DALRRD (2022) and the CGA (2022), South Africa achieved a positive contribution as it's estimated that a total of more than 100, 000 hectares (ha) of the country's soil was planted to citrus in the marketing year 2021/2022, which constituted an increase of two percent to 47,750 hectares (ha) from 46, 809 hectares being achieved in the marketing year 2020/2021.

In the marketing year 2021/2022, South Africa is estimated to have spent R4 billion (US$232 million) to comply with the EU market requirements (Esterhuizen and Caldwell, 2022). Despite citrus trade challenges such as Covid-19 pandemic, the newly introduced EU FCM regulations, phytosanitary constraints, transport costs, inputs costs and many others, the country managed to provide the world with a total record of 2.7 million tons of citrus. During the last decade, most of South Africa's exports of oranges went to the European and Asian markets as the country's major markets. South African citrus industry is known to export its citrus through four ports of exit which include Durban, Cape Town, Port Elizabeth and Coega ports. However, the Northern region (Limpopo, Kwa-Zulu Natal, and Mpumalanga) exports through Durban port whereas the Northern and Western region (Northern Cape and Western Cape) exports through Cape Town port and Eastern Cape region (Eastern Cape) exports via Port Elizabeth and Coega ports (Chisoro-Dube and Roberts, 2021). In the Limpopo Province, the major citrus exporting region is Mopani which includes Hoedspruit and Letsitele areas (Department of Agriculture, Forestry and Fisheries, (DAFF), 2017; CGA, 2019). Nonetheless, the latter backdrop shows that the South African citrus industry works very hard to remain stable and ensure that the industry dispatches reasonable volume of citrus cartons to the global markets despite any form of international trade challenge. This study therefore examines the most relevant determinants of successful trading of outbound oranges in the Limpopo province's citrus industry which may serve as guide for export bound orange producers and to provide a basis for informed policy decisions by government and relevant stakeholders. Table 2.1 shows the world fresh citrus export figures for 2020/2021 citrus season.

Table 2.1: World fresh citrus exports 2020/2021 (Thousand Tons)

Country	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	Rank
Spain	3 862	3 761	3 925	3 947	3 622	3 699	2 658	3 935	3 712	1
RSA	1 541	1 649	1 675	1 702	1 692	1 929	2 131	2 092	2 599	2
Turkey	1 144	1 497	1 542	1 708	1 724	1 913	2 009	1 602	1 958	3
Egypt	1 182	1 182	1 182	1 520	819	1 594	792	2 002	1 928	4
China	1 030	1 030	913	934	872	936	939	1 014	1 045	5
Mexico	550	550	663	750	744	823	805	835	893	6
USA	951	951	833	990	1 350	808	712	732	694	7
Morocco	385	584	500	640	610	706	341	652	569	8
Greece	445	451	433	613	589	416	339	395	481	9
Argentina	454	406	341	394	395	379	353	358	377	10

Source: Trademap, USDA (2022)

As observed from the above table 2.1 orange export figures, a decrease in export orange figures to export markets between 2020 and 2021 marketing years was mainly due to Coronavirus disease 2019 (Covid-19) pandemic, cyberattack incidences and phytosanitary challenges. South African government introduced disaster management regulations following the discovery of the Covid-19 pandemic in the country. This pandemic therefore precluded movements of many people from one place to another within the country and ultimately had a huge impact on the orange export figures during the marketing year 2020/2021. Additionally, the unfortunate incidences of KwaZulu-Natal (KZN) July 2021 unrest or riots also contributed to the decline in the orange export figures for the marketing year 2020/2021. During this July unrest period, highways were closed, vehicles were also damaged and burned, and people's business properties were highly looted turning the situation into a predicament which consequently affected international trade of oranges. Considering that meeting the citrus export requirements is costly particularly in respect of the latest surge in prices of inputs such as fertilizers and chemicals, citrus production, and export figures from citrus farms in the study area also got highly affected. Moreover, it is believed that phytosanitary constraints such as False Codling Moth, and Citrus Black Spot also contributed immensely to the challenge of insufficient supply of oranges to export markets during the marketing year 2020/2021. Additionally, authors such as Rambau (2023) and Bulbulia (2023) share a common sentiment that ongoing power cuts or load-shedding also cause huge damage to cold storage facilities, which preserve orange quality and shelf life. In his research results, author Bulbulia (2023) indicated that after having a challenging 2021/2022 citrus season, the industry resolved to establish private-public partnerships with other fruit industries at Durban and Ngqura ports to repair port infrastructure.

2.6 European Union (EU) demand for citrus from South Africa and the world

Exporting oranges to EU markets remains a difficult trade test for South Africa and other countries across the globe. Getting fruit to the export market has also currently become commercially unrealistic to many citrus farmers as constraints such as public infrastructure deterioration or decay, and load-shedding are expected to persist in 2023/2024 citrus season (Arnoldi, 2023; Meintjies, 2023). To address the EU citrus demands, the CGA and Spanish producer organizations created the World Citrus Organisation (WCO) in late 2019 to assess and discuss in depth opportunities and challenges facing citrus producing countries (CGA, 2022). During its assessment of the EU market access opportunity cost regarding CBS and FCM costs, and the Bureau for Food and Agriculture Policy (BFAP), the WCO calculated it to a total cost of more than R3.2 billion annually. In overall, 906 containers of citrus were shipped to Spanish ports during the 2021 citrus season representing less than 1% of South African citrus exports worldwide, and 22% of the EU-UK exports. Unfortunately, South Africa had six FCM and four CBS interceptions recorded in Spanish ports, all in the last two weeks of exports (CGA, 2022). Based on the afore-mentioned backdrop, all the six False Codling Moth interceptions (out of a total of fifteen in the EU) in Spain became the main driver for Spanish call for a cold sterilization provision for all citrus imported from third countries (Chisoro-Dube and Roberts, 2021; CGA, 2022). Following the above-mentioned situation, the CGA Board eventually took a decision to exclude Spanish ports from the South African citrus destinations list for the 2022 citrus season, which the FPEF board also endorsed (CGA, 2022).

In terms of phytosanitary matters, the European Commission (EC) has through the European Food Safety Authority (EFSA) engaged the DALRRD to provide its opinion on the FCM systems approach used by South Africa, who in turn referred the matter to the Citrus Research Council (CRI) to prepare a response to the questionnaire received from the EFSA for return to the EFSA by the end of January 2021 (DALRRD, 2022). In summary, the proposed new FCM regulations were opposed by the overwhelming majority whereby South Africa, Eswatini and Zimbabwe governments used the World Trade Organisation (WTO) notification procedure (with a closing date of the 11th of April 2022) to submit their written objections. On CBS regulations matters, the EU provided the new draft regulations to all its trade partners such as Argentina, Brazil, South Africa, Uruguay, and Zimbabwe requesting them to give feedback. In response to these CBS regulatory matters, a bilateral meeting took place between South Africa and European

Union with the matter having been communicated to the CRI by the DALRRD and its stakeholders during the DALRRD and PPECB pre-season workshops (DALRRD, 2022). Based on the above-mentioned citrus export market challenges, this study therefore achieved its main research purpose.

2.7 EU market requirements for imported oranges

Compliance matters contribute immensely to the success of citrus farmers in international trade of oranges. As the major citrus market for South Africa, the EU has established a commission called the European Commission (EC) which its key role is to ensure that EU countries receive safe food from the world and ensure that importers comply with their food safety requirements (CGA, 2021). This means that exports to the EU countries are expected to adhere to EU food safety regulations to supply food in that market (Arnoldi, 2023; DALRRD, 2022). Part of the European Commission's regulations requires that the country of origin comply with the following: Exports are to be accompanied by plant health certificates issued by the exporting authorities; subjected to phytosanitary inspection at the point of entry into the EU; imported into the EU market by an importer registered in the official register of the EU country; made known to the customs office at the point of entry before its arrival in the country (Potelwa, 2017; DALRRD, 2022).

The core objective of laying down the above EU market regulations is to prevent the introduction of organisms harmful to plants and plant products in the EU. In the case of South Africa, the EU conducts phytosanitary inspections to ensure that citrus fruit is free of plant pests and diseases. However, some common challenges often encountered during citrus export period of oranges to both EU and special markets include: the presence of phytosanitary pests and diseases, sand, soil and/or stones in orange cartons, late or non-arrival of containers for loading and uncalibrated containers and the waiting periods for export approval from importing countries such as United States of America (USA) and China (DALRRD, 2022; Chisoro-Dube and Roberts, 2021). South Africa has thus established initiatives for compliance with EU requirements to minimize the chances of pest occurrences during transit, which include a quarantine programme; orchard sanitation; the use of chemical control and spraying programme; and risk management system to ensure management of fruit harvested. In conclusion, DALRRD holds annual workshops on compliance of the NPPO with EU citrus market requirements every citrus season (CGA, 2022; DALRRD, 2022). Figure 2.2 shows a picture of pest and disease-free oranges preferred by EU export markets.

Figure 2.2: Fresh export-bound oranges (*Citrus sinensis* (L.) Osbeck (pro.sp)
Source: Island Fresh Online (2020).

2.8 Influence of Oriental fruit fly and False Coddling Moth on Botany and Physiology of Outbound Orange

Plants and fruits of orange are prone to various pests and pathogens which include Oriental fruit fly, False Coddling Moth, Aphids, Red Scale, Soft Brown Scale, Citrus Thrips, Orange Dog Caterpillars, Asian Citrus Psyllid, Fruit Flies and Citrus Bud Mites. This study will focus its attention on the effect of both *Bactrocera dorsalis* and False Coddling Moth as identified by CGA (2022) report as two key phytosanitary pests during citrus marketing year 2020/2021.

2.8.1 Oriental fruit fly, *Bactrocera dorsalis* (Hendel)

Oriental fruit fly, *Bactrocera dorsalis* (Hendel) or *B. dorsalis* is defined as a serious pest of fruit and vegetables across the world (Manurung *et al*., 2022). The risk this pest often poses to fruits and vegetables is globally known to negatively influence export markets, national food security, and the livelihoods of the citizens. Historically, *B. dorsalis* was first recorded in India as Musca ferruginea scopoli in 1974 and around 1910, and it is reported to have first been discovered in eastern Africa in 2003 before quickly spreading to East, Central West, and Southern Africa. The insect species was therefore well-known across tropical Asia in Burma, Bengal, Sri Lanka, Singapore, and Indonesia. The pest was later reported in Taiwan Island and China around 1912 (Mutamiswa, 2021). Considerable attempts to control this invasive species were initially made in 2003 by the Food and Agriculture Organization (FAO) which funded countries such as Kenya, Tanzania, and Uganda governments, with the International Centre for Insect Ecology and Physiology (ICIPE) providing technical support, to develop an emergency response and management options for *B. dorsalis* through monitoring and surveillance programs (Mutamiswa *et al.,* 2021)*.*

As a highly polyphagous insect with very large capacity to sustain its populations even during unfavorable climatic conditions, this insect species comprises over 75 species with a few being economically significant within the horticulture industry (Liu *et al*., 2019). The fruit fly is well-known as pest of quarantine importance occurring in over 65 countries of Oceania, America, and Africa, and adapting to multiple climatic conditions. In support of the aforesaid statement, Fang *et al*. (2019) defines this invasive species as an important quarantine pest in Asia, and Pacific Plant Protection Commission (APPPC), European Plant Protection Organisation (EPPO), Caribbean Plant Protection Commission (CPPC), Comité de Sanidad Vegetal del Sur (COSAV) Inter-African Phytosanitary Council (IAPSC) and Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA). Fruit crops which are mostly attacked by this invasive species include citrus, avocadoes, mangoes, guavas, bananas, papayas, passion fruits, apples, and tomatoes (Musasa *et al*., 2019; Fang *et al*., 2019). Besides, the invasion process of this pest into the produce is reported to begin with introduction, followed by colonization, establishment and eventually spread. However, the actual damage or spoilage process starts when female fruit flies lay eggs between the fruit peel and flesh, followed by hatching of the larvae which eat and damage the fruit and gradually penetrating the flesh causing the entire fruit to get rotten (Ni *et al*., 2020; Manurung *et al*., 2022). The spreading process of this invasive species is often promoted by transboundary trade and favourable climatic conditions. Additionally, its spread and establishment mostly depend on globalization, human travel, and availability of suitable hosts. This invasive species negatively affects citrus farmers as they often cause reduced yield and increased management costs (Ni *et. al*., 2020).

The recommended control measures for this invasive species are a long-term management framework in Africa to encompass control on invaded areas as well as continuous monitoring and surveillance in areas where fruit fly is unavailable. The Integrated pest management (IPM) is also considered to be the best strategy used to control *B. dorsalis,* as well as application of management methods such as protein baits or ME-lure traps, parasitoids, high efficiency and low toxicity insecticides, bagging of fruits and field sanitation keep the *B. dorsalis* populations below the economic threshold (ET) for a particular fruit thereby avoiding fruit crop losses without incurring any health or environmental hazards (Ni *et al*., 2020; Manurung *et al*., 2022). As this pest causes serious international trade security, it is further recommended that cold treatment cultural practice has the potential to be a commercial quarantine treatment in international trade (Fang *et al*., 2019). Having noted the influence of this invasive species on export oranges, research is therefore deemed necessary to find solutions to the problem statement of this study. This study therefore seeks to examine the B. *dorsalis* control measures applied by citrus farmers in the study and provide a framework for successful trading of outbound oranges in the Limpopo province's citrus industry which may serve as guide for export bound orange producers and provide the basis for informed policy decisions by government and relevant stakeholders.

2.8.2 False Codling Moth, *Thaumatotibia leucotreta* (Meyrick)

False Codling Moth, *Thaumatotibia leucotreta* (Meyrick) is described as an insect species of the family of Tortricidae. This insect species is also known as native pest to South Africa. Female moths lay eggs which look oval and 0.9 in diameter on the surface of the fruit. The larvae look yellowish white with dark spots. The adult stage of False Codling Moth is of 15 to 16 mm (Male) and 19 to 20 mm (Female). It is a polyphagous pest of many South African export crops having host plants of about 70 food plants like citrus, stone fruit, avocadoes, pomegranate, persimmons, macadamias, hot peppers, and many others. Symptoms of the False Codling Moth appear as Larvae that bore and feed into the fruit and eventually cause orange fruit decay. On orange, symptoms appear yellowish-brown rind around a penetration hole on fruit. The FCM larvae also feed on the orange tree leaves and seeds. Additionally, when the eggs hatch, the Larvae of the False Codling Moth drop into the soil where puparium forms. Eventually, adults emerge within a couple of few weeks (Moore, 2021; Li *et al*.,2022).

False Codling Moth is regarded as a quarantine pest of economic importance, and it is also endemic to sub-Saharan Africa. The CGA (2022) describes this pest as the most destructive at its larvae stage as it undergoes five development stages within the fruit. In many citrus orchards, FCM causes the fruit to drop in three (3) to five (5) weeks after larvae penetration. However, this insect species also spread via international movements of infested fruits. Effective control methods for this insect species include the use of natural enemies, weekly orchard sanitation practices, removal of out-of-season oranges in November and after harvest, monitoring of population levels and timing of control actions using pheromones lures, mating disruption, attract and kill, and sterile insect technique (EPPO Global Database, 2021; CGA, 2022).

During 2021/2022 citrus export season, the European Union market introduced a new EU regulation to curb the spread of this insect species in the EU countries. The European Food Safety Authority (EFSA) also backed up a decision to subject export oranges to cold treatment to avoid FCM entry into the EU through imports. Based on the effects of these FCM pests, South African distributors incurred huge orange losses in recent months including two seizures in July 2022 marketing year (CGA, 2022). Nevertheless, South African citrus exporters already put cold treatment in use when distributing to countries like United States even though the CGA (2022) fears that the new rules for EU will have a negative impact on the citrus trade between them, and the local industry and the 140 000 jobs it continuously creates (*Mutamiswa et al.,* 2021). According to the current EU new rules, detection of a single larvae can result in rejection of an entire consignment (CGA, 2022). This research therefore aims to identify and analyse the FCM control measures applied by citrus farmers in the study and provide a framework for successful trading of outbound oranges in the Limpopo province's citrus industry which may serve as guide for export bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders.

2.9 Effects of Citrus Black Spot (CBS), *Phyllostica citricarpa* (McAlpine) disease on botany and physiology of outbound orange

2.9.1 Citrus Black Spot (CBS), *Phyllostica citricarpa* (McAlpine)

Citrus Black Spot (CBS) is a fungal disease caused by pathogen *Phyllostica citricarpa.* occurring in tropical and sub-tropical citrus production areas and affecting the peel of almost all varieties of citrus, particularly in warm, humid climates. The only citrus species considered to be resistant to CBS are sour oranges (*Citrus aurantium* L.) and their hybrids and 'Tahiti' limes (DALRRD (2022); Hendricks *et al*. (2020)). The CBS is considered a quarantine pathogen by some countries, impacting domestic and international trade of citrus fruit. Historically, CBS was first discovered on sweet oranges in Southwest Florida in April 2010. Owing to its worldwide distribution, CBS was also reported in Australia, South Africa, and Argentina since the early 1900's. It has also been introduced into Brazil, Cuba, Uganda, Ghana, Italy, Malta, and Portugal. However, CBS is absent from some Mediterranean climate regions including Spain, Greece, and Italy in Europe and California in the United States of America (USA). The CBS causes a significant damage by means of invading and colonizing the fruit rind producing six distinct lesion types or symptoms which include false melanose, hard spot, freckle spot, virulent spot, cracked spot, and lacy spot (Rudriguez *et al*., 2018; Gottwald *et al*., 2021). However, lesions are believed not to affect the internal quality of the fruit, but the fruit may be prevented from being sold in export markets where the fruit is quarantined.

The CBS damage on fruit appears in a form of pre-mature fruit drop mostly under severe infections and rind or fruit blemishes therefore leading to high yield loss only in high favourable climatic conditions. CBS may infect the fruit for 20 to 24 weeks after petal fall.

In their study, Hendricks *et al*., (2020) discovered that hard spot lesions of CBS usually develop on the surface of the fruit exposed to sunlight and the symptom development is strongly influenced by light. In their study, Moyo *et al*. (2020) and Hendricks *et al*. (2020) revealed that *phyllosticta citricarpa* produces ascospores and conidia as infective propagules. These ascospores are formed on the citrus leaf litter, whereas conidia, produced in the pycnidia, are formed on fruit dead twigs and leaves of the tree as well as on leaf litter. According to Rudriguez *et al*. (2018) and Moyo *et.al*. (2020), these ascospores are spread mainly by wind and are crucial to the introduction of CBS into new areas whereas the conidia are washed down to the adjacent fruit, twigs and leaves and are influential in CBS endemic in regions with higher rainfall such as Brazil and Ghana. In essence, poor control of the CBS disease in the field can promote infection which occurs through ascospores released from pseudothecia produced and matured on dead infected leaves on the orchard grounds.

According to Miles *et al*. (2019), CBS can be controlled by fungicides which include copper, strobilurius, fenbuconazole, premix combinations, such as azoxystrobin/difenoconazole and pyraclostrobin/ boscalid. Postharvest treatments followed by cold storage can significantly reduce the viability of lesions and render resultant, pycmidiospores dead. Pre-harvest sprays of benzymidazole fungicides are also effective in preventing or delaying symptom expression of CBS during transport or storage. Nevertheless, treatment with guazatine or Imazalil, hot water or waxing decreases the viability of the pathogen in black spot lesions (Centre for Agriculture and Biosciences International (CABI), 2021). Additionally, packing house treatments and shipping or storage temperature conditions also limit CBS lesion development, survival, and inoculum viability (Moyo *et al*., 2020; Gottwald *et al*., 2021).

2.10 Impact of harvesting mode-related injuries on outbound orange

Harvesting is a process of picking ripe fruits from a plant using harvesting tools such as clippers, gloves, picking bags and ladders (Bentil *et.al*., 2020). In addition, the process of harvesting is defined by Sabale *et al.* (2017) as labour intensive operation and involving

35 – 45% of total production cost. During harvesting period, citrus farmers ought to closely monitor the whole process to avoid unnecessary orange losses. Harvesting methods commonly used within the citrus industry include hand-picking and mechanical. In the absence of proper harvesting procedures, there may be a huge impact on the quality of the harvested fruits. When stored and transported to the market, fruits need to be carefully picked, harvested, and packed to avoid fruit damage and spoilage (Bentil *et.al*., 2020). As has also been noted by authors Kassem *et al*. (2021), hand picking methods are inefficient and result in deterioration of fruit quality and fruit damage. Additionally, hand-picking methods contain disadvantages such as striking with a stick causing severe damage to the fruit. Based on the afore-mentioned backdrop, hand-picking therefore poses high risk on both harvested fruits and disorders of the musculoskeletal system of workers during harvest. However, a high stress on the human motoric system also occurs when the picker is holding a container of fruit (basket, bucket) with one hand and picking fruit with the other hand. In that vein, injuries to workers also do occur due to falling from trees ladder and unbalance of a stick (Ortiz *et.al*., 2022).

Nevertheless, application of proper harvesting procedures plays an immense role in respect of generation of a good revenue for citrus farmers in the study area. As there are different ways of harvesting from one farmer to another, some citrus growers use mechanical harvesters such as limb shaker, canopy shaker, trunk shaker, and air blast designed for mass removal of orange fruits. Part of the advantages of mechanical harvesters is drawn from the fact that they can provide higher harvesting rates over traditional hand-picking harvesting methods. Conversely, its disadvantages are that mechanical harvesters have some issues associated with them such as fruit quality, size selection and damage to the fruit tree. In summary, mechanical harvesters also have a potential to halt the physical appearance of orange fruits and degrade the fruit quality (Sabale *et al.*, 2017; Bentil *et al*., 2020). Amongst others, abiotic factors such as temperature, moisture stress, chemicals and nutrient excesses and deficiencies are the major causes for physiological disorders in citrus fruits. A significant loss in citrus can occur because of physiological disorders which are the outcome of dysfunction or malfunction of the physiological processes of the fruit tissues due to abiotic factors.

Harvesting mode is one of the cultural practices classified under post-harvest practices contributing to orange spoilage, damage, or injury in the form of bruises or blemishes if not properly managed. During the harvesting period, export orange spoilage occurs in the form of blemishes which eventually render the fruit unmarketable in the international markets. According to Ortiz *et al*. (2022), blemishes on the oranges usually appear as undesirable marks or spots often appearing in sunken and brown form because of chilling injury or human activities such as throwing orange fruits into harvesting bins or bags (rough handling).

According to Kassem *et al*. (2021), it is believed that at chilling temperatures, orange tissues can take a long time to show injury symptoms which among others include a pitting of the peel. In their study, authors Ortiz *et.al*. (2022) further proved that more chilling injuries often occur because of changes in physical properties of cell membrane because of physical state of the cell membrane lipids and variations in structural proteins such as tubulin and enzymes, resulting in changes in enzyme kinetics. The negative impact of chilling injuries involves the collapse of cells which creates irregular areas that are sunken and brown in form (Bentil *et.al*., 2020; DALRRD, 2022). However, orange fruit is perishable in nature that careful handling remains necessary to avoid injuries and damage. Damaged and injured oranges cannot be exported, and as a result, the farm gets a lot less money for the fruit which constitutes serious spoilage. Safer practices of picking outbound oranges as recommended by CGA (2019) are illustrated in a Do's and Don'ts table 2.2.

Table 2.2: Illustration of the Do's and Don'ts of picking outbound orange fruits.

Number	Do's	Don'ts
	Hands must be clean before picking process starts.	Avoid long nails as they damage the fruits.
	Use clean and dry glove on your left to touch the fruit and your right hand to hold the clipper.	Avoid the use of dirty and wet or torn glove.
	Use clippers to cut fruit stems flat and short while picking.	Do not cut long stems as they damage other fruits.
	Carry picked fruits with the bag open at the bottom with quick release clips and a bag only open at the top.	Do not use a torn or ripped bag repaired with wire as it will injure the fruit rather repair using thread.
	Use strong and sturdy ladders to pick fruits from tall trees.	Never use loose ladders with metal pieces as they will injure you, the tree, or the fruit.
	After emptying bags, shake out all the leaves before putting fruit into it again.	Do not bump picking bag against the ladder.
	All picking tools like gloves, clippers, picking bags and ladders must be clean before using them again.	Do not pick wet or soiled fruit (e.g., dropped fruit, and fruits hanging) lower on the tree or touching the soil.
	Harvesting temperature must be between 13-30°C and the relative humidity not higher than 70%.	Do not run to the bin or trailer when emptying picking bags to avoid fruit injuries.
	Orange must always be dry when picked.	When emptying the bag do not throw the fruit into the bin.

Source: Citrus Growers Association of Southern Africa (2019)

According to Table 2.2, citrus farmers in the study area give more attention to hand-picking mode of citrus harvesting as opposed to other citrus harvesting methods. As previously demonstrated, harvesting practice in oranges is usually done by bare hands and presently, approximately 95 percent is hand-harvested as opposed to machine-picked. During the harvesting period, the pickers use 20-foot ladders that are propped up on the tree limbs as the fruit is picked. For safety reasons, workers wear long-sleeve shirts and pants due to the abrasive nature of the citrus foliage. The fruit is therefore placed in a long bag that is eventually emptied into either a bulk trailer (processed orange) or bins /boxes (fresh fruit). Thereafter, the fruit will then be transported to either the processing plant or the packing house. It is estimated that on average, one picker can pick ten 90-pound boxes per hour (Sabale *et al.*, 2017; CGA, 2020). However, harvesting oranges differs completely from other fruits. To determine the amount of sugar (soluble solids) and the acid to sugar ratio prior to harvest, orange fruit must first mature on the tree and be sampled. The rind colour and quality are very crucial to fresh fruit market, rejected fruit is processed while fruit destined for packinghouses after harvest must have cosmetic appeal to the consumer. During harvesting, harvesters climb on ladders and pick fruit by hand, place it in the back and eventually take it to the bulk trailer. When fresh market fruit reaches packinghouses, trash is eliminated, as well as split and rotten fruit. Thereafter, fruit is sprayed with water, washed, and rinsed at which time the fruit is hand graded. Fresh market fruit is treated with wax and fungicides to inhibit postharvest decay while off-grade fruit goes to processing (National Plant Protection of South Africa (NPPOZA), 2018; Ortiz *et al*., 2022).

As part of orange spoilage control measure, it is necessary to consider sanitation practices after harvesting oranges. Grove sanitation needs to be practised by reducing trash and soil on equipment as it leaves a field. Preferably, canker wash stations and portable spray bottles can be used to reduce the spread of diseases. The purpose of this practice is primarily to minimize the chance of spreading nematodes and citrus canker from one grove to another. Regarding labour sanitation, portable toilets and non-portable water for washing must be provided for labourers on the grove. As part of sanitation practices, the removal and burying of rotten fruits in plastic bags also serves as an effective control measure for phytosanitary pests and diseases in orange plantations (NPPOZA, 2019). There are two crucial aspects of fresh fruit market which are rind colour and quality requiring careful attention of the citrus farmers. Oranges destined for packinghouses following harvest must have cosmetic appeal to consumers. It is estimated that approximately 60-65 percent of fruit passes the fresh fruit quality tests. Usually, failure of quality tests is believed to be mainly due to poor colour, rind blemish caused by citrus rust mites, scab, melanose, greasy spot, or inadvertent puncturing of fruit as it is picked. All rejected oranges are usually processed and lastly as mandated by law, fresh oranges are treated with postharvest fungicides to inhibit decay. According to Bentil *et.al*. 2020, citrus farmers must consider proper management procedures such as the selection of optimum time to harvest in relation to product maturity and climatic conditions, training and supervision of workers and proper implementation of effective quality control. In South Africa, Citrus fruit is picked for export from March to October and/or November depending on the type of citrus (CGA, 2020). Orange picking season starts in May and ends in November. This study therefore aims to examine the harvesting modes applied by citrus farmers in the study and provide a framework for successful trading of outbound oranges in the Limpopo province's citrus industry which may serve as guide for export bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders. Table 2.3 illustrates harvest period of different citrus varieties in South Africa.

Table 2.3 Harvesting seasons of different citrus varieties

Citrus type	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Oranges					**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Grapefruits				**X**	**X**	**X**	**X**	**X**	**X**			
Lemons			**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Easy peelers				**X**	**X**	**X**	**X**	**X**	**X**			

Source: Citrus Growers of Southern Africa (2020)

2.11 Influence of packaging mode-related injuries on outbound orange

Packaging mode is defined as a process of packing fruits, vegetables, flowers and other plant products in cartons, net bags, standard boxes, half-boxes, wire bound boxes, and fruit crates made of corrugated board or wood for convenient handling, storage, and transportation purpose (Kassim *et al*., 2020). The packaging process of the orange is usually known to begin from harvesting through to post-harvest handling, packing, transportation and distribution where highly significant orange damages or injuries (bruising) occur (CGA, 2021). During the packaging period, pre-cooling of oranges plays a valuable role in rendering the quality of oranges more desirable, fresh, and marketable (Cao *et al*., 2020). Through pre-cooling process, field heat gets removed from fresh oranges, thereby slowing down metabolism and reducing deterioration before storage and transportation of oranges. During the packaging period, injuries occur mainly on fruit flesh, peel or skin and eventually render the fruit unmarketable. As fruit products are subjected to severe losses during post-harvest orange supply chain, between 45% and 55% of fruits and vegetables get lost world-wide (Zheng *et al*., 2022). At this stage of the orange supply chain, more citrus fruit loss is experienced due to injuries resulting from ineffective pre-packing treatments. Based on the afore-said backdrop, close monitoring and supervision actions need to be put in place to avoid orange injuries and yield losses (Cao *et al*., 2020; Zheng *et al*., 2022). However, fruits often get transported to packhouses during post-harvest period of oranges usually for the assortment and packaging process. At that juncture, excessive compression on oranges also occurs thereby contributing to more bruising impact affecting the appearance of fruit in export markets (CGA, 2022). In support of the CGA (2021) statement, Zheng *et al*. (2022) indicate that compression, vibration, and impact are the most common forces triggering mechanical damage to postharvest fruits.

Considering that different farmers have their own unique packaging systems in place, not all export-orange farmers pack good-quality fruits as others mistakenly pack and export even the damaged fruits which sometimes appear unappealing to consumers in the global markets. To avoid orange bruises and losses, some farmers offer their staff members pre-packing training sessions to avoid injuries caused by farmworkers whereas others just rely on experienced farmworkers to teach the newly employed ones on how the packaging job is conducted. Nevertheless, in South Africa, packaging materials such as sack bags, jute bags and baskets are recommended to be the most common packing system of export oranges. The findings of Kassim *et al*. (2020) concur with the outcome of this study that in the process of packaging, all punctured fruits due to pulp temperature must be thrown away as they would rapidly spoil and infect the other fruits. In summation, the bruising injuries on fruits can be effectively controlled by proper care of equipment and fruit handling. Besides, it is also recommended that every storage facility must be disinfected regularly and well-equipped with insect proof facilities to prevent entry of pests from outside (DALRRD, 2021). As a control measure for pathogens during pre-packaging period, Kassim *et al*. (2022) also recommends integrated treatment such as hot water treatments and chlorine disinfection to be the most effective method for the control of pre- and post-harvest pathogens. Lastly, the citrus industry of South Africa recommends proper post-harvest packing to protect oranges against CBS as this fungal disease has high impact on the quantity and quality of the oranges together with the combination of pre-packing treatments such as disinfectant, curative, and preventive treatments to control pre- and post-harvest pathogens (CGA, 2021; DALRRD, 2021).

2.12 Effects of storage and transportation mode on outbound orange

As part of a process of keeping fruits under prescribed EU and other global markets cooling and safe conditions, storage of oranges require proper management to avoid orange spoilage, export ban and loss of revenue. Transportation of oranges, being a movement of these fruits from farm gate to the global markets also have regulations to sustain the quality of fruits destined to the global markets (DALRRD, 2021). South African fresh oranges are usually harvested, packed, stored, and transported to export markets via refrigerated trucks and reefer containers on a seasonal basis. As oranges get cooled to a temperature of below 2-degree Celsius in terms of the new EU market regulations, citrus farmers in the study area have a responsibility to ensure that chilled fruits are packed into ventilated cartons on pallets allowing for correct storage into the reefer as fresh fruits are highly perishable and therefore requiring a fast mode of transport for the movement of fruits from the farm to the market. In their study, Alzubi *et al*. (2023) found that food loss and waste consume several categories of resources such as land, energy water, warehousing and transportation being one of the categories which incur additional and unnecessary costs. However, some stakeholders within the citrus supply value chain have through collaborative effort establish an innovative, efficient, and effective food supply chains (FSCs) to decrease food loss and waste (FLW) (Alzubi *et al*., 2023).

Nevertheless, during storage period, post-harvest pathogens do cause severe economic loss from export of various fruits. These pathogens are encouraged by inadequate post-harvest handling of oranges resulting in physical damage, for instance, bruising because of falling fruits during transportation. Through these bruises, pathogens can infect the oranges. As a control measure for the afore-mentioned constraints, Dwiastuti *et al*. (2021) and Khumalo *et al.* (2023) recommend cold-chain as vital to prolong the shelf-life of citrus fruit. It is further alluded that cold chain reduces physiological developments in the fruit, eliminates pests and diseases and influences market rates. Based on the said backdrop, the EU market has in the export year 2021 imposed new regulations, stipulating that citrus fruit must undergo cold sterilization treatment for up to 25 days at low temperatures. Conversely, the prescribed low temperatures required for cold-sterilization treatment increases the risk if chilling injuries on oranges depending on the cultivar (Dwiastuti *et al*., 2021). This study therefore aims to examine the storage and transportation modes applied by citrus farmers in the study and provide a framework for successful trading of outbound oranges in the Limpopo province’s citrus industry which may serve as guide for export bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders.

2.13 Chapter summary

This chapter provided information sourced from the reviewed relevant literature that was conducted to generate a picture of what is known and not known about relevant determinants of successful trading of outbound oranges as hypothesized to be cultural practices (plant pest and disease control, harvest, package, storage, and transportation modes). The key purpose of this literature review was mainly to assist the researcher to gain insight into the problem under study, verify the significance of the problem, and put the research problem into context. In summary, this chapter's primary aim was to provide the scope of literature reviewed including the citrus industry structure, citrus production regions, citrus market structure, citrus fruit export performance, European Union (EU) demand for citrus from the world and EU market requirements for imported oranges, cultural practices related to the influence of insect pests/diseases, harvesting, packaging, storage and transportation modes of outbound oranges produced in the Limpopo farms of South Africa.

CHAPTER THREE
THE RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, to achieve the desired objectives of the study, a quantitative approach using primary data from survey using questionnaires through face-to-face interviews is applied. Secondary information was also used where necessary such as articles from journals and records. The ensuing chapter describes the study area, research design, sample size and sampling technique, data collection instrument, method of data analyses, and ethical considerations.

3.2 Study area

The study took place in the Limpopo province which is in the Northeastern corner of the Republic of South Africa bordering Zimbabwe to the north; Mozambique to the east; the provinces of Mpumalanga, Gauteng, and North-West to the South; and Botswana to the west and northwest (South African High Commission, 2023), from September 2020 to October 2021. The province was named after the Limpopo River which flows along the northern border, and it is in the Savanna Biome, an area of mixed grassland and trees, which is commonly known for bushveld and wildlife reserves, including part of the Kruger National Park. The Limpopo province’s coordinates are 23.4013 S, 29.4179 E. The province of Limpopo is a subtropical plateau, a flat elevated interior area, hot and dry with winter rain and the moderate eastern plateau with warm to hot and rainy summers, and cold dry winters. Its points of interest include: Mapungubwe National Park, Marakele National Park, Balule Nature Reserve and more. Citrus production in the province is the most used enterprise for household survival followed by tourism and mining projects, state grants, operating shebeens and taverns. Most of the residents in the designated research areas depend more on commercial citrus farms for survival (South African High Commission, 2023). To ensure that the study gets to the heart of the research problem and enables the study to properly answer the research questions, the research was carried out at 215 selected farms in Hoedspruit, Groblersdal, Letsitele and Vhembe areas of the Limpopo Province. During the 2020/2021 citrus cropping season, the farms in the Limpopo province contributed 39% (37 825 ha) of the total citrus production in South Africa (CGA, 2021). The major citrus production areas in the Limpopo Province include Groblersdal, Hoedspruit, Letsitele and Vhembe. The most planted citrus variety in 2021 was Valencia or Midseason at 57% (16 929 ha). The Limpopo province is followed by Eastern Cape Province at 18% (5 198 ha) and Western Cape Province at 9% (2 790 ha) whilst Mpumalanga contributed only 8% (CGA, 2021). Two hundred and fifteen (215) farms have been randomly selected for the survey of the study in Groblersdal, Hoedspruit, Letsitele, and Vhembe areas of the Limpopo province to identify and analyze the main determinants of successful trading of outbound oranges (Valencia/Midseason) produced in the province.

3.3 Map of the study area

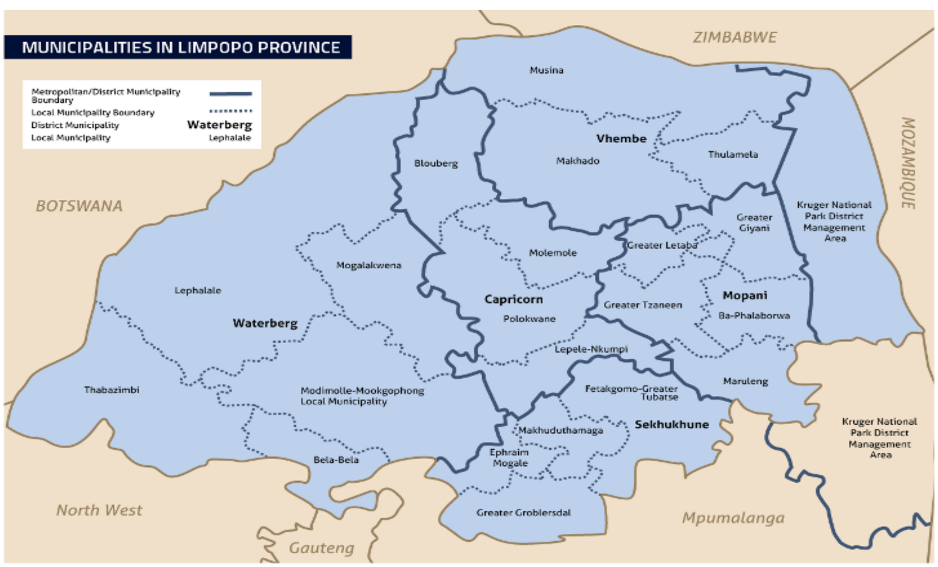

Figure 3.1 A map of the area of the study (The Limpopo Province of South Africa)
Source: Municipal Demarcation Board (2016) and Statistics South Africa (2016)

The map in Figure 3.1 shows both local and district municipalities' locations in Limpopo province where the study took place. Hoedspruit is in Maruleng local municipality (Mopani District), Groblersdal in Elias Motsoaledi local municipality (Sekhukhune District), Letsitele in Greater Tzaneen local municipality (Mopani District), and Vhembe in Thohoyandou-Venda (Vhembe District).

3.4 Research design

The study used mixed methods research design which include both quantitative and qualitative methods to understand a research problem. The first part of the study for objectives 1,2,3 and 4 employed the positivism philosophy, deductive approach, quantitative methodological choice, and the survey strategy with a cross-sectional time horizon.

3.5 Research methods

3.5.1 Population of the study

In total, the population of export orange farmers included in the study area as indicated by the Department of Agriculture, Land Reform and Rural Development during the study period was 490 (DALRRD, 2019). As shown in Table 3.1, the study area was divided into four (4) orange production regions hence the estimated sample had to be proportionally allocated with respect to the total sample size.

Table 3.1: The Sample distribution

Location/area	Number of citrus farmers	Representative	Sample per area
Hoedspruit	130	130/490*215=57	57
Groblersdal	118	118/490*215=52	52
Letsitele	128	128/490*215=56	56
Vhembe	114	114/490*215=50	50
Total	**490**		**215**

Source: Author's PhD Research Proposal, 2020

3.5.2 Sample size

The study used Krejcie and Morgan's (1970) formula to determine the sample size. Both Krejcie and Morgan's (1970) developed the formula for determining sample size for categorical data. The afore-mentioned authors further designed a table for determining sample size for a given population for ease of reference. The use of this formula has a crucial benefit because it provides a systematic approach to determine the sample size of a study. Amongst other formulas for determining the sample size include Cochran's (1977) formula, Fisher's formula, Yamane's formula, and many others who differs from both Krejcie and Morgan's (1970) by not using the table as a point of reference to determine the sample size for categorical data.

Since the research was a quantitative study and the target population was finite as 490, the formula stated below by Krejcie and Morgan (1970) was used as the most appropriate to determine the sample size.

$$S = \frac{X^2NP\,(1-P)}{d^2\,(N-1) + X^2P\,(1-P)}$$

Where:

S = Required Sample size

X = Z value (e.g., 1.96 for 96% confidence level)

N = Population size

P = Population proportion (expressed as decimal) (assumed to be 0.5 (50%)

d = Degree of accuracy (5%), expressed as proportion (0.05) is the margin of error

For this study the population size N was 490. This sample size was further distributed proportionately informed by the number of farms in each major producing area. The outbound orange farms constituting the proportion for each major area were selected randomly through a form of lottery.

$$S = \frac{X^2NP\,(1-P)}{d^2\,(N-1) + X^2P\,(1-P)}$$

$$= \frac{1.96^2 \times 490 \times 0.5 \times (1-0.5)}{(0.05^2 \times 490) + (1.96^2 \times 0.5 \times 0.5)}$$

$$= \frac{3.8416 \times 490 \times 0.25}{0.0025 \times 490 + 3.8416 \times 0.25}$$

$$= \frac{470.596}{1.225 + 0.9604}$$

$$= \frac{470.596}{2.1854}$$

= 215.33

Sample size = 215

Lastly, the calculation of a sample size using the above equation emerged with the sample size of 215.

3.5.3 Sampling techniques

As a result of the unequal distribution of the outbound orange farms within the study area, a random sampling technique called stratified random sampling was used to select the respective samples in the respective major producing areas as shown in the table above. The random sampling technique ensured that everyone in the respective populations of the major producing areas had an equal chance of being selected to constitute the sample for the study (Dudovskiy, 2019). A stratified random sampling method was used to ensure that the sample size of farmers per area in a total population size are fairly represented. When using this sampling method, the population size gets divided into small groups or strata based on shared characteristics. In this case, each number of citrus farmers per area was divided by the population size which was further multiplied by the total sample size to get the sample size per each area.

3.6 Data collection

This study used a semi-structured questionnaire to collect data from the citrus farms in the study area. A survey of outbound orange farms provided much needed information on the 215 outbound orange farms selected in Groblersdal, Hoedspruit, Letsitele and Vhembe areas. According to authors Khapayi & Celliers (2016), questionnaire survey methods make it possible to measure what a person knows and the type of information he/she has, the values and beliefs of a person and the attitudes towards what the questionnaire is all about. In their perspectives, the questionnaire survey can be used in three different ways namely, personal interviews, telephonic interviews, and mail interviews (Khapayi & Celliers, 2016).

In this study, personal interviews were used to enable the interviewer to observe phytosanitary constraints confronting farms in the research areas as well as other practices influencing the quality and export of the oranges. The questions in the questionnaire were both closed and open ended informed by the specific objectives of the study. Spoilage parameters (bruises and blemishes) and export phytosanitary compliance were assumed to be reflection of the cultural practices (pest/disease control, harvesting, losses of orange outputs of farms, packaging, storage and transportation modes) applied in the respective farms to be sampled in this study. Secondary data from published books, journals, and online or internet was used where necessary. Since there was a great need for secondary data from all major relevant stakeholders with the aim of sharing data, export orange producers' data collected from one-on-one interview sessions was also used to develop the framework for successful export orange trading in the global market.

3.7 Validity and reliability of the data collection instrument

The questionnaire was validated by experts in agricultural economics from UNISA through UNISA Ethics Committee, while the reliability of the questionnaire was determined through pre-testing (pilot project). The questionnaire was administered to 10 outbound orange farmers in the study area. Comments from the respondents were used to improve the questions for ease of comprehension during the actual survey. The 10 respondents for the pilot study were not included in the main survey for the study.

3.8 Data analysis

The term data analysis is commonly defined in diverse ways by various researchers in the field of science. It is also said that this idea helps to lessen the risks which are highly significant in decision-making by providing important perceptions and statistics which are mostly presented in a form of tables, charts, graphs, and images. In this study, the descriptive statistics and regression models were used for the data analyses. The qualitative method in the form of a workshop was used to achieve the qualitative aspects of objective 5.

Having outlined all the analytical procedures, the data was thus analysed based on the following research questions posed in this study:

i. What are the general (demographic and socio-economic) characteristics of the citrus farmers/farms involved in the study?

ii. What are the factors affecting the losses of oranges in respect of cultural modes (plant pest and disease control especially of Citrus Black Spot (CBS), *Bactrocera dorsalis* (*B. dorsalis*), and False Codling Moth (FCM), harvesting, packaging, storage, and transportation) applied on each of the 215 randomly selected outbound orange farms in the Limpopo province?

iii. What are the significant factors which inform the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of storage and transportation used among the export bound orange farms in the study area?

iv. What are the determinants of successful trading of outbound oranges of farmers in the study area?

v. Which framework should be developed suitable for successfully trading outbound oranges from orange farms in the study area?

Following completion of the data collection process, the researcher considered cleaning, coding, arranging, and analyzing data into descriptive statistics using Statistical Package for Social Sciences software (SPSS version 28.0.). By applying the analysis of descriptive statistics, the researcher was able to reduce, summarize and describe quantitative data gathered from all the 215 participants included in the study.

Objective 1: Descriptive statistics were employed to analyse the general (demographic and socio-economic) characteristics of the citrus farms/producers in the study area.

(a) Descriptive statistics

Descriptive statistics such as mean, percentage, standard deviations and frequency tables were used to present the results of descriptive analyses. To identify and analyze the level of losses of oranges in respect of cultural modes (plant pest and disease control, harvesting, packaging, storage, and transportation modes) applied on each of the selected outbound orange farms in the study area; the research used tables on the research questionnaire to collect data from the respondents in the study area. The tables were also used to solicit information from each citrus farmer regarding identification of types of cultural modes used on their citrus farms which included; Plant Pest Control Modes (Integrated Pest Management, Chemical, Biological, Heat Treatment, Ionizing Radiation Treatment, Cold Treatment, and Fumigation); Plant Disease Control Modes (Integrated Pest Management, chemical, biological, cold treatment, fumigation, and heat treatment); Types of harvesting used (Hand-picking, Air blast, Limb shaker, Canopy shaker, and Trunk shaker); Types of Packaging used (Use of bags, Use of cartons or boxes, Use of nets or sacks, Use of crates, and Use of pallets); Types of storage used (Cool rooms, and Pack houses); and Types of transport for products to the market (Refrigerated trucks, Shipping Containers, and Aircrafts).

The research further used the tables on the research questionnaire to collect data from the respondents regarding the types of pests and disease experienced on farm over the past five (5) years. The types of Plant Pests included African Citrus Psyllid, Ants, Aphids or Thrips, Asian Citrus Psyllid, Australian bug, Ball worm, Bud mite, False Codling Moth, Flat mite, Fruit flies, Fullers Rose Beetle, Leaf Hoppers and Plant Rollers, Leaf Rollers, Lemon Bore Moth, Loppers, Mealy Bugs, Orange Dogs, Oriental Fruit fly, Red Scales, Rust Mites, Silver Mites, Snails and Slugs, Soft Scales, and Waxy Scales. In addition, the types of diseases experienced on farm over the past five (5) years included Alternaria fruit rot, Brown Rot on Fruit, Brown wood rot, Citrus Black Spot, Citrus Canker, Dry root rot, Exocortis, Foot Rot, Greasy Spot Rind Blotch, Melanose on fruit, Melanose on leaves, Post Bloom Fruit Drop, Psorosis Greasy Spot, Scab, Sooty canker, Stubborn Disease, and Tristeza virus. A Likert scale was also used to assess the level of orange losses in respect of cultural modes of the citrus farms on the previous season's products from the producers' records. The level of losses among citrus farms were indicated in the form of tones and number of orange losses in respect of cultural practices which include Plant pests, Plant diseases, Harvesting, Packaging bruises, Storage, and Transportation.

Objective 2: The multinomial logistic regression model was used to analyse factors influencing disease control modes used by the citrus farmers in the study area.

(a) The multinomial logistic regression model

The multinomial logistic regression model is scientific and appropriate for the set objective in that the respective dependent variables, which are: the modes of plant pests' control among the export bound orange farms in the study area are categorical in nature (not binary). Similarly, there are more independent variables that are continuous, ordinal and dichotomous variables. However, the ordinal independent variables were treated as being either continuous or categorical as required (Lani, 2010). Even though collinearity is low in logistics, SPSS software was used to test that there is no multicollinearity using Variance Inflationary factor (VIF) values. Multicollinearity occurs when one has two or more independent variables that are highly correlated with each other. This leads to problems with understanding which variable contributes to the explanation of the dependent variable and technical issues in calculating a multinomial logistic regression. It is worth mentioning that the respective modes used by the farmers vary according to their respective socio-economic characteristics. The model permits the use of a categorical dependent variable, and there are several alternatives that generate the probability (Aguilera-Alfred *et al*., 1994).

As in other forms of linear regression, multinomial logistic regression uses a linear predictor function to predict the probability that observation *i* has outcome *k*, of the following form:

$$f\ (k,i) = \beta_{0,k} + \beta_{1,k}x_{1,i} + \beta_{2,k}x_{2,i} + \ldots + \beta_{M,k}x_{M,i},$$

where is a regression coefficient associated with the *m*th explanatory variable and the *k*th outcome. The regression coefficients and explanatory variables are normally grouped into vectors of size *M+1*, so that the predictor function can be written more compactly:

$$f\ (k,i) = \beta_k . x_{i,}$$

Where is the set of regression coefficients associated with outcome *k*, and (a row vector) is the set of explanatory variables associated with observation *i*.

The maximum likelihood technique was used to estimate the following equation:

$$log_e\ \left(\frac{p_j}{p_1}\right) = \alpha_{j} + \beta_{jk}X_{ki} + \mu_{ji} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

where: *J* = 1,2,3,4,5 categories;

i = 1,…., *n* observations;

α = intercepts;

β = coefficients;

X_k = 1,…., *m* explanatory variables; and

μ = error terms.

Specifically, for the Plant Disease Control Modes, the model test comprised five possibilities, P_j $(j = 1,..,5)$, associated with the categorical variable and the mode used by respondent. The probability of respondent using Integrated Pest Management is denoted by P_1, the probability of respondent using chemical method is represented by P_2, the probability of respondent using Biological method is denoted as P_3 respondent using Cold treatment is represented as $P_{4,}$ while the probability of respondent using fumigation is denoted as P_5 .The estimation procedure generates the coefficients of the probabilities of an observation falling into categories. The first set of estimated coefficients was used to calculate the probabilities of the respondents regarding citrus plant disease control modes used in the study area. The definition and explanation of variables used in the empirical multinomial logit model are presented in Table 3.2.

Table 3.2: Definition and explanation of variables used in the empirical multinomial logit model

Variable	Type	Description and value	Expected sign
Type of Plant disease control mode used by producer (Y_i)	Categorical	Respondent using Integrated Pest Management = 1 Respondent using chemical method = 2 Respondent using biological method = 3 Respondent cold treatment = 4 Respondent using fumigation=5	
Years of education (X_1)	Continuous	Years	+
Size of farm (X_2)	Continuous	Ha	+
Years involved in the outbound trade (X_3)	Continuous	Number of years involved in the outbound trade	+
Member of farmers' org. (X_4)	Binary	Yes=1, No=0	+
Age of citrus plants (X_5)	Continuous	Number	-
No. of disease control training received (X_6)	Continuous	Number	-

Source: Author's PhD Research Proposal, 2020. The last option of the dependent variable is the reference category.

Objective 3: The Poisson regression model was used to determine which of a set of specified independent variables have significant relationship with the individual farmers' orange losses as measured by counts of oranges.

(a) The Poisson regression model

The Poisson regression is a scientific and appropriate model concerned with the analyses of factors which influence the degree/level of losses of orange outputs in respect of cultural practices on the farms. The researcher employed the Poisson regression model for the analyses of objective 3. A Poisson regression is a regression model in which a dependent variable that consists of counts is modeled with a Poisson distribution. Count dependent variables, which can take on only nonnegative integer values, appear in many social science contexts. Poisson regressions are based on the Poisson distribution.

Model Specification

The model specification for a Poisson regression is based on assuming that a count-dependent variable y_i has, conditional on a vector of independent variables $\mathbf{x}_i$, a Poisson distribution independent across other observations *i* with mean μ_i and the following probability distribution function:

$$f(y_i|x_i) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i} \qquad (1)$$

The link between μ_i and x_i is assumed to be

$$\mu_i = \exp(x_i'\boldsymbol{\beta}) \qquad (2)$$

where β is a parameter vector (with the same dimension as $\mathbf{x}_i$) to be estimated. Note that the exponential link function between μ_i and $\mathbf{x}_i$ ensures that μ_i is strictly positive; this is essential because the mean of the Poisson distribution cannot be nonpositive. Based on a set of *n* observations (y_i, $\mathbf{x}_i$), equations (1) and (2) together generate a log-likelihood function of

$$\log L = \sum_{i=1}^{n} \lfloor y_i x_i' \beta - \exp(x_i' \beta) - \log(y_i!) \rfloor. \qquad (3)$$

where log (·) denotes natural logarithm. The first-order conditions from this log-likelihood function—there is one such condition per each element of β—are nonlinear in β and cannot be solved in closed form. Therefore, numerical methods must be used to solve for the value of β^ that maximizes equation (3).

Interpretation of Poisson regression output is like interpretation of other nonlinear regression models. If a given element of β^ is positive, then it follows that increases in the corresponding element of $\mathbf{x}_i$ are associated with relatively large count values in y_i. However, comparative statics in a Poisson regression model are complicated by the fact that the derivative of μ_i with respect to an element of $\mathbf{x}_i$ in equation (2) depends on all the elements of $\mathbf{x}_i$ (cross-partial derivatives of μ_i with respect to different elements of $\mathbf{x}_i$ are not zero, as they are in an ordinary least square regression). Hence, with a vector estimate β^, one can vary an element of $\mathbf{x}_i$ and, substituting β^ for β in equation (2), generate a sequence of estimated μ_i values based on a modified $\mathbf{x}_i$ vector. It is then straightforward to generate a probability distribution over the nonnegative integers—an estimated distribution for y_i—using the link function in equation (2). This distribution, it is important to point out, will be conditional on the elements of $\mathbf{x}_i$ that are not varied.

The log likelihood in equation (3) satisfies standard regularity conditions, and from this it follows that inference on β^ can be carried out using standard asymptotic theory. Accordingly, significance tests, likelihood ratio tests, and so forth can easily be calculated based on β^ and an estimated covariance matrix for this parameter vector. The Poisson regression model is a special case of a generalized linear model (McCullagh & Nelder, 1989); hence, generalized linear model theory can be applied to Poisson regressions. The definition and explanation of variables used in the empirical Poisson model are presented in Table 3.3.

Table 3.3: Definition of variables used in the empirical Poisson model (n=215)

Variables	Type	Description and value	Expected effect
Number of orange losses on orange farms in the study area (Yi)	Count	Number	
Gender (X_1)	Binary	Assistance of household in farming: Male = 1, Female = 0	+
Years in the outbound trade (X_2)	Continuous	Number (years)	+
Size of farm (X_3)	Continuous	Ha	+
Farm Ownership (X_4)	Nominal	Types of ownership held by the producer	+
Years of education (X_5)	Continuous	Years	+
Farm Age (X_6)	Continuous	Years of existence of farm	-
Age of citrus plants (X_7)	Continuous	Number	-
No. of disease control training received (X_8)	count	Number	-
Type of main labour used (X_9)	Binary	Mainly Family Labour=0; Hired Labour=1	+
Mode of transport used (X_{10})	Nominal	Refrigerated trucks=1, Shipping containers=2, Aircrafts=3.	+
Mode of storage used (X_{11})	Binary	Cold rooms=1, otherwise=0	+

Source: Author's PhD Research Proposal, 2020

Objective 4: Objective 4 was concerned with analyses of main factors influencing successfully traded outbound oranges from export bound orange farms in the study area. The researcher used the Tobit regression model to achieve the best results for objective 4.

(a) Tobit Regression Model

First, the Tobit Regression Model was used to analyze the main factors influencing successful traded outbound oranges from export bound orange farms in the study area. The nature of the dependent variable determines the econometric model used. The Tobit model is considered appropriate in this study, since the dependent variable Y* is in the form of proportion or percentage (proportion of oranges not rejected or not excluded or not lost because of damages by plant pest, plant disease, packaging used, and type of harvesting of oranges among the export bound orange farms in the study area). In this study, the proportion of oranges of the season's harvest not damaged which were exported was the dependent variable, lower censored at zero and upper censored at 1. Farmers who do not have damaged oranges because of the aforementioned factors were at a 1 value of dependent variable. Tobit model is the most common censored regression model appropriate for analysing dependent variables with upper or lower limits (Tobin, 1958).

Generally, the Tobit model uses Maximum Likelihood Estimation (MLE) method to estimate the parameters, assuming normality and homoscedasticity conditions. The Tobit model, introduced by the Nobel laureate economist, James Tobin in 1958, is used when the dependent variable in a regression model equation has a lower and upper limit. In general, Tobit is specified like Ordinary Least Squares (OLS), with a dependent variable and a list of independent variables as in the equation below. According to Greene (2003), the general formulation of the censored Tobit is an index function shown below.
The Tobit model is specified as:

$$Y_i{*} = \beta_1 + \beta_2 X_i + \varepsilon_i$$

In this equation, X_i is the vector of independent variables as specified in Table 3.4, and ε_i is an error term. Additionally, a truncation in normal distribution is made at some threshold value that is often set at zero. In such a case, the model specification is given by:

$$y = \begin{cases} y_{\mathrm{i}} & if\ y_{\mathrm{i}} * > 0 \\ o & if\ y_{\mathrm{i}} * < 0 \end{cases}$$

where Y_i is the dependent variable that is only observed or only exists when the latent or unobservable variable $Y_i *$ is greater than zero. Tobit can also be used to model the dependent variables where the cut-off value is different from zero, or where observations with large values are those not observed (Dinarte, 2009). Tobit model parameters do not directly correspond to changes in the dependent variable brought about by changes in independent variables. The coefficients on modes of plant disease control used due to changes in the explanatory variable are given as follows:

$$\frac{\partial \in \left[\frac{y_{\mathrm{i}}}{x_{\mathrm{i}}}\right]}{(\partial\ x_{\mathrm{i}})} = \beta \emptyset \left[\frac{\beta x_{\mathrm{i}}}{\sigma}\right]$$

The coefficients as well as Maximum Likelihood Estimates are done through the Tobit model, using STATA computer software. The marginal effects/ coefficients indicate the plant disease control mode, resulting from a unit change in the independent variables. The coefficients also account for the plant disease control mode. A Tobit model provides a single coefficient for each independent variable. Hence, the interpretation of coefficients in the Tobit model differs substantially from the interpretation of an OLS regression. A coefficient represents the effect of an independent variable on the dependent variable in an OLS analysis, because the coefficient is the first order partial derivative of the independent variable. The OLS interpretation is not valid for Tobit coefficients because the Tobit coefficients represent the effects of the independent variables on the latent variables of the Tobit model. Table 3.4 below shows the definition of variables used in the empirical Tobit model.

Table 3.4: Definition of variables used in the empirical Tobit model (n=215)

Variables	Type	Description and value	Expected effect
Proportion of oranges exported; not rejected or not excluded or not lost because of damages by plant pest, plant disease, packaging used, and type of harvesting of oranges among the export bound orange farms in the study area (Yi)	Proportion	Proportion or percentage	
Gender (X_1)	Binary	Assistance of household in farming: Male = 1, Female = 0	+
Years in the outbound trade (X_2)	Continuous	Number (years)	+
Size of farm (X_3)	Continuous	Ha	+
Farm Ownership (X_4)	Nominal	Types of ownership held by the producer	+
Years of education (X_5)	Continuous	Years	+
Farm Age (X_6)	Continuous	Years of existence of farm	-
Age of citrus plants (X_7)	Continuous	Number	-
No. of disease control training received (X_8)	count	Number	-
Type of main labour used (X_9)	Binary	Mainly Family Labour=0; Hired Labour=1	+
Mode of transport used (X_{10})	Nominal	Refrigerated trucks=1, Shipping containers=2, Aircrafts=3.	+
Mode of storage used (X_{11})	Binary	Cold rooms=1, otherwise=0	+

Source: Author's PhD Research Proposal, 2020

Objective 5: A workshop comprising all major stakeholders was organized to achieve objective 5 to develop a framework for successfully traded outbound oranges from orange farms in the Limpopo province. The framework when developed was validated by the major stakeholders (Department of trade and Agriculture reps, Agricultural economics experts, selected successful outbound orange traders and technical personnel at the phytosanitary section at the OR Tambo International Airport) in a form of a collective agreement or resolution.

3.9 Ethical consideration

Table 3.5 Ethical consideration

The researcher was provided with an Ethical Approval from the Ethics Committee at UNISA.

Risk: Injury or attack while visiting respondents for interview

Mitigation – permission to interview the respondents was obtained from the Department of Agriculture, Land Reform and Rural Development in Pretoria

Risk-Possible delay in data collection

Mitigation: using my own car and prior scheduling of interviews with respondents

Risk- Possible failure of the respondent to attend the interview.

Mitigation: convinced and motivated them to participate by briefing them on the objectives of the study and how the study would benefit them. However, participation was free.

Risk: Ensure proper handling and security of completed questionnaires

Mitigation: questionnaires were kept in a locked cabinet and were destroyed after completion of research.

Source: Author’s PhD Research Proposal, 2020

3.10 Summary of chapter

This chapter presented information regarding the study area, research design, sample size, sampling technique, data collection instrument, method of data analyses and ethical considerations. Primary data of the study was collected through a questionnaire whereas secondary data was obtained from the citrus farmers included in the study and from desktop information. The software computer programme used to analyse the data of the study was the Statistical Package for Social Sciences (Version 28.0). The descriptive statistics, the Multinomial Logistics Regression Model, the Poisson Regression Model, and the Tobit Regression Model were used for the statistical analyses of the study.

CHAPTER FOUR
DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS OF CITRUS FARMS/PRODUCERS

4.1 Introduction

This section discusses the results of the study encompassing analysis of the demographic and socio-economic characteristics of the citrus farms/producers. It further comprises demographic and socio-economic characteristics of the citrus farms/producers included in the study. The main variables for analysis will include gender group, age of the farmer, marital status, level of education, farm ownership status, sources of income, farm size, farm age, years of outbound orange farming experience, average farm income per season and types of labour used in the previous citrus season.

4.2 Demographic and socio-economic characteristics of citrus farmers

Descriptive statistics method was the scientific model employed to analyze the demographic and socio-economic characteristics of the citrus farms/producers included in the study. The main purpose of applying this analytical method was to discover statistics such as mean values, percentage, standard deviations, and frequency tables and use them to present the results of descriptive analysis.

4.3 Demographic characteristics of citrus farmers

Having noted all what is thought to be necessary for achievement of success in citrus international trade, the study results concur with other global research findings deeming knowledge and understanding of respondents' historical background extremely significant. Table 4.1 illustrates the demographic characteristics of the respondents in the study area.

Table 4.1 Demographic characteristics of citrus farmers (n = 215)

Variables		Frequency	Percentage
Gender			
	Female	4	1.9
	Male	211	98.1
Age group			
	20 – 30 years	6	2.8
	31 – 40 years	62	28.8
	41 – 50 years	89	41.4
	Above 50 years	58	27.0
Marital status			
	Married	211	98.1
	Single	4	1.9
Level of education			
	Primary education	16	7.4
	Secondary education	93	43.3
	Tertiary education	104	48.4
	No education	2	.9

Source: Results from SPSS generated from field survey, 2021

The findings of Table 4.1 revealed that 98.1% of the respondents under investigation were males, which provides a clear indication that males are more dominant in international trade of oranges than females who accounted for only 1.9% of the study population sample. Part of the reasons for having low population of female farmers in the citrus industry highlighted by citrus farmers during the survey was that majority of women possess perception that citrus farming is a man's job. Over and above, women's household responsibilities of taking care of kids after working hours, dealing with kids' sicknesses, and lastly getting kids to and from school also make it more difficult for female producers to participate in export orange trading business efficiently and effectively. The Citrus Growers Association of Southern Africa's (CGA, 2021) annual report on the role of women within the citrus industry in South Africa, also agrees with the findings of this study that indeed women have a negative perception that citrus farming is a man's job. It was further indicated in the CGA's report that women lack self-confidence thereby deeming export orange farming as a job that requires men since they are physically stronger than women linking their justification with the responsibilities such as operation of heavy machinery and doing the hard labour as tasks needing man's physical powers.

However, other research findings regarding gender equity in agriculture sector also concur with the discovery of this study. In accordance with the results of the study conducted by Loubser (2020), it was revealed that high percentage of farmers in the citrus industry are men. He further stressed that although the proportion of female farmers is less, they still have a significant role to play within the citrus industry world-wide. Due to the foregoing backdrop, Lobster (2020) revealed that indeed women lack self-confidence but also conversely argues that women can still make a positive impact within the industry due to current development of new technology which renders physical strength less of a barrier in export orange farming business. In a study conducted by Fuyane and Sikwela (2017), it was found that 71.7% of the citrus farmers dealing with citrus export undertaking are married males whereas 28.3% of them are married females. The core justification for this gender disparity of respondents within the industry was found to be stemming from a traditional notion that farming is a man’s job, particularly the married men. The afore-mentioned belief was also held by Manenzhe (2021) who also found that more married men are the ones making an immense contribution in the citrus industry more than the married women.

Based on the information provided by respondents in this study, the Table 4.1 further illustrates that a large proportion of citrus farmers within the Limpopo citrus industry fall within the age group of between 41 and 50 years at 41.4%, followed by those of between 31 and 40 years at 28.8%, above 50 years at 27.0%, and between 20 and 30 years at 2.8% respectively. Due to the afore-mentioned backdrop, most respondents highlighted that majority of the youth population are unable to take part in citrus farming owing to their tight study schedules. It was also mentioned that export orange production business demands adequate attention to make a significant impact which on one hand contradicts with students’ study schedules which ought to take place during the same period. Moreover, a small proportion of respondents in the age group of above 50 years is often triggered by ongoing farm risks such as farm attacks, farm killings, urbanization and ageing of citrus farmers. The outcomes of this study are further supported by Fuyane and

Sikwela (2017) who found that 71.7% of the role players in the citrus industry are mostly old and experienced male farmers.

In support of these research findings, a study conducted by authors Kassem *et al.* (2020) in Egypt also highlighted the significance of age group as one of the main determinant factors in international trade of oranges. The CGA's (2021) Annual Report further supports the age group factor deeming it labour-intensive and very much important as it is a responsibility that requires close monitoring, dedication, and hard work to comply with the international market requirements. High (98.1%) proportion of the citrus producers in the study area were married, whereas 1.9% of them were single. Amongst the married citrus farmers, there were two widows who demonstrated their fear of becoming part of the farm causalities as they lost their husbands and left only with their children who some of them do not have a desire to do farming business whereas others do work and stay in their own homes far away from them. Based on the afore-mentioned justification by the widows in the study, it becomes apparent that citrus export production and sustainability under such difficult living conditions are likely to be negatively affected. In some instances, determinations to either put the farm for sale or relocate to urban areas are often considered. Based on the outcome of this study, it was also found that 48.4% of the respondents had tertiary education, followed by secondary education at 43.3%, primary education at 7.4% and no education at 0.9% respectively. The highest number (48.4%) of the outbound orange farmers with tertiary education is a demonstration that export orange trade business requires good educational background to achieve a success. Amongst those who have secondary education were old men and women who did not further their studies to tertiary level due to the busy nature of their citrus farms' schedules.

4.4 Socio-economic characteristics of the citrus farmers involved in the study.

Employment is considered as one of the most important resources in human life. Numerous households' breadwinners continue to have hectic schedules day-by-day on the lookout for sources of income to feed their family members efficiently and sustainably. This kind of a social responsibility is very crucial for improvement of the lives of the society at large. The socio-economic characteristics of the respondents are thus demonstrated in Table 4.2 and Table 4.3.

Table 4.2 Summary of the socio-economic characteristics of the respondents (n = 215)

Variables	Frequency	Percentage
Other employment		
No other work	212	98.6
Bookkeeper	1	.5
Engineer	2	.9
Farm ownership status		
Private	210	97.7
Community	1	.5
Other/Government	4	1.9
Other source of income		
Salary	215	100.0
Farm size		
1 – 20 hectares	2	.9
21 – 40 hectares	1	.5
Above 60 hectares	212	98.6
Farm age		
1 – 10 years	2	.9
11 – 20 years	1	.5
Above 20 years	212	98.6
Outbound orange farming experience		
1 – 5 years	2	.9
6 – 10 years	3	1.4
11 – 15 years	2	.9
Above 15 years	208	96.7
Average farm income per export season		
R1 – R200 000	2	.9
R401 – R600 000	1	.5
Above R600 000	212	98.6
Average orange export costs per season		
R1 – R100 000	2	.9
Above R300 000	213	99.1

Source: Results from SPSS generated from field survey, 2021

The findings of Table 4.2 revealed that 98.6% of the respondents receive salaries as their only monthly source of income, followed by those who do extra engineering and bookkeeping work at both 0.9% and 0.5% respectively. The fact that citrus production in

South Africa is mainly labour-intensive and aimed at the export market truly means that successful international trade of citrus cannot be realized if producers do not work around the clock in ensuring that they earn adequate turnover at the end of every citrus export season (DALRRD, 2018; Sikuka, 2018). In support of the idea that farming requires hard work, dedication and close monitoring and continuous evaluation of plans and programs, Materechera and Catherine (2022) also conducted a study in Vhembe district of the Limpopo province regarding understanding the drivers of production in South African farming systems where it was found that more farmers (91.5%) in the province were dependent primarily on salaries obtained from their farming businesses as their only main source of income.

However, the research further investigated about the status of the land ownership under citrus production in the study area and discovered that 97.7% of the citrus farms in the area were privately owned, followed by private and community at 1.9% and community at 0.5% respectively. During data collection period, almost all the respondents had a common concern over the challenge of ownership status of their farmlands due to the current rising South African government policy discussion agenda regarding the land expropriation without compensation. Majority of the South African export orange volumes continue to suffer a devastating impact of the aforesaid risk as citrus farmers operate under uncertain farming conditions every citrus season. On one hand, the Citrus Growers' Association of Southern Africa (2021) alluded to this risk as part of the country's citrus industry risks. The CGA further demonstrated steps taken to address this risk as it had highlighted in its annual report that there is an ongoing communication and extensive engagement with industry body Agricultural Business Chamber of South Africa (AGBIZ) on this matter. The CGA also stressed that it had engaged with the Minister of Trade and Industry on the matter and further made submissions to the parliamentary review committee for its attention. By virtue of the foregoing statement, the research findings concur with the concept that if these risky conditions remain unchanged, the outbound orange volumes in the study area will also become negatively affected. Table 4.3 (a) study results further revealed that 98.6% of respondents own farm sizes of above 60 hectares, followed by those owning farm sizes of between 1 and 10 hectares at 0.9% and between

11 and 20 hectares at 0.5% respectively. In other words, these study findings mean that for an export orange trader to become successful one needs a larger land size of above 60 hectares. In terms of farm age, majority (98.6%) of the citrus farms in the study area are aged above 20 years old, followed by those falling within the age brackets of between 1 and 10 years old at 0.9% and between 11 and 20 years at 0.5% respectively.

Table 4.2 study results also showed that 96.7% of the outbound orange producers have above 15 years' export orange farming experience, followed by those falling between the age of 6 and 10 years at 1.4%, between 11 and 15 years at 0.9% and between 1 and 5 years at 0.9% respectively. It is therefore a fact that experience in export orange farming mostly serves as an indicator for the degree of knowledge and skill individual farmers possess. In this study, majority (96.7%) of the respondents are experienced and fully understand the value of citrus production, international market environment and the efforts anticipated of a farmer to become a success and all available export challenges happening along the export orange supply chain. According to Esterhuizen and Caldwell, (2022), world citrus production is considered as a daunting task necessitating broad knowledge and experience as the citrus industry is more diverse with its fruits grown on small, medium, large, and very large farms world-wide. One more necessary factor about becoming a successful international citrus trader includes possessing sufficient capacity and experience in dealing with aspects such as natural barriers which include distance and language, tariff barriers or taxes on imported goods and non-tariff barriers which involve import quotas, embargos, national regulations, and exchange controls laid down by collective governments world-wide.

Despite all the seasonal export orange challenges being faced by the citrus producers such as production costs, fertilizer costs, pesticide costs, labour costs, tool depreciation costs, fuel costs, water supply costs, electricity costs, storage costs, transportation costs and many others, citrus export business in the study area still carry on as usual. Table 4.2 study revelations provided evidence regarding the export orange farm income per season with an indication that 98.6% of the citrus farmers earn above R600 000 farm income every citrus export season, followed by those earning between R1 and R200 00 at 0.9% and between R401 000 – R600 000 at 0.5% respectively. Even though the said figures are determined by a range of factors of production such as farm size, climate, and many others, most respondents in the study area showed that majority (98.6%) of their export orange farm sizes measures above 60 hectares and generate above R600 000 income per citrus export season. The findings of the study showed that the majority (99.1%) of respondents in the Limpopo province's citrus industry spent above R300 000 at 0.9%. Given the above scenario, citrus farmers spend more money to sustain their export orange businesses.

Table 4.3 Summary of the socio-economic characteristics of the respondents (n = 215)

Variables	Frequency	Percent
Type of labour used on the farm		
Mainly family labour	1	.5
Hired labour	196	91.2
Hired labour, Mainly family labour	6	2.8
Hired labour, Permanent	11	5.1
Hired labour, Temporary employees	1	.5
Transport mode used to convey oranges to the export market		
Refrigerated trucks	78	36.3
Aircrafts	1	.5
Shipping containers	20	9.3
Other (Normal trucks)	14	6.5
Refrigerated trucks, Shipping containers	97	45.1
Refrigerated, Normal trucks	1	.5
Shipping containers, Normal trucks	4	1.9

Source: Results from SPSS generated from field survey, 2021

Based on the results of the study, majority (91.2%) of the respondents used hired labour, followed by hired labour and permanent at 5.1%, hired labour and mainly family labour at 2.8%, hired labour and temporary employees and mainly family labour at 0.5% respectively. According to Table 4.3 outcomes, majority (45.1%) of the respondents used both refrigerated trucks and shipping containers to convey their oranges to the export markers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively. This implies that conveyance of export oranges using both the refrigerated trucks and shipping containers transport mode was more efficient and effective than the other transport modes used in the study area.

4.5 Identification and analysis of the efficacy of cultural modes in the study area

Considering that citrus devastation occurs from various stages of the citrus supply chain, to identify and analyze the effectiveness of cultural modes (plant pest and disease control, harvesting, packaging, storage, and transportation modes) applied on each of selected outbound orange farms in the study area, the research therefore used Tables 4.4, Table 4.5 Table 4.6, Table 4.7, and Table 4.8.

Table 4.4: Identification and analysis of the efficacy of cultural practices used in 2020/21 citrus season (n = 215)

Cultural Control Modes	Frequency	Percent
Pest control modes		
Integrated Pest Management (IPM)	145	67.4
Chemical (CH)	2	0.9
Ionizing Radiation Treatment (IRT)	1	0.5
Cold Treatment (CT)	2	0.9
IPM, CH	21	9.8
IPM, CH, CT	7	3.3
IPM, CH, CT, Bio, HT	4	1.9
IPM, CH, Bio	11	5.1
IPM, CH, CT, Fum	1	0.5
IPM, Fum	3	1.4
IPM, CT	2	0.9
IPM, CH, Bio, CT	3	1.4
IPM, Bio	1	0.5
IPM, CT, Fum	1	0.5
IPM, CH, Bio, Fum	6	2.8
IPM, CH, HT, CT, Fum	1	0.5
IPM, CH, Bio, HT, IRT, Fum	2	0.9
IPM, CH, Fum	1	0.5
IPM, CH, Bio, CT, Fum	1	0.5
Disease control modes		
Integrated Pest Management (IPM)	153	71.2
Chemical (CH)	6	2.8
Biological (Bio)	1	0.5
IPM, CH	28	13.0
IPM, CH, CT	6	2.8
IPM, CH, Bio	15	7.0
IPM, CH, CT, Fum	1	0.5
IPM, CH, Bio, CT, Fum, HT	1	0.5
IPM, Fum	1	0.5
CH, Bio	1	0.5
CH, Post-Harvest Treatment (PHT)	2	0.9

Source: Results from SPSS generated from field survey, 2021

In accordance with the results of Table 4.4, the majority (67.4%) of the citrus farmers in the study area used the Integrated Pest Management (IPM), followed by the IPM and Chemical at 9.8% and IPM, Chemical and biological plant pest control method at 5.1% respectively. This therefore means that for citrus farmers to trade successfully in the international markets, they can consider using the IPMs as an effective pest control mode to protect their oranges against plant pests or choose between IPM, Chemical and biological pest control methods. In terms of Table 4.4 study findings, the majority (71.2%) of the citrus farmers in the study area used the IPM, followed by the IPM and Chemical at 13.0% and IPM, Chemical and biological plant disease control method at 2.8% respectively. This therefore means that for citrus farmers to trade successfully in the international markets, they can consider using the above options of pest and disease control measures as they proved to be effective plant pest and disease control modes to protect their oranges. Table 4.5 shows the identification and analysis of the efficacy of cultural practices used in the study area during 2020/2021 citrus season.

Table 4.5 Identification and analysis of the efficacy of cultural practices used in 2020/21 citrus season (n = 215)

Cultural control modes	Frequency	Percent
Harvesting modes		
Hand-picking	215	100.0
Packaging modes		
Use of bags	3	1.4
Use of cartons or boxes	62	28.8
Use of cartons or boxes, use of nets or sacks	128	59.5
Use of bags, use of cartons or boxes, use of pallets	7	3.3
Use of cartons or boxes, use of pallets	4	1.9
Use of cartons or boxes, use of crates, use of pallets	10	4.7
Use of cartons or boxes, use of crates	1	0.5
Storage modes		
Cool rooms	22	10.2
Pack houses	46	21.4
Cool rooms, Pack houses	147	68.4

Source: Results from SPPS generated from field study, 2021

Consistent with Table 4.5 study results, majority (100%) of the citrus farmers in the study area used hand-picking method as their preferred harvesting method for export oranges. This implies that hand-picking method is the most effective harvesting mode citrus farmers can put in use to minimise the phytosanitary risks caused by blemishes, bruises and any other unnecessary injury that may occur on their export oranges. The findings of Table 4.5 showed that majority (59.5%) of the citrus farmers in the study area used cartons or boxes and nets or sacks to pack their export oranges, followed by those who used cartons or boxes at 28.8%, cartons, crates, and pallets at 4.7%, bags, cartons, and pallets at 3.3%, cartons and pallets at 3.3%, boxes and pallets at 1.9% and bags at 1.4% respectively. This is indication that the use of cartons or boxes and nets or sacks to pack export oranges was more effective than the packaging methods used by other citrus farmers in the study area. Table 4.5 study findings further revealed that reveal that majority (68.4%) of the citrus farmers in the study area used both cool rooms and pack houses as their effective storage modes followed by pack houses at 21.4% and cool rooms at 10.2% respectively. The results of Table 4.5 proved that the use of both cool rooms and pack houses are more effective than the rest of the packaging modes used by other citrus farmers in the study area. Table 4.6 illustrates the top five pests experienced in the study area over the past five years.

Table 4.6: Top five (5) types of pests experienced on farms over the past five (5) years (n = 215 respondents)

Variables (X)	Variables (Y)	Frequency	Percentage
Pests experienced over the past five (5) years.	False codling moth, ants, fruit-fly, loppers, and mealy bugs	30	14.0
	False codling moth, fruit-fly, mealy bugs, and ants	12	5.6
	False codling moth, aphids/thrips, fruit-fly, loppers, and mealy bugs	8	3.7
	False codling moth, ants, fruit fly and red scales	6	2.8
Total		56	26.1

Source: Results from SPPS generated from field study, 2021

Based on Table 4.6 study findings, False Codling Moth (FCM), ants, fruit-fly, loppers, and mealy bugs respectively at 14% were found to be the top five citrus pests occurring within the Limpopo citrus industry. In overall, majority (31.7%) of the respondents agree that all the afore-mentioned pests occur in large quantity in the study area. Consistent with the results of this study, it is thus necessary for the Limpopo province's citrus farmers to lay down effective phytosanitary control measures to avoid orange spoilage and export ban in future. In its annual report, the CGA (2021) identified the False Codling as one of the most destructive pests in the study area. In summation, it is therefore recommended that effective phytosanitary control measures be put in place throughout the whole orange supply chain period for citrus farmers in the study area to comply with the citrus export market requirements and be able to achieve success in the international trade of oranges. Table 4.7 indicates the top five diseases experienced in the study area over the past five years.

Table 4.7: Top five (5) types of diseases experienced on farms over the past five (5) years (n = 215 respondents)

Variables (X)	Variables (Y)	Frequency	Percentage
Diseases experienced over the past five (5) years.	Alternaria fruit rot, Scab	84	39.1
	Citrus Black Spot	9	4.2
	Alternaria fruit rot and Melanose on fruit	6	2.8
	Botrytis on fruit, wind damage and rind pitting	4	1.9
Total		103	48

Source: Results from SPPS generated from field study, 2021

In accordance with Table 4.7 study findings, Alternaria fruit rot and Scab at 39%, Citrus Black Spot at 4.2%, Alternaria fruit rot and Melanose on fruit at 2.8% and botrytis on fruit at 1.9% were the top five citrus diseases occurring within the Limpopo citrus industry. These results imply that for the Limpopo province's citrus farmers to trade successfully in the international markets, placement of effective phytosanitary control measures in their orange supply chain is of critical importance to deal with the afore-mentioned citrus diseases. Amongst other citrus diseases identified by the CGA (2021) annual report to be a disease of phytosanitary importance rendering the oranges unmarketable include the Citrus Black Spot (CBS). In terms of assessment of level of orange losses in respect of cultural modes of the citrus farms on the previous season's products from the producers' records, the research used a Likert scale to draw comparison of the orange losses on Table 4.8.

Table 4.8 Level of losses due to cultural practices (n = 215 respondents)

Item	**1** >5% fruits spoiled	**2** 3-5% fruits spoiled	**3** 1-2% fruits spoiled	**4** <1% fruits spoiled
Losses due to Plant pest	95.8	3.3	0	0.9
Losses due to Disease	93.9	3.8	0	0
Losses due to Harvesting bruises	94	3.7	0	0
Losses due to Packaging bruises	96.2	3.3	0	0.5
Losses due to Storage	92.6	3.7	0	0.5
Losses due to Transportation	95.3	0	1.9	0

Source: Results from SPPS generated from field study, 2021

According to Table 4.8 results, 96.2% lost due to packaging, 95.8% of oranges were lost due to plant pests, 95.3% lost due to transport modes, 94% lost due to harvesting followed by 93.9% lost due to diseases, and 92,6% lost due to storage respectively. Based on the afore-mentioned outcome, the highest losses occurred during packaging period which was dominantly done using boxes/cartons and nets/sacks. These outcomes therefore indicate that citrus farmers in the study area need to strengthen their packaging modes to avoid orange spoilages occurring due to ineffective packaging methods used during packaging period.

4.6 Summary of the chapter

This section presented an overview of the demographic and socio-economic characteristics of the citrus farms and producers included in the study which comprised gender group, age of the farmer, marital status, level of education, farm ownership status, sources of income, farm size, farm age, outbound orange farming experience, average farm income per season and types of labour and transport modes used in the previous citrus season. This chapter also assessed the modes of the plant pest, disease control, harvesting, packaging and storage used in the study area. The results of the descriptive statistics of the respondents showed that gender, age group, and education were the most influential factors in the study area.

CHAPTER FIVE
DETERMINANTS OF PLANT DISEASE CONTROL MODES USED BY CITRUS FARMERS IN THE STUDY AREA

5.1 Introduction

This chapter discusses the factors influencing successful trading of outbound oranges produced in the Limpopo province of South Africa. The selected study areas for this study included Groblersdal, Hoedspruit, Letsitele and Vhembe. The objective of this chapter was to analyse the determinants of modes of plant disease control in the study area. This chapter presented the results and discussions of the multinomial logistic regression of the study. It further provided analysis of factors influencing the modes of disease control on the export bound orange farms in the study area using the multinomial logistic regression model.

5.2 Analysis of factors influencing the modes of plant disease control used in the study area: the multinomial logistic regression model

This section presents the results and discussions of the multinomial logistic regression analysis. As citrus farmers use different types of disease control measures to comply with international market requirements, this section seeks to test the efficacy of the disease control modes used by citrus farmers in the study area. Presentation of the results and discussions included the case processing summary, model fitting, goodness of fit, pseudo-R-square, likelihood ratio tests and parameters estimates.

5.2.1 Case Processing Summary

This section shows the results and discussions of analysis of factors influencing the modes of plant disease control among the citrus farmers using the multinomial logistic regression model. The case processing summary indicates how many cases and observations were detected in each category of the outcome variables including their percentages. It further shows whether there was any missing data or not. The marginal percentage provides the number of valid observations found in each variable outcome group and it was 100%. No valid missing data were observed. The valid data was 215 number observed in the dataset and all predictor variables were non-missing.

5.2.2 Model Fitting Information

The model fitting information shows the various indices for measuring the intercept only model and the final model that comprises all the forecasters and the intercept. The -2 Log Likelihood is a likelihood ratio and represents the inexplicable variance in the outcome variable. It is therefore hypothesized that the smaller the value, the better the fit. The Likelihood Ratio chi-square-based test is the alternative test of goodness-of-fit. As with most chi-square-based tests, it is prone to inflation as the sample size increases.

5.2.3 Goodness-of-Fit

According to the results, the p-value is less than 0.05 ($p \leq 0.05$) which indicates that it is statistically significant at 5% and that the model does fit the data well. In agreement with the results, the p-value is $p<0.05$ (from the "sig." column) and this indicates that the sample data represents the expected data in the actual population and therefore statistically significant at 5%. Based on this measure, the model fits the data well. The other part of the results (i.e., the "Deviance" row) presents the Deviance chi-square statistic. These two measures of goodness-of-fit might be or not always give the same result. It can thus be concluded that the proportion of the outcome Y, as explained by the covariates X, commonly described as a measure of goodness of fit, shows good evidence on the results that the sample data fits the model well and it is therefore statistically significant at 5%. Goodness of fit test refers to a statistical hypothesis test used to determine whether a variable is likely to come from a specified distribution or not. It compares actual data to expected or predicted data. In conclusion, as indicated on the results as "Pearson", that presents the Pearson chi-square statistic.

5.2.4 Pseudo R-Square

There are three pseudo-R-squared values in the study results. Logistic regression does not have an equivalent to the R-squared found in between “linear” regression and “limited dependent variable” regressions such as Logistic etc. The R-Squared in Linear Regression is also called Coefficient of Determination and has a straight-forward interpretation. Pseudo R-Squared is calibrated differently but the interpretation is slightly different.

5.2.5 The Likelihood Ratio Tests

The Likelihood Ratio Tests results show the independent variables which are statistically significant at 5% level of significance. The age group, level of education and transport mode variables in the model are statistically significant at 5% level of significance.

5.2.6 Parameter estimates of the multinomial logistic regression results

Estimation of parameters is known to be a scientific method of finding the value of a population parameter from sample statistics. The parameter estimates (also called coefficients) demonstrate the logistic coefficient (B) for each predictor variable for each alternative category of the outcome variable (alternative category meaning, not the reference category). The logistic coefficient is the expected amount of change in the logit for each one-unit change in the predictor. Based on that rationale, the logit which serves as a function representing probability values from 0 to 1, and negative infinity to infinity signifies what is being predicted; it is the odds of membership in the category of the outcome variable which has been specified. Estimation parameters further shows the standard error, Wald statistic, *df*, Sig. (*p*-value), as well as the Exp(B) and confidence interval for the Exp(B). The Wald test (and associated *p*-value) is used to evaluate whether the logistic coefficient is different than zero. The Exp(B) is the odds ratio associated with each predictor. It is expected of predictors which increase the logit to display Exp(B) greater than 1.0, those predictors which do not influence the logit will display an Exp(B) of 1.0 and predictors which decrease the logit will have Exp(B) values less than 1.0. In accordance with parameter estimates results, one-unit change in the disease control mode does not significantly change the odds of being classified in the 4^{th}

category of the outcome variable relative to the first or second or third categories of the outcome variable, while controlling for the influence of the others.

5.2.7 Factors influencing/associated with the use of disease control mode amongst the citrus farmers on export oranges

In this section, it is projected that there are factors influencing the use of disease control modes by citrus farmers in the study. The presented data shows the parameter estimates of the multinomial logistic regression model on plant disease control modes used by citrus farmers in the previous export season. Table 5.1 presents estimation results of the multinomial logistic regression model on plant disease control mode (Integrated Pest Management (IPM)) used in the previous citrus export season.

Table 5.1: Parameter estimates of the multinomial logistic regression model on Integrated Pest Management control mode used in the previous citrus season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Integrated Pest Management (IPM)	16.626	315.528	0.003	1	0.958		
Gender	-.242	15.774	0.000	1	0.988	0.785	2.934e-14
Age group	-1.595	0.656	5.904	1	0.015	0.203	0.056
Marital status	-1.155	132.503	0.000	1	0.993	0.315	5.150e-114
Level of education	-1.738	0.753	5.326	1	0.021	0.176	0.040
Farm size	2.613	0.000	-	1	-	13.646	13.646
Farm age	3.203	18.653	0.029	1	0.864	24.618	3.263e-15
Outbound orange farming experience	0.358	62.003	0.000	1	0.995	1.431	2.389e-53
Transport mode used to convey oranges to the export market	-1.077	0.399	7.278	1	0.007	0.341	0.156

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.1 Age of the citrus farmers

The results of Table 5.1 revealed that the coefficient of the age of the citrus farmers on the application of disease control mode of the Integrated Pest Management (IPM), was statistically significant at 1% and negative (Sig. 0.015, Coef = -1.595), therefore, the null hypothesis is rejected. This result indicates that aging farmers had a huge influence on the usage of the IPMs. As evidently seen from the findings of this study, most citrus farmers (41.4%) fell within the age group of between 41 and 50, followed by 31 to 40 years at 28.8%, above 50 years at 27% and 20 to 30 years at 2.8% respectively. The implication given thereof was that when age of the citrus farmer increases, the usage of the modes of IPMs over the control of citrus diseases decreases while other factors remain constant. Crop protection cultural practice such as IPM is generally assumed to be a combination of all pest or disease control methods which include chemical, cold treatment, fumigation and biological. Based on the current citrus farming systems, the elderly citrus farmers no longer utilize all these phytosanitary control measures collectively but use their experience to choose the one that they deem effective and can be used at a cheaper cost.

In most cases, old age citrus farmers apply less IPMs due to their citrus farming knowledge and experience or skill on the usage of cost-saving disease control measures than their younger counterparts. The age influence was also recommended by a study conducted by Joseph *et al*. (2021) where the majority (63.9%) of the citrus farmers aged between 36 and 55 years proved to be the most active age group making a significant contribution in citrus farming in the Limpopo province. Conversely, by taking into consideration the state of security in agricultural farming industry in South Africa, more farmers lose their lives due to lack of effective security on their farms. Due to the preceding backdrop, elderly citrus farmers therefore feel vulnerable, abandon their farms, and relocate to safe areas mostly located in urban towns and cities or even abroad, transferring ownership of their citrus farms to either their children or selling them (Wangithi, 2019).

5.2.7.2 Level of education of the citrus farmers

The results in Table 5.1 revealed that the coefficient of the level of education of the citrus farmers on the application of disease control modes of the Integrated Pest Management (IPM) in the study area was statistically significant at 5% and negative (Sig. 0.021, Coef = -1.738), thus, the null hypothesis is rejected. The findings of this study also indicated that the level of education of the citrus farmers had a huge influence on the usage of the IPMs. As evidently seen from the outcome of this study, most citrus farmers (48.4%) have tertiary education, followed by secondary education at 43.3%, primary education at 7.4% and no education at 0.9% respectively. This implies that when level of education of the citrus farmers rises, the usage of the modes of IPMs over the control of citrus diseases decreases while other factors remain constant. The cause for such a reduction in the usage of IPMs by the citrus farmers may be attributed by the fact that the more farmers stay long in this industry, the more their knowledge and skill of orange export increases and therefore enabling them to adopt alternative method to achieve effective control of diseases through minimum usage of IPMs. The idea of education level is globally recommended to play a critical role within the agricultural sector as it enables farmers to acquire technological advances and market information particularly the price. Conversely, low level of education adversely affects agricultural output (Ninh, 2020). This disparity in terms of access to market information may be attributed by the fact that farmers with enhanced level of education are able to take better and informed decisions than those with no education. The dependency of citrus farmers on the IPM control modes also reduces whenever their level of knowledge, skill and confidence increases. This study result is not supported by the results of a survey conducted by Singh *et al*. (2021) which found positive effects of educational level on the application of both IPMs and chemicals to control diseases on various types of crops.

However, the general picture emerging so far is that education level of the citrus farmers has a negative relationship with the usage of a disease control mode of IPM in the study area. The findings of this study are also supported by Singh *et al*. (2021) who also got statistically significant results in their study about the relationship between the use of IPMs and the level of education of farmers. In conclusion, Table 5.1 shows that for citrus farmers to trade successfully in the international markets, they have an obligation to consider education as one of their key requirements. The idea of education level was also highlighted by Umana-Hermosila *et al*. (2020) as one of the most crucial factors to resolve problems within both private and public sector. According to Umana-Hermosila *et al*. 2020, it was found that education creates new opportunities when faced with difficulties of unemployment generated by pandemics such as Covid-19 which was the main problem of their study. Consistent with the findings of Nohamba *et al*. (2022) of the Eastern Cape in South Africa, education proved to be the most crucial factor in terms of enhancement of human's conceptual skills and enable farmers to make informed decisions. By recognising the value of education within the citrus industry, the citrus farmers may achieve more, including the ability to improve their communication and trading skills, identifying potential export markets, increasing farm productivity and farm income, avoiding orange spoilage and export ban, sharpening their thinking skills, creating jobs for the rural communities, and reducing poverty and lastly, providing a good sense of discipline within the global society.

5.2.7.3 Transport modes used by citrus farmers to convey oranges to the export markets

The results of Table 5.1 revealed that the coefficient of transport modes used by the citrus farmers on the application of disease control mode of the Integrated Pest Management (IPM), was found to be statistically significant at 1% and negative (Sig. 0.007, Coef = -1.077), therefore, the null hypothesis is rejected. These study results indicated that transport modes used by the citrus farmers had a huge influence on the usage of the IPMs. As evidently seen from the study findings, most citrus farmers (45.1%) used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, followed by shipping containers at 9.3%, followed by normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, refrigerated, both normal trucks and aircrafts at 0.5% respectively. This implies that when the transport mode used by the citrus farmers rises, the usage of the modes of IPMs over the control of citrus diseases also decreases while other factors remain constant. This implies that when the use of the mode of transport increases, the usage of the mode of IPMs over the control of citrus diseases also decreases. The study conducted by Deguine *et al*. (2021) also attests to the idea of using IPMs for the control of citrus pests by adding that farmers need to be sufficiently involved in IPM development, from design up till in-field validation. Table 5.2 shows the estimation results of the multinomial logistic regression model on plant disease control mode (chemical (CH)) used in the previous citrus export season.

Table 5.2 Parameter estimates of the multinomial logistic regression model on Chemical control mode used in the previous citrus season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Chemical (CH)	-54.141	362.744	0.022	1	0.881		
Gender	-.840	28.952	0.001	1	0.977	0.432	9.811e-26
Age group	-.912	0.946	0.931	1	0.335	0.402	0.063
Marital status	-.532	152.110	0.000	1	0.997	0.587	1.961e-130
Level of education	-.542	1.115	0.236	1	0.627	0.582	0.065
Farm size	15.160	0.000	-	1	-	3835070.857	3835070.857
Farm age	2.760	21.508	0.016	1	0.898	15.793	7.770e-18
Outbound orange farming experience	0.076	71.133	0.000	1	0.999	1.079	3.050e-61
Transport mode used to convey oranges to the export market	-1.033	0.463	4.967	1	0.026	0.356	0.144

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.4 Transport modes used by citrus farmers to convey oranges to the export markets

The results of Table 5.2 showed that the coefficient of the transport mode used by the citrus farmers on the application of chemical was also statistically significant at 5% and negative (Sig. 0.026, Coef = -1.033), thus, the null hypothesis is rejected. This implies that when the usage of refrigerated trucks and shipping containers rises, the application of chemicals also decreases while the other factors remain constant. These results indicated that the transport modes used by the citrus farmers had a huge influence on the usage of chemicals. Table 5.3 reveals the estimation results of the multinomial logistic regression model on plant disease control mode (Biological (Bio)) used in the previous export season.

Table 5.3 Parameter estimates of the multinomial logistic regression model on plant Biological (Bio) control mode used in the previous citrus season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Biological (Bio)	11.664	545.745	0.000	1	0.983		
Gender	-.694	60.389	0.000	1	0.991	0.500	1.974e-52
Age group	-3.292	1.487	4.901	1	0.027	0.037	0.002
Marital status	-2.563	228.097	0.000	1	0.991	0.077	5.378e-196
Level of education	-2.283	1.311	3.032	1	0.082	0.102	0.008
Farm size	5.481	0.000	.	1	.	240.161	240.161
Farm age	5.121	32.202	0.025	1	0.874	167.449	6.503e-26
Outbound orange farming experience	0.917	106.697		1	0.993	2.502	3.784e-91
Transport mode used to convey oranges to the export market	-.502	0.688	0.531	1	0.466	0.605	0.157

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.5 Age of the citrus farmers

Table 5.3 results also revealed that the coefficient of the age of the citrus farmers on the application of biological control mode was also statistically significant 5% and negative (Sig. 0.027, Coef = -3.292), therefore, the null hypothesis is rejected. This implies that when the age of the citrus farmer increases, the usage of biological control mode also decreases. This shift may be caused by the knowledge and experience possessed by the elderly citrus farmers which enable them to apply this mode of biological control of citrus diseases at a minimum rate and less costs. Table 5.4 reveals the estimation results of the multinomial logistic regression model on plant disease control mode (Integrated Pest Management (IPM), and Chemical (CH)) used in the previous citrus export season.

Table 5.4 Parameter estimates of the multinomial logistic regression model on Integrated Pest Management and Chemical control modes used in the previous citrus season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Integrated Pest Management (IPM) and Chemical (CH)	30.773	313.866	0.010	1	0.922		
Gender	-4.561	14.888	0.094	1	0.759	0.010	2.222e-15
Age group	-1.592	0.726	4.808	1	0.028	0.203	0.049
Marital status	-1.002	132.315	0.000	1	0.994	0.367	8.680e-114
Level of education	-1.430	0.833	2.946	1	0.086	0.239	0.047
Farm size	9.339	0.000	.	1	-	11376.217	11376.217
Farm age	3.570	19.276	0.034	1	0.853	35.526	1.389e-15
Outbound orange farming experience	-3.634	61.604	0.003	1	0.953	0.026	9.658e-55
Transport mode used to convey oranges to the export market	-.864	0.417	4.304	1	0.038	0.421	0.186

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.6 Age of the citrus farmers

Table 5.4 results also revealed that the coefficient of the age of the citrus farmers on the application of both the IPM and chemical was also statistically significant at 5% and negative (Sig. 0.028, Coef = -1.592), thus, the null hypothesis is rejected. This implies that when the age of the citrus farmer increases, the usage of a combination of both the IPM and chemical also decreases. This difference may be triggered by the farming experience the elderly citrus farmers have, as opposed to that of the younger farmers in terms of farm management skills. The elderly farmers' age group is also largely prone to various health illnesses which therefore negatively affect their ability to work and monitor the farm efficiently and effectively.

5.2.7.7 Transport modes used by citrus farmers to convey oranges to the export markets

The results of Table 5.4 revealed that the coefficient of the transport modes used by the citrus farmers on the application of disease control mode of a combination of both the IPM and Chemical (CH), was statistically significant at 5% and negative (Sig. 0.038, Coef = -.864), thus, the null hypothesis is rejected. This outcome therefore indicates that when the use of modes of transport rises, the usage of the modes of a combination of both the IPM and Chemical (CH) over the control of citrus diseases also decreases. The DALRRD (2021) annual report also supports the idea of a combination of all the disease control methods for effective control of various citrus diseases. Not in support of the results of this study, the study results of Moyo *et al*. (2020) found that since it is a standard post-harvest treatment for fresh citrus fruit in South Africa, a combination of postharvest sanitation and fungicide treatments, including wax application and cold storage is also recommended to be effective for the control of citrus diseases during transportation of citrus to the export markets. Moreover, it has also been found that the new EU regulations require citrus, primarily oranges from Southern Africa to the European Union to undergo cold treatment at temperatures of between 0°C and -1°C for at least 25 days (Vutula and Mlangeni, 2022). Table 5.5 reveals the estimation results of the multinomial logistic regression model on plant disease control mode (Integrated Pest Management (IPM), Chemical (CH), and Biological (Bio)) used in the previous export season.

Table 5.5: Parameter estimates of the multinomial logistic regression model on IPM, CH and Bio control mode used in the previous export season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Integrated Pest Management (IPM), Chemical (CH) and Biological (Bio)	16.859	333.694	0.003	1	0.960		
Gender	-8.241	14.826	0.309	1	0.578	0.000	6.325e-17
Age group	-2.345	0.819	8.200	1	0.004	0.096	0.019
Marital status	-2.007	140.233	0.000	1	0.989	0.134	5.779e-121
Level of education	-.565	0.974	0.337	1	0.562	0.568	0.084
Farm size	4.023	0.000	-	1	-	55.851	55.851
Farm age	4.129	19.825	0.043	1	0.835	62.144	8.290e-16
Outbound orange farming experience	0.835	65.581	0.000	1	0.990	2.305	3.470e-56
Transport mode used to convey oranges to the export market	-.947	0.435	4.748	1	0.029	0.388	0.165

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.8 Age of the citrus farmers

Table 5.5 results discovered that the coefficient of the age of the citrus farmers on the application of a combination of the Integrated Pest Management (IPM), Chemical (CH) and Biological (Bio) was statistically significant at 1% and negative (Sig. 0.004, Coef = -2.345), therefore, the null hypothesis is rejected. The study findings also showed that the age brackets of farmers play a significant role in terms of choosing a proper phytosanitary control measure which is easy and cost-saving to use. In their research paper, Deguine *et al*. (2021) defines Integrated Pest Management (IPM) as a pest population management system that utilizes all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below those causing economic injury. By taking into consideration of what was said by respondents in the study area, the concept of ageing in South African citrus industry has a huge bearing on the usage of IPMs, chemical, cold treatment, fumigation, and biological cultural modes for the control of citrus diseases. Local citrus farmers' organization such as the Citrus Growers' Association of Southern Africa (CGA) also concurs with the results of this study and further recommends that the use of IPMs within the country's industry enables citrus farmers to trade successfully in the citrus export markets as it is more effective to render a crop free of pests (CGA, 2021). Notwithstanding the fact that the application of IPMs, chemicals, biological, fumigation and cold treatment modes in the study area do well in terms of rendering the crop secure and enabling farmers to trade successfully good-quality oranges with freedom from diseases such as Citrus Black Spot (CBS) and others in citrus export markets, the elderly citrus farmers still have to play an immense role of transferring their knowledge and skills over the application of International Standards on Phytosanitary Measures (ISPMs) to the younger generation of citrus farmers in order to sustain their orange export business and contribute very positively to the Agricultural gross domestic production (GDP) of this country.

5.2.7.9 Transport modes used by citrus farmers to convey oranges to the export markets

The results of Table 5.5 revealed that the coefficient of the transport modes used by the citrus farmers on the application of disease control mode of a combination of the Integrated Pest Management (IPM), Chemical (CH) and Biological (Bio) was statistically significant at 5% and negative (Sig. 0.029, Coef = -.947), therefore, the null hypothesis is rejected. These results showed that when the use of transport mode rises, the usage of the modes of a combination of the IPM, Chemical (CH) and Biological (Bio) over the control of citrus diseases also decreases. Table 5.6 shows the estimation results of the multinomial logistic regression model on plant disease control mode (Integrated Pest Management (IPM), Chemical (CH), Cold Treatment (CT), and Fumigation) used in the previous citrus season.

Table 5.6: Parameter estimates of the multinomial logistic regression model on IPM, CH, CT and Fumigation control mode used in the previous export season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Integrated Pest Management (IPM), Chemical (CH), Cold Treatment (CT) and Fumigation (Fum)	5.741	543.559	0.000	1	0.992		
Gender	-1.773	36.270	0.002	1	0.961	0.170	2.276e-32
Age group	-5.355	1.359	15.514	1	<,001	0.005	0.000
Level of education	.676	1.078	0.393	1	0.531	1.966	0.237
Farm size	3.740	0.000	-	1	-	42.078	42.078
Farm age	5.702	32.153	0.031	1	0.859	299.569	1.283e-25
Outbound orange farming experience	2.766	106.694	0.001	1	0.979	15.900	2.417e-90
Transport mode used to convey oranges to the export market	-.423	0.478	0.781	1	0.377	0.655	0.257

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.10 Age of the citrus farmers

Table 5.6 results discovered that the coefficient of the age of the citrus farmers on the application of a combination of the Integrated Pest Management (IPM), Chemical (CH), Cold Treatment (CT), and Fumigation (Fum) and Biological (Bio) was statistically significant at 1% and negative (Sig. 0.001, Coef = -5.355), therefore, the null hypothesis is rejected. The study findings by Deguine *et al*. (2021) and Singh *et al*. (2021) also support the findings of Table 5.6 regarding the age of farmers being a key determinant regarding the application of IPMs, Chemicals, Fumigation and Cold Treatment modes in the study area. Table 5.7 presents the estimation results of the multinomial logistic regression model on Chemical (CH), and Biological (Bio) control modes used in the previous citrus season.

Table 5.7: Parameter estimates of the multinomial logistic regression model on Chemical, and Biological control mode used in the previous export season

Variables	Estimate(B)	Std Error	Wald	df	Sig.	Exp (B)	95% Confidence Interval for Exp(B) Lower Bound
Chemical (CH) and Biological (Bio)	10.233	544.796	0.000	1	0.985		
Gender	-.346	51.539	0.000	1	0.995	0.707	9.548e-45
Age group	-1.516	1.145	1.752	1	0.186	0.220	0.023
Level of education	0.072	1.715	0.002	1	0.966	1.075	0.037
Farm size	4.281	0.000	-	1	-	72.332	72.332
Farm age	5.292	32.176	0.027	1	0.869	198.657	8.128e-26
Outbound orange farming experience	1.011	106.697	0.000	1	0.992	2.747	4.156e-91
Transport mode used to convey oranges to the export market	-1.671	0.711	5.527	1	0.019	0.188	0.047

Source: *Results from SPSS generated from field survey, 2021*
****, **, * represents significance level at 1%, 5% & 10%, respectively;* Base category: Number of observations: Pseudo-R^2=; Goodness-of-Fit, Pearson =0.000; LR =

5.2.7.11 Transport modes used by citrus farmers to convey oranges to the export markets.

The results of Table 5.7 revealed that the coefficient of the transport modes used by the citrus farmers on the application of disease control mode of a combination of the Chemical (CH) and Biological (Bio) was also statistically significant at 1% and negative (Sig. 0.019, Coef = -1.671), thus, the null hypothesis is rejected. This indicates that when the use of transport modes rises, the usage of the modes of a combination of the Chemical (CH) and Biological (Bio) over the control of citrus diseases also decreases. The idea of the use of the refrigerated trucks for conveyance of South African fruits to the export markets also enjoys the support of Deguine *et al*. (2021) whom in their study results recommended monitoring of temperature breaks as a key factor for successful trading of fruits in international markets. In their study results, Deguine *et al*. (2021) recommended to all partners across the entire export cold chain to work together in ensuring efficient and effective temperature control.

5.3 Summary of the chapter

This chapter provided an overview of the factors influencing successful trading of outbound oranges produced in the Limpopo province of South Africa. The selected study areas for this study included Groblersdal, Hoedspruit, Letsitele and Vhembe. The objective of this chapter was to analyse the determinants of modes of plant disease control in the study area. This chapter presented an overview of the results of the multinomial logistic regression model of the study. It further provided analysis of factors influencing the modes of disease control on the export bound orange farms in the study area using the multinomial logistic regression model. The results of the multinomial regression model indicated that factors such as age group, education, and transport modes were the main determinants of modes of disease control used by the citrus farmers.

CHAPTER SIX
FACTORS INFLUENCING ORANGE LOSSES DUE TO CULTURAL PRACTICES

6.1 Introduction

This chapter addresses the main factors influencing orange losses on the farms in respect of cultural practices using the Poisson regression model. The main objective of this chapter was to determine which of a set of specified independent variables has a significant relationship with the individual farmers' orange losses as measured by counts of oranges. The researcher employed the Poisson regression model for the analyses of objective 3 of this study. When a Poisson regression model is applied, a dependent variable consisting of counts is modeled with a Poisson distribution. The Poisson regression is a scientific and appropriate model concerned with the analyses of factors which influence the level of losses of orange outputs in respect of cultural practices on the farms. Count dependent variables, which can take on only nonnegative integer values, appear in many social science contexts.

6.2 Analysis of the main factors influencing orange losses on the citrus farms in respect of plant pests using the Poisson regression model

This section seeks to provide an overview of the main factors influencing orange losses on the citrus farms in respect of plant pests using poisson regression model. Through analysis of these factors, the study attempts to obtain an insight of the main factors causing orange losses and recommend to citrus farmers in the study area effective plant pest control measures. Table 6.1 shows the estimation results of factors influencing orange losses on the citrus farms in respect of plant pests using the Poisson regression model.

Table 6.1: Estimation results of factors influencing orange losses on the citrus farms in respect of plant pests using the Poisson regression model (n=215)

Losses due to plant pests	Coefficient	P>|z|	95% Conf. Interval	
Transport mode used to convey oranges				
Aircrafts	1.396637	0.008	.3630567	2.430218
Normal trucks	1.043401	0.001	.6126088	1.474194
Shipping containers, Normal trucks	1.039973	0.002	.3724175	1.707529

Poisson regression	Number of observations =	215
	LR chi2(19) =	54.44
	Prob > chi2 =	0.0000
Log likelihood = -244.46029	Pseudo R2 =	0.1002

Source: Results from SPSS generated from field survey, 2021***, **, * represents significance level at 1%, 5% & 10%, respectively

6.2.1 Factors influencing orange losses due to plant pests using the Poisson regression model

6.2.1.1 Transport mode used to convey oranges to the export market

The results in Table 6.1 revealed that the coefficient of the transport modes used by citrus farmers on orange losses on the farms in respect of plant pests were statistically significant at 1% and positive (aircrafts Sig. 0.008, Coef = 1.396637; normal trucks Sig. 0.001, Coef = 1.043401; and a combination of shipping containers and normal trucks Sig 0.002, Coef = 1.039973 respectively), therefore, the null hypothesis is rejected. In accordance with Table 6.1 study results, the transport modes used by the citrus farmers had a huge influence on orange losses incurred by citrus farms in the study area. As observed from the study findings, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively. According to the study results in Table 6.1, the use of aircrafts, normal trucks and a combination of both shipping containers and normal trucks were less effective for the control of plant pests in the study area. The study results further showed that when the usage of aircrafts, normal trucks, and a combination of both the shipping containers and normal trucks rises, losses due to plant pests also increase. This implies that to avoid citrus losses in respect of plant pests, citrus farmers in the study area must reduce the usage of aircraft, normal trucks and a combination of both shipping containers and normal trucks to transport their produce to citrus export markets. In support of these study results, Kilalo *et al*. (2021) in their study conducted in Kenya proved that citrus insect pests are the major causes of citrus decline. The study results were further supported by Jose *et al*. (2022), in their research conducted in Brazil who discovered that insect pests caused high losses in citrus orchards and recommended the use of biological control methods to control the plant pests in the study area.

6.3 Analysis of factors influencing orange losses on the citrus farms in respect of diseases using the Poisson regression model

This section provides an outline of the main factors influencing orange losses on the citrus farms in respect of diseases using poisson regression model. Through analysis of these factors, the study seeks to determine the main problem causing orange losses and recommend to the citrus industry in the study area effective disease control measures. Table 6.2 indicates the estimation results of factors influencing orange losses.

Table 6.2: Estimation results of factors influencing orange losses on the citrus farms in respect of plant diseases using the Poisson regression model (n=215)

Losses due to diseases	Coefficient	P>|z|	95% Conf. Interval	
Age group				
41-50 years	-1.276512	0.026	-2.402176	-.1508473
Transport mode used to convey oranges				
Shipping containers	1.002681	0.019	.1637716	1.841591
Normal trucks	1.686673	0.000	.9908678	2.382478

Poisson regression Number of observations = 215
LR chi2(19) = 61.57
Prob > chi2 = 0.0000
Log likelihood = -169.43347 Pseudo R2 = 0.1538

Source: Results from SPSS generated from field survey, 2021

6.3.1 Factors influencing orange losses on the farms in respect of diseases using the Poisson regression model

6.3.1.1 Age of the citrus farmers

According to the results in Table 6.2, the coefficient of the age of the citrus farmers on orange losses in respect of plant diseases was statistically significant at 5% and negative (41 - 50 years; Sig.0.026, Coef = -1.276512), therefore, the null hypothesis is rejected. These results indicated that an increase in 41 – 50 years age group of the respondents had a huge influence on orange losses incurred in respect of plant diseases in the study area. The suggestion given thereof is that when age of a citrus farmer increases, the citrus farmer's energy to control plant diseases also decreases. As evidently seen from the findings of this study, most citrus farmers (41.4%) fell within the age group of between 41 and 50, followed by 31 to 40 years at 28.8%, above 50 years at 27% and 20 to 30 years at 2.8% respectively. Based on the outcome of Table 6.2, it is evident that the elderly citrus farmers lack proper energy to spend more time in the orchards implementing the required phytosanitary control measures due to aging aspects. The relationship between 41 – 50 years age group and the losses of oranges in respect of cultural practices such as plant diseases was also identified to be of a risk of greatest concern in a study conducted by Joseph *et al*. (2021) where the majority (63.9%) of the citrus farmers aged between 36 and 55 years proved to be the most dominant age group in citrus farming in the Limpopo province.

6.3.1.2 Transport mode used to convey oranges to the export markets

In terms of Table 6.2 results, the coefficient of the transport modes used by citrus farmers on orange losses on the farms in respect of diseases were statistically significant at 1% and positive (shipping containers Sig. 0.019, Coef = 1.002681 and normal trucks Sig. 0.000, Coef = 1.686673 respectively), thus, the null hypothesis is rejected. These results showed that the transport modes used by citrus farmers had a huge influence on the orange losses on the farms in respect of diseases. As observed from the study outcomes, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and a combination of both refrigerated and normal trucks at 0.5% respectively. According to the respondents, the use of both shipping containers and normal trucks were less effective for the control of citrus diseases in the study area. The results in Table 6.2 means that when the usage of shipping containers and normal trucks increases, the quantity of citrus losses in respect of plant diseases also rise. Consistent with the study conducted by Gebreslasie and Meresa (2018), their results disclosed a positive relationship between the transport modes and the failure of citrus farmers in the study area. In their study, the laboratory results discovered that bacteria and fungi caused most of the diseases of citrus occurred in the study area. The outcome of this study was further supported by Poudel *et al*. (2022) in their study conducted in Nepal who discovered that citrus diseases were counted among factors which caused major decline in citrus orchards.

6.4 Analysis of factors influencing orange losses on the citrus in respect of harvest using the Poisson regression model

This section provides an outline of the main factors influencing orange losses on the citrus farms in respect of harvest using poisson regression model. Through analysis of these factors, the study seeks to determine the main problem causing orange losses and recommend to citrus farmers in the study area effective harvest modes. Table 6.3 illustrates the estimation results of factors influencing orange losses on the citrus farms in respect of harvest using the Poisson regression model.

Table 6.3: Estimation results of factors influencing orange losses on the citrus farms in respect of harvest using the Poisson regression model (n=215)

Losses due to diseases		Coefficient	P>│z│	95% Conf. Interval	
Transport mode used to convey oranges	Shipping containers	2.396234	0.001	1.0449	3.747568
	Normal trucks	3.175507	0.000	1.914865	4.436148
	Shipping Containers, Normal trucks	3.837727	0.000	2.422822	5.252632

Poisson regression — Number of observations = 215
LR chi2(19) = 135.59
Prob > chi2 = 0.0000
Log likelihood = -244.46029 — Pseudo R2 = 0.4520

Source: Results from SPSS generated from field survey, 2021

6.4.1 Factors influencing orange losses on the farms in respect of harvest using the Poisson regression model

6.4.1.1 Transport mode used to convey oranges to the export markets

Table 6.3 results revealed that the coefficient of the transport modes used by citrus farmers on orange losses on the farms in respect of harvest were statistically significant at 1% and positive (shipping containers Sig. 0.001, Coef = 2.396234; normal trucks Sig. 0.000, Coef = 3.175507; and shipping containers and normal trucks Sig. 0.000, Coef = 3.837727 respectively), therefore, the null hypothesis is rejected. These results indicated that the transport modes used by citrus farmers had a huge influence on the the previous season's exported orange cartons. As observed from the study discoveries, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, a combination of both shipping containers and normal trucks at 1.9%, aircrafts and a combination of both refrigerated and normal trucks at 0.5% respectively. According to the citrus farmers in the study area, the use of shipping containers, normal trucks and a combination of shipping containers and normal trucks were less effective to avoid damages caused by poor harvesting methods in the study area. These results imply that when the usage of shipping containers, normal trucks and a combination of shipping containers and normal trucks increase, the orange losses in respect of harvest also rises. In support of this study results, Hanif, and Ashari (2021) conducted research in Indonesia on post-harvest losses of citrus fruits and perceptions of farmers in marketing decisions and discovered that high percentage of citrus losses in citrus orchards is mainly caused by improper handling procedures in the field and incorrect harvesting before reaching correct maturity. Hanif and Ashari (2021) further recommended harvesting with pruning shears and plastic fruit baskets to reduce fruit damage. In line with the study conducted by Nohamba *et al*. (2022), a recommendation given was that tailored capacity-building on good agricultural practices in citrus production can be a solution to reduce post-harvest losses in citrus orchards.

6.5 Analysis of factors influencing orange losses on the citrus in respect of packaging using the Poisson regression model

This section focuses its attention on the main factors influencing orange losses on the citrus farms in respect of packaging using poisson regression model. Through analysis of these factors, this research seeks to determine the main factors causing orange losses and recommend to citrus industry in the study area effective packaging modes. Table 6.4 shows the estimation results of factors influencing orange losses on the citrus farms in respect of packaging using the Poisson regression model.

Table 6.4: Estimation results of factors influencing orange losses on the citrus farms in respect of packaging using the Poisson regression model (n=215)

Losses due to packaging	Coefficient	P>|z|	95% Conf. Interval	
Farm age				
11-20 years	2.880350	0.022	0.4114104	5.349289
Above 20 years	-	-	-	-
Type of labour used on the farm				
Hired labour	17.31079	0.000	15.07135	19.55023
Hired labour, Mainly family labour	16.75515	-	-	-
Hired labour, Permanent	19.23295	0.000	16.9891	21.4768
Hired labour, Temporary employees	-61.12702	-	-	-
Transport mode used to convey oranges				
Aircrafts	80.00438	-	-	-
Shipping containers	2.547873	0.003	0.8546645	4.241081
Normal trucks	3.19141	0.000	1.6714.74	4.711345
Refrigerated trucks, Shipping containers	0.0141819	0.000	-1797075	1.825439
Refrigerated, Normal trucks	-78.42363	-	-	-
Shipping containers, Normal trucks	3.916218	0.000	2.172438	5.659998

Poisson regression Number of observations = 215
LR chi2(13) = 107.13
Prob > chi2 = 0.0000
Log likelihood = -244.46029 Pseudo R2 = 0.4600

Source: Results from SPSS generated from field survey, 2021

6.5.1 Factors influencing orange losses on the farms in respect of packaging using the Poisson regression model

6.5.1.1 Farm age

The study findings in Table 6.4 revealed that the coefficient of the 11 – 20 years age of the citrus farms on orange losses on the farms in respect of packaging modes was statistically significant and positive at 1% (11- 20 years Sig. 0.022, Coef = 2.88035), therefore, the null hypothesis is rejected. The results of this study showed that the age of citrus farms had a huge influence on orange losses on the farms in respect of packaging modes in the study area. As evidently observed from the revelations of this study, majority (98.6%) of the citrus farms in the study area were aged above 20 years old, followed by those falling within the age brackets of between 1 and 10 years old at 0.9% and between 11 and 20 years at 0.5% respectively. According to this study results there was a correlation between the coefficient of the citrus farm of 11 – 20 years age and packaging modes used by respondents in the study area. This implies that when the age of citrus farms increase, the quantity of orange yield losses also increases. It can therefore be concluded that the factor of aging of the citrus farm plays a crucial role in determining the orange yield losses because of packaging modes in the citrus orchards. In other words, if packaging modes of respective citrus farms in the study area could be more effective, citrus farms might have not experienced high orange yield losses. The results of this study conformed to the study outcome by Wangithi (2019) in Kenya, which discovered that the age of the farm, farm size, insect pests, diseases and many other factors influenced the citrus yield losses. The results of Wangithi (2019) showed that the aged citrus farms produce relatively low yield and require intensive management and hard work to reduce the citrus yield losses.

6.5.1.2 Type of labour used on the farms

The results in Table 6.4 showed that the coefficient of the type of labour used by the farmers on orange losses on the farms in respect of packaging modes were statistically significant at 1% and positive (hired labour Sig. 0.000, Coef = 17.31079) and (hired labour and permanent Sig. 0.000, Coef = 19.23295), thus, the null hypothesis is rejected. In respect of the outcome in Table 6.4, the type of labour used by the citrus farms had a huge influence on orange losses on the farms in respect of packaging modes in the study area. As clearly seen from the study results, majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. These study results mean that the hired labour and a combination of hired labour and permanent labour had a huge influence on the quantity of orange losses incurred on the farms in respect of packaging modes. This also means that when the usage of hired labour and a combination of hired labour and permanent labour increases, the orange losses in respect of packaging modes also rise. This may be due to mechanical damages which create entry points for decaying or destructive micro-organisms causing fruit deterioration during subsequent handling stages. In support of the results of this study, Majubwa *et al*. (2022), in their study conducted in Tanzania discovered that incorrect fruit handling after harvest might negatively impact on the quantity and quality of the fruit resulting in different types of blemishes on the fruit peels. Strano *et al*. (2022), and Yun and Liu (2020) also subscribed to the outcome of this study that poor packaging modes cause immense orange losses and recommended that post-harvest physiological disorders can generally be reduced by avoiding harvesting fruit in wet conditions e.g., after rains, cooling citrus fruit immediately after harvest and storing it at appropriate temperatures and high relative humidity.

6.5.1.3 Transport mode used to convey oranges to the export markets

According to Table 6.4 study results, the coefficient of the modes of transport used by the farmers on orange losses on the farms in respect of packaging modes were statistically significant at 1% and positive (aircrafts Sig. 0.003, Coef = 2.547873; normal trucks Sig.0.000, Coef = 3.19141; and shipping containers and normal trucks Sig.0.000, Coef = 3.916218 respectively), therefore, the null hypothesis is rejected. These study results indicated that the transport modes used by citrus farmers in the study area had a huge influence on orange losses on the farms in respect of packaging modes. As observed from Table 4.3, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively. Consistent with the citrus farmers in the study area, the use of aircrafts, normal trucks, a combination of both shipping containers and normal trucks and a combination of both refrigerated trucks and shipping containers were less effective to avoid the orange losses in the study area. These study results imply that when the usage of aircrafts, normal trucks, a combination of both shipping containers and normal trucks and a combination of both refrigerated trucks and shipping containers increase, the losses of oranges in respect of packaging modes also rise. The results of this study are supported by Rajapaksha *et al*. (2021) who conducted their study in Sri Lanka and found that post-harvest operations such as improper packaging at various stages of the process and improper transportation are some of the major reasons for high post-harvest orange losses. Table 6.4 shows a summary of factors influencing orange losses on the citrus farms in respect of packaging using the Poisson regression model.

6.6 Analysis of factors influencing orange losses on the citrus in respect of storage using the Poisson regression model

This section directs its attention to the main factors influencing orange losses on the citrus farms in respect of storage using poisson regression model. Through analysis of these factors, this research attempts to determine the main factors causing orange losses and recommend to citrus industry in the study area effective storage modes. Table 6.5 shows the estimation results of factors influencing orange losses on the citrus farms in respect of storage using the Poisson regression model.

Table 6.5: Estimation results of factors influencing orange losses on the citrus farms in respect of storage using the Poisson regression model (n=215)

Losses due to storage	Coefficient	P>│z│	95% Conf. Interval	
Type of labour used on the farm				
Hired labour	16.43432	0.000	14.33575	18.5329
Hired labour, Permanent	17.15664	0.000	13.75439	20.55888
Transport mode used to convey oranges				
Normal trucks	2.98619	0.000	1.625927	4.346454
Shipping containers, Normal trucks	3.936717	0.000	2.333999	5.539436

Poisson regression Number of observations = 215
LR chi2(19) = 103.44
Prob > chi2 = 0.0000
Log likelihood = -244.46029 Pseudo R2 = 0.5191

Source: Results from SPSS generated from field survey, 2021

6.6.1 Factors influencing orange losses on the farms in respect of storage using the Poisson regression model

6.6.1.1 Type of labour used on the farms

In line with the study results in Table 6.5, the coefficient of the type of labour used by the farmers on orange losses on the farms in respect of storage modes were statistically significant at 1% and positive (Sig.0.000, Coef = 16.43462) and (hired labour and permanent Sig.0.000, Coef = 17.15664), therefore, the null hypothesis is rejected. In accordance with the study results in Table 6.5, the type of labour used by the citrus farms had a huge influence on orange losses on the farms in respect of storage modes in the study area. As clearly seen from the revelations of this study, majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. These study results mean that the hired labour and a combination of hired labour and permanent labour had a huge influence on the quantity of orange losses incurred on the farms in respect of storage modes. This also means that when the usage of hired labour and a combination of hired labour and permanent labour increases, the orange losses in respect of storage modes also rise. These orange losses may be triggered by post-harvest operations such as exposure of oranges to high temperature just after harvesting which eventually leads to initiation of rapid fruit deterioration. These study results also enjoyed the support of Rajapaksha *et al*. (2021) who conducted their study in Sri Lanka and found that improper storage of oranges have a potential to cause common post-harvest diseases such as green mold, blue mold, and sour rot. The study outcome of Rajapaksha *et al*. (2021) further recommended that to reduce post-harvest losses of oranges, it is important to provide temperature and humidity-controlled storage systems which control the rate of deterioration of oranges.

6.6.1.2 Transport mode used to convey oranges to the export markets

The study results in Table 6.5 revealed that the coefficient of the modes of transport used by the farmers on orange losses on the farms in respect of storage modes were statistically significant at 1% and positive (normal trucks Sig.0.000, Coef = 2.98619; and shipping containers and normal trucks Sig.0.000, Coef = 3.936717), thus, the null hypothesis is rejected. These study results indicated that the transport modes used by citrus farmers in the study area had a huge influence on orange losses on the farms in respect of storage modes. As observed from the findings of this study, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively. Consistent with the citrus farmers in the study area, the use of normal trucks and a combination of shipping containers and normal trucks were less effective to avoid the orange losses in the study area. These study results suggest that when the usage of normal trucks and a combination of shipping containers and normal trucks increase, the losses of oranges in respect of storage modes also rise. In support of these study results, Bhatta (2022), conducted a study in the United States of America and discovered that fruit wounds and molds were the most common problems during storage period. Bhatta (2022) also stressed that green mould and blue mould were counted among the most economically impactful post-harvest diseases of citrus fruit world-wide and recommended that these post-harvest diseases can largely be controlled with synthetic fungicides such as pyrimethanil, imazalil, fludioxonil and thiabendazole.

6.7 Analysis of factors influencing orange losses on the citrus in respect of transportation using the Poisson regression model

This section provides an overview of the main factors influencing orange losses on the citrus farms in respect of transportation using poisson regression model. Through analysis of these factors, this research seeks to discover the main factors causing orange losses and recommend to citrus industry in the study area effective transportation modes. Table 6.6 shows the estimation results of factors influencing orange losses on the citrus farms in respect of transportation using the Poisson regression model.

Table 6.6: Estimation results of factors influencing orange losses on the citrus farms in respect of transportation using the Poisson regression model (n=215)

Losses due to storage	Coefficient	P>│z│	95% Conf. Interval	
Age group				
31 – 40 years	-3.516037	0.002	-5.690372	-1.341701
41 – 50 years	-4.176569	0.005	-7.059086	-1.294053
Above 50 years	-3.953512	0.000	-6.044799	-1.862226
Type of labour used on the farm				
Hired labour	24.46264	0.000	21.90131	27.02398
Hired labour, Mainly family labour	-109.2047	-	-	-

Poisson regression	Number of observations =	215
	LR chi2(19) =	83.77
	Prob > chi2 =	0.0000
Log likelihood = -244.46029	Pseudo R2 =	0.5508

Source: Results from SPSS generated from field survey, 2021

6.7.1 Factors influencing orange losses on the farms in respect of transportation using the Poisson regression model

6.7.1.1 Age group of the citrus farmers

The study results in Table 6.6 revealed that the coefficient of the age group of the citrus farmers on orange losses on the farms in respect of transportation modes were statistically significant at 1% and negative (31-40 years Sig.0.002, Coef = -3.516037), (41-50 years Sig.0.005, Coef = -4.176569) and (above 50 years Sig.0.000, Coef = -3.953512 respectively), thus, the null hypothesis is rejected. These results indicate that the age group of the citrus farmers had a huge influence on orange losses on the farms in respect of transportation modes. As evidently observed from the study results, majority (41.4%) of the citrus farms fell within the age group of between 41 and 50 years, followed by those falling within the age group of between 31 and 40 at 28.8% and those falling within the age category of above 50 years at 27% respectively. In relation to these study results, there is a strong correlation between the proportion of orange losses on the farms in respect of transportation modes used by the farmers and the age group of the citrus farmers in the study area. These study results suggest that when the age group of the citrus farmers rise, the losses of oranges in respect of transportation modes decrease. This implies that the respondents can use their experience to avoid orange losses and apply less fungicides to control diseases during transportation period. According to respondents, common problems which occur during transportation period are physical loss due to injuries and diseases and quality losses due to metabolic and compositional changes in the fruit. The results of this study are supported by Marco (2021), who conducted a study on orange storage and transport and discovered that orange losses mostly occur due to poor storage and transportation methods. According to Marco (2021), oranges require rapid cooling to improve fruit quality, reduce respiration, slow pathogen growth, reduce water loss and increase shelf life.

6.7.1.2 Type of labour used on the farms

In relation to the study results in Table 6.6, the coefficient of the type of labour used by the respondents on orange losses on the farms in respect of transportation modes was statistically significant at 1% and positive (hired labour Sig.0.000, Coef = 24.46264), thus, the null hypothesis is rejected. According to the results of this study, the type of labour used by the citrus farms had a huge influence on orange losses on the farms in respect of transportation modes in the study area. As it can be observed from the findings of the study, majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. These study results mean that the hired labour had a huge influence on the quantity of orange losses incurred on the farms in respect of packaging modes. This also means that when the usage of hired labour increases, the orange losses in respect of transportation modes also rise. The justification from the respondents regarding these outcomes were that the usage of hired labour often becomes effective whenever there is effective monitoring of post-harvest operations such packaging and storage methods of oranges in both reefer containers and refrigerated trucks during transportation period. In support of the results of this study, Khamsaw *et al*. (2022), conducted their study in Switzerland and found that poor post-harvest management is the primary cause of post-harvest losses of oranges such as fruit weight loss, fruit quality loss, fruit nutritional loss and commercial loss.

6.8 Summary of the chapter

This chapter addressed the main factors influencing orange losses from the farms in respect of cultural practices using the Poisson regression model. The main objective of this chapter was to determine which of a set of specified independent variables had a significant relationship with the individual farmers' orange losses as measured by counts of oranges. The research employed the Poisson regression model for the analyses of objective 3 of this study. When a Poisson regression model was applied, a dependent variable consisting of counts was modeled with a Poisson distribution. The Poisson

Regression Model results indicated that factors such as storage mode, transport mode, farm age and the type of labour used by the respondents were the key determinants of orange losses in respect of cultural practices. The afore-mentioned factors proved to be statistically significant with the null hypothesis being rejected. Based on the outcome of this chapter, it is therefore concluded that a relationship exists between both the independent variables and the dependent variables.

CHAPTER SEVEN
THE MAIN FACTORS INFLUENCING SUCCESSFULLY TRADED OUTBOUND ORANGES

7.1 Introduction

This chapter addresses the main factors influencing successfully traded outbound oranges from export-bound orange farms in the study area. The selected study areas for this study include Groblersdal, Hoedspruit, Letsitele and Vhembe. This chapter presents the results and discussions of the Tobit Regression Model of the study.

7.2 Analysis of factors influencing successfully traded oranges from export orange farms in the study area using the Tobit regression model

Firstly, the Tobit Regression Model was the scientific method used to analyze the main factors influencing successful traded outbound oranges from export bound orange farms in the study area. In this model, the nature of the dependent variable determines the econometric model used. The Tobit model is considered appropriate in this study, since the dependent variable Y^* is in the form of proportion or percentage (proportion of oranges not rejected or not excluded or not lost because of damages by plant pest, plant disease, packaging used, and type of harvesting of oranges among the export bound orange farms in the study area). Thus, the proportion of oranges of the season's harvest not damaged which were exported was the dependent variable, lower censored at zero and upper censored at 1. Farmers who do not have damaged oranges because of the aforementioned factors were at a 1 value of dependent variable. Tobit model is the most common censored regression model appropriate for analysing dependent variables with upper or lower limits (Tobin, 1958).

Generally, the Tobit model uses Maximum Likelihood Estimation (MLE) method to estimate the parameters, assuming normality and homoscedasticity conditions. The Tobit model, introduced by the Nobel laureate economist, James Tobin in 1958, is used when the dependent variable in a regression model equation has a lower and upper limit. Table

7.1 shows factors influencing successfully traded outbound oranges using the Tobit Regression Model.

Table 7.1: Factors influencing successfully traded outbound oranges using Tobit Regression Model (n=215)

Variables	Coefficient	P>|z|	95% Conf. Interval	
Age group				
31 – 40 years	1.761222	0.000	.9060296	2.616414
41 – 50 years	1.843514	0.000	.9907534	2.696274
Above 50 years	1.619909	0.000	.758366	2.481451
Farm ownership status				
Community & Government	-1.423961	0.011	-2.51547	-.3324529
Type of labour used on the farm				
Hired labour	1.941487	0.008	.5006513	3.382323
Hired labour, Mainly family labour	2.558537	0.001	.9796551	4.137419
Hired labour, permanent	2.042184	0.008	.5431521	3.541216
Transport mode used to convey oranges				
Normal trucks	-.9401603	0.000	-1.377982	-1.5023385

Tobit regression Number of observations = 215
Uncensored = 215
Limits: Lower = -inf Left-censored = 0
Upper = +inf Right censored = 0
Wald chi2(19) = 85.17
Log likelihood = -236.06961 Prob>chi2 = 0.0000

Source: Results from SPSS generated from field survey, 2021

7.2.1 Factors influencing successfully traded oranges from export orange farms in the study area using the Tobit regression model

7.2.1.1 Age group of the citrus farmers

The results in Table 7.1 revealed that the coefficient of the age group of the citrus farmers on the proportion of the exported oranges among citrus farms in the study area was statistically significant at 1% and positive (Sig.0.000, Coef = 1.761222), (Sig.0.000, Coef = 1.843514), (Sig.0.000, Coef = 1.619909), therefore, the null hypothesis is rejected. These results designate that the age groups of the citrus farmers had a huge positive influence on the the previous season's exported oranges. As evidently observed from the study findings, majority (41.4%) of the citrus farms fell within the age group of between 41 and 50 years, followed by those falling within the age group of between 31 and 40 at 28.8% and those falling within the age category of above 50 years at 27% respectively. These outcomes show that there is a strong correlation between the proportion of exported oranges and the age group of the citrus farmers in the study area. According to the results of the study, citrus farmers falling within the age group of between 41 and 50 years are mostly adults and considered to have sufficient knowledge and skill regarding the mostly required export oranges which are in high demand in the export markets. In support of these study findings, Brown *et al*. (2018) has in their study discovered that older farmers aged between 40 and 49 years take part in farming activities because of family tradition and are likely to adopt new technologies or to change or intensify land uses whereas, young farmers are less risk averse, more influenced by social norms and less focused on finances. In the same study, it was further found that higher age group is positively correlated with farmer's success as it potentially influences farming objectives, decisions, and future intentions.

7.2.1.2 Farm ownership status

Table 7.1 results reveal that the coefficient of the government/community farm ownership status on the proportion of exported oranges among citrus farms in the study area was statistically significant at 1% and negative (Sig.0.011 Coef = -1.423961), thus, the null hypothesis is rejected. These results indicate that the government/community ownership status of the citrus farms had a negative influence on the the previous season's exported orange cartons. As evidently seen from the study results, the majority (97.7%) of the respondents were under private ownership, followed by government at 1.9% and the community at 0.5% respectively. These effects mean that when ownership of the citrus farms remain in the hands of private individual farmers, the number of export orange cartons increases than when the ownership of the citrus farms lies in the hands of both the government and the community. The findings of this study are supported by similar observations in the Eastern Cape where the study results showed that where land was under the ownership of private farmers, it improved lives and provided good commercial benefits than when land ownership was in the hands of both government and/or the community (Rusenga, 2022).

7.2.1.3 Type of labour used on the farms

The results of Table 7.1 show that the coefficient of the type of labour used on the proportion of exported oranges among citrus farms in the study area was statistically significant at 1% and positive (Sig.0.000, Coef = 1.941487); (Sig.0.001, Coef = 2.558537) and (Sig.0.008, Coef = 2.042184), thus, the null hypothesis is rejected. Table 6.1 results indicate that the type of labour used by the citrus farms had a huge influence on the the previous season's exported orange cartons. As clearly seen from the study revelations, the majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. The results of this study imply that citrus farmers who use hired labour in the farms do better than those using both family and permanent or hired and permanent labour respectively. This also means that labour used on the farm had more influence on the proportion of oranges exported during export season. According to Devereux *et al*. (2019), hired, seasonal or contractual labour has a positive impact on the success of farmers within the agricultural sector. The authors further recommend that innovative arrangements must be found to ensure that seasonal farm workers have income and food security throughout the year as they play an immense role in the success of many farms within the farming industry.

7.2.1.4 Transport mode used to convey oranges to the export markets

Table 7.1 results revealed that the coefficient of the normal truck transport mode used by citrus farmers on the proportion of exported oranges in the study area was statistically significant at 1% and negative (Sig.0.000, Coef = -.9401603), thus, the null hypothesis is rejected. These results indicated that the normal truck transport mode used by citrus farmers had a negative influence on the the previous season's exported orange cartons. As observed from the findings of this study, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively. According to the citrus farmers in the study area, the use of both refrigerated trucks and shipping containers is the most effective than other modes of transport in the study area. In support of this study results, Sheng *et al*. (2018) in their study conducted in Australia reported that the growth of agriculture and related industries begins and ends with the efficiency in the transport sectors. Consistent with the study conducted by Sheng *et al*. (2018), their results showed a clear relationship between the transport mode and the success of farmers in the study area. The table below shows factors that influenced the successfully traded outbound oranges in the study area.

7.3 Summary of the chapter

This chapter addressed the main factors influencing successfully traded outbound oranges from export-bound orange farms in the study area. The selected study areas for this study included Groblersdal, Hoedspruit, Letsitele and Vhembe. The results of the Tobit regression model showed that factors such as age group, farm ownership, type of labour and transport mode were the main determinants of successfully traded export oranges produced from citrus farms in the study area. It is therefore concluded that the afore-mentioned factors proved to be statistically significant as the null hypothesis also got rejected. Overall findings of the chapter shows that there is a relationship between both the dependent and independent variables.

CHAPTER EIGHT
FRAMEWORK FOR SUCCESSFULLY TRADED OUTBOUND ORANGES

8.1 Introduction

This chapter develops a framework for successfully traded outbound oranges from orange farms in the Limpopo province. The framework may serve as a guide for export bound orange producers in the Limpopo province and provide basis for informed policy decisions by government and relevant stakeholders. This section further identified the types of plant pests and disease challenges confronted by citrus farmers in the study area over the past five years. The study provided an overview of the results and discussions of a developed framework for successfully traded outbound oranges from orange farms in the Limpopo province.

8.2 Identification of the challenges confronted by citrus farmers in the study area

In an effort to collect more data for development of an effective framework for successful trading of export oranges in the study area, citrus farmers in the study area were requested through one-on-one interviews to raise challenges encountered in their previous five years. The challenges outlined by the citrus farmers in the study area are therefore presented below in the Tables 8.1 and 8.2 respectively.

8.2.1 Challenges caused by the citrus diseases in the study area

The results of this study showed that citrus diseases such as Citrus Black Spot, Alternaria fruit rot, Scab, Melanose on fruit and Botrytis on fruit were the top five (5) types of diseases experienced on the Limpopo citrus farms over the past five (5) years citrus export seasons. According to the descriptive statistics results of this study, key variables such as the age group, level of education and transport modes had significant influence on the disease control modes used by the citrus farmers in the study area. As seen from this study data, most citrus farmers (41.4%) fell within the age group of between 41 and 50. The elderly farmers' age group was also largely prone to various health illnesses which therefore negatively affect their ability to work and monitor the farm efficiently and effectively. By taking into consideration of what was said by respondents in the study area, the concept of ageing in South African citrus industry has an enormous bearing on the usage of IPMs, chemical, cold treatment, fumigation, and biological cultural modes for the control of the citrus diseases. Local citrus farmers' organization such as the Citrus Growers' Association of Southern Africa (CGA) also concurs with the results of this study that indeed the above-mentioned diseases are problematic to the study area. The CGA (2021) annual report further identified amongst others, a disease such as CBS as one of the major citrus phytosanitary constraints in the study area. An example of the CBS symptoms on export orange are shown in Figure 8.1.

Figure 8.1 Citrus Black Spot (CBS) symptoms on export orange
Source: Picture taken by the researcher in the study area, 2020

To circumvent the citrus phytosanitary constraints, the CGA (2021) annual report recommends the use of IPMs within the country's citrus industry to enable citrus farmers to trade successfully in the citrus export markets as this control measure is considered more effective for rendering a citrus crop free of diseases (CGA, 2021). In accordance with the study findings, the majority (71.2%) of the citrus farmers also recommended the usage of the Integrated Pest Management (IPM) for effective control of the citrus diseases occurring in the Limpopo province. Based on the outcome of this study, the IPM together with the biological control mode, a combination of IPM and chemical, the IPM, chemical and biological control mode were therefore considered to be effective for the control of the citrus diseases in the Limpopo province. In accordance with the findings of this study, it is true that the demographic and socio-economic characteristics of farmers/farms and cultural practices have a significant influence on the successful traded outbound oranges from farms in the Limpopo province. Additionally, it is also true that the demographic and socio-economic characteristics of farmers/farms are the main determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the province. Table 8.1 shows the top five citrus diseases observed in the study area during the past five years.

Table 8.1: Top five citrus diseases detected in the study area over the past five years (n = 215)

Variables (X)	Variables (Y)	Frequency	Percentage
Top five diseases experienced over the past five (5) years	Alternaria fruit rot, Scab	84	39.1
	Citrus Black Spot	9	4.2
	Alternaria fruit rot and Melanose on fruit	6	2.8
	Botrytis on fruit, wind damage and rind pitting	4	1.9
Total		103	48.0

Source: Results from SPSS generated from field survey, 2021

8.2.2 Challenges caused by the citrus pests in the study area

The findings of the descriptive statistics in this studyindicated that citrus pests such as false codling moth, ants, fruit-fly, loppers, and mealy bug were the top five (5) types of pests experienced on the Limpopo citrus farms over the past five (5) years. The research results also identified pest such as Oriental fruit fly or *Bactrocera dorsalis* as one of the major destructive pests which is currently under effective control in the study area. According to DALRRD (2021) annual report, the above-mentioned citrus pests are considered as quarantine pests requiring implementation of effective orchard/field sanitation or management of the movement of host material from quarantine (infested) areas to non-quarantine (non-infested) areas. Figure 8.2 shows symptoms of a damage caused by the False Codling Moth (FCM) on the export orange.

Figure 8.2 False Codling Moth (FCM) larvae on export orange
Source: Picture taken by the researcher in the study area, 2020

According to the South African legislation called the Agricultural Pest Act, 1983 (Act no.36 of the 1983), regarding phytosanitary measures, infested areas must be quarantined to avoid the introduction and spread of pests to non-infested areas. All traders and exporters of fruits and vegetables that are hosts to the above pests are from time to time advised through both formal communication channels and media reports by the State President, the DALRRD Minister and departmental spokespersons to apply for a removal permit from infested to non-infested areas to avoid the spread of these destructive pests. As part of the South African food security control measures, international travellers are also advised through official communication channels to avoid illegal importation of agricultural commodities into South Africa since such a practice may lead to the introduction and spread of pests which are costlier and hard to control.

However, the findings of this study disagree with the hypothesis of the study that the demographic and socio-economic characteristics of farmers/farms and cultural modes do not significantly influence successful traded outbound oranges from farms in the Limpopo province. The study findings further disagree with the hypothesis that the demographic and socio-economic characteristics of farmers/farms are not the main determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the province. In accordance with the findings of this study, it is true that the demographic and socio-economic characteristics of farmers/farms and cultural practices have a significant influence on the successful traded outbound oranges from farms in the Limpopo province. Additionally, it is also true that the demographic and socio-economic characteristics of farmers/farms are the main determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the province.

In their efforts to avoid orange spoilage and export ban, the majority (67.4%) of the citrus farmers recommended the usage of the Integrated Pest Management (IPM) as effective control measures for the identified top five citrus pests occurring in the Limpopo citrus industry. The IPM together with the biological control mode, a combination of IPM and chemical, the IPM, chemical and biological were also considered effective for the control of the citrus pests in the study area. Table 8.2 shows the top five citrus pests detected in the study area over the past five years.

Table 8.2 Top five citrus pests detected in the study area over the past five years (n = 215 respondents)

Variables (X)	Variables (Y)	Frequency	Percentage
Top five Pests experienced over the past five (5) years	False codling moth, ants, fruit-fly, loppers, and mealy bug	30	14.0
	False codling moth, fruit-fly, mealy bugs, and ants	12	5.6
	False codling moth, aphids/thrips, fruit-fly, loppers, and mealy bugs	8	3.7
	False codling moth, ants, fruit fly and red scales	6	2.8
Total		56	26.1

Source: Results from SPSS generated from field survey, 2021

8.3 Recommended framework for successful international trade of oranges produced from farms in the Limpopo province.

Based on the results of this study and comments obtained from the citrus farmers in the Limpopo province, a framework has been developed to serve as a guide for export bound orange producers in the study area and also to provide basis for informed policy decisions by government and relevant stakeholders.

8.3.1 Framework for successful trade of outbound oranges

The framework in Figure 8.3 reveals that cultural practices which include pest and disease control, packaging, harvesting, storage, and transportation; natural factors such as human theft, baboons, monkeys, and rodents; and climatic factors such as drought, high temperature, hail, and tropical storms, play an important role in terms of the successful trading of outbound oranges produced in the study area. According to the developed framework, international bodies such as IPPC which is a member of the WTO set plant standards for NPPOZA/DALRRD to share with citrus farmers organisations. Citrus farmers receive citrus directives, guidelines, standards, and regulation from the NPPOZA through citrus farmers organisation such as CGA and others. With the information citrus farmers get from farmers organizations, citrus farmers utilize it to comply with citrus export markets by means of managing amongst other determinants which include cultural practices such as pest and disease control, packaging, harvesting, storage, and transportation; natural factors such as human theft, baboons, monkeys, and rodents; and climatic factors such as drought, high temperature, hail, and tropical storms. This framework recommends that partnerships between relevant stakeholders such as citrus farmers, citrus farmers' organizations, PPECB, DALRRD, and international bodies (e.g., IPPC), and others, may enable farmers to achieve success in international trade of oranges. Additionally, citrus farmers or exporters have huge responsibility to render their oranges exportable and marketable by means of securing fruit quality and size for them to trade successfully in the citrus export markets. In accordance with the outcome of this study, it is recommended that citrus farmers in the study area adopt this framework and make use of it as a guide for export orange production system, and basis for informed policy decisions by government and relevant stakeholders. Figure 8.3 shows a Framework for successful trade of outbound oranges.

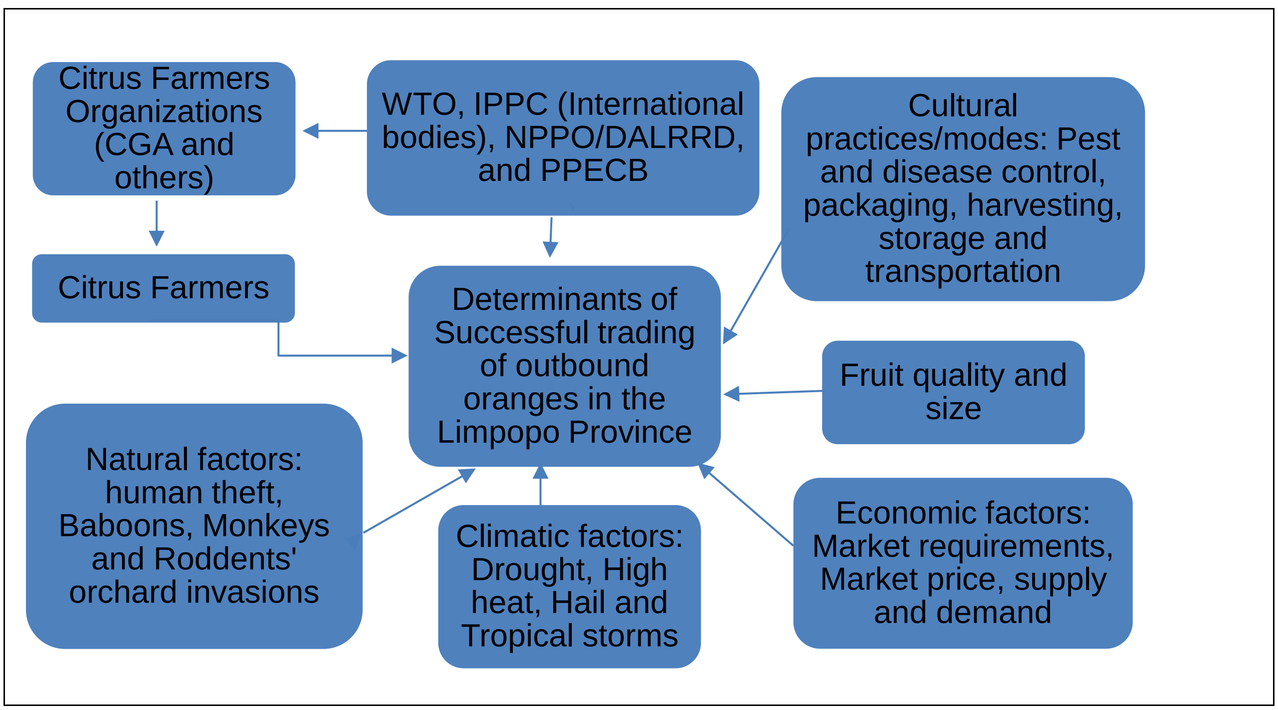

Figure 8.3: Framework for successful trade of outbound oranges
Source: Results from SPSS generated from field survey, 2021

8.4 Summary of the major results of the study

This chapter developed a framework for successfully traded outbound oranges from orange farms in the Limpopo province. All the study respondents were consulted and interviewed on a one-on-one basis to solicit their views regarding challenges being experienced at their respective farms on a seasonal basis. Besides, each farmer had also been provided with a questionnaire to give their comments and inputs regarding questions being asked. A workshop had also taken place with citrus farmers in the study area to discuss the key challenges hampering success in the international trade of oranges. Literature from various scientific sources together with the outcome of the workshop and inputs and comments from the study respondents had been used to develop this framework. Based on the said backdrop, it is therefore believed that through this framework, citrus farmers will benefit more, by taking reference from it. Additionally, the framework will also enable farmers, farmers organisations, universities, government, agricultural research institutions, and many others to get an insight and knowledge of the key determinants of success in the international trade of oranges before sending their produce to the citrus export markets. This framework will therefore serve as a guide for export-bound orange producers in the Limpopo province and provide basis for informed policy decisions by government and relevant stakeholders.

CHAPTER NINE
SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

This chapter presents the summary of the results, conclusions, and recommendations of the study. This study was conducted to analyse the general (demographic and socio-economic) characteristics of farms/farmers, the determinants of modes of plant pests control, plant disease control, type of packaging used, type of harvesting of oranges, and type of storage and transport modes among the export bound orange farms, to analyse the main factors influencing successfully traded outbound oranges from export-bound orange farms in the study area and lastly, to develop a frame-work for successfully traded outbound oranges from orange farms in the Limpopo province of South Africa. The primary aim of this research was to identify and analyze the most relevant determinants of successful trading of outbound oranges in the Limpopo province’s citrus industry which may serve as guide for export bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders. The total number of 215 respondents were randomly selected and interviewed through the semi-structure questionnaire. To achieve objectives 1 to 4 of the study, the collected research data were analysed using the descriptive statistics, Likert scale, the Multinomial Logistics Regression Model, and the Tobit Regression Model.

9.2 Summary of the study

The most relevant determinants of successful trading of outbound oranges in the Limpopo province’s citrus industry were investigated and analyzed. The study also investigated the challenges faced by citrus farmers in the study area regarding major citrus diseases and pests. The main objectives of the study were to: (1) identify and analyze the general (demographic and socio-economic) characteristics and the level of losses of citrus in respect of cultural modes (plant pest and disease control especially of Citrus Black Spot (CBS), Bactrocera *dorsalis* (BD) and False Coddling Moth (FCM), harvesting, packaging, storage and transportation) applied on each of selected outbound orange farms in the

Limpopo province. (2) analyze determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the study area. (3) analyze factors influencing successful traded outbound oranges from export bound orange farms in the study area and (4) develop a framework for successful traded outbound oranges from orange farms in the study area. The primary data was collected using a semi-structured questionnaire. A survey of outbound orange farms provided much needed information on the 215 outbound orange farms randomly selected in Groblersdal, Hoedspruit, Letsitele and Vhembe areas. Personal interviews were used to enable the interviewer to observe phytosanitary constraints confronting citrus farms in the research areas as well as other practices influencing the quality and export of the oranges.

Primary data of the study was collected through a questionnaire whereas secondary data was obtained from the citrus farmers included in the study and from desktop information. The questions in the questionnaire were both closed and open ended informed by the specific objectives of the study. Secondary data from published books, journals, and online or internet was used where necessary. Since there was a great need for secondary data from all major relevant stakeholders with the aim of sharing data, export orange producers' data collected from one-on-one interview sessions was also used to develop the framework for successful export orange trading in the global market. The questionnaire was validated by experts in agricultural economics from UNISA, while the reliability of the questionnaire was determined through pre-testing (pilot project). The questionnaire was pre-tested and administered to 10 outbound orange farmers in the study area. Comments from the respondents was used to improve the questions for ease of comprehension during the actual survey. The 10 respondents for the pilot study were not included in the main survey for the study.

This study further described the study area, research design, sample size and sampling technique, data collection instrument, method of data analyses, and ethical considerations. The computer software programme used to analyse the data of the study was the Statistical Package for Social Sciences (Version 28.0.). The descriptive statistics, the Multinomial Logistics Regression Model, the Poisson Regression Model, and the Tobit Regression Model were used for the statistical analyses of the study. Descriptive statistics was employed to analyse the general (demographic and socio-economic) characteristics of the citrus farms/producers included in the study. The multinomial logistic regression was used to analyze the determinants respectively of the following: modes of plant pests' control, plant disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the study area. The Poisson Regression Model was used to analyse the determinants of orange losses due to all the afore-mentioned modes. The Tobit Regression Model was used to analyse the main factors influencing successful traded outbound oranges from export bound orange farms in the study area.

9.3 The major results of the study

9.3.1 Objective One: To identify and analyse the general (demographic and socio-economic) characteristics of the farms/farmers involved in the study

The results of this study revealed that 98.1% of the respondents under investigation were males, followed by 1.9% females. The results further showed that a large proportion (41.4%) of citrus farmers fell within the age group of between 41 and 50 years, followed by 31 and 40 years at 28.8%, above 50 years at 27.0%, between 20 and 30 years at 1.9% and 0.9% who did not provide information about their age during the research period. High proportion (98.1%) of the citrus producers in the study area are married, followed by 0.9%, and 0.9% who refrained from providing information to the researcher regarding their marital status. The study found that 48.4% of the respondents had tertiary education followed by 43.3% secondary education, 7.4% Primary education and 0.9% who refrained from disclosing their educational status to the researcher. The study findings revealed that 98.6% of the respondents receive salaries as their only monthly source of income, followed by 0.5% who earn both salary and extra income from their bookkeeping work and lastly 0.9% who earn income from both salaries and their engineering work respectively. The findings of this study showed that 98.1% of the citrus farmers in the study area had no other extra source of income except their salaries followed by 1.9% who did not disclose their other sources of income to the researcher.

The study results discovered that 97.7% of the citrus farms in the area were privately owned, followed by 0.9% owned by both private and community, 0.9% owned by the community alone and 0.5% who refrained from providing the researcher with their farm ownership status. The study results further revealed that 98.6% of respondents own farm sizes of above 60 hectares, followed by 0.5% farms of between 21 and 40 hectares and 0.9% who did not disclose their farm size statuses to the researcher. The majority (98.6%) of the citrus farms in the study area are above 20 years old, followed by those falling within the age brackets of between 11 and 20 years old at 0.5% and lastly, 0.9% who did not disclose their farms' age brackets. The study results further proved that farmers who carry out their citrus farming activities at farms of over 20 years old perform better than those who farm on farms falling within the age brackets of between 11 and 20 years old. The study results showed that 96.7% of the outbound orange producers have above 15 years' export orange farming experience, followed by 1.4% who had 6 to 10 years, 0.9% who had 11 to 15 years and 0.9% who did not disclose their export orange farming experience to the researcher. The study results showed that 98.6% of the citrus farmers earn above R600 000 farm income followed by 0.9% who did not disclose their annual income per export season.

The findings of the study showed that the majority (99.1%) of the respondents in the study area spent above R300 000 as their export costs followed by 0.9% who did not disclose their export orange costs to the researcher. The results of the study showed that 90.7% of the respondents used hired labourers, followed by 5.1% who used both hired and permanent labourers, 2.8% who used both hired and mainly family labourers, 0.5% who used mainly family labourers and only 0.9% who did not disclose the types of labour used in their citrus farms. The findings also revealed that 44.2% used both refrigerated and shipping containers to convey their export oranges to international markets, followed by 36.3% who used refrigerated trucks, 9.8% who used shipping containers, 6.5% who used normal trucks, 1.9% who used both normal trucks and shipping containers, 0.5% who used both refrigerated and normal trucks and 0.9% who did not disclose their transport modes to the researcher. The study outcomes discovered that 48.8% of the respondents used pack houses to store export oranges on their farms, followed by 47.4% who used both pack houses and cool rooms, 2.8% who used cool rooms and lastly, 0.9% who did not expose the storage modes they used to the researcher.

9.3.2 Objective Two: To analyse the determinants respectively of the following: modes of plant pest control, plant disease control, type of packaging used, type of harvesting of oranges, transportation, and storage modes among the export bound orange farms in the study area using The Multinomial Logistic Regression

According to the study results, majority (67.4%) of the citrus farmers in the study area used the integrated Pest Management (IPM) plant pest control method to control pests in their export oranges' value chain than the rest of other available plant pest control modes. This therefore means that for citrus farmers to trade successfully in the international markets, they can consider using the IPMs as an effective pest control mode to protect their oranges against plant pests and diseases. In terms of the study effects, majority (71.2%) of the citrus farmers in the study area used the Integrated Pest Management (IPM) plant disease control mode to control citrus diseases occurring in their export oranges' value chain than the other available plant disease control modes. This therefore means that for citrus farmers to trade successfully in the international markets, they can consider using the IPMs as an effective plant disease control mode to protect their oranges against citrus diseases.

The results of this study showed that the majority (100%) of the citrus farmers in the study area used hand-picking as their preferred method of harvesting export oranges. According to the respondents of the study, this harvesting method proved to be more efficient to render the oranges marketable in export markets level. The study further discovered that majority (59.5%) of the citrus farmers in the study area use cartons, nets, and sacks as the packaging method of their preference. Results of this study proved that majority (68.4%) of the citrus farmers in the study area use cool rooms and pack houses as the storage mode of their choice. Considering the findings of this study there is an indication that majority (54.4%) of the citrus farmers in the study area use the refrigerated trucks and shipping containers as the most effective mode of transport to convey their oranges to the citrus export markets. This implies that transportation of export oranges using refrigerated trucks and shipping containers transport mode is considered more efficient and effective than any form of transportation modes.

9.3.3 Objective Three: To analyse the determinants of orange losses in respect of the respective modes using the Poisson Regression Model

The study results revealed that the coefficient of the transport modes used by citrus farmers on orange losses on the farms in respect of plant pests were statistically significant and positive (aircrafts Sig.0.008, Coef = 1.396637; normal trucks Sig.0.000, Coef = 1.043401; and a combination of shipping containers and normal trucks Sig.0.002, Coef = 1.039973 respectively). In accordance with the study results, the transport modes used by the citrus farmers had a huge influence on orange losses incurred by citrus farms in the study area. As observed from the study findings, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively. According to the study results, the use of aircraft, normal trucks and a combination of both shipping containers and normal trucks were less effective for the control of plant pests in the study area. In terms of the results, the coefficient of the age of the citrus farmers on orange losses in respect of plant diseases was statistically significant and negative at 95% confidence level (41- 50 years; Sig.0.026, Coef = -1.276512). The findings of this study indicated that an increase in 41– 50 years age group of the respondents had a huge influence on orange losses incurred in respect of plant diseases in the study area. As evidently seen from the study revelations, most citrus farmers (41.4%) fell within the age group of between 41 and 50, followed by 31 to 40 years at 28.8%, above 50 years at 27% and 20 to 30 years at 2.8% respectively.

In terms of results of this study, the coefficient of the transport modes used by citrus farmers on orange losses on the farms in respect of diseases were statistically significant and positive (shipping containers Sig.0.019, Coef = 1.002681 and normal trucks Sig.0.000, Coef = 1.686673 respectively). The results of this study showed that the transport modes used by citrus farmers had a huge influence on the orange losses on the farms in respect of diseases. As observed from the study outcomes, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and a combination of both refrigerated and normal trucks at 0.5% respectively. The study results revealed that the coefficient of the transport modes used by citrus farmers on orange losses on the farms in respect of harvest were statistically significant and positive (shipping containers Sig.0.001, Coef = 2.396234; normal trucks Sig.0.000, Coef = 3.175507; and shipping containers and normal trucks Sig.0.000, Coef = 3.837727 respectively). The results of this study indicated that the transport modes used by citrus farmers had a huge influence on the the previous season's exported orange cartons. As observed from the study findings, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, a combination of both shipping containers and normal trucks at 1.9%, aircrafts and a combination of both refrigerated and normal trucks at 0.5% respectively.

The study findings revealed that the coefficient of the 11 – 20 years age of the citrus farms on orange losses on the farms in respect of packaging modes was statistically significant and positive (11- 20 years Sig.0.022, Coef = 2.88035). The results of this study showed that the age of citrus farms had a huge influence on orange losses on the farms in respect of packaging modes in the study area. As evidently observed from the study results, majority (98.6%) of the citrus farms in the study area were aged above 20 years old, followed by those falling within the age brackets of between 1 and 10 years old at 0.9% and between 11 and 20 years at 0.5% respectively. The results of this study showed that the coefficient of the type of labour used by the farmers on orange losses on the farms in respect of packaging modes were statistically significant and positive (hired labour Sig.0.000, Coef = 17.31079) and (hired labour and permanent Sig.0.000, Coef = 19.23295) respectively. In respect of the outcome of this study, the type of labour used by the citrus farms had a huge influence on orange losses on the farms in respect of packaging modes in the study area. As clearly seen from the study findings, majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. According to the study results, the coefficient of the modes of transport used by the farmers on orange losses on the farms in respect of packaging modes were statistically significant and positive (aircrafts Sig.0.003, Coef = 2.547873; normal trucks Sig.0.000, Coef = 3.19141; and shipping containers and normal trucks Sig.0.000, Coef = 3.916218 respectively). The study results indicated that the transport modes used by citrus farmers in the study area had a huge influence on orange losses on the farms in respect of packaging modes. As observed from the study findings, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively.

In line with the study results, the coefficient of the type of labour used by the farmers on orange losses on the farms in respect of storage modes were statistically significant and positive (Sig.0.000, Coef = 16.43462) and (hired labour and permanent Sig.0.000, Coef = 17.15664) respectively. In accordance with the study results, the type of labour used by the citrus farms had a huge influence on orange losses on the farms in respect of storage modes in the study area. As clearly seen from the study findings, majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. The study results revealed that the coefficient of the modes of transport used by the farmers on orange losses on the farms in respect of storage modes were statistically significant and positive (normal trucks Sig.0.000, Coef = 2.98619; and shipping containers and normal trucks Sig.0.000, Coef = 3.936717) respectively. The study findings indicated that the transport modes used by citrus farmers in the study area had a huge influence on orange losses on the farms in respect of storage modes. As observed from the study outcome, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively.

According to the study results, the coefficient of the type of labour used by the farmers on orange losses on the farms in respect of storage modes were statistically significant and positive (Sig.0.000, Coef = 16.43462) and (hired labour and permanent Sig.0.000, Coef = 17.15664) respectively. In accordance with the study results, the type of labour used by the citrus farms had a huge influence on orange losses on the farms in respect of storage modes in the study area. As clearly seen from the study findings, majority (91.2%) of the citrus farmers used hired labour, followed by both hired labour and permanent labour at 5.1%, both hired and mainly family labour at 2.8% and mainly family labour, hired labour and temporary employees at 0.5% respectively. The study results revealed that the coefficient of the modes of transport used by the farmers on orange losses on the farms in respect of storage modes were statistically significant and positive (normal trucks Sig.0.000, Coef = 2.98619; and shipping containers and normal trucks Sig.0.000, Coef = 3.936717) respectively. The study results indicated that the transport modes used by citrus farmers in the study area had a huge influence on orange losses on the farms in respect of storage modes. As observed from the study findings, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by refrigerated trucks at 36.3%, shipping containers at 9.3%, normal trucks at 6.5%, both shipping containers and normal trucks at 1.9%, aircrafts and both refrigerated and normal trucks at 0.5% respectively.

9.3.4 Objective Four: To analyze the main factors influencing successfully traded outbound oranges from export bound orange farms in the study area using the Tobit Regression Model

The results of this study revealed that the coefficient of the age group of the citrus farmers on the proportion of the exported oranges among the citrus farms in the study area was statistically significant and positive (Sig.0.000, Coef = 1.761222), (Sig.0.000, Coef =

1.843514), (Sig.0.000, Coef = 1.619909), These study results showed that the age group of the citrus farmers had a huge influence on the proportion of the previous season's exported orange cartons. As evidently observed from the study findings, majority (41.4%) of the citrus farms fell within the age group of between 41 and 50 years, followed by those falling within the age group of between 31 and 40 at 28.8% and those falling within the age group of above 50 years at 27% respectively. These outcomes showed that there is a strong correlation between the proportion of exported oranges and the age group of the respondents in the study area. In line with the results of this study, the coefficient of the farm ownership status on the proportion of exported oranges among citrus farms in the study area appeared to be statistically significant and negative (Sig.0.011 Coef = -1.423961). The study results demonstrated that the coefficient of the farm ownership status of the citrus farmers had a huge impact on the previous season's exported orange cartons in the study area. As evidently seen from the study findings, most citrus farms (97.7%) were under private ownership, followed by government at 1.9% and the community at 0.5% respectively. These study findings signify that when ownership of the citrus farms stays in the hands of private individual farmers, the number of export orange cartons increases than when it is in the hands of both the government and the community.

The results of this study revealed that the coefficient of the types of labour used by the respondents on the proportion of exported oranges in the study area were statistically significant and positive (Sig.0.000, Coef = 1.941487). (Sig.0.001, Coef = 2.558537) (Sig.0.008, Coef = 2.042184). Table 6.1 results indicated that the type of labour used by the citrus farmers had a huge influence on the the previous season's exported orange cartons. As seen from the study findings, the majority (91.2.7%) of the citrus farmers used hired labour, followed by both hired and permanent labour at 5.1% and mainly family and hired labour at 28% respectively. The results of this study imply that citrus farmers who use hired labour on the farms do better than those using both hired and permanent labour together with those using mainly family and hired labour respectively. This also means that the type of labour used on the farm had more influence on the proportion of oranges exported during export season. The study results revealed that the coefficient of the transport mode used by the citrus farmers on the proportion of exported oranges in the study area was statistically significant and negative (Sig.0.000, Coef = -.9401603). These study results indicated that the transport mode used by the citrus farmers had a huge influence on the the previous season's exported orange cartons. As observed from the study results, majority (45.1%) of the citrus farmers used both refrigerated trucks and shipping containers, followed by the refrigerated trucks at 36.3%, the shipping containers at 9.3%, normal trucks at 6.5% and the shipping containers and normal trucks at 1.9% respectively. According to the results of this study, the transport modes used by the citrus farmers to convey their oranges to the citrus export markets were more effective and statistically significant.

9.3.5 Objective Five: To develop a framework for successfully traded outbound oranges from orange farms in the study area.

The study findings and comments from the citrus farmers had been used to develop a framework for successfully traded outbound oranges from orange farms in the Limpopo province. The framework will serve as a guide for export bound orange producers in the Limpopo province and provide basis for informed policy decisions by government and relevant stakeholders.

9.4 Conclusion

It can be concluded that all the main objectives set for this study which included: (1) identifying and analyzing the general (demographic and socio-economic) characteristics and the level and determinants of losses of citrus in respect of cultural modes (plant pest and disease control especially of Citrus Black Spot (CBS), Bactrocera *dorsalis* (BD) and False Coddling Moth (FCM), harvesting, packaging, storage and transportation) applied on each of selected outbound orange farms in the Limpopo province. (2) analyzing determinants of the modes of plant pests and disease control, type of packaging used, type of harvesting of oranges and type of trading modes among the export bound orange farms in the study area. (3) analyzing factors influencing successful traded outbound oranges from export bound orange farms in the study area and (4) developing a framework for successful traded outbound oranges from orange farms in the study area have been achieved.

The results of the descriptive statistics

The results of the descriptive statistics of the respondents showed that gender, age group, and education were the most influential factors in the study area.

The multinomial logistic regression model results

The results of the multinomial regression model indicated that factors such as age group, education, and transport modes were the main determinants of modes of disease control used by the citrus farmers.

The results of the Poisson Regression Model

The Poisson Regression Model results indicated that factors such as storage mode, transport mode, farm age and the type of labour used by the respondents were the key determinants of orange losses in respect of cultural practices.

The results of the Tobit Regression Model

The results of the Tobit regression model showed that factors such as age group, farm ownership, type of labour and transport mode were the main determinants of successfully traded export oranges produced from citrus farms in the study area.

The framework for successfully traded outbound oranges from orange farms in the Limpopo province

The framework for successfully traded outbound oranges from orange farms in the study area was developed based on the results of this study and the citrus farmers' comments. The framework may serve as a guide for export bound orange producers in the Limpopo province and will also provide basis for informed policy decisions by government and relevant stakeholders.

9.5 Recommendations

Considering the specific objectives of this study, the following recommendations are proposed based on the findings of this study.

9.5.1 Recommendations on the demographic and socio-economic characteristics of the citrus farms/farmers in the Limpopo province using the descriptive statistics

The main purpose of applying the descriptive analysis method in this study was to discover statistics such as mean values, percentage, standard deviations, and frequency tables and use them to present the results of descriptive analysis. The study analyzed, discussed and presented the results of the demographic and socio-economic characteristics of the citrus farms and producers included in the study which comprised gender group, age of the farmer, marital status, level of education, farm ownership status, sources of income, farm size, farm age, outbound orange farming experience, average farm income per season, types of labour used in the previous citrus season, transport mode used and storage mode used in the previous citrus season. The findings of this study showed that 98.1% of the respondents in the study area were males with most women possessing perceptions that citrus farming is a man’s job. The study also found that women’s household responsibilities of taking care of kids after working hours, dealing with kids’ sicknesses, and lastly getting kids to and from school also make it more difficult for female producers to participate in export orange trading business efficiently and effectively. Furthermore, respondents in the study area also highlighted that a large proportion of citrus farmers within the Limpopo citrus industry fall within the middle-aged bracket, well-educated and experienced. In accordance with this study, a high population of youth are unable to take part in citrus farming owing to their tight study schedules. This study also showed that export orange production business demands adequate attention to make a significant impact in it, which on one hand contradicts with students’ study schedules which ought to take place during the same period. According to the outcome of this study, it can be concluded that while men dominate the citrus industry in the study area more still need to be done by the citrus industry in the Limpopo province and the Department of Agriculture, Land Reform and Rural Development at national level to encourage and support women to play active roles within the industry too.

9.5.2 Recommendations on the the determinants of mode of plant disease control in the study area using the multinomial logistic regression model

The main objective of this study chapter was to analyse the determinants of modes of plant disease control in the study area. The study provided analysis of factors influencing the modes of disease control on the export bound orange farms in the study area using the multinomial logistic regression model. The study found that the majority (67.4%) of the citrus farmers used the integrated Pest Management (IPM) plant pest control method to control pests in their export oranges' value chain. The results of the multinomial logistic regression analyses further revealed that the coefficient of age, the level of education and transport modes used by the citrus farmers on the application of disease control mode of the Integrated Pest Management (IPM) were statistically significant and negative. This means that when the age, the level of education and transport modes of the citrus farmers increases, the use of the integrated Pest Management (IPM) plant pest control method to control pests decreases.

However, comments obtained from the citrus farmers in the study area placed more emphasis on freedom of the outbound oranges from diseases using the IPMs to render the fruit marketable. Besides, in situations where fruits become punctured due to pulp temperature, citrus farmers are also advised to immediately consider the fruit rejected for export as they would rapidly spoil and infect the other export orange fruits. The issue of the awareness and promotion of proper hygienic practices throughout the fruit supply value chain was also considered necessary. Consequently, storage facility was also recommended to be regularly disinfected and well-equipped with insect proof facilities to prevent entry of pests from outside if the citrus farmers in the study aspire success in international trade of orange business. In accordance with the results of this study, the coefficient of age, the level of education and transport modes used by the citrus farmers on the application of disease control mode of the Integrated Pest Management (IPM), was statistically significant and negative. It is recommended that citrus farmers in the study area within the higher age range, high level of education, and the significant transport categories should be trained in the IPM and other new technological methods of plant pest and disease control to ensure that they have a reliable alternative method/s for citrus disease control on their farms. On-going training sessions play a crucial in capacitating farmers to effectively deal with new challenges emerging within the citrus export industry.

9.5.3 Recommendations on factors influencing orange losses on the citrus farms in respect of cultural practices in the study area using the Poisson Regression Model

This chapter addressed the main factors influencing orange losses on the farms in respect of cultural practices/modes using the Poisson regression model. The main objective of this chapter was to determine which of a set of specified independent variables has a significant relationship with the individual farmers' orange losses as measured by counts of oranges with respect to the various modes. In accordance with the outcome of this study chapter, there is still a huge need for citrus farmers in the study area to reinforce their phytosanitary measures to avoid orange losses occurring in their orchards in respect of cultural practices. The outcome of the Poisson Regression Model in this study, show that some cultural practices cause significant spoilage on export oranges. According to the results of the Poisson regression model on the determinants of orange losses in respect of cultural practices, factors such as age of the citrus farmers**,** transport modes used, and the type of labour used by the farmers were statistically significant and positive which indicate that crucial farm income gets lost in respect of cultural practices in the study area. It is recommended that older citrus farmers be workshopped about ways of reducing outbound oranges from their farms. The citrus farmers in the study area should also be workshopped about the use of the appropriate means of transport and labour for their oranges to reduce the losses.

9.5.4 Recommendations on the main factors influencing successful traded outbound oranges from export bound orange farms in the study area using both the Tobit Regression Model

This study identified the main factors influencing successfully traded outbound oranges from export-bound orange farms in the study area. The selected study areas for this study included Groblersdal, Hoedspruit, Letsitele and Vhembe. The study presented the results and discussions of the Tobit Regression Model. The results of this study revealed that the coefficients of the age group, farm ownership status (government and community), hired and family labour, transport mode and storage mode used among the respondents on the previous season's exported orange cartons, were statistically significant and mostly positive. This means that the afore-mentioned factors had a huge influence on the the previous season's exported orange cartons. It is recommended that private ownership be promoted among the citrus farmers since it encourages high productivity, good yield, and increased exportable oranges, hence improved income from citrus trade. The farmers should also be encouraged to engage more of hired labour for effective and efficient production system. Based on the outcome of this study, appropriate management of cultural practices such as pest and disease control, storage and transport modes thus proved to be fundamental to successful avoidance of orange spoilage, export rejection and export ban within the study area. The usage of refrigerated trucks and shipping containers to transport oranges to export markets should also be considered necessary, and orange shipments to export markets also need to be handled with care to enable citrus farmers achieve success in the export markets. However, to avoid orange spoilage by plant diseases and pests, phytosanitary control measures need to be reinvigorated. Lastly, to enable citrus farmers to trade successfully in the international markets, storage facilities such as cool rooms and pack-houses also need to be always kept clean. In overall, the NPPOZA, research institutions and the citrus industry also ought to provide technical and financial support to the citrus farmers in the study area to sustain their export orange trading businesses.

9.5.5 Recommendations on a framework for successfully traded outbound oranges from orange farms in the Limpopo province.

This study developed a framework for successfully traded outbound oranges from orange farms in the Limpopo province. The framework may serve as a guide for export bound orange producers in the Limpopo province and provide basis for informed policy decisions by government and relevant stakeholders. This study included the results, discussions, and comments from orange farmers in the Limpopo province. Based on the data collected from the citrus farmers, a framework for successfully traded outbound oranges from orange farms in the Limpopo province was developed. In accordance with the interviews conducted with the citrus farmers in the study area, if citrus farmers may properly follow this framework, they may succeed in the international trade of their oranges. Moreover, this framework may also enable government and other relevant stakeholders to make well-informed policy decisions. In summation, the citrus farmers in the study require the support of the South African government, research institutions and farmers' organizations to produce quality oranges, and trade successfully in the international markets.

9.6 Future research

Considering the results of this study, citrus farmers in the Limpopo province will possibly be able to avoid export related crises such as export ban, farm retrenchments, farm repossession, urban drift, loss of farm income and revenue for the Republic of South Africa and trade successfully in the international markets. Having noted the determinants of successful trading of oranges produced in the study area, the next research area must focus on the citrus export market compliance strategies and citrus export infrastructure development to avoid the ongoing citrus export trade barriers such as tariffs, non-tariffs, quotas, and embargos occurring during citrus export period.

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QUESTIONNAIRE

TOPIC: DETERMINANTS OF SUCCESSFUL TRADING OF OUTBOUND ORANGES PRODUCED IN THE LIMPOPO PROVINCE, SOUTH AFRICA

Dear respondent

My name is Mr. Mafadi Abram Bjang. I am a student on my PHD study with the University of South Africa in the Department of Agriculture and Animal Health. The purpose of this study is to identify and analyse the most relevant determinants of successful trading of outbound oranges produced in the Limpopo province's citrus industry which may serve as a guide for export bound orange producers and to provide basis for informed policy decisions by government and relevant stakeholders. You are kindly invited to take part in this study.

Kindly take note that the information you provide will only be used for the purpose of this study and be treated with confidentiality. Your name is not required and there are neither wrong nor right answers therefore please be as honest as you can be in answering the questions.

Thank you so much for your time.

Questionnaire no: ______________

Date of Interview: _______________

Place of interview: ________________________

Section 1

Background information

1. Gender

1. Male	2 Female

2. Age group

1. Between 20 and 30 years	2. Between 31and 40 years
3. Between 41and 50 years	4. Above 50 years

3. Marital status

1.Married	2.Divorced	Other specify
3.Single	4.Widowed	

4. Level of education

1.Primary education	2.Secondary education	5.Other (Specify)
3.Tertiary education	4.No education	

5. Other Employment (specify if applicable) ……………………………

6. Farm ownership status

1. Private	2. Government
3.Community	4. Other (specify)

7. Other Sources of your income

1. Salary	3.Other (specify)
2. Social grants (Old age, disability grant, etc.)	

8. Farm size

1. ≤ 20 ha	2. 21 to 40 ha
3. 41-60 ha	4. more than 60 ha

9. Farm age

1. ≤ 10years	2. 11 to 20 years

3. >20 years	

10. Outbound orange farming experience

1. ≤5years	2. 6 to 10 years
3. 11 to 15 years	4. more than 15 years

11. How much is the average farm income per export season?

1. ≤ R200 000	2.R201 000 to R400 000
3.R401 000-R600 000	4.Greater than R600 000

12. How much is your average orange export costs per season?

1. Less than R100 000	2. R101 000 – R200 000
3. R201 000 – R300 000	3. Above R300 000

13. What type of labour is used on your citrus farm (in the previous export season)?

Mainly family labour	Hired labour	Other specify

14. Which mode of transport did you use to convey your oranges to the export markets in the last export season?

Refrigerated trucks	Aircrafts
Shipping containers	Other (specify)

Section 2

Preferences and perceptions about outbound orange trade

15. Did you export oranges in the previous/last season?

Yes	No

16. If no, please explain/provide reasons?
…………………………………………………………………………
………………………………………………………………………………………..

17. If yes, indicate how many times did you export oranges during the last season?

1. Once	2. Twice	3. 3 times
4. 4 times	5. More than 4 times	

18. What orange type do you mostly export?

1. Valencia	2. Navel	3. Both	Other specify

19. Why do you prefer this type of orange?

1. Highly demanded	2. Profitable
2.Nutritious	3.Tasteful
4. Other (specify)	

21. How many cartons of oranges did you export during 2020/2021 marketing season?
…………………………………………………………………………………………

22. What price did you receive per carton of oranges exported during last season?
……………………………………………………………………………………………

23. Where is your export market?

1. United Kingdom	2. European Union
3. Asia	4. United Arab Emirates
5. Other (specify)	

24. How many cartons of oranges were harvested on your farm during the previous season?
…………………………………………………………………………….

25. Indicate the level of losses in respect of cultural modes of the citrus/orange farm on the previous season's records.

Item	**Losses in tones**	**Losses in numbers of oranges**
Losses due to Plant pests		
Losses due to Diseases		
Losses due to Harvesting		
Losses due to Packaging		
Losses due to Storage		
Losses due to Transportation		
Nutritional content detected by sensors		
Rejected at the market end		
Other specify		

26. Please tick or cross the appropriate cultural modes used on your farm in the previous/last season

Types of Cultural Modes	Types of cultural modes Used on farms	Cross or Tick the appropriate mode used on the farm
Plant pest control	Integrated Pest Management	
	Chemical	
	Biological	
	Heat treatment	
	Ionizing radiation treatment	
	Cold treatment	
	Fumigation	
	Other specify	
Plant Disease control	Integrated Pest Management	
	Chemical	
	Biological	
	Cold treatment	
	Fumigation	
	Heat treatment	
	Other specify	
Types of harvesting used	Hand-picking	
	Air blast	
	Limb shaker	
	Canopy shaker	
	Trunk shaker	
	Other specify	
Types of Packaging used	Use of bags	
	Use of cartons or boxes	
	Use of nets or sacks	
	Use of crates	
	Use of pallets	
	Other specify	
Types of storage used	Cool rooms	
	Pack houses	
	Other specify	

27. Indicate the types of pests and disease experienced on farm over the past five (5) years

Types of pests	Cross or Tick next to pest observed on farm over the past five (5) years
False Coddling Moth	

Oriental Fruit fly (Bactrocera dorsalis)	
Ants	
Aphids or Thrips	
Australian bug	
Ball worm	
Bud mite	
Flat mite	
Fruit Flies	
Fullers Rose Beetle	
Leaf Hoppers and Plant Rollers	
Leaf Rollers	
Lemon Bore Moth	
Loopers	
Mealy Bugs	
Orange Dogs	
Red Scales	
Rust Mites	
Silver Mites	
Snails and Slugs	
Soft Scales and Waxy Scales	
Asian Citrus Psyllid	
African Citrus Psyllid	
Other specify	
Types of diseases	**Cross or Tick next to disease observed on farm over the past five (5) years**
Citrus Black Spot	
Sooty canker	
Alternaria fruit rot	
Brown wood rot	
Stubborn Disease	
Tristeza virus	
Dry root rot	
Exocortis	
Psorosis Greasy Spot	
Greasy Spot Rind Blotch	
Scab	
Melanose on fruit	
Melanose on leaves	
Post Bloom Fruit Drop	
Foot Rot	

Brown Rot on Fruit	
Citrus Canker	
Other specify	

28. How many diseases' trainings have you received during the marketing year 2020/2021?

Section 3

Questions on willingness to attend a workshop comprising all major stakeholders.

The purpose of the workshop will be to develop a framework for successfully traded outbound oranges from orange farms in the Limpopo province. The framework when developed will be validated by the major stakeholders (Department of trade and Agriculture reps, Agricultural economics experts, selected successful outbound orange traders and technical personnel at the phytosanitary section at the Airport).

29. Would you like to attend workshop?

1.Yes	2.No

30. If yes, would you be willing to take part in the development process of a framework for successfully traded outbound oranges from orange farms in the Limpopo province?

1.Yes	2.No

31. If no to question 28, what would be the reason for not willing to attend the workshop? ……………………………………………………………………..

32. Are you a member of farmers' organisation?

1.Yes	2.No

Thank you!

APPENDIX 1

Overview of the South African citrus industry risks and recommendations (Marketing Year (MY) 2022)

Risks	Mitigation measures
Effect of Phytosanitary constraints on export volumes and associated levy income: (CBS, FCM, BD and Biosecurity-Huang Long Bing (HLB).	Citrus Black Spot control modes: • Disaster management committee is in place. • Relevant government departments are engaged on this matter. • New export markets are being developed. • Additional funds allocated to CRI for research on CBS. • Trade lawyers have been engaged to prepare a case for the WTO dispute. • A risk management system has been developed and implemented. False Codling Moth control modes: • An FCM management committee has been established to assess, monitor, and manage risk. • Discussions with government representatives are taking place. • The FCM management systems have been developed and implemented. Bactrocera dorsalis control modes: • Movement of fruit from Bactrocera dorsalis regions is being controlled. • The CGA and CRI action plan is in place and being managed by the committee. • Other fruit groups have provided contributions towards the management of this risk. Biosecurity-Huang Long Bing (HLB) control modes: • A biosecurity manger position has been created at CRI to manage this risk. • The HLB Steering Group convened and an HLB action plan has been developed.

Logistical constraints on export volumes and levy income	The CGA employed the logistics manager to address this risk. • A logistics risk committee has been formed to assist the logistics development manager. • Work is being done to reduce the supply chain costs.
Socio-political constraints on export volume and associated levy income.	Land expropriation without compensation (LEWC) control modes: • Communications between the CGA and the industry's body Agbiz, are on-going, and submissions have been made to parliamentary review committee. Transformation control modes: • The CGA Grower Development Company is focused on developing black growers and has developed good relationships with DALRRD and other government departments. • The Citrus Academy continue to focus on human capital development for the industry.
Effect of Black Economic Empowerment (BEE) status on future levy approvals.	• The CGA underwent a BEE verification audit in March 2022 and obtained a level 5 compliance rating under the AgriBEE Sector Codes.
Constraints that buy-in from producers may have on future levy approval and income.	• To mitigate the risk, a grower representation and effective communication with growers is essential. • The CGA holds the CGA Citrus Summit every two years and conducts roadshows to each citrus-producing region in alternate years. • The CGA communicates regularly with growers through weekly newsletters and various other publications.
Information Technology (IT) systems failure putting industry data at risk and resulting in the	• The CGA employed an information manager to address this risk. • Regular data backups are done. • The cyber risk review was conducted in 2021 and recommendations from this review were implemented to improve and strengthen IT and Cyber security.

company being unable to operate	
The effect of Covid-19 in 2022 citrus season and exports	• A Covid-19 response committee was established to assess and deal with matters arising from the pandemic. • The committee engages with government through Agbiz.

Source: CGA (2022)