Cape Peninsula University of Technology

Development of a sustainable cultivation protocol for *Artemisia afra* in the Western Cape

by

SIBUSISO XEGO

Thesis submitted in fulfilment of the requirements for the degree

Doctor of Horticulture: Horticultural Sciences

In the Faculty of Applied Sciences at the

CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

Supervisor: Prof. L. Kambizi

Co-supervisor: Prof. F. Nchu

Bellville

March 2025

DECLARATION

I, Sibusiso Xego, hereby declare that the contents of this thesis are my own unaided work and have not been previously submitted for academic examination towards any qualification. Additionally, the opinions expressed herein are my own and do not necessarily reflect those of the Cape Peninsula University of Technology.

March 2025

Signed: SIBUSISO XEGO **Date**

DEDICATION

This study is wholeheartedly dedicated to my beloved late grandmother, Tazana Regina Nowezile Sidumo. Thank you for instilling in me a love of agriculture and teaching me to always strive for excellence. To my parents, Bulelwa Sylvia Xego and my beloved late father Mbuyiseli Eric Xego, you have been my pillars of strength and inspiration, providing unwavering moral, spiritual, and emotional support. I love you deeply. This work is also dedicated to the loving memory of my late sister, Phumeza Monica Sidumo.

To the Almighty God, my redeemer, and my ancestors (*Camagu zihlwele*), I express my deepest gratitude for your guidance, strength, power, protection and the blessing of wisdom. "*LIVUMILE ICAMAGU*".

ACKNOWLEDGEMENTS

I extend my deepest gratitude to my supervisors, Prof. Learnmore Kambizi and Prof. Felix Nchu for their unwavering support and encouragement throughout my postgraduate studies. You have become more than just supervisors; you are family. Your guidance, especially during challenging times, has been invaluable and motivated me to persevere and complete this journey. Thank you for being there and for pushing me to reach my full potential. I am profoundly grateful for everything you have done for me.

To my parents and grandmother, thank you for instilling in me the values of hard work and perseverance. Your sacrifices and firm belief in my potential have inspired me to strive for excellence. Rest in peace Dad this is dedicated to you “oJili abanikezeli”. To my siblings and my aunts, thank you for being my pillars of support and for always cheering on me (Sindiswa Sidumo, Nikelwa Sidumo, Aphiwe Wellem, Yanga Xego, Asavela Kema and Ayabonga Kema). Your consistent support and prayers have been a source of comfort and strength, I’m really grateful for your presence in my life. Aphiwe Wellem you are a blessing in my life.

To all my friends (Asanda Mlungwana, Phumla Staffa, and Aviwe Rhalarhala), I am immensely grateful for your steadfast support, you have been a constant source of strength, helping me navigate through the challenges and triumphs of academic life. A special thank you to Sinovuyo Ncuku for her exceptional guidance and friendship, which have been pivotal in keeping me focused and motivated.

My colleagues and the Department of Horticultural Sciences, I want to extend my heartfelt appreciation, your support and assistance have played a significant role in the success of my study. I am deeply grateful for the opportunities provided by the department, particularly in conducting workshops, which have contributed to my study advancement. Phumlani Roto, Yonela Vakele, Terence Mabela and Timothy Jasson.

I extend my gratitude to our partners, traditional healers, and small-scale farmers for their trust and knowledge sharing, especially Chief Vulikhaya Sihluku for connecting us with the traditional healers’ organizations in the Western Cape, and Mawethu Nyakatya for questionnaire translation. Their contributions, alongside with funding from the National Research Foundation (NRF), greatly advanced my study.

LIST OF PUBLICATIONS, CONFERENCES AND CONTRIBUTIONS

Publications:

1. Embracing herbal medicine through collaboration among traditional healers, biomedical health practitioners and research institutes.
   Journal name: *Plant Archives*. 21(2): 632-638
2. Recognizing the impact of traditional herbal medicine in managing cancer: The South African context.
   Journal name: *Journal of Medicinal Plants for Economic Development*.
3. The effect of different organic amendments on growth, secondary metabolites, and antioxidant capacities of *Artemisia afra.*
   Journal name: *Medicinal Plants Journal*
4. **Article publication:** "Organic cultivation of endangered and extinct medicinal plants", published by CPUT Media and Events. This workshop, held on Africa day, was an integral part of my data collection process.
   https://www.cput.ac.za/newsroom/news/article/4995/horticultural-sciences-commits-to-medicinal-plant-conservation.

Conference presentations and contributions:

1. SOMPED International conference, Cape Town South Africa 2022
   Topic: 'Embracing herbal medicine through collaboration among traditional healers, biomedical health practitioners and research institutes: A review'
   Award: 2nd best student presenter (oral presentation)
2. 71st International congress and annual meeting of the society for medicinal plant and natural product research (GA), Dublin, Ireland 2023.
   Topic: The effect of different organic amendments on growth, secondary metabolites, and antioxidant capacities of *Artemisia afra*.
3. Sustainable plant medicine: 1-day workshop on the sustainable harvesting and cultivation of indigenous medicinal plants. Workshop organizer: Happy By Nature.
   Topics: sustainable cultivation, regeneration, rewilding, substitutions/alternatives, propagation techniques of certain common but threatened medicinal plants.
4. Cape Peninsula University of Technology: VC's Business and Industry Engagement and Institutional Advisory Forum Launch Post-Event Survey.
   Activity: display presentation (exhibition stand).

Project presented: Fostering collaboration between the institution and industry partners (traditional healers and small-scale farmers) to initiate organic cultivation of medicinal plants in the Western Cape.

5. 8th U6+ International conference: Consortium of African Universities: September 2024.

   Topic: Enhancing sustainable cultivation and use of medicinal plants through collaborative partnerships in the Western Cape.

6. Heritage Day commemoration 2024: Showcasing Indigenous Knowledge and its integration into the academic pursuits of the Faculty of Applied Sciences.

   Topic: Enhancing sustainable cultivation and use of medicinal plants through collaborative partnerships with Western Cape Traditional Healers and Small-Scale Farmers (oral presentation).

7. NRF Next Generation and Emerging Researchers Symposium: Research for better society: October 2024.

   Topic: Enhancing sustainable cultivation and use of medicinal plants through collaborative partnerships (poster presentation).

The project is now supported by **National Research Funds (NRF)**: securing **funding for the years 2025-2026** to advance the initiative and establish the first four medicinal plant gardens in the Western Cape, specifically dedicated to traditional healers.

TABLE OF CONTENTS

Chapter Two

The effect of different organic amendments on growth, secondary metabolites and antioxidant capacities of *Artemisia afra*

Chapter Three

Traditional healers' perspectives, beliefs, and awareness on the use of cultivated medicinal plants, and plant conservation status.

Chapter Four

Bridging knowledge and practice: traditional healers and small-scale farmers' training workshops to improve sustainable practices.

Chapter Five

General discussion, conclusions and recommendations

LIST OF ACRONYMS

ANOVA- Analysis of variance

HIV- Human immunodeficiency virus

WHO- World Health Organization

IUCN- The International Union for Conservation of Nature

WWF- World Wildlife Fund

DAAF- Department of Agriculture, Forestry and Fisheries

SANBI- The South African National Biodiversity Institute

COVID-19- Coronavirus disease 2019

mm; nm- Millimetres; Nanometres

cm; cm^3- Centimetre; Cubic centimetre

%- Percentage; ºC- Degree Celsius

Covid-19- Coronavirus diseases

HCl- Hydrogen chloride

ICP-OES- Inductively coupled plasma - optical emission spectrometry

kg/m^3- Kilogram per cubic metre

g and mg/kg- Gram; Milligrams per kilogram

KCl- Potassium chloride

mL- Millilitre

µM- Micrometre

µL- Microliter

TE/g- Tellurium per gram

GAE/g- Milligrams of gallic acid equivalents per gram

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Abstract

In Africa, the substantial demand for medicinal plants, predominately sourced from wild populations, exerts pressure on natural habitats. Although species such as *Artemisia afra* Jacq., ex Willd are extensively utilized, conservation measures for various species are either limited or proven inadequate. Additionally, research efforts have had limited impact on farmers and users of medicinal plants, primarily due to minimal stakeholder engagement, as most studies are conducted in controlled settings. The current production levels of medicinal plants through commercial farming are insufficient to meet the trade demand and modern farming technology alone cannot address the world's pressing healthcare needs. Therefore, engaging local communities is essential for the preservation of biodiversity conservation and the promotion of sustainable cultivation techniques. This study aimed to develop and implement cost-effective organic cultivation techniques to optimize plant growth and metabolite content of *Artemisia afra* in the Western Cape. Additionally, investigated traditional healers willingness to adopt these cultivation practices and utilize raw materials produced by small-scale farmers. Ultimately, the study aimed to equip traditional healers and small-scale farmers with essential medicinal plant cultivation techniques, fostering sustainable agricultural practices.

In chapter 1, the conceptual background and scientific rationalizations of the study are presented. Chapter 2 focused on assessing the effects of different organic amendments on the growth, secondary metabolites, and antioxidant properties of *A. afra*, to establish a sustainable and feasible cultivation approach. Four organic amendments were selected in response to the increasing demand for organically cultivated medicinal plants. These included vermicompost, mushroom compost, poultry and kraal manure, mixed with coarse river sand at a ratio of 70% sand and 30% organic amendments. The results highlighted a significant improvement in growth parameters with the use of poultry manure, likely due to its rich nutrient content compared to other organic amendments studied. Poultry manure also exhibited the highest concentration of secondary metabolites (polyphenols and flavonols) and antioxidant activities in *A. afra*, including (ferric reducing antioxidant power (FRAP), 1,1-diphenyl-2-picrylhydrazyl (DPPH) and Trolox equivalent antioxidant capacity (TEAC). Furthermore, there was a strong correlation between secondary metabolites and antioxidant activity, suggesting that the presence of secondary metabolites

influenced the overall antioxidant activity of the plant. Substantially, the application of poultry manures positively influenced the growth, secondary metabolites and antioxidant activities of *A. afra*.

Chapter 3 explored the readiness of traditional healers in the Western Cape to engage with cultivated medicinal plants, their views on conservation efforts, and identify the species they prioritize for conservation. A total of 75 traditional healers were randomly selected to complete semi-structured questionnaires, and two workshops were organized to promote collaboration among different stakeholders (traditional healers and researchers). The results indicated that 52% of the respondents depend on the collection of medicinal plants as their main source of income, while 92% noted that the sale of these plants contributes to their overall earnings. The research identified 64 medicinal plant species that are frequently used, with *Artemisia afra* being the most prevalent, followed by *Rhoicissus digitata* and *Silene undulata*. A significant majority (96%) expressed a strong interest in the cultivation of medicinal plants, and 66.7% recognized the decline of certain species. Furthermore, an overwhelming 98.7% of participants reported using and selling *A. afra*, underscoring its high demand. Respondents identified 44 medicinal uses for *A. afra*, with common applications including treatments for respiratory and digestive issues, pain relief, immune booster, and various ritualistic practices.

Chapter 4 presented a training workshop designed to enhance the propagation skills of traditional healers and small-scale farmers. Conducted at the Cape Peninsula University of Technology, the workshop attracted 58 participants who took part in practical training sessions covering seed sowing, vegetative propagation, transplanting, composting, and soil preparation. Evaluations conducted after the workshop indicated that all participants deemed the training pertinent, with 71.7% reporting a boost in their confidence regarding the cultivation of medicinal plants. A significant number of small-scale farmers expressed a desire to create nurseries for indigenous medicinal plants, highlighting the workshop’s effectiveness in promoting sustainable cultivation methods. The collaboration and engagement of a diverse array of stakeholders, including researchers, small-scale farmers, and traditional healers, facilitated the exchange of knowledge and reinforced collaborative initiatives.

This study emphasized the critical necessity for conservation-oriented programs and community driven cultivation approaches to mitigate dependence on wild harvesting. By merging scientific inquiry with traditional practices, the results lay the groundwork for sustainable production of medicinal plants, thereby ensuring enduring advantages for both ecological preservation and the livelihood of local communities.

Structure of the thesis

The study comprises five chapters, each of which is succinctly outlined.

Chapter One: General introduction, background to the research problem, and literature review. The chapter provides the conceptual background and scientific justification for the study. It includes an overview of the problem that motivates the research undertaken in this thesis, along with the aims and specific objectives of the study.

Chapter Two: The effect of different organic amendments on growth, secondary metabolites and antioxidant capacities of *A. afra*.

The main objective of this chapter was to assess the effect of various organic amendments on plant growth, secondary metabolites, and antioxidant capacity of *A. afra*, considering the reported advantages of organic farming. This chapter presents the rationale for the research, details of materials and methods, and the results and discussions thereof.

Chapter Three: Traditional healers' perspectives, beliefs, and awareness on the use of cultivated medicinal plants, and plant conservation status.

This chapter aimed to ascertain and document the willingness of the traditional healers in the Western Cape to utilize and accept plant material from cultivated plants. Furthermore, this research seeks to explore traditional healers' perspectives concerning the conservation status of indigenous medicinal plants, with a particular focus on *A. afra* and identify plants deemed priority by healers. This chapter outlines the research rationale, provides details of the materials and methods employed, and presents the corresponding results and discussions.

Chapter Four: Traditional healers and small-scale farmers' perspectives on a training workshop on medicinal plant cultivation for traditional healers and small-scale farmers: towards enhancing the uptake of medicinal plant cultivation.

The main purpose of this chapter was to facilitate a training workshop to equip traditional healers' and small-scale farmers with essential propagation practices and skills for growing medicinal plants. The workshop's goal was to merge traditional knowledge with hands-on horticultural skills, promoting sustainable farming methods and enabling participants to successfully grow medicinal plants in their communities.

This chapter details the research rationale, describes the materials and methods used, and presents an analysis and discussion of the results.

Chapter Five: General discussion, conclusions, and recommendations

This chapter integrates the findings from previous chapters through general discussion, followed by the study's conclusions. Recommendations are provided for further research directions and future topics of investigation.

CHAPTER ONE

Introduction, background to the research problem and literature review

1.1. General introduction

Medicinal plants and traditional medicine continue to hold significant importance in the healthcare systems of most developing countries (Kasagana & Karumuri, 2011; Thorsen & Pouliot, 2016). Despite the availability of Western medicine in the modern era, various cultural communities in South Africa rely on and often prefer traditional medicine as an important component of primary healthcare (Williams *et al*., 2013). Studies estimate that 72% of the Black African population in South Africa utilize traditional medicine, with an average frequency of 4.8 times per year and per consumer, resulting in the consumption of approximately 20 000 tons of plant material, predominantly indigenous species (Mander *et al*., 2007; Mothibe & Sibanda, 2019). Moreover, the rising number of traditional practitioners utilizing or commercializing herbal remedies and medicinal plants indicates a significant acceptance and prevalence of herbal medicine within the population (Khumalo *et al*., 2006).

South Africa, ranked as the third most biologically diverse country globally, boasts vast forests harbouring a plethora of traditional medicinal plants (Tewari, 2004). However, this biodiversity faces depletion due to both human-induced and natural calamities (Kasagana & Karumuri, 2011). Over-exploitation of medicinal plants poses a severe to numerous species, pushing many toward extinction (Rukangira, 2001). Raimondo (2011) and Van der Colff *et al*. (2023) reported that 33 plant taxa in South Africa are considered extinct, while 2577 are classified as threatened, and an additional 2232 are listed as near threatened or rare. Despite habitat loss being a major contributor to resource depletion, the collection of wild plants for traditional medical use is immensely detrimental to certain species. Traditional healthcare practice is mainly dependent on medicinal plants collected from the wild (Rukangira, 2001; Mander *et al*., 2007; Kasagana & Karumuri, 2011).

In a study by Moeg (2010), *Artemisia afra, Capparis sepiaria, Drimia sanquinea, Hypoxis obtuse, Monsonia angustifolia, Securidaca longipendunculata* and *Siphonochilus aethiopicus* were identified as some of the most preferred and traded medicinal plants. The populations of these targeted medicinal plants are rapidly declining in the wild, with some on the verge of extinction thus leaving their therapeutic

potential unfulfilled (Rasethe *et al*., 2019). *A. afra* is undoubtedly one of the most important and widely used herbs in traditional medicine (Patil *et al*., 2011) and is heavily exploited in African ethnopharmacology (Liu *et al*., 2009). According to Prinsloo *et al*. (2011), there is limited information available on the cultivation of this plant. Therefore, the cultivation of alternative sources for popular and high conservation priority species outside of primary conservation areas is essential (Mathibela, 2013).

The conservation of medicinal plants has become a critical priority due to the increasing number of rare or endangered plant species (Jain *et al*., 2012). According to Okigbo *et al*. (2008), effective conservation strategies for medicinal plants should encompass four main areas: in-situ and ex-situ conservation, education, and research. Among these, on-farm conservation is the widely practiced in-situ technique for plant conservation; and it is integrated into the traditional agriculture systems (Jain *et al.*, 2012).

Efforts are required to recommend appropriate cropping patterns for the incorporation of medicinal plants into the conventional agricultural and forestry cropping systems (Rezaeieh *et al*., 2012). Cultivation of medicinal plants using traditional methods has the advantage of preserving the secondary metabolites that enhance medicinal efficacy and meet the global demand for raw medicinal materials (Mahapatra, 2012).

As global healthcare demand escalates, it is imperative to enhance the productivity of medicinal plants without depleting essential environmental sources. Recently, organic farming has emerged as a significant sustainable cultivation alternative due to growing awareness of the detrimental effects associated with conventional farming methods (Jiang *et al*., 2022). The term “organic agriculture” refers to the efficient use of locally available resources and the adaptation of sustainable agricultural practices (Badalingappanavar *et al*., 2018). Organic cultivation of medicinal plants is the simplest approach and contributes to increased biodiversity, better utilization of natural resources, higher yields of many plants, and reduced abundance of weeds and pests (Golijan & Marković, 2018). The application of different organic amendments can supply the nutrient requirements of organic medicinal plant cropping system (Raei & Milani, 2014). Given the significant

role of medicinal plants in various industries, it is crucial to increase biomass production without the use of harmful chemicals (Badalingappanavar *et al*., 2018). While fertilizers and pesticides remain important tools in agricultural production, their undesirable effects cannot be overlooked, particularly when sustainable agriculture is a universal focus (Prashar & Shah, 2016).

Food crop farmers, traditional healers, gatherers, street traders and shop traders have the capability to cultivate certain at-risk species. This cultivation could potentially alleviate the pressure on wild populations and promote conservation-friendly plant options. Golijan and Markovic (2018) emphasised that due to a lack of scientific data on the cultivation of medicinal plants, especially within organic systems, further research is necessary to enhance understanding of this system. Cultivating medicinal plants not only ensures a sustainable supply but can also has the potential to increase the income of smallholder farmers. This practice addresses issues of over-harvesting and resource degradation that have reduced the availability of wild materials. Additionally, the cultivation of medicinal plants is essential for creating opportunities to sustain livelihoods and for developing strong linkages between agriculture and sectors of the economy (Reinten & Coetzee, 2002; Alam & Belt, 2009).

On farm cultivation of medicinal plants offers a viable alternative source of raw materials. However, evidence regarding the willingness of traditional healers to source these materials from farms is limited. This study aims to evaluate willingness of medicinal plant users to utilize raw materials sourced from Western Cape smallholder farmers and to assess the potential for increasing the cultivation of medicinal plants in small-scale farms and home gardens. Additionally, the study will focus on opportunities for cultivating *Artemisia afra*, one of the most widely used indigenous medicinal herbs, by providing training to traditional healers and small-scale farmers on its cultivation practices.

1.2 Background to the research problem

Approximately 80% of the rural populations in developing countries rely on traditional medicinal plants for their health care needs (WHO, 2023). The African continent has a particularly high dependence on plant-based medicines compared to other regions (Shahidullah, 2007). In African settings, the tendency to self-medicate is remarkably prevalent among individuals with chronic diseases such as HIV, cancer, diabetes, and arthritis. This trend is exacerbated by poor socioeconomic status, holistic approaches and cultural beliefs that often hinder access to Western medicine (Muwanga, 2006; Latif, 2010).

Many industrially and commercially used pharmaceuticals originate from secondary metabolism in microbial or plant systems (Malik *et al*., 2001). As a result, the availability of valuable plant resources is diminishing at an alarming rate due to unsustainable use, increasing economic importance (Alam, 2004), environmental factors, poor harvesting and management techniques (Magoro, 2008; Thakur *et al*., 2014). The growing global interest in medicinal plants has created a sustained demand and the hidden trade in plant materials leads to indiscriminate harvesting of wild varieties and thus posing a serious threat to biodiversity (Deshpande *et al*., 2006).

1.3 Statement of the research problem

In South Africa, many plants used in traditional medicines are predominately collected from wild populations (Alam, 2004). The high demand for these medicinal plants exerts immense pressure on their natural populations due to extensive harvesting. For most popular and commonly used medicinal plant species, including *Artemisia afra,* little to no conservation action has been implemented. African wormwood (*A. afra*) is one of South Africa's most widely used medicinal plants and is extensively utilized in traditional herbal preparations (Gwebu, 2003). It is used to treat a variety of conditions, including coughs and colds, flu, dyspepsia, loss of appetite, stomach-ache, croup, gout, headaches, inflammation, sore throat, asthma, and other health related conditions (du Toit & van der Kooy, 2019). Recently, after Madagascar promoted an *A. afra* tonic as a remedy against Coronavirus (Covid-19), there has been a significant increase in the harvesting of this plant for personal use and commercial gain, placing South Africa's wormwood species under increased pressure (Cowan,

2020; Feni & Khoza, 2020). Traditional doctors, environmentalists and biodiversity conservationists have raised concerns about the possible over-harvesting of *A. afra*, which could lead to its depletion in certain areas (Cowan, 2020; Feni & Khoza, 2020).

The over-exploitation of medicinal plants from *in-situ* sources poses a significant threat to natural resources (Shahidullah, 2007). The supply of wild medicinal plant stocks is declining, and highly valued species are becoming inaccessible due to over harvesting, extinctions, and rapidly rising market prices (Mander *et al*., 2007). An increase in demand, value and quantity sold for a species indicates potential overexploitation, which can threaten its persistence in the wild (Williams *et al*., 2007). The current production levels of medicinal plants through commercial farming are insufficient to meet the trade demand (Mander *et al*., 2007). Consequently, modern farming technology alone cannot address the world's pressing healthcare needs (Shahidullah, 2007).

In Africa, research on medicinal plants has generated substantial information; however, the integration of medicinal plants into traditional cropping systems remains underexplored (Amujoyegbe *et al*., 2012). Despite the efforts of numerous research institutes, their contributions have had minimal impact on farmers and medicinal plant users. The participation of these stakeholders in the research process is negligible, as most of studies are conducted in laboratories. Therefore, researchers miss the opportunity to leverage the practical experience of farmers' and local community members who utilize medicinal plants. While there has been a significant emphasis on the potential for discovering new drugs, insufficient attention has been given to the various challenges associated with the use of traditional medicines by local populations (WHO, IUCN & WWF, 1993).

Shava (2011), highlights the need for education, awareness and initiatives to propagate and conserve medicinal plants among users. This approach involves engaging local traditional health practitioners, who are significant users of medicinal plant resources, by raising awareness about the current status of medicinal plants and promoting their cultivation. Thus, increasing production requires a strategy focused on cultivation techniques, research, and development, while also considering economic growth to ensure the expansion and sustainability (Samanhudi *et al*., 2014).

Additionally, prioritizing the cultivation of organic medicinal plants is crucial, given the increasing global demand for organic medicinal and aromatic products (Raei & Milani, 2014).

To our knowledge, despite the increasing significance of *A. afra*, there have been few efforts to initiate practical research examining the effects of organic amendments on its growth, secondary metabolites, and antioxidant capacities. Moreover, limited research has been conducted to promote collaboration between community participants and research institutes to identify essential management and cultivation interventions for the conservation of existing medicinal plant species.

1.4 Literature review

1.4.1 *Artemisia afra*

Artemisia afra Jacq., ex Willd, commonly known as African wormwood is one of the most popular and extensively used herbal medicines in southern Africa (Liu *et al*., 2009; DAFF, 2012). It is also referred to as “umhlonyane” (Xhosa, Zulu), “lengana” (Sotho, Tswana) and “wilde als” (Afrikaans) (van Wyk *et al*., 1997; Gwebu, 2003; Swart, 2020). In Europe, Iran, Siberia, and North Africa, it is commonly known as mugwort (van der Walt, 2004). *A. afra* is the sole *Artemisia* species native to sub-Saharan Africa (van Wyk *et al*., 1997; Gakuba, 2009), with a medical reputation dating back to the 15th century. The name “*Artemisia*” originates from the ancient Greek word ‘Artemis’ referring to the Greek goddess associated with the hunt, wildlife, vegetation, chastity and childbirth, later identified with Diana by the Romans (Vuuren, 2007; Koul *et al*., 2018). The term ‘Wormwood’ reflects its traditional use as a remedy for intestinal worms (Koul *et al*., 2018).

A. afra belongs to the family Asteraceae, also known as the ‘compositae family’, ‘sunflower family’, ‘thistle family’ or ‘daisy family’. The Asteraceae family comprises approximately 600 genera, encompassing diverse species such as asters (daisies), arnica, chamomile, goldeneye, marigold, snakeroot, tansy, thistle, and wormwood (Aronson, 2015). In southern Africa, Asteraceae is one of the largest families of flowering plants, with around 246 genera and 2 300 species, many of which hold

economic value (Koekemoer, 1996; Herman, 2004). The popularity of African wormwood can be attributed not only to its wide use in treating respiratory ailments but also to its abundant presence in the wild (Vuuren, 2007).

1.4.2 Distribution of *A. afra*

Artemisia afra is widely distributed in the southern tropical eastern area of Africa including countries such as Kenya, Zimbabwe, Tanzania, and Angola (Gwebu, 2003; Liu *et al*., 2009). In South Africa, *A. afra* is a common species found across all provinces except the Northern Cape (DAFF, 2012). The plant is abundant in mountainous regions along forest margins and streams in the South Western Cape and is frequently found along the eastern coast. Its natural distribution extends from the Northern and Eastern Mpumalanga, Limpopo, and the North West province to the Western Cape. Additionally, it grows wild in Lesotho, Swaziland and further north into tropical Africa (Gwebu, 2003; van Wyk & Gericke, 2005; Kriel, 2010; DAFF, 2012).

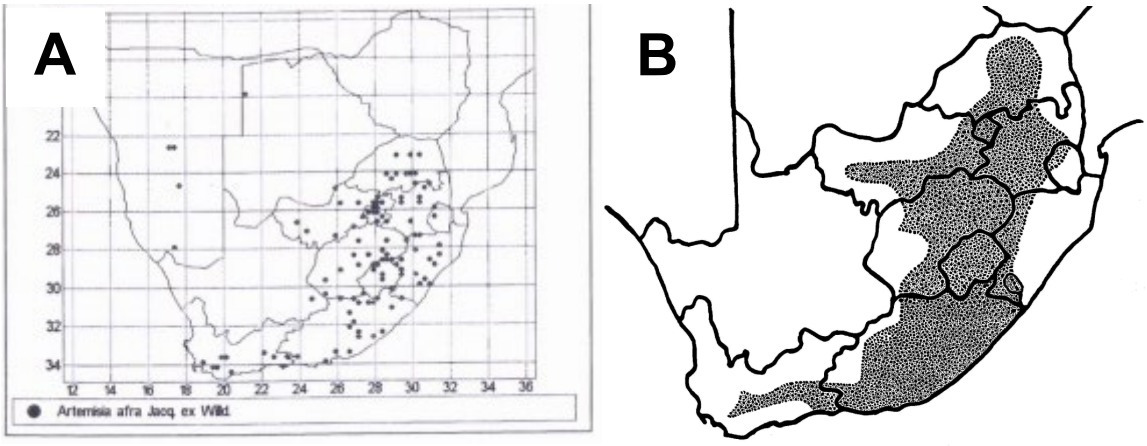


Figure 1.1: (A) Geographical distribution map of *A. afra* in southern Africa (B) Distribution map of *A. afra* in South Africa. Adapted from: (Gwebu, 2003; Scott & Springfield, 2004).

1.4.3 Morphological characteristics of *A. afra*

A. afra is an upright and highly aromatic perennial woody shrub with multiple stems ranging from 0.6 m up to 2 m in height (van Wyk *et al*., 1997; van Vuuren, 2007; Gakuba, 2009; DAFF, 2012; Swart, 2020). The plant features leafy, hairy, and ridged stem, with basal stems that are thick, firm, and woody compared to the upper parts.

The leaves are feathery, oval shaped, and emit a sweet aroma when touched, cut, or crushed (van Vuuren, 2007; Gakuba, 2009; du Toit & van der Kooy, 2019) (Figure 1.2A). They are narrowly ovate, bi-pinnatipartite and finely divided, with linear segments ending in an acute tip and smooth or toothed margin, reaching up to 10 mm in length and 2 mm width (Dube, 2006). The overall appearance of *A. afra* is greyish-green due to the two-toned leaf coloration: dark green on the upper surface and covered with small white hairs on the underside (Gakuba, 2009). The plant produces small (3-4 mm in diameter) creamy to pale, yellow-coloured flowers in late summer, typically from March to May (Figure 1.2B). In areas susceptible to frost, it regresses in winter and re-grows in spring (Gakuba, 2009; Swart, 2020).

Figure 1.2: (A) *A. afra* aromatic, oval shaped and greyish-green leaves. (B) Pale yellow flowers of *A. afra*.

1.4.4 Growth requirements and propagation of *A. afra*

Artemisia requires lower inputs compared to conventional crops, including reduced needs for planting, tillage, fertilizer and pest control (Hansen-Quartey *et al*., 1998). *A. afra* thrives in temperate and subtropical regions and can be successfully cultivated where annual rainfall exceeds 650 mm (DAFF, 2012). The optimal temperature range for African wormwood growth is between 10 to 35ºC with the best growth occurring between 13 to 29°C (DAFF, 2013). High summer humidity or rainfall often leads to foliage decline (Amidon *et al*., 2014). The plant can grow in soils ranging from volcanic ash, loamy sands, to sandy or calcareous clay loams of volcanic or granite origin (Gwebu, 2003; Van der Walt, 2004). However, it thrives best in well-drained, sandy, sandy loam and loam soils with a pH ranging from 5,0 to 7,5 (DAFF,

2013). While it can tolerate poor soils, *A. afra* is vulnerable to root rot in excessively wet conditions (Amidon *et al*., 2014).

Artemisia afra can be propagated through root or stem cuttings. According to Amidon *et al*. (2014) African wormwood is best propagated from seed or slips from spring through fall. Seeds should be sown 50 cm apart within rows, with a distance of 1,5 m between rows (DAFF, 2013), at a depth of 5 mm below the soil surface (Gwebu, 2013). Regular irrigation is necessary after transplanting, particularly during the first 3 months, to establish the plants (DAFF, 2012). Heavy pruning during winter will encourage new growth in spring (Amidon *et al*., 2014).

1.4.5 Medicinal and traditional uses of African wormwood

Fresh, and dried leaves of *Artemisia afra,* along with the young stems and roots, are used as ingredients to prepare herbal infusions, decoctions, molasses and tinctures (Gwebu, 2003; DAFF, 2012). The extensive list of health conditions treated with *A. afra* suggests it may be considered a panacea. Traditionally, African wormwood can be smoked, snuffed or consumed as a tea to address various ailments (DAFF, 2012; Swart, 2020), including coughs and colds, chills, bronchial complaints, blocked nasal passages, dyspepsia, measles, loss of appetite, stomach-ache, gastric derangements, colic, croup, fever, gout, purgative, flu, headaches, earache, convulsions, inflammation, sore throat, heartburn, malaria, diabetes, bladder and kidney disorders, asthma, intestinal worms, constipation, arthritic and rheumatic swelling (Roberts, 1990; van Wyk *et al*., 2005; SANBI, 2006; Thring & Weitz, 2006; Liu *et al*., 2009; DAFF, 2012; Sunmonu & Afolayan, 2012; du Toit & van der Kooy, 2019; Swart, 2020). While tea infusion is common, the most frequent method of use is inhaling steam from boiled leaves (van Wyk *et al*. 2002). Van Wyk *et al*. (2005) further explain that for headache and nasal congestion, *A. afra* can be used as an inhalant or applied as a lotion to treat haemorrhoids. Warmed leaves can be used externally as a poultice to relieve inflammation, and aqueous infusions can be administered rectally (Felhaber, 1997; SANBI, 2006).

According to Skeenkamp (2003), the genitals can be steamed with *A. afra* to alleviate menstrual cramps. Additionally, *A. afra* is used by women to regulate the

menstrual cycle, enhance fertility, ameliorate menopausal symptoms, and serve as either abortifacients or as antiabortifacients. In traditional practices, fresh leaves are placed in boiling water to create steam for postpartum care (SANBI, 2006). Other applications include placing leaves in socks to prevent sweating, using them on wounds and employing them as an insecticide (von Koenen, 2001). Several nutraceuticals have been developed containing dried *A. afra* plant material, which are taken orally to treat some of the aforementioned ailments (Figure 1.3).

Figure 1.3: Some of African wormwood processed products.

Adapted from: (A): https://earthboundorganics.co.za/product/artemisia-afra/; (B): https://www.amazon.com/Miracle-Botanicals-Wormwood-Essential Artemisia/dp/B078Y9QC2R; (D): Vyawahare (2020) (C & E): http://www.artemisia.co.za/; (F): https://www.indizatea.com/product/artemisia-tea/;.

1.4.6 Phytochemical constituents and bioactive compounds of *A. afra*

Artemisia afra, a widely recognized plant in ethnopharmacology (Liu *et al*., 2009), has recently attracted growing scientific interest for its potential in managing modern diseases such as diabetes, cardiovascular diseases, cancer, and respiratory disorders (Patil *et al*., 2011). In southern Africa, *A. afra* along with other species such

as *Artemisia armeniaca*, *Bidens pilosa*, *Solanecio mannii* and *Solanecio nandensis* has been traditionally used in the management of various cancers, notably those affecting the skin, breast, and colon (Raimi *et al*., 2020). In a study screening 7500 different plant extracts for anti-cancer properties, Fouche *et al*. (2008) identified *A. afra* as one of 32 plant extracts showing significant anti-cancer activity, specifically against melanoma, renal, and breast cancer. (As part of this study, a paper was **Published in the** *Journal of Medicinal Plants for Economic Development*, 5(1), focusing on the management of cancer attributed to the reported anti-cancer activities of *A. afra*. **The paper is titled** "Recognising the impact of traditional herbal medicine in managing cancer: The South African context" (see Appendix 1).

A. afra exhibits antiviral, antibacterial, antiseptic, antidepressant, and anti-inflammatory activities (Liu *et al*., 2009; Swart, 2020). Species within the genus *Artemisia* are frequently employed in the treatment of ailments including malaria, diabetes, hepatitis, and various bacterial, fungal and viral infections (Gwebu, 2003; van Vuuren, 2007; Liu *et al*., 2009).

Numerous sesquiterpenes have been identified across *Artemisia* species (Gakuba, 2009). As documented by Liu *et al*. (2009) *A. afra* is reported to contain both volatile and non-volatile secondary metabolites, including monoterpenoids, sesquiterpenes, glaucolides, guaianolides, and flavonoids. Essential oils derived from African wormwood are primarily composed of α-thujone, β-thujone, camphor, 1.8-cineole and bomeol (Gwebu, 2003). Significant quantities of flavonoids such as luteolin, kaempferol, apigenin, hesperetin and quercetin are also found in *A. afra*, which are believed to contribute to the bronchodilatory effects observed in its extracts (Dube, 2006; Mjiqiza *et al*. 2013; Nkengla, 2014; Tikiso, 2015).

In a study by Kane *et al*. (2019), phytochemical screening of extracts from *A. afra* revealed the presence of terpenoids, alkaloids, tannins, saponins and cardiac glycosides. This investigation suggested that African wormwood holds promise as a source for discovering potential antimalarial compounds or lead compounds. *A. afra* is notably rich in terpenes, which likely contribute to its valuable biological activities (Liu *et al*., 2009). This assertion is supported by Bora and Sharma (2011), who noted that among various *Artemisia* species; *A. afra* is particularly rich in terpenoids. Additionally, it has been documented to exhibit broad-spectrum inhibitory activity

against various microorganisms due to the presence of essential oils (Liu *et al*., 2009; Muleya *et al*., 2014).

1.5 Cultivation of medicinal plants

South Africa hosts approximately 20 000 known plant species, representing about 10% of all plant species on Earth (Poulsen, 2020). The country also supports over 200 000 practicing traditional healers who primarily use medicinal plants and herbs to prepare therapeutic substances (Hassim *et a*l., 2007; McFarlane, 2015). One in every four prescription drugs have been derived from plants or synthetic copies of plant chemicals, underscoring the importance of conservation efforts (Alam, 2004; Ndawonde, 2015). Medicinal plants are valuable natural resources, but their unplanned development and over-exploitation have led to shortages and even extinction of several species (Deshpande *et al*., 2006). Conservationists and resource users are increasingly alarmed by threats such as uncontrolled trade, over-exploitation of wild plants, destructive harvesting techniques, and habitat destruction (Shahidullah, 2007).

As global population, particularly in Africa continues to increase, so does the demand for traditional medicines, placing greater pressure on medicinal plant resources (Rukangira, 2001). Despite this, the cultivation of medicinal plants in Africa remains nascent, with only a handful of countries such as Egypt, Libya, Madagascar, Morocco, Tunisia, Sudan, and South Africa actively pursuing viable cultivation efforts (Kuete, 2013). Recent increases in market prices for certain medicinal plants have been linked to their extinction or severe genetic loss, leading to diminished supplies. Consequently, there is a growing call among researchers to cultivate indigenous medicinal plants to address biodiversity and market sustainability concerns (WHO, IUCN & WWF, 1993; Macaskill, 2018). Conservation of biodiversity through cultivation of medicinally valuable plants is seen as crucial for meeting current and future demands for large-scale production of plant-based drugs and herbal preparations (Rajkumari & Sanatombi, 2016).

Research in South Africa is actively investigating cultivation and commercialization of indigenous plants to alleviate pressure on wild population (Rajkumari & Sanatombi,

2016; Tanga *et al*., 2018). However, the benefits and detriments of using cultivated medicinal plants have been widely debated. Some critics argue that traditionally it is not acceptable to use cultivated varieties (Keirungi & Fabricius, 2005). Contrarily, a recent report undertaken by Loundou (2008) revealed that a significant proportion of medicinal plant traders and users are willing to purchase and utilize cultivated medicinal plants. Furthermore, studies by Macaskill (2018) and Keirungi & Fabricius (2005) indicated a general acceptance of the farmed plant materials, both raw and dried, among most traditional healers and their clients in South Africa.

Developing appropriate frameworks and technologies for the cultivation of medicinal plants is essential to ensure a continuous and reliable supply (Phondani *et al*., 2016). The market demand for native South African herbs stimulates the introduction of these plants into cultivation (Webber, 1999). Cultivation not only provides an ecological and consistent supply of medicinal plant materials (Tanga *et al*., 2018) but also addresses the issues of overharvesting and resource degradation that have reduced the abundance of wild materials (Langford, 2013). For cultivation to succeed in providing an alternative supply source and alleviate harvesting pressure on wild stocks, plants must be produced cheaply and in large quantities (Cunningham, 1997). The growing demand for medicinal plant products as a means for primary health care in both developed and developing countries presents an opportunity for medicinal plants to serve as an appropriate substitute for traditional crop cultivation, enhancing employment with minimal competition in product quality, efficiency and commercialization (Tanga *et al*., 2018).

Despite ongoing efforts to promote the cultivation of medicinal plants, their adoption by farmers and users has faced significant challenges (Malik, 2007). Therefore, it is imperative for small-scale farmers and collectors/users to acquire expertise in the domestication, cultivation, and management of the most frequently used, endangered and extinct medicinal species. The ultimate objective it to achieve successful commercial cultivation that produces high quality drugs using low input methods (Hishe *et al*., 2016). Consequently, medicinal plant cultivation by various stakeholders and the establishment of community gardens may represent the future approach to ensuring a sustainable supply of both scarce and in-demand medicinal plant species.

1.5.1 Involvement of traditional healers in medicinal plant cultivation

The demand for medicinal plants exceeds their supply, necessitating education, awareness and proactive measures for their propagation and conservation among users. Traditional healers, as the key resource users and significantly impacting the availability of medicinal plants, should be integral to conservation projects (Wiersum *et al*., 2006). These healers utilize plant resources for treating diseases globally, yet the regeneration of these vital plants receives little to no attention. For effective conservation of these herbal resources and broader ecosystem, it is imperative that governments and stakeholders in renewable natural resource management establish medicinal plant farms in designated communities to ensure a stable supply and conservation of medicinal plants (Phondani *et al*., 2016; Olujobi *et al*., 2022).

Effective engagement between conservation practitioners, traditional healers and muthi gatherers is crucial to determine necessary management interventions for conserving medicinal plant species and ensuring their future availability (Oladele *et al*., 2011; SANBI, 2020). Traditional healers play a pivotal role in identifying native medicinal plants, their uses and appropriate conservation measures. Thus, accumulating information on medicinal plants through interactive discussions and practical training with communities is essential (Khan *et al*., 2005).

To acknowledge the significant role of traditional healers in medicinal plant conservation, it is crucial to actively involve them in conservation initiatives. Accordingly, numerous conservation organizations are endeavouring to create participatory programs that incorporate traditional healers (Botha, 1998). Cultivating medicinal plant species has been recommended to reduce the pressure on wild popu lations; however, some traditional healers and muthi traders resist this practice (Mbongwa *et al*., 2021). Despite cultural beliefs regarding the potency of cultivated medicinal plants, the continues decline of species may persuade traditional healers to adopt the use of cultivated plants (Shava, 2011).

Traditional healers' involvement is vital in developing cultivation trials and long-term conservation strategies. Strengthening indigenous techniques of medicinal and aromatic plant cultivation should be encouraged through cost-effective technologies (Phondani *et al*., 2016). Extinct, rare or endangered medicinal plants should be conserved in home gardens by traditional healers, medicinal plant traders and local

communities (Kumar & Nair, 2004). The scarcity of medicinal plants in natural habitats has shifted ethno-botanists focus to both wild and home-grown plants, with indigenous knowledge often linked more to home-garden plants (Semenye and Potgieter, 2014). Traditional healers have identified cultivation as a key conservation intervention and are willing to grow plants in their home gardens if seedlings are provided (SANBI, 2020). In a study conducted by Oladele *et al*. (2011), traditional medicinal practitioners have expressed interest in medicinal plant farms if they are available. This willingness will contribute to the conservation of these valuable natural resources by alleviating the pressure on wild populations.

1.5.2 Encouraging the cultivation of medicinal plants on farmers' fields

Many of today's biotechnological innovations tend to neglect resource-poor farmers, mainly because these technologies are not suitable for the challenging environments where these farmers operate (Altieri, 2003). While biotech investors favour conventional technologies like tissue culture and hydroponics, these methods are impractical for most farmers due to their high costs (Hartzell, 2011). Moreover, large-scale commercial hydroponic production of medicinal plants remains uncommon and requires significant capital investment (Macaskill, 2017). Farmers are more likely to adopt technologies that integrate smoothly with their existing farm management practices and align with their cultural and social values (Chinangwa, 2006).

Farmers are encouraged to diversify their crops to meet the demand and market opportunities for medicinal and aromatic plants (Sujatha *et al*., 2011). Cultivating medicinal crops on private land is essential not only for species conservation but also to ensure a sustainable supply of high-quality raw materials for the industry (Deshpande *et al*., 2006). Rashid *et al*. (2014) emphasized the need for comprehensive attention to the cultivation and management of medicinal plants by stakeholders, including farmers, users, researchers, policy planners and entrepreneurs, to achieve sustainability goals. As the global population increases and pharmaceutical and perfumery industries demand more medicinal plants, cultivating these crops offers an attractive alternative to conventional crops (Khan & Sharma, 2010).

According to Alam (2004), farmers are reluctant to convert large portions of their land to medicinal plants due to economic risks and often opt to use small areas

or fallow land instead. Farmers also lack experience in cultivating medicinal plants, posing significant challenges. However, cultivating medicinal and culinary plants offers a promising alternative, especially for small and medium-sized farms (Meyer, 2005). Many medicinal and aromatic plants thrive under natural stress conditions and require minimal agricultural inputs (Dangash, 2016). Horticultural investigations are essential for endangered species to determine optimal cultivation practices, including soil conditions, water management, fertilization, and shading requirements, as well as assessing planting and harvesting periods, yield potential, and financial returns (Ndawonde, 2015).

The cultivation of medicinal plant species on private land by farmers has proven successful in various regions (Deshpande *et al*., 2006). Eid (2000) documented the successful integration of medicinal plants into traditional farming systems in Guatemala, providing stable incomes to farmers. Medicinal plants provide significant income for indigenous farming communities, and they are valued for their high market prices and extended shelf life compared to conventional crops (Alam & Belt, 2009). Consequently, the cultivation of medicinal plants not only enhances income but also provides employment opportunities for rural communities (George *et al*., 2001; Deshpande *et al*., 2006; Wiersum *et al*., 2006; Rashid *et al*., 2014). It is possible to improve the livelihood of farmers by creating an environment that is supportive of the commercial cultivation of medicinal plants (Alam, 2004; Rashid *et al*., 2014). Joshi & Joshi (2014) confirmed through field surveys that medicinal plant cultivation can indeed uplift the livelihoods of impoverished farmers.

Engaging local communities directly and indirectly involved in the medicinal plant sectors and combining their traditional knowledge with scientific expertise is crucial for both conservation and livelihood enhancement (Phondani *et al*., 2016). Interested farmers play a vital role in conducting demonstrative cultivation trials and developing effective long-term conservation strategies (Phondani *et al*., 2016). Encouraging farmers to integrate medicinal plant species into their fields is essential for sustainable cultivation and conservation efforts (CAPART, 2007). This innovative approach aims to foster farmer participation in cultivating medicinal plants through practical farming systems (Nautiyal, 2016; Phondani *et al*., 2016).

1.5.3 Feasible and orthodox farming systems for promoting medicinal plant adoption on farmers' fields:

1.5.3.1 Intercropping (mixed cropping)

Modern farming techniques have largely replaced traditional indigenous methods, leading to unfeasible and unsustainable agricultural practices. To address this, alternative farming systems and approaches must be explored (Reddy, 2010). Many introduced technologies clash with traditional farming practices, highlighting the need for developing countries to integrate medicinal plant cultivation into existing cropping systems to enhance their value (Amujoyegbe *et al*., 2012). Mixed cultivation, or intercropping involves growing multiple species simultaneously on the same field; offering benefits such as yield stability and resource efficiency (Meyer, 2005). Intercropping remains a common practice among small farmers (ICRISAT, 1981; Kattel *et al*., 2002) and semi-intensive agricultural systems due to its labour flexibility and lower risk (Amujoyegbe *et al*., 2012).

Monocropping medicinal plants poses risks and uncertain economic returns, making farmers hesitant to adopt this practice. A viable solution is to promote the cultivation of medicinal plants intercropped with local food crops (Rawat & Puni, 2009). Limited land forces farmers to carefully select which crops to cultivate (Torri & Herrmann, 2011). Growing medicinal plants as cash crops alongside food crops (Tripathi, 2013) is a technique many farmers already use to maximize yields (Akre *et al*., 2016). Increasing pressure on land for food and commercial crops makes expanding medicinal crop areas alone challenging. Thus, including medicinal plants in intercropping systems is a potential solution to meet demand (Shafagh-Kolvanagh & Shokati, 2012), enhance farmers' marginal returns particularly for smallholders (Himmelstein *et al*., 2016; Kanta, 2015), satisfy market demand, and aid in wild conservation (Rawat & Puni, 2009). Besides being ecologically significant, localized integrated farming practices with low investment and no additional farmland required are increasingly promising due to the rising demand for medicinal plants and their products (Horse, 2000). Combining food production with medicinal plants can support organic farming goals by reducing pesticide and chemical fertilizer use (Meyer, 2005).

1.5.3.2 Organic cultivation

The desire for conservation has led to the search for technologies aimed at establishing sustainable organic production systems (Alves *et al*., 2014). Organic products have gained significant global popularity, prompting a marked increase in organic food production over recent decades due to high market demand (Raei & Milani, 2014). As this demand continues to grow, adoption of organic farming approaches becomes a viable option (Malik *et al*., 2001; Sujatha *et al*., 2011). Furthermore, given the increasing demand for organic products, especially medicinal and aromatic plants, efforts should focus on developing species that are suitable for cultivation under organic farming conditions (Malik, 2007).

Inorganic fertilizers play a crucial role in global crop production, forming a cornerstone of modern agriculture. However, increasing apprehensions regarding their environmental impact and future costs underscore the importance of integrating more organic materials into cultivation practices to enhance crop yields (Siddiqui *et al*., 2011). Organic farming offers a solution to the challenges posed by the unsustainable utilization of chemical fertilizers and pesticides in conventional cropping systems, thereby promoting bio-environmental sustainability (Raei & Milani, 2014).

Initiating trials for organic cultivation of medicinal plants should be a community-driven effort involving every grower (Government of Himachal Pradesh, 2006). According to Raei and Milani (2014), applying organic cultivation systems significantly improves morpho-physiological traits, growth parameters, biochemical constituents, yield components and essential oil yields in medicinal plants. The application of various organic amendments, combined cumulatively, supplies the nutrient requirements of organic medicinal plants. Organic cultivation ensures sustainable development across production, socio-economic, and ecological dimensions (Malik *et al*., 2001).

1.5.3.2.1 Application and benefits of organic amendments

Composting is a biological process whereby organic biodegradable wastes are converted into a hygienic, humus rich product that serves as a soil conditioner and organic fertilizer (Popkin, 1995). High-quality compost enhances soil with water retention, nutrients, organic matter, and beneficial microorganisms, thereby improving

crop health, growth, quality, and yields. Additionally, compost improves soil structure and long-term nutrient availability, aiding plants in tolerating drought and suppressing diseases (Ryan, 2003; Chinangwa, 2006). In South Africa, where only about 13% of the surface area is arable (Department of Agriculture, 2007), it is crucial to maintain and increase soil fertility (Goldblatt, 2010). Thus, developing sustainable soil fertility replenishment techniques is an urgent priority (Naidoo, 2009; Goldblatt, 2010).

The use of manure is an established technology suitable for small-scale farmers in South Africa, where mixed livestock and crop farming is common (Mkhabela, 2006). Studies have demonstrated that compost application enhances soil structure and fertility, thereby improving the development and productivity of medicinal plants (Edris *et al*., 2003; Adholeya and Prakash, 2004; Gharib *et al*., 2008; Hendawy & Khalid, 2011). These studies further reveal that both compost and liquid compost treatments increase essential oil content more effectively than chemical fertilizers. Furthermore, organic composts not only supply essential nutrients for plant growth but also offer a sustainable method for managing and disposing of farm residues (Alves *et al*., 2014).

In the modern context, concerns such as accumulating waste, limited freshwater and fossil fuel resources, decreasing biodiversity, and world hunger are prevalent (Leudtke, 2010). Composting helps mitigate significant environmental problems by reducing the volume of organic waste, thereby addressing issues related to the disposal of large quantities of organic matter (Sabiiti, 2011). Researchers are urged to collaborate with farmers to document the impacts of organic amendments on plant health, soil fertility, and microbiological quality. This collaboration will enable farmers to make informed decisions about compost into their production systems (Scheuerell, 2004).

Among the numerous organic amendments applied to soil to support crop production, the most commonly used are compost and animal manure, along with peat moss, wood chips, straw, sewage sludge and sawdust (Goss *et al*., 2013). Studies have demonstrated the benefits of using of compost and animal manure as organic substrate additives in plant cultivation and in suppressing soil-borne diseases (Siddiqui *et al*., 2011). These amendments also provide biological control against various plant pathogens (Hoitink & Grebus, 1994). Organic manures have been reported to increase yields and chemical constituents in *Plantago arenaria* (Kolodziej, 2006). Additionally,

the application of organic manure is a key factor in increasing biomass and essential oil production in many medicinal plants, as it supplies nutrients and improves their uptake (Alves *et al*., 2014). Antonious (2016) highlighted a significant gap in knowledge regarding the impact of organic amendments on the nutritional and antioxidant properties of plants, underscoring the need for ongoing research in the organic cultivation of medicinal plants.

Many traditional healers assert that cultivated plants treated with agrochemicals such as fertilizers, pesticides, and insecticides, lack the medicinal efficacy of wild plants (Macaskill, 2018). Webber (1999) reported that to secure sales in first world markets, herbs must be organically farmed, as these markets demand medicinal plants that are free from residues of pesticides, herbicides, heavy metals, and radioactive contaminants.

1.5.4 Community based research in higher institutions

Communities play a crucial role in biodiversity conservation efforts (Berkes, 2007). The effectiveness of conservation projects, which are vital for protecting and preserving natural environments and resources, significantly depends on the active involvement of local communities. Community-based research is a collaborative effort between academic researchers and community members to address community identified needs, exchange knowledge and contribute to social change (Strand *et al*., 2003). Such studies reduce conflict and litigation, enhance trust among stakeholders, increase community capacity to address problems, and improve natural resource management (Ansell & Gash., 2008; Smith 2009; Thomas and Koontz, 2011). This approach emerged in response to criticism that higher education institutions often fail to adequately respond to community needs. Therefore, it is crucial to assess the knowledge, attitudes, and practices of traditional healers and small-scale farmers in Western Cape communities, with a focus on the cultivation of medicinal plants. Community based research in higher institutions plays a vital role in this context by fostering collaboration between academic researchers and community members. This collaboration ensures that the research addresses the real needs and concerns of the community while also enhancing the distribution, acceptance, and practical application of researchers' findings. Engaging the community in the research process leads to

more relevant and impactful outcomes, improves trust between stakeholders, and empowers communities to manage their natural resources more effectively.

1.5.5 Collaborations between farmers and research institutes: brief overview

Although several research institutes in South Africa are focusing on medicinal plants, there has been insufficient effort to establish a robust partnership between these institutes and farmers regarding the cultivation of medicinal plants. The current relationship between research institutes and farmers is minimal, leading to a disconnect where farmers' issues are not adequately addressed in research initiatives (Nayak *et al*., 2016). Studies indicate that wild collection of medicinal plants remains the primary source of supply. Without effectively transferring cultivation technologies to farmers, large-scale collection will persist, and farmers will likely remain hesitant to cultivate medicinal plants (Alam & Belt, 2004). According to Kala and Silori (2013), the weak links between research institutes and farmers create significant communication barriers, which limit researchers' ability to comprehensively address the challenges faced by farmers.

Strengthening communication channels between researchers, institutional extension services, and farmers is crucial (Singh, 2009). Addressing the challenges in the medicinal plant sector requires building effective partnerships among farmers, non-governmental organizations, researchers and more importantly by enhancing information exchange (Maikhuri *et al*., 2005). Such collaboration would enable researchers to gain a deeper understanding of the challenges encountered by farmers (Bogers *et al*., 2006).

Farmers and professional researchers possess distinct knowledge and skills that can complement each other, leading to more effective outcomes through collaboration than when working in isolation. Often, the strengths of farmers and the limitations of researchers are overlooked, resulting in superficial communication and interaction between the two groups (Hoffmann *et al*., 2007). Various cultivation practices, such as intensive farming, organic farming and sustainable agriculture have been identified and proven effective in farmers' fields (Bogers *et al*., 2006). A better understanding of famers' issues can help researchers define their roles in the research process, recognizing the strengths and weaknesses of both their own and farmers' research approaches, bridge communication gaps, and develop creative solutions for

challenges that arise during cultivation (Hoffmann *et al*., 2007). Such collaboration can enhance information exchange and accelerate the cultivation of medicinal plants (Maikhuri *et al*., 2005).

1.5.6 Collaboration among traditional healers and research institutes

Certain aspects of the above collaborations were published in: *Plant Archives*, 21(2): 632-638. Embracing herbal medicine through collaboration among traditional healers, biomedical health practitioners and research institutes: A review (see Appendix 2).

1.6 Research hypotheses

a) Different organic amendments will significantly impact the growth of *Artemisia afra*, with some amendments proving more effective than others.
b) The application of different organic amendments will significantly affect the levels of secondary metabolites and antioxidant activity in *A. afra*, due to their chemical and physical properties.
c) The willingness of traditional healers to adopt and use cultivated plant material will differ depending on factors such as the quality and efficacy of plants grown in home gardens and supplied by smallholder farmers.
d) A comprehensive list of plant species prioritized and frequently used by traditional healers will be compiled, reflecting their importance and use in traditional medicine.
e) Traditional healers will provide valuable insights into the conservation status and depletion of indigenous plants, including *A. afra*, highlighting issues related to its demand, availability, and medicinal uses.
f) Training workshops on cultivation techniques will improve the expertise and practices of small-scale farmers and traditional healers, leading to improved medicinal plant production.

1.7 Objectives of the research

1.7.1 Main objective

This study aimed to develop and implement cost-effective organic cultivation techniques to optimize plant growth and metabolite content of *Artemisia afra* in the

Western Cape. Additionally, investigated traditional healers willingness to adopt these cultivation practices and utilize raw materials produced by smallholder farmers. Ultimately, the study aimed to equip traditional healers and small-scale farmers with essential medicinal plant cultivation techniques, fostering sustainable agricultural practices.

1.7.2 Specific objectives

a) To evaluate the growth performance of *A. afra* under different organic amendments and identify the most effective amendment for maximizing plant development, to be recommended to traditional healers and farmers.
b) To investigate the impact of different organic amendments on the secondary metabolites and antioxidant activity of *A. afra*.
c) To evaluate and document traditional healers' willingness to utilize and accept cultivated plant material, with an emphasis on plants grown in home gardens and supplied by smallholder farmers.
d) To compile and document a list of plant species identified as high priority and frequently utilized by traditional healers in the Western Cape.
e) To investigate traditional healers' perspectives on the conservation status and depletion of indigenous plants, with a specific focus on the demand, availability, and medicinal uses of *A. afra*.
f) To organize and conduct training workshops for small-scale farmers and traditional healers, focusing on diverse cultivation techniques and their effectiveness in enhancing the production of medicinal plants.

1.8 References

Adholeya, A. & Prakash, A. 2004. Effect of different organic manures/composts on the herbage and essential oil yield of *Cymbopogon winterianus* and their influence on the native AM population in a marginal alfisoil. *Bio resource Technology.*, 92: 311−9.

Akre, M., Kharat, R. & Ghotankar. A. 2016. A brief review on inter-cropping method for cultivation of medicinal plants. *World Journal of Pharmaceutical Research.*, 5(10): 392−400.

Alam, G. 2004. Database on medicinal plants. CUTS Centre for International Trade, Economics & Environment. http://www.cuts-international.org/pdf/Database-fullreport.pdf. Date accessed: 8/08/2017.

Alam, G. & Belt, J. 2004. Searching synergy: stakeholder views on developing a sustainable medicinal plant chain in Uttaranchal. Bulletin 359, Royal Tropical Institute.

Alam, G. & Belt, J. 2009. Developing a medicinal plant value chain: Lessons from an initiative to cultivate Kutki (*Picrorhiza kurrooa*) in Northern India. KIT Working Papers Series C5. Amsterdam: KIT

Altieri, M.A. 2003. The case against agricultural biotechnology. Corp Watch. https://corpwatch.org/article/case-against-agricultural-biotechnology. Date accessed: 10/01/2019.

Alves, P.A.C., Gross, E., Costa, L.C.B., Silva, C., Correa, F.M. & de Oliveira, R.A. 2014. Biomass and essential oil production from menthe is influenced by compost and lime. *Journal of Medicinal Plant Research.*, 8(12): 468−474.

Amazon. 2020. Miracle Botanicals Organic African Wormwood Essential Oil. https://www.amazon.com/Miracle-Botanicals-Wormwood-Essential-Artemisia/dp/B078Y9QC2R. Date Accessed: 23/11/2020.

Amidon, C., Barnett, R., Cathers, J., Chambers, B., Hamilton, L., Kellett, A., Kennel, E., Montowski, J., Thomas, M.A. & Watson, B. 2014. Artemisia- An Essential guide from the Herb Society of America. Caroline, A., Thomas, M., Kennel, E., Eds.

Amujoyegbe, B.J., Agbedahunsi, J.M &. Amujoyegbe, O.O. 2012. Cultivation of medicinal plants in developing nations means of conservation and poverty alleviation. *International Journal of Medicinal and Aromatic Plants.*, 2(2): 345−353.

Ansell, C., & Gash, A. 2008. Collaborative governance in theory and practice. *Journal of Public Administration Research & Theory*., 18(4): 543–571.

Antonious, G.F. 2016. Soil amendments for agricultural production. Organic fertilizers: from basic concepts to applied outcomes. Larramendy, ML, and Soloneski, S. (eds.). Intech, Rijeka, Croatia: 157−187.

Aronson, J.K. ed. 2015. Meyler's side effects of drugs: the international encyclopedia of adverse drug reactions and interactions. 16th ed. Asteraceae. Elsevier. https://doi.org/10.1016/B978-0-444-53717-1.00335-8.

Badalingappanavar, R., Hanumanthappa, M., Veeranna, H.K., Kolakar, S. & Khidrapure, G. 2018. Organic fertilizer management in cultivation of medicinal and aromatic crops: a review. *Journal of Pharmacognosy and Phytochemistry.*, 126−129.

Berkes, F. 2007. Community-based conservation in a globalized world. *Proceedings of the National academy of sciences.*, 104(39): 15188−15193.

Bogers, R.J., Craker, L.E. & Lange, D. 2006. Medicinal and aromatic plants: agricultural, commercial, ecological, legal, pharmacological, and social aspects.

Bora, K.S. & Sharma, A. 2011. The genus *Artemisia*: a comprehensive review. *Pharmaceutical Biology.*, *49*(1): 101−109.

CAPART (Council for Advancement of People's Action and Rural Technology). 2007. Guidelines for formulation of project proposal for sustainable cultivation and harvesting of medicinal plants. http://capart.nic.in/scheme/guidelines_med_plants.html. Date accessed: 20/06/2017.

Chinangwa, L.L.R. 2006. Adoption of soil fertility improvement technologies among smallholder farmers in Southern Malawi. A thesis submitted in fulfilment of the academic requirements of Master of Science. Norwegian University of Life Sciences.

Coetzee, M. 2019. Southern Africa's amazing indigenous medicinal plants have been used by inhabitants for centuries. Alberton Record.

albertonrecord.co.za/224510/southern-africas-amazing-indigenous-medicinal-plants-used-inhabitants-centuries/. Date accessed: 21/05/2020.

Cowan, D. 2020. Traditional medicine for COVID-19. Quest Volume 16 Number 3. ASSAf Research Repository. Academy of Science of South Africa (ASSAf).

Cunningham, A. B. 1997. An African-wide overview of medicinal plant harvesting conservation and health care. *Medicinal plants for forest conservation and health care*., 11: 116−129.

Department of Agriculture, Forestry and Fisheries. 2007. Sectoral overview and performance. https://www.nda.agric.za/docs/stratplan07/07sectoral.pdf. Date Accessed: 02/03/2021.

Department of Agriculture, Forestry and Fisheries. 2012. African wormwood. https://www.dalrrd.gov.za/Portals/0/Brochures%20and%20Production%20guidelines/Brochure%20Wormwood.pdf. Date Accessed: 10/12/2020.

Department of Agriculture, Forestry and Fisheries. 2013. Medicinal plants of South Africa.https://www.dalrrd.gov.za/Portals/0/Brochures%20and%20Production%20guidelines/Brochure%20Medical%20Plants%20Of%20South%20Africa.pdf. Accessed: 01/02/2021.

Dangash, A. 2016. Amendment of artemisinin content in *Artemisia annua* L. through in *vivo* and in *vitro* approach. Thesis Submitted to the Maharaja Sayajirao University of Baroda for the Degree of Doctor of Philosophy in Botany. Maharaja Sayajirao University of Baroda.

Deshpande, R.S., Neelakanta, N.T. & Hegde, N. 2006. Cultivation of medicinal crops and aromatic crops as a means of diversification in Agriculture. Research Report. Agricultural Development and Rural Transformation Unit, Nagarbhavi, Bangalore.

Dube, A. 2006. The design, preparation, and evaluation of *Artemisia afra* and placebos in tea bag dosage form suitable for use in clinical trials. A thesis submitted in partial fulfilment of the requirements for the degree of Magister Pharmaceuticiae in the School of Pharmacy, University of the Western Cape, Bellville, South Africa.

Du Toit, A. & van der Kooy, F. 2019. *Artemisia afra*, a controversial herbal remedy or a treasure trove of new drugs? *Journal of Ethnopharmacology.*, 244: 112–127.

Earthbound Organics. Unpublished. *Artemisia Afra*. https://earthboundorganics.co.za/product/artemisia-afra/.Date Accessed: 23/11/2020.

Edris, A.E., Ahmad, S. & Fadel, H.M. 2003. Effect of organic agriculture practices on the volatile aroma components of some essential oil plants growing in Egypt II: sweet marjoram (*Origanum marjorana* L.) essential oil. *Flavor and Fragrance Journal.*, 4: 345–351.

Eid, U. 2000. Medicinal plants in German development co-operation. In “Medicinal utilization of wild species: challenge for man and nature in the new millennium” (eds TRAFFIC/WWF). WWF Germany and TRAFFIC Europe, Hanover: 24–25.

Feni, L. & Khoza, M. 2020. Roaring trade as villagers cash in on umhlonyane as covid-19 'cure'. Available from: https://www.sowetanlive.co.za/news/south-africa/2020-05-14-roaring-trade-as-villagers-cash-in-on-umhlonyane-as-covid-19-cure/. Date accessed: 30/01/2021.

Felhaber, T. ed. 1997. South African Traditional Healers’ Primary Healthcare Handbook. Traditional aspects compiled by I. Mayeng. Kagiso, Cape Town: 48–57.

Fouche G., Cragg G.M., Pillay P., Kolesnikova N., Maharaj V.J. & Senabe, J. 2008. *In vitro* anticancer screening of South African plants. *Journal of Ethnopharmacology*., 119: 455–461.

Gakuba. E. 2009. Isolation and characterisation of secondary metabolites of two Asteraceae species, *Artemisia afra* and *Elytropappus Rhinocerotis*. Submitted in fulfilment of the requirements for the degree of Master of Science. School of Chemistry University of KwaZulu-Natal Pietermaritzburg.

George, J., Laing, M.D. & Drewes, S.E. 2001. Phytochemical research in South Africa. *South African Journal of Science.*, 97 (3-4): 93–105.

Gharib, F.A., Moussa, L.A. & Massoud, O.N. 2008. Effect of Compost and Bio-fertilizers on growth, yield and essential oil of Sweet Marjoram (*Majorana hortensis*) Plant. *International Journal of Agriculture and Biology.*,10(4): 381–387.

Goldblatt, A. 2010. Agriculture: Facts & Trends: South Africa. CEO WWF-SA.

Golijan, J. & Marković, D. 2018. The benefits of organic production of medicinal and aromatic plants in intercropping system. *Acta Agriculturae Serbica.*, *23*(45): 61–76.

Gomez, I. & Thivant, L. 2015. Training manual for organic agriculture. Food and Agriculture Organization of the United Nation (FAO). Technologies and practices for smallholder farmers.

Goss, M.J., Tubeileh, A. & Goorahoo, D. 2013. A review of the use of organic amendments and the risk to human health. *Advances in agronomy.*, 120: 275–379.

Government of Himachal Pradesh, 2006. Himachal Pradesh Forestry Sector Medicinal Plants Policy. Notified vide No. FFE-B-C (16)-8/2005.

Gwebu, L. 2003. *The antimicrobial activity and phytochemistry of African wormwood (Artemisia)*. A Thesis submitted for the partial fulfilment of the requirements for the degree of Masters of Science in Medicine (Pharmaceutical Affairs) at the University of Witwatersrand, Johannesburg.

Hassim, A., Heywood, M. & Berger, J. 2007. Health and Democracy: A Guide to Human Rights, Health Law and Policy in Post-apartheid South Africa. Cape Town: Siber Ink.

Hendawy, S. & Khalid, A. 2011. Effect of chemical and organic fertilizers on yield and essential oil of chamomile flower heads. *Medicinal and Aromatic plant science and biology.*, 5: 43−48.

Hansen-Quartey, J.A., Nyamapfene, K. & Materechera, S.A. 1998. Effects of aqueous extracts from *Artemisia afra* parts and soil on seed germination and early seedling development in selected plant species. *South African Journal of Plant and Soil.*, 15 (1): 1−5.

Herman, P.P.J. 2004. SANBI: *Asteraceae.* http://pza.sanbi.org/asteraceae. Date Accessed: 31/01/2021.

Himmelstein, J., Ares, A., Gallagher, D. & Myers, J. 2016. A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects. *International Journal of Agricultural Sustainability.*, 15(1): 1–10.

Hishe, M., Asfaw, Z. & Giday, M. 2016. Review on value chain analysis of medicinal plants and the associated challenges. *Journal of Medicinal Plants Studies.*, 4(3): 45–55.

Hoffmann, V., Probst, K. & Christinck, A. 2007. Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agriculture and Human Values.*, 24 (3): 355–368.

Hoitink, H.A.J. & Grebus M.E. 1994.Status of biological control of plant disease with composts. *Compost Science Utilization.*, 2: 5–12.

Horse, K.H. 2000. Cultivation of medicinal plants as mixed crops in Malenadu region: a study highlights how medicinal plants could be integrated into traditional cropping systems. India.

House of Indiza. 2021. *Artemisia* Tea. https://www.indizatea.com/product/artemisia-tea/. Date Accessed: 01/02/2021.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1981. Proceedings of the International Workshop on Intercropping, 10-13 Jan 1979, Hyderabad, India. Available from ICRISAT, Patancheru, A.P. 502 324.

Jain, M., Johnson, T.S. & Krishnan, P. 2012. Biotechnological approaches to conserve the wealth of nature: endangered and rare medicinal plant species, a review. *Journal of Natural Remedies.*, 12(2): 93−102.

Jiang, L., Chen, Y., Wang, X., Guo, W., Bi, Y., Zhang, C, Wang, J. & Li, M. 2022. New insights explain that organic agriculture as sustainable agriculture enhances the sustainable development of medicinal plants. *Frontiers in Plant Science*., 13: 959810.

Joshi, B.C. & Joshi, R.K. 2014. The role of medicinal plants in livelihood improvement in Uttarakhand. *International Journal of Herbal Medicine.*, 1(6): 55−58.

Kala, C.P. & Silori, C.S. (eds). 2013. Biodiversity, communities and climate change. The Energy and Resources Institute.

WHO, 2023. Traditional Medicine Day.

https://www.afro.who.int/regional-director/speeches-messages/traditional-medicine-day-2023?utm_source=chatgpt.com. Date accessed: 12/05/2025.

Kane, N.F., Kyama, M.C., Nganga, J.K., Hassanali, A., Diallo, M. & Kimani, F.T. 2019. Comparison of phytochemical profiles and antimalarial activities of *Artemisia afra* plant collected from five countries in Africa. *South African Journal of Botany.*, *125*: 126−133.

Kanta, S. 2015. Intercropping of some medicinal plants with Mulberry. *Cibtech Journal of Bio-Protocols.*, 4(1): 27−30.

Kasagana, V.N. & Karumuri, S.S. 2011. Conservation of medicinal plants (past, present & future trends). *Journal of Pharmaceutical Sciences and Research.*, 3(8): 1378.

Kattel, S., Chhetri, R.B. & Dhakal, S. 2002. Peanut cultivation and consumption in Nepal: A social and cultural perspective. Peanut in local and global food systems series report No.7. University of Georgia.

Keirungi, J. & Fabricius, C. 2005. Selecting medicinal plants for cultivation at Nqabara on the Eastern Cape Wild Coast, South Africa. *South African Journal of Science.*, 101(11): 497–501.

Khan, M., Mannan, M.A., Chowdhury, M.T.I., Irfanullah, H.M. & Nishat, A. 2005. Medicinal plant conservation through community participation.

Khan, N. & Sharma, H.O. 2010. Cultivation of medicinal and aromatic crops as a means of diversification in Agriculture in Madhya Pradesh. http://jnkvv.org/PDF/AERC/Study-93.pdf. Date accessed: 8/08/2017.

Khumalo, S.G., Fröde, A. & Sola, P. 2006. Guidelines for the sustainable harvesting of traditional medicinal plants in Zimbabwe. Southern Alliance for Indigenous Resources.

Koekemoer, M. 1996. An overview of the *Asteraceae* of southern Africa. In D.J.N. Hind and H.J Beentje (eds.), Compositae: systematics, 95-110. Royal Botanic Gardens, Kew, England.

Kolodziej, B. 2006. Effect of mineral fertilization on ribwort plantain (*Plantago lanceolata* L.) yielding. *Acta Agrophysica.*, 8(3): 637−647.

Koul B., Taak P., Kumar A., Khatri T., Sanyal I. 2018. The *Artemisia* Genus: A Review on traditional uses, phytochemical constituents, pharmacological properties and germplasm conservation. *Journal of Glycomics & Lipidomics.*, 7: 1−7.

Kriel, Y. 2010. The immune-modulating activity of *Artemisia afra*. Thesis submitted in fulfilment of the requirement for the degree, Magister Scientiae (M.Sc.) at the University of The Western Cape, South Africa.

Kuete, V. (eds). 2013. Medicinal plant research in Africa: Pharmacology and chemistry. Newnes. 1−887.

Kumar, B.M. & Nair, P.R. 2004. The enigma of tropical home gardens. *Agroforestry Systems*., 61: 135−152.

Langford, K. 2013. Agroforestry World. http://blog.worldagroforestry.org/index.php/2013/06/12/rising-demand-for-herbal-medicine-can-drive-medicinal-tree-cultivation/. Date accessed: 8/08/2017.

Latif, S.S., 2010. Integration of African traditional health practitioners and medicine into the health care management system in the province of Limpopo. Thesis presented in partial fulfilment of the requirements for the Degree of Master of Public Administration University of Stellenbosch, Stellenbosch.

Leudtke, B. 2010. Use of Compost Tea as a Nutrient Amendment for Plant Growth in a Re-Circulating Hydroponic System. System Solid Waste Research Program. Student Project Report. University of Wisconsin-Stevens Point.

Liu, N. Q., Van der Kooy, F. & Verpoorte, R. 2009. *Artemisia afra*: A potential flagship for African medicinal plants? *South African Journal of Botany.*, 75(2): 185–195.

Loundou, P.M. 2008. Medicinal plant trade and opportunities for sustainable management in the Cape Peninsula, South Africa. Thesis submitted in partial fulfilment of the requirement for the Degree of Master of Science. Stellenbosch University, Stellenbosch.

Macaskill, C. 2017. Hydroponics & undercover growing.

http://www.agrihandbook.co.za/index.php/book/services-technologies/hydroponics-undercover-growing?showall=1&limitstart. Date accessed: 24/08/2017.

Macaskill, C. 2018. Indigenous medicinal plants: Forestry and Industrial crops. http://www.agrihandbook.co.za/index.php/book/forestry-industrial-crops/indigenous-medicinal plants?showall=1&limitstart Date accessed: 24/08/2017

Magoro, M.D. 2008. Traditional health practitioners' practices and the sustainability of extinction-prone traditional medicinal plants. A thesis submitted in part fulfilment of the requirements for the degree of Master of Human Ecology. University of South Africa.

Mahapatra, B. N. 2012. Sustainable cultivation of medicinal plants: A multi dimentional solution of global problems. *Ancient Science of Life.*, 32 (Suppl 1): S104.

Maikhuri, R.K., Rao, K.S., Kandari, L.S., Joshi, R. & Dhyani, D. 2005. Does the outreach programme make an impact? A case study of medicinal and aromatic plant cultivation in Uttaranchal. *Current Science.*, 88 (9): 1480−1486.

Malik, R.P.S. 2007. Cultivation of medicinal and aromatic crops as a means of diversification of agriculture in Uttaranchal. Agricultural Economics Research Centre University of Delhi.

Malik, A.A., Sunghmitra, S. &. Ahmad, J. 2001. Chemical vs. Organic Cultivation of Medicinal and Aromatic Plants: the choice is clear. *International Journal of Aromatic and Medicinal Plants.*, 1(1): 5−13.

Mander, M., Ntuli, L., Diederichs, N. & Mavundla, K. 2007. Economics of the Traditional Medicine Trade in South Africa. South African Health Review. http://www.hst.org.za/uploads/files/chap13_07.pdf. Date accessed: 30/06/2017.

Mathibela, K.M. 2013. An investigation into aspects of medicinal plant use by traditional healers from Blouberg Mountain, Limpopo Province, South Africa. A dissertation submitted in fulfillment of the requirements for the degree: Masters of Science in Botany. Faculty of Science and Agriculture. University of Limpopo.

Mbongwa, N.S., Twine, W.C. & Williams, V.L. 2021. Medicinal plant cultivation: Beliefs and perceptions of traditional healers and muthi traders in KwaZulu-Natal and Gauteng, South Africa. *South African Journal of Botany*., 143: 123−132.

McFarlane, C. 2015. South Africa: The rise of traditional medicine. *Insight on Africa.*, *7*(1): 60−70.

Medico Herbs. 2015. Best natural remedies. Overview of Artemisia (Wormwood) http://www.artemisia.co.za/. Date Accessed 23/11/2020.

Meyer, R. 2005. Alternative crop plants and methods of cultivation. Office of technology assessment at the German bundestag. Working report.

Mjiqiza, S.J., Syce, J.A. & Obikeze, K.C. 2013. Pulmonary effects and disposition of luteolin and Artemisia afra extracts in isolated perfused lungs. *Journal of ethnopharmacology.*, 149(3): 648−655.

Mkhabela, T.S. 2006. A Review of the Use of Manure in Small-Scale Crop Production Systems in South Africa. *Journal of Plant Nutrition.,* 29 (7): 1157−1185.

Moeg, T.E. 2010. An investigation into the trade of medicinal plants by muthi shops and street vendors in the Limpopo Province, South Africa.

Mothibe, M.E. & Sibanda, M. 2019. African Traditional Medicine: South African Perspectives. Available from: https://www.intechopen.com/online-first/african-traditional-medicine-south-african-perspective. Date accessed: 21/05/2020.

Muleya, E., Ahmed, A.S., Sipamla, A.M., Mtunzi, F.M. & Mutatu, W. 2014. Evaluation of anti-microbial, anti-inflammatory and anti-oxidative properties *Artemisia afra*, *Gunnera perpensa* and *Eucomis autumnalis*. *Journal of Nutrition and Food Sciences.*, 4(6): 1−6.

Muwanga, C. 2006. An assessment of *Hypoxis hemerocallidea* extracts, and actives as natural antibiotic, and immune modulation phytotherapies. A thesis in partial fulfilment of the requirements for the degree of Magister Scientiae in the South African Herbal Science and Medicine Institute, Faculty of Natural Sciences, University of the Western Cape.

Naidoo, K.D. 2009. The practice, constraints and perceptions of improving soil quality through manure application: A case study of three smallholder farmer groups. Thesis submitted in partial fulfilment of the degree of M Agric (Food Security). University of KwaZulu-Natal, Pietermaritzburg.

Nautiyal, M.C. 2016. Herb farming can generate huge revenue for govt, jobs for locals. http://www.tribuneindia.com/news/uttarakhand/community/herb-farming-can-

generate-huge-revenue-for-govt-jobs-for-locals/318399.html. Date accessed: 14/08/2017.

Nayak, B.K., Nanda, A. & Bhat, M.A. 2016. Integrating Biologically- Inspired nanotechnology into medicinal practice. Advances in medical technologies and clinical practice.

Ndawonde, B.G. 2015. Education for Sustainable Development of Medicinal Plant Sellers: challenges in relation to marketing, sales, storage and conservation. A Thesis submitted in the fulfilment of the Doctors in Education Degree (D. Ed), University of Zululand.

Nkengla, A. 2014. Investigation of the in vitro bioavailability of luteolin from modified preparations of *Artemisia afra*. A Master's thesis, University of the Western Cape, Bellville.

Okigbo, R.N., Eme, U.E. & Ogbogu, S. 2008. Biodiversity and conservation of medicinal and aromatic plants in Africa. *Biotechnology and Molecular Biology Reviews.*, *3*(6): 127−134.

Oladele, A.T., Alade, G.O. & Omobuwajo, O.R. 2011. Medicinal plants conservation and cultivation by traditional medicine practitioners (TMPs) in Aiyedaade Local Government Area of Osun State, Nigeria. *Agriculture and Biology Journal of North America*., 2(3): 476−487.

Olujobi, O.J., Iyanda, M.K., Ayotunde-Ojo, M.O. & Ayodeji, A. 2022. Role of traditional medicine practitioners in the conservation of medicinal plants in Kwara State, Nigeria.

Patil, G.V., Dass S.K & Chandra, R. 2011. *Artemisia afra* and modern diseases. *Journal of Pharmacogenom & Pharmacoproteomics.*, 2(3): 1−22.

Phondani, P.C., Bhatt, I.D., Negi, V.S., Kothyari, B.P., Bhatt, A. & Maikhuri, R.K. 2016. Promoting medicinal plants cultivation as a tool for biodiversity conservation and livelihood enhancement in Indian Himalaya. *Journal of Asia-Pacific Biodiversity*., 9(1): 39–46.

Popkin, R. 1995. Good news for waste watchers: recycling, composting show results for the future. *Environmental Protection Agency Journal,* 21: 188–190.

Poulsen, Z. 2020. Endangered species day: Threatened plants of South Africa. https://botanicalsociety.org.za/endangered-species-day-threatened-plants-of-south-africa/. Date accessed: 27/02/2021.

Prashar, P. & Shah, S. 2016. Impact of fertilizers and pesticides on soil microflora in agriculture. In *Sustainable agriculture reviews*. Springer, Cham. 331-361.

Prinsloo, G., Viljoen, J.C. & Du Plooy, C.P. 2011. Effect of nitrogen fertilisation on the growth of *Artemisia afra* and its antimicrobial activity. In II International Symposium on Underutilized Plant Species: Crops for the Future-Beyond Food Security 979: 357-364.

Raei, Y. & Milani, M. 2014. Organic cultivation of medicinal plants: a review. *Journal of Biodiversity and Environmental Sciences.*, 4 (4): 6−18.

Rajkumari, S. & Sanatombi, K. 2016. Medicinal Plants and its therapeutic uses: biodiversity and conservation of medicinal plants. OMICS Group eBooks.

Raimi, I.O., Kopaopa, B.G., Mugivhisa, L.L., Lewu, F.B., Amoo, S.O. & Olowoyo, J.O., 2020. An appraisal of documented medicinal plants used for the treatment of cancer in Africa over a twenty-year period (1998–2018). *Journal of Herbal Medicine.*, 23: 100371.

Raimondo, D. 2011. The red list of South African plants-a global first. *South African Journal of Science*, 107(3): 1–2.

Rasethe, M.T., Semenya, S.S. & Maroyi, A. 2019. Medicinal Plants Traded in Informal Herbal Medicine Markets of the Limpopo Province, South Africa. *Evidence-Based Complementary and Alternative Medicine.*, 2019.

Rashid, A.Z.M., Tunon, H., Khan, N.A. & Mukul, S.A. 2014. Commercial cultivation by farmers of medicinal plants in northern Bangladesh. *European Journal of Environmental Sciences.*, 4(1): 60−68.

Rawat, N. & Puni, L. 2009. Intercropping of medicinal and aromatic plants with vegetable crops - a review. *Centre of Minor Forest Products for Rural Development & Environmental Conservation.*, 19(2): 14−18.

Reddy, B.S. 2010. Organic Farming: Status, Issues and Prospects – A Review. *Agricultural Economics Research Review.,* 23: 343−358.

Reinten, E. & Coetzee, J.H. 2002. Commercialization of South African indigenous crops: aspects of research and cultivation of products. *Trends in new crops and new uses. ASHS Press, Alexandria, VA*, 76−80.

Rezaeieh, K.A.P., Gürbüz, B. & Uyanik, M. 2012. Screening global challenges and prospects facing medicinal and aromatic plants. *Manas Fen Bilimleri Dergisi.*, 2(13): 55−64.

Roberts, M. 1990. Indigenous Healing Plants. Southern Book Publishers, Halfway House: 226−228.

Rukangira, E. 2001. The African herbal industry: constraints and challenges. *Erboristeria Domani.*, 1: 1−23.

Ryan, M. 2003. Compost tea production, application and benefits. The Rodale Institute.

Sabiiti, E.N. 2011. Utilizing Agricultural waste to enhance food security and conserve the environment. *African Journal of Food, Agriculture, Nutrition and Development.*, 11(6): 1−9.

Samanhudi, A.Y., Pujiasmanto, B. and Rahayu, M., 2014. Effect of organic manure and arbuscular mycorrhizal fungi on growth and yield of young ginger (*Zingiber officinale* Rosc.). *IOSR Journal of Agriculture and veterinary Science.*, *7*(5): 1−5.

Scheuerell, S.J. 2004. Compost tea production practices, microbial properties, and plant disease suppression. International Conference, Soil and Compost Eco-biology. Paper 5, Oregon State University.

Scott, G., Springfield, E.P. & Coldrey, N. 2004. A Pharmacognostical Study of 26 South African Plant Species Used as Traditional Medicines. *Pharmaceutical Biology.*, 42(3): 186−213.

Semenya, SS. & Potgieter, MJ. 2014. Medicinal plants cultivated in Bapedi traditional healers home gardens, Limpopo Province, South Africa. *African Journal of Traditional Complementary and Alternative Medicines*., 11(5):126−32.

Shafagh-Kolvanagh, J & Shokati, B. 2012. Effect of different intercropping patterns on shoot parts of dill and fenugreek. *International Journal of Plant, Animal and Environmental Sciences.*, 2(3): 115−120.

Shahidullah, A.K.M. 2007. The role of medicinal plants in livelihood improvement and ecological sustainability in Bangladesh: An Application of a Participatory Approach to Management and Marketing. A Thesis submitted to the Faculty of Graduate Studies in partial fulfilment of the requirements for the Degree Master of Natural Resources Management (M.N.R.M.): University of Manitoba.

Shava, S. 2011. Power/Knowledge in the governance of natural resources: A Case study of medicinal plant Conservation in the Eastern Cape. *Southern African Journal of Environmental Education*., 28: 72–84.

Siddiqui, Y., Islam, T.M., Naidu, Y. & Meon, S. 2011.The conjunctive use of compost tea and inorganic fertiliser on the growth, yield and terpenoid content of *Centella asiatica* (L.) urban. *Scientia Horticulturae.*, 130: 289–295.

Singh, K.M. 2009. Scope of medicinal and aromatic plants farming in Eastern India.

Smith, C.R. 2009. Institutional determinants of collaboration: An empirical study of county open-space protection. *Journal of Public Administration Research & Theory.*, 19(1): 1–21.

South African National Biodiversity Institute. 2006. South African Medical Research Council, University of the Western Cape. *Artemisia afra* Herba. http://www.plantzafrica.com/medmonographs/artemisiaafra.pdf. Date accessed: 10/12/2020.

SANBI, 2020. Traditional healers discuss sustainable use of medicinal plants. https://www.sanbi.org/news/traditional-healers-to-discuss-sustainable-management-and-use-of-medicinal-plants/. Date Accessed 15/07/2024.

Strand, K.J., Cutforth, N., Stoecker, R., Marullo, S. & Donohue, P. 2003. Community-based research and higher education: Principles and practices. John Wiley & Sons. 1st ed. Pages 10–11.

Steenkamp, V. 2003. Traditional herbal remedies used by South African women for gynaecological complaints. *Journal of Ethnopharmacology.,* 8(2003): 97–108.

Sujatha, S., Bhat, R., Kannan, C. & Balasimha, D. 2011. Impact of intercropping of medicinal and aromatic plants with organic farming approach on resource use efficiency in arecanut (*Areca catechu* L.) plantation in India. *Industrial Crops and Products.*, 33 (1): 78−83.

Sunmonu, T.O. & Afolayan, A.J. 2012. Evaluation of polyphenolic content and antioxidant activity of Artemisia afra Jacq. Ex Willd. Aqueous extract. *Pakistan Journal of Nutrition.*, 11(7): 520.

Swart, Z. 2020. *Artemisia Afra*. Mountain Herb Estate. http://www.herbgarden.co.za/mountainherb/article.php?tag=WildeAls. Accessed 10 December 2020.

Tanga, M., Lewu F.B., Oyedeji, O.A. & Oyedeji, O.O. 2018. Cultivation of medicinal plants in South Africa: A solution to quality assurance and consistent availability of medicinal plant materials for commercialization. *Academia Journal of Medicinal Plants.,* 6(7): 168−177.

Tewari, S. 2004. The Medicinal Plants Economy of South Africa: Profile and Future Perspectives. *Journal of Interdisciplinary Economics.*, 15(3-4): 293−300.

Thomas, C.W. & Koontz, T.M. 2011. Research designs for evaluating the impact of community-based management on natural resource conservation. *Journal of Natural Resources Policy Research*., 3(2): 97−111.

Tikiso, T. 2015. Comparison of flavonoid profile and respiratory smooth muscle relaxant effects of Artemisia afra versus *Leonotis leonurus*. A Master's thesis, University of the Western Cape, Bellville.

Thakur, K. S., Kumar, M., Bawa, R. & Bussmann, R. W. 2014. Ethnobotanical study of herbaceous flora along an altitudinal gradient in Bharmour forest division, District

Chamba of Himachal Pradesh, India. *Evidence-based complementary and alternative medicine.*, 2014: 1−7.

Thorsen, R.S. & Pouliot, M. 2016. Traditional medicine for the rich and knowledgeable: challenging assumptions about treatment-seeking behaviour in rural and peri-urban Nepal. *Health policy and planning.*, 31(3): 314−324.

Thring, T.S.A. & Weitz, F.M. 2006. Medicinal plant use in the Bredasdorp/ Elim region of the Southern Overberg in the Western Cape Province of South Africa. *Journal of Ethnopharmacology.*, 103: 261–275.

Torri, M.C. & Herrmann, T.M. 2011.Bridges between tradition and innovation in Ethnomedicine. Springer.

Tripathi, I.P. 2013. Chemistry, biochemistry and Ayurveda of Indian medicinal plants. International E-Publication, India.

Van der Colff, D., Kumschick, S., Foden, W., Raimondo, D., Botella, C., Von Staden, L. & Wilson, J.R.U. 2023. Drivers, predictors, and probabilities of plant extinctions in South Africa. *Biodiversity and Conservation.*, 32(13): 4313–4336.

Van der Walt, L. 2004. *Artemisia afra*. page downloaded from the South African Biodiverisity Institute's Plant Information, accessed from plantzafrica.com.

Van Vuuren, S. 2007. The Antimicrobial Activity and Essential Oil Composition of Medicinal Aromatic Plants Used in African Traditional Healing. A thesis submitted to the Faculty of Health Sciences, University of the Witwatersrand, in fulfilment of the requirements for the Degree of Doctor of Philosophy. Johannesburg.

Van Wyk, B.-E., Van Oudtshoorn, B. & Gericke, N. 1997. Medicinal plants of South Africa Briza publications. Pretoria.

Van Wyk, B.-E., van Oudtshoorn, B. & Gericke, N. 2002. Medicinal Plants of South Africa, 407. 2nd ed. Briza Publications, Pretoria, South Africa.

Van Wyk, B.E. & Gericke, N. 2005. Medicinal Plants of the World, Pretoria: Briza Publications.

Van Wyk, B-E., Van Oudtshoorn, B. & Gericke N. 2005. Medicinal Plants of South Africa. Pretoria, Briza Publications, 1–304.

Von Koenen, E. 2001. Medicinal, Poisonous and Edible plants in Namibia, Klaus Hess 413. Publishers, Windhoek –Göttingen.

Vyawahare, M. 2020. Madagascar's president promotes unproven herbal cure for COVID-19. https://news.mongabay.com/2020/04/madagascars-president-promotes-unproven-herbal-cure-for-covid-19/. Date Accessed: 15/01/2021.

Webber, J. 1999. The Buchu Barrier- a hidden industry. Doctoral dissertation, University of Cape Town.

Wiersum, K.F., Dold, A.P., Husselman, M. & Cocks, M. 2006. Cultivation of medicinal plants as a tool for biodiversity conservation and poverty alleviation in the Amatola region, South Africa. Rhodes University: South Africa. Bogers, R.J., Craker, L.E. & Lange, D. (Eds). Medicinal and Aromatic Plants. Springer: Netherlands.

Williams, V.L., Witkowski, E.T. & Balkwill, K., 2007. Volume and financial value of species traded in the medicinal plant markets of Gauteng, South Africa. *International journal of sustainable development & world ecology.*, *14*(6): 584–603.

Williams, V.L., Victor, J.E. & Crouch, N.R. 2013. Red Listed medicinal plants of South Africa: Status, trends, and assessment challenges. *South African Journal of Botany.*, 86: 23–35.

World Health Organization (WHO), The World Conservation Union (IUCN), World Wide Fund for Nature (WWF). 1993. Guidelines on the Conservation of Medicinal Plants. UK.

CHAPTER TWO

This chapter was published

Medicinal Plants
Vol. 16 (2), June 2024, 300-310

doi : 10.5958/0975-6892.2024.00031.X

Research Article

The effect of different organic amendments on growth, secondary metabolites and antioxidant properties of *Artemisia afra*

Sibusiso Xego, Learnmore Kambizi and Felix Nchu*
Department of Horticultural Sciences, Cape Peninsula University of Technology, Cape Town, South Africa

Received: March 10, 2024; Accepted: May 17, 2024

The effect of different organic amendments on growth, secondary metabolites and antioxidant capacities of *Artemisia afra*

2.1 Introduction

Traditional medicine plays an imperative role in treating various ailments in South Africa, often serving as a primary intervention or an alternative complementary therapy (Human Science Research Council, 2021). With approximately 72% of South Africans relying on medicinal plants from the wild, there's mounting pressure on these populations, posing threatens to their survival (South African National Biodiversity Institute, 2021). *Artemisia afra* Jacq. ex Willd. known as 'Umhlonyane' in the local isiXhosa language, stands as one of South Africa's oldest and most utilized herbal medicines (Liu *et al*., 2009). Known for its efficacy in treating flu-related symptoms like colds, fever, coughs, headaches, inflammation and pain (Liu *et al*., 2009; Ramalepe, 2020), *A. afra* gained even more attention during South Africa's first COVID-19 outbreak, as people turned to this plant despite the lack of robust, peer-reviewed evidence validating its efficacy against the virus. The surge in demand led to rise in the herb's prices, prompting excessive harvesting and purchase (Mbhele, 2020; Wild, 2021).

Meeting the rising demand for medicinal plants requires the adoption of sustainable cultivation practices to ensure a stable supply of high-quality materials (van Wyk and

Prinsloo, 2018). Therefore, to compete with wild-harvested plants, growers of medicinal and aromatic plants must use low-input and eco-friendly cultivation methods to produce high-quality medicinal plants (Dajic-Stevanovic and Pljevljakusic, 2015). In recent years, organic medicinal plants have become increasingly popular due to their environmental benefits and cost-effectiveness (Raei and Milani, 2014, SA and El Sayed, 2021). The use of organic manure has been associated with improvements in soil characteristics, and increased plant growth and yield, primarily due to elevated levels of organic matter and microbial activity (Oyedeji *et al*., 2014; Mitran *et al*., 2017).

Organic fertilizers also enhance the production of secondary metabolites like phenolics, flavonoids, vitamin C, and antioxidant activity of medicinal plants (Mohd *et al*., 2013; Zeinab *et al*., 2013; SA and El Sayed, 2021). Several studies have shown that applying organic amendments can enhance the accumulation of phenolics, flavonoids, and antioxidant compounds in plants. For instance, Ezeocha *et al*. (2014) discovered that the use of poultry manure significantly affected the nutrient content and functional properties of *Dioscorea bulbifera*. Similarly, Javanmardi and Ghorbani (2012) and Haddad *et al*. (2019) also reported that the application of organic materials improved yields, essential oils, antioxidant activity and levels of total phenolics. Thus, this study aimed to assess the effect of various organic amendments on plant growth, secondary metabolites, and antioxidant capacity of *A. afra*, considering the reported advantages of organic farming.

2.2 Materials and methods

2.2.1 Organic matter analysis (chemical and physical properties)

Prior to application, sample of each organic material and potting soil, weighing 1kg, were sent to a commercial laboratory (Bemlab [Pty] Ltd) for the analysis of available or extractable elements. Standard procedures outlined in Campbell and Plank (1998) and Miller (1998) were followed for the analysis of Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and micronutrients. The samples were dried overnight at 70ºC and milled to about 40 microns, ashed at 480°C and then shaken in a 50:50 HCl (32%) solution for extraction through filter paper. The cation and micronutrient content [Boron (B), Iron (Fe), Zinc (Zn), Manganese (Mn), and Copper (Cu)] were measured using a Varian ICP-OES optical emission spectrometer.

Total nitrogen was determined directly on a Leco N-Analyzer by complete combustion. ICP-OES was preferred due to its high sensitivity, accuracy, and ability to measure multiple elements simultaneously.

2.2.1.1 Moisture, bulk density, and ash content

The organic material was dried overnight at 70°C to estimate the gravimetric water content on a mass/mass basis. The bulk density was measured by weighing 60 cm^3 of compost at 20°C and expressing it in kg/m^3. The ash (%) content was determined by weighing 2 g of the dry and sieved organic material (40 micron) sample before ashing overnight in a muffle furnace at 480°C. The ash percentage is expressed as a proportion of the dry (70°C) sample.

2.2.1.2 pH of organic matter

The soil pH measurement method, as described by The Non-affiliated Soil Analyses Work Committee, was adopted. The organic material was dried overnight at 105°C. A paste of 5 g dried samples: 25 mL 1N KCl was then prepared, to measure the Ph.

2.2.1.3 Foliar Feed Product

The product (5 mL) was digested on a sand bath with 20 mL nitric acid (55%) and 5 mL hydrogen peroxide until the volume was reduced to < 10 mL. The sample was then made up to 10 mL with distilled water and analyzed for Zn, Cu, Cadmium (Cd), Lead (Pb), Arsenic (As) & Chromium (Cr) on an ICP-OES.

2.2.1.4 The solubility test of dry materials

10 g of material was mixed with 100 mL of water. The mixture was stirred in a laboratory shaker for five minutes at 25°C and filtered through a Whatman 2 filter paper. The mixture was dried after filtration to determine the weight of the insoluble fraction, which was then expressed as a percentage of the initial 10 g material.

2.2.2 Plant material

A. afra plant material was obtained from Boshoff commercial nursery in Cape Town, South Africa. Stem cuttings were made from healthy parts of the plant material and planted in a mixture of sand, sifted bark, coconut fiber and perlite, using (1:1:1:1) ratio. The cuttings were placed in an environmentally controlled greenhouse, maintaining an average daytime temperature of 26ºC and 70% relative humidity.

2.2.3 Treatments

Four organic amendments, namely vermicompost, mushroom compost, poultry and kraal manure were used in the experiment. Vermicompost, mushroom compost and potting soil were sourced from Stanler Farms Nursery in Cape Town, while river sand, kraal and poultry manure were obtained from Stodels, Cape Town. River sand and regular potting soil were used as control treatments due to the prevalence of sandy soil in the Western Cape (Alan *et al*. 2019). Eight-week-old seedlings were transplanted into sterilized pots filled with specified growing media, as outlined in Table 2.1.

Table 2.1: Composition of different organic amendment blends used in the study.

Treatment	Composition
T1	100% River sand
T2	100% Potting soil containing one part of Sand, Peat, Bark and Loam soil
T3	70% River Sand + 30% Vermicompost
T4	70% River Sand + 30% Kraal
T5	70% River Sand + 30% Poultry
T6	70% River Sand + 30% Mushroom compost

2.2.4 Organic material ratios

The organic amendments were mixed with river sand to create the growing media for the experiment, with a ratio of 70% coarse river sand and 30% of organic amendment by volume (70:30). For the test treatments, the pots were filled with coarse river sand to a depth of approximately 12.6 cm (2216,7 g), representing 70% of the total volume and then topped with compost/manure to a depth of 5.4 cm (372,34 g), representing the remaining 30% of the volume. Each filled pot weighed 2589 g, comprising 100% of the growth media mixture. Control treatments were filled either with 100% coarse river sand or 100% potting soil.

2.2.5 Experimental design

The preliminary study was conducted at the Department of Horticultural Sciences, Cape Peninsula University of Technology, Bellville campus, Cape Town, South Africa. The experimental area had an average related humidity (RH) of 74.5%, with temperatures ranging from 17-25ºC during the day and 8-15ºC in the evening. The average rainfall during the experiment period was 55 mm. The experiments followed a completely randomized block design with three replicates for each treatment, totalling 72 plants (Figure 2.1). Irrigation was administered regularly based on the nursery watering schedule to ensure uniform soil moisture, with irrigation running for 15 minutes twice a day, providing approximately 10 mm of water during each session, totalling about 20 mm of water daily per plant.

Project layout

Figure 2.1: Plant material propagated from stem cuttings. Eight-week-old seedlings were transplanted into 18 cm pots, using a 70:30 growing medium mix. The experiment was conducted using a randomized block design.

2.2.6 Plant growth parameters

Various parameters were recorded, including stem length (cm), number of leaves, new shoots and side branches were counted on each plant, plant height (cm),

total plant weight/total biomass (g), dry weight of aerial parts (g), fresh weight of aerial parts (g), fresh root weight (g) and dry root weight. To determine the dry weight, plants were placed in paper bags and dried in a thermo-oven at 70ºC, the dried plant samples were then weighed.

2.2.7 Secondary metabolites and antioxidant analysis

The harvested plants were dried at 70ºC for 72 hours, weighed, ground, and sent to the Oxidative Stress Research Centre at the Cape Peninsula University of Technology for analysis.

2.2.8 Determination of antioxidant activities (FRAP, TEAC and DPPH)

2.2.8.1 Ferric Reducing Antioxidant Powder (FRAP)

The FRAP assay was performed using the protocol described by Benzie and Strain (1996). Three replicates from each treatment were analyzed. 1 g of dried plant material was extracted with 10 mL of ethanol, and the resulting crude extract was used at the required concentrations. In a 96-well microplate, 10 µL of the crude extract was mixed with 300 µL FRAP reagent (0.3 µM acetate buffer, pH 3.6), 10 mM 2,4,6-tripyridyl-striazine (TPTZ) in 0.1 µM HCl and 20 mM iron (III) chloride hexahydrate (FeCl, 593 nm). As a standard, L-ascorbic acid was employed at concentrations ranging from 0 to 1000 µM. Milligrams of ascorbic acid per gram of dry weight (milligrams of AAE/g DW) were used to express the results.

2.2.8.2 Antioxidant capacity of DPPH radicals

The DPPH free radical scavenging activities of the samples were evaluated according to Katalini´c *et al*. (2004). Approximately 300 µL of DPPH solution was combined with 25 µL of the crude extract and graded concentrations (0 and 500 µM) of Trolox standard (6-hydroxy-2,5,7,8-tetramethylchroman-2-20 carboxylic acid). After a 30-minute incubation period, the absorbance at 517 nM was determined as micromole Trolox equivalent per gram of dry weight (µM TE/g DW).

2.2.8.3 Trolox equivalent antioxidant capacity (TEAC)

The radical cation decolorization test, which employs the 2, 2′-azinobis (3-ethylbenzothiazolie-6-sulfonate) diammonium salt (ABTS) method in line with the method reported by Re *et al*. (1999) with minor modification was used to measure the TEAC of the extract. About 8 mM ABTS (in water) and 3 mM potassium persulfate were combined to create ABTS, which was then allowed to stand for 16 h. The ABTS

+ solution was then diluted with ethanol (approximately 1:90 v/v) to obtain an absorbance of 0.7 ± 0.02 at 734 nm. Subsequently, 100 µL diluted extract or Trolox standard solution (0–500 µM) was added to 2.4 mL ABTS solution. Absorbance was measured at exactly 6 min at 734 nm using a Multiskan Spectrum plate reader (Thermo Fisher Scientific, USA). Results were presented as micromole Trolox Equivalent per gram sample (µM TE/g), with Trolox serving as the analytical reference. The standard curve was linear between 0 and 1000 µM Trolox.

2.2.9 Secondary metabolite contents

2.2.9.1 Determination of Total Polyphenol and Flavonol Contents

The total polyphenol contents of dried *A. afra* leaf samples were determined using the Folin-Ciocalteu procedure. Twenty-five microliters of aqueous extracts were mixed with 125 µL of Folin-Ciocalteu reagent (Merck (Pty) Ltd., Cape Town, South Africa) in a 96-well microplate and diluted 1:10 with distilled water in a 96-well microplate. The well was filled with 100 µL of aqueous Na2CO3 (7.5%) after 5 min (Sigma Aldrich SA (Pty) Ltd., Kempton Park, South Africa). The plates were incubated for 2 h at room temperature before being examined at 765 nm with a Multiskan plate reader (Thermo Electron Corporation, Waltham, Massachusetts, USA). The results are represented as mg gallic acid equivalents per gram of dry weight (mg GAE/g DW) using 0, 20, 50, 100, 250, and 500 mg/L gallic acid in 10% ethanol. The total flavonol content of dried leaves of *A. afra* plants was evaluated using a standard of quercetin 0, 5, 10, 20, 40, and 80 mg/L in 95% ethanol (Sigma Aldrich SA (Pty) Ltd., Kempton Park, South Africa). A volume of 12.5 L of crude aqueous extracts was combined with 12.5 µL of 0.1% HCl (Merck (Pty) Ltd., Cape Town, South Africa) in 95% ethanol and 225 µL of 2% HCl in the sample wells, which were incubated at room temperature for 30 min. At a temperature of 25ºC, the absorbance was measured at 360 nm. The results are represented in milligrams of quercetin equivalent per gram of dry weight (mg QE/g DW). Three replicates from each treatment were analyzed.

2.2.10 Statistical analysis

The experimental data were statistically analyzed using one-way ANOVA and Tukey's HSD test, with significance set at $p<0.05$. These computations were performed using SPSS Statistics 27.0.1 and PAST 4.03 software.

2.3 Results

2.3.1 Unamended organic material characteristics

Table 2.2 illustartes the chemical and physical properties of the organic amendments. The N content ranged from 9500 to 18000 mg/kg, with mushroom and vermicompost having the highest values and poultry manure the lowest. P concentrations were highest in poultry manure (9300 mg/kg) and lowest in kraal manure (4200 mg/kg). The highest K levels were found in mushroom compost (663 mg/kg) and were lowest in vermicompost. Mushroom compost also had higher Mg and Na contents (61.2 and 5080 mg/kg, respectively), while vermicompost had the lowest. Contrarily, poultry manure had the highest Ca level (1240 mg/kg), while the lowest level was detected in vermicompost (184 mg/kg). Carbon content ranged from 24700 mg/kg in poultry manure to 214000 mg/kg in vermicompost.

Poultry manure exhibited the highest concentrations of Mn, Fe, Zn and B (279, 41.7, 347 and 30.4 mg/kg, respectively), followed by mushroom compost (267, 32.6, 288 and 28.8 mg/kg, respectively). Conversely, vermicompost showed the lowest Mn and Zn levels, while kraal manure had the lowest Na and B levels. Furthermore, kraal manure displayed the highest Nickel (Ni) and Cr (69.5, 170 mg/kg, respectively), whereas vermicompost had the highest Cd (0.24 mg/kg) and Mercury (Hg) (4.5 mg/kg) content. Lead levels were similar in kraal manure and vermicompost (8.3 mg/kg), except for Cd and Hg, which were notably higher in vermicompost (0.24 and 4.5 mg/kg, respectively).

The pH values of the organic amendments surpassed the neutral pH of 7, with kraal manure registering the highest pH at 7.7, while mushroom compost displayed the lowest pH at 7.3 indicating neutrality. Moisture content varied among compost/manure types, ranging from 26.2% to 59.4%. Vermicompost exhibited the lowest moisture content at 33.6, whereas mushroom compost had the highest at 59.4%. Poultry and kraal manure showed relatively similar moisture levels.

Table 2.2: Some physical and chemical properties of organic materials used in the study as soil amendments.

		Poultry	Mushroom compost	Kraal manure	Vermicompost	Potting soil
Analyte	**Unit**					
pH KCl	pH Units	7.4	7.3	7.7	7.4	6.8
Resistance	ohm	70	160	70	560	60
Moisture	%	37.0	59.4	38.2	33.6	26.2
Bulk density	kg/m3	470.00	516.00	570.00	652.00	390.00
Sodium (Na)	mg/kg	2760	5080	3360	1550	3542
Potassium (K)	mg/kg	624	663	390	163.8	79.5
Calcium (Ca)	mg/kg	1240	840	320	184	541
Magnesium (Mg)	mg/kg	60	61.2	39.6	31.2	28.4
Total Nitrogen LECO (N)	mg/kg	14000	18000	9500	18000	_
Manganese (Mn)	mg/kg	279	267	159	146	31.6
Copper (Cu)	mg/kg	41.7	32.6	26.3	27.5	1.9
Iron (Fe)	mg/kg	5280	5640	4870	6560	2590
Zinc (Zn)	mg/kg	347	288	178	171	37.6
Boron (B)	mg/kg	30.4	28.8	19.4	21.8	1.8
Phosphorus (P)	mg/kg	9300	7800	4200	4600	9062
Ash	%	47.20	51.50	73.40	64.60	_
Total Carbon (C)	mg/kg	247000	262000	140000	214000	27700
Nickel (Ni)	mg/kg	51.0	55.3	69.5	58.4	_
Cadmium (Cd)	mg/kg	0.15	0.11	0.09	0.24	_
Chromium (Cr)	mg/kg	130	129	170	146	_
Mercury (Hg)	mg/kg	0.01	0.02	0.01	0.03	_
Arsenic (As)	mg/kg	3.6	4.2	3.0	4.5	_
Lead (Pb)	mg/kg	3.0	4.6	8.3	8.3	_

2.3.2 Growth parameters

2.3.2.1 Stem length

At ten weeks post-treatment, a significant difference was observed among organic amendments regarding stem length (df = 5, 66; F = 26.21; P < 0.05) (Table 2.3). T5 exhibited the most favourable results (29.67 ± 1.02 cm) followed by T4 (25.75 ± 0.65 cm), T6 (24.67 ± 0.80 cm) and T3 (23.33 ± 0.94 cm), respectively. Conversely, T2 (18.67 ± 1.16 cm) and T1 (16.96 ± 0.83 cm) resulted in the shortest stem lengths, with T1 yielding the lowest.

2.3.2.2 Number of leaves

Table 2.3 showed a significant variance in the number of leaves among plants treated with various organic amendments (df = 5, 66; F = 113.41; P = 0.000). T5 exhibited the highest number of leaves (100.50 ± 3.63), significantly differing from the

other treatments (T6 [89.58 ± 4.43], T3 [83.67 ± 2.00] and T4 [79.92 ± 3.07] respectively). Conversely, lowest mean values were recorded in T1 (23.17 ± 0.95).

2.3.2.3 Plant height

Significant differences in the plant height of *A. afra* were observed among treatments (df = 5,66; F = 91.61; P = 0.000). T5 yielded the tallest plants (36.92 ± 1.02 cm), followed by T4 (33.33 ± 0.80 cm), T3 (32.50 ± 1.00 cm), and T6 (31.25 ± 0.69 cm), respectively. Whereas T1 and T2 notably produced the shortest plant heights, with T1 recording the shortest (17.63 ± 0.37 cm) among all treatments (Table 2.3).

2.3.2.4 New shoots

Table 2.3 shows a significant discrepancy in the number of new shoots (df = 5,66; F = 4.00; P = 0.003) among different organic amendments. T5 exhibited the highest number of new shoots per plant (2.92 ± 0.45), followed by T6 (2.25 ± 0.57), T4 (1.50 ± 0.45) and T3 (1.33 ± 0.40), respectively. Conversely, T1 and T2 yielded a relatively similar and significantly lower number of new shoots, with (T1 (0.58 ± 0.23) recording the lowest count.

2.3.2.5 Number of side branches

The analysis of variance depicted in Table 2.3 reveals notable variation (df = 5,66; F = 4.00; P = 0.003) in the number of branches per plant among different organic amendments. Notably, T5 exhibited the highest number of branches (6.50 ± 0.40), followed by T6 (5.17 ± 0.24), T4 (4.67 ± 0.38) and T3 (3.50 ± 0.29), respectively. Conversely, the lowest count of branches was recorded in T1 (1.67 ± 0.19).

Table 2.3: Effect of various organic fertilizers on growth characteristics of *A. afra.*

Treatments	Parameters				
	Stem length (cm)	Number of leaves	Plant height (cm)	New shoots	Side branches
T1	16.96 ± 0.83^{c}	23.17 ± 0.95^{d}	17.63 ± 0.37^{d}	0.58 ± 0.23^{b}	1.67 ± 0.19^{e}
T2	18.67 ± 1.16^{c}	39.58 ± 1.66^{c}	23.54 ± 0.29^{c}	1.00 ± 0.39^{b}	2.92 ± 0.26^{de}
T3	23.33 ± 0.94^{b}	83.67 ± 2.00^{b}	32.50 ± 1.00^{b}	1.33 ± 0.40^{ab}	3.50 ± 0.29^{cd}
T4	25.75 ± 0.65^{b}	79.92 ± 3.07^{b}	33.33 ± 0.80^{b}	1.50 ± 0.45^{ab}	4.67 ± 0.38^{bc}
T5	29.67 ± 1.02^{a}	100.50 ± 3.63^{a}	36.92 ± 1.02^{a}	2.92 ± 0.45^{a}	6.50 ± 0.40^{a}
T6	24.67 ± 0.80^{b}	89.58 ± 4.43^{ab}	31.25 ± 0.69^{b}	2.25 ± 0.57^{ab}	5.17 ± 0.24^{b}

Means that do not share a letter are significantly different (P < 0.05). Values shown are mean ± standard error. Different letters down the same column represent significant differences at P < 0.05. *T1, T2, T3, T4, T5 – treatments.

Figure 2.2: Plant growth/development from week one to week 10.

2.3.2.6 Aerial parts fresh and dry weight

The statistical analysis presented in Table 2.4 indicates significant variations in the fresh and dry weights of arial parts among different organic amendments (df = 5,66; F = 130.16; P = 0.000) and (df = 5,66; F = 49.05; P = 0.000), respectively. Notably, aerial parts exhibited higher fresh and dry weights under T5 (14.03 ± 0.70 and 3.35 ± 0.25, respectively), while lower weights were recorded under T1 (1.06 ± 0.13 and 0.31 ± 0.07 g, respectively).

2.3.2.7 Root fresh and dry weight

The statistical analysis showed significant impacts of various organic amendments on the fresh and dry weights of *A. afra* roots (df = 5,66; F = 150.16; P = 0.000 and df = 5,66; F = 91.84; P = 0.000) (Table 2.4). T5 recorded the best outcomes for both fresh and dry weight (19.75 ± 1.09 and 3.98 ± 0.21 g, respectively), followed by T4, T3 and T6, respectively. While the fresh and dry weights were notably lower under T1 and T2, with T2 showing the lowest results (1.81 ± 0.12 and 0.29 ± 0.03 g, respectively).

2.3.2.8 Plant total weight

The results presented in Table 2.4 indicated a significant difference (P < 0.05) in the total weight of *A. afra* plants among treatments (df = 5,66; F = 139.96; P = 0.000). It was observed that the highest total weight was recorded in T5 (37.31 ± 1.76 g), followed by T3 (25.56 ± 0.99 g) and T4 (23.85 ± 0.89 g), respectively. The lowest total weight (4.41 ± 0.206 g) was obtained in T1.

Table 2.4: Effect of various organic fertilizers on plant fresh and dry weight, and plant total weight of *A. afra.*

Treatments	**Parameters**				
	Fresh weight (Aerial parts) (g)	Dry weight (Aerial parts) (g)	Fresh weight (roots) (g)	Dry weight (roots) (g)	Plant total weight (g)
T1	1.06 ± 0.13^{e}	0.31 ± 0.07^{c}	2.47 ± 0.26^{d}	0.50 ± 0.09^{c}	4.41 ± 0.206^{d}
T2	4.92 ± 0.22^{d}	0.83 ± 0.10^{c}	1.81 ± 0.12^{d}	0.29 ± 0.03$_{c}$	8.50 ± 0.45^{d}
T3	9.79 ± 0.32^{b}	2.29 ± 0.14^{b}	12.88 ± 0.50^{b}	2.16 ± 0.16^{b}	25.56 ± 0.99^{b}
T4	7.61 ± 0.19^{c}	1.86 ± 0.11^{b}	13.52 ± 0.54^{b}	2.18 ± 0.13^{b}	23.85 ± 0.89^{bc}
T5	14.03 ± 0.70^{a}	3.35 ± 0.25^{a}	19.75 ± 1.09^{a}	3.98 ± 0.21^{a}	37.31 ± 1.76^{a}
T6	7.91 ± 0.45^{c}	1.85 ± 0.18^{b}	9.52 ± 0.31^{c}	1.68 ± 0.15^{b}	19.69 ± 1.04^{c}

Means that do not share a letter are significantly different (P < 0.05). Values shown are mean ± standard error. Different letters down the same column represent significant differences at P < 0.05. *T1, T2, T3, T4, T5 – treatments.

2.3.3 Secondary metabolites

The phytochemical screening results, as shown in Table 2.5, demonstrated significant differences in the mean concentrations of polyphenols (df = 5,17; F = 28.04, P = 0.000) and flavonols (df = 5,17; F = 28.19; P = 0.000) in dried *A. afra* aerial parts samples post-harvest. T5 had significantly higher concentrations of polyphenols (40.69 ± 0.69 mg GAE/g) and flavonols (23.83 ± 0.30 mg QE/g), followed by T1, T4 and T6, respectively, for both compounds. Conversely, T2 displayed the lowest concentrations of polyphenols (21.98 ± 1.47 mg GAE/g) and flavonols (12.24 ± 0.46 mg QE/g). It is noteworthy that none of the samples tested positive for flavanols or alkaloids.

Table 2.5: Effect of various organic amendments on secondary metabolites of *A. afra* aerial parts.

Treatments	**Compounds**	
	Polyphenols (mg GAE/g)	**Flavonols (mg QE/g)**
T1	36.75 ± 0.69^{ab}	21.96 ± 0.63^{ab}
T2	21.98 ± 1.47^{c}	12.24 ± 0.46^{e}
T3	32.89 ± 1.10^{b}	17.77 ± 0.49^{d}
T4	36.52 ± 0.93^{ab}	20.97 ± 0.50^{bc}
T5	40.69 ± 0.69^{a}	23.83 ± 0.30^{a}
T6	34.29 ± 1.88^{b}	18.87 ± 0.70^{cd}

Means that do not share a letter are significantly different (P < 0.05). Values shown are mean ± standard error. Different letters down the same column represent significant differences at P < 0.05. *T1, T2, T3, T4, T5 – treatments.

2.3.4 Antioxidant potential of *A. afra* extracts

The results from Table 2.6 showed a significant difference (P < 0.05) in the antioxidant capacity of *A. afra* cultivated in various organic amendments; as indicated FRAP (df = 5,17; F = 28.19), DPPH (df = 5,17; F = 31.04) and TEAC assays (df = 5,17; F = 31.87). Specifically, T5 exhibited the highest antioxidant capacity with values of 239.40 ± 11.6 umol AAE/g for FRAP, 168.42 ± 8.25 umol TE/g for DPPH, and 516.2 ±

17.9 umol TE/g for TEAC. This was followed by T1, T4 and T6 correspondingly. Whereas T2 showed significantly lower antioxidant activities.

Table 2.6: The effects of different organic amendments on the antioxidant activities of the aerial parts of *A. afra*.

Treatment	**Antioxidants**		
	FRAP (umol AAE/g)	**DPPH (umol TE/g)**	**TEAC (umol TE/g)**
T1	219.88 ± 5.28^{ab}	162.05 ± 0.95^{ab}	485.3 ± 10.0^{ab}
T2	103.42 ± 7.14^{d}	26.34 ± 3.11^{d}	228.7 ± 16.9^{d}
T3	169.82 ± 4.45^{c}	105.9 ± 7.12^{c}	368.7 ± 12.8^{c}
T4	192.68 ± 7.35^{bc}	134.51 ± 7.68^{abc}	422.7 ± 15.7^{bc}
T5	239.40 ± 11.6^{a}	168.42 ± 8.25^{a}	516.2 ± 17.9^{a}
T6	173.14 ± 13.8^{c}	119.80 ± 18.0^{bc}	398.0 ± 28.8^{c}

Means that do not share a letter are significantly different ($P < 0.05$). Values shown are mean ± standard error. Different letters down the same column represent significant differences at $P < 0.05$. *T1, T2, T3, T4, T5 – treatments.

2.3.5 Correlation between secondary metabolites and antioxidant capacities of *A. afra*

A correlation scatter plot analysis was conducted to assess the relationship between each secondary metabolite and the antioxidant potential of *A. afra* extracts (Figure 2.3). Total polyphenols showed a strong and positive correlation with the antioxidant activities identified in the aerial parts of the plants, with values of r^2 = 0.9429 (FRAP), r^2 = 0.9627 (DPPH), and r^2 = 0.951 (TEAC). Congruently, antioxidant capacities [FRAP (r^2 = 0.9827), DPPH (r^2 = 0.98) and TEAC (r^2 = 0.9849)] also showed a strong positive relationship with total flavonols (Figure 2.2).

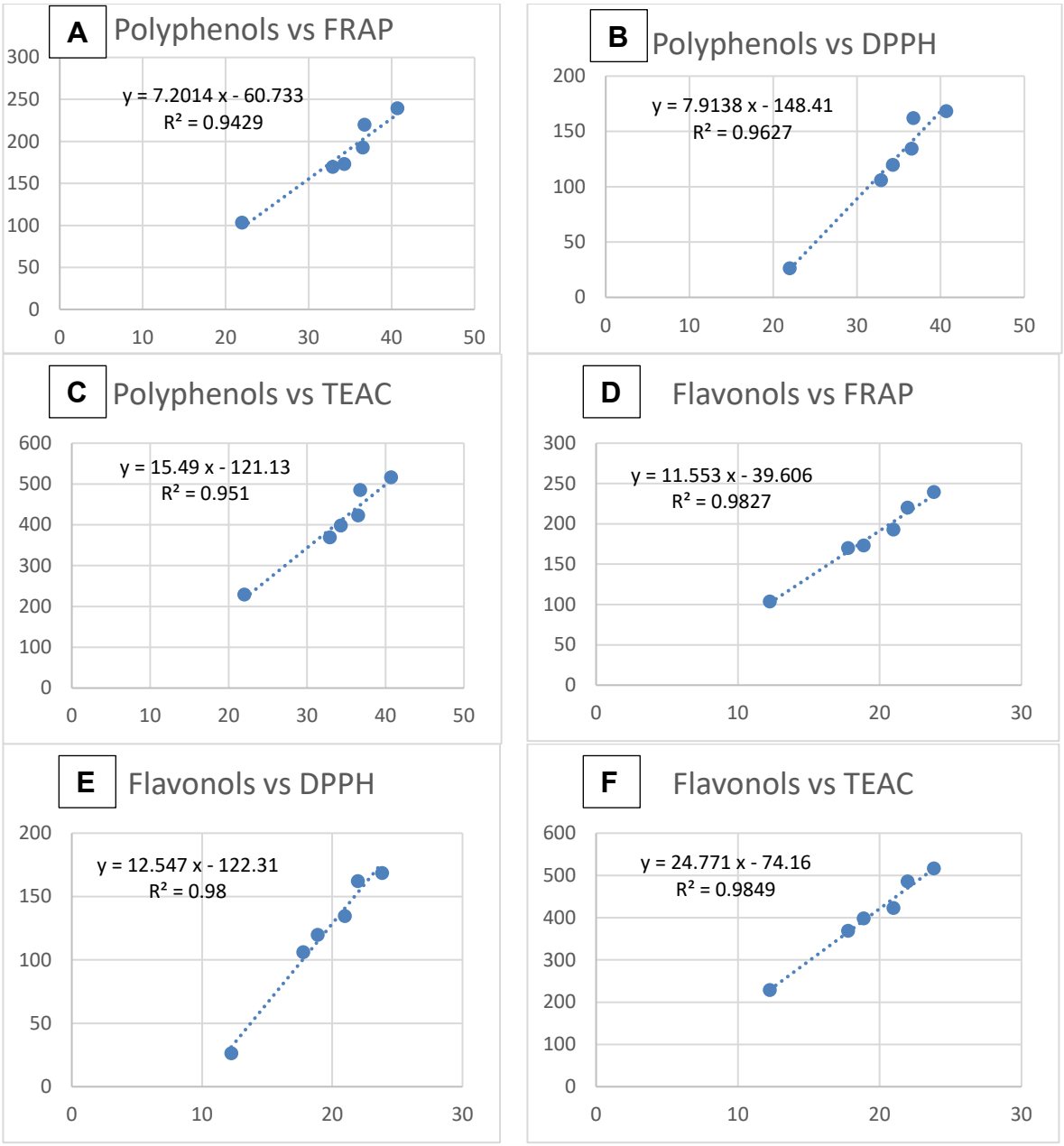


Figure 2.3: Scatter plots A, B & C show correlations between total polyphenols and antioxidant activities while D, E & F show correlations between total flavonols and antioxidant activities.

2.4 Discussion

The effects of various organic amendments on the growth, secondary metabolites, and antioxidant capacity of *A. afra* varied significantly in this study. Notably, plants treated with poultry manure (T5) exhibited higher results in all growth parameters measured. This assertion is corroborated by the findings of Hassan (2002), Masarirambi *et al*. (2012) and Asfaw (2022), who reported that the use of chicken manure significantly increased the number of leaves per plant, crop height, thick stem and produced the highest crop yields. These findings are also consistent with those reported by Akon *et al*. (2008), Zeid *et al*. (2015) and Ndzingane *et al*. (2022), who found that application of poultry manure improved plant growth at all stages of plant development and recorded the highest plant height, maximum number of leaves, leaf weight, highest root yield, maximum values for shoot dry weight and highest crop growth.

This variation in growth parameters observed could be attributed to the chemical and physical properties of the organic amendments. Poultry manure enhanced growth parameters by providing a sufficient quantity of nutrients that expedite growth. As shown in Table 2.2, poultry manure exhibited high phosphorus levels and adequate nitrogen content, crucial for plant development. Consistently, Masarirambi *et al*. (2012) and Asfaw (2022) found that poultry manure had higher phosphorus levels compared to other treatments. According to Donalue *et al*. (1990) nitrogen, phosphorus and potassium are essential nutrients abundant in organic manures. Furthermore, poultry manure showed elevated levels of calcium and various micronutrients like manganese, copper, zinc, and boron, aligning with findings from Zeid *et al*. (2015). The presence of these micronutrients indicates poultry manure's potential as a soil amendment to address nutrient deficiencies (Biratu *et al*., 2018), this attribute likely contributes to the variations observed in growth parameters.

A. afra thrives in well-drained soils with a pH of 5.0 to 7.7 as recommended by the Department of Agriculture (2009). Among the organic amendments used poultry manure had a pH of 7.4, falling within the ideal range. As noted by Jensen (2010), neutral soils with a pH between 6.5 and 7.5, are considered optimal for plant growth. This pH range ensures maximum availability of nutrients to plants and promotes healthy root growth (Kanton *et al*., 2016).

The study also demonstrated that poultry manure exhibited the highest concentrations of secondary metabolites and antioxidant activities in *A. afra*. This aligns with previous research by Juliani and Simon (2002) and Ibrahim *et al*. (2013) who observed that the application of chicken manure resulted in higher production of secondary metabolites, especially flavonols and increased antioxidant activity of lemon basil plants and *Labisia pumila* Benth. The results are also in accordance with the findings of Betty and Suketi (2021), who established that cultivation using chicken manure enhanced the production of flavonoids and anthocyanins in *Vernonia amygdalina* (bitter leaf). These findings are also linked to the micronutrient content of poultry manure, as shown in table 2.2. Ibrahim and Jaafar (2011) attributed the presence of secondary metabolites to the micronutrients in organic fertilizers such as chicken manure. Poultry manure's moderate nitrogen content, as noted by Guster *et al*. (2005), can induce plant stress, leading to increased antioxidants production. Similarly, Stewart (2001) found that nitrogen limitation promoted higher flavonol accumulation.

The study revealed a robust positive correlation between secondary metabolites like polyphenols and flavonoids and the overall antioxidant activity of *A. afra*. This indicates that the plant's total antioxidant activity is attributed to the presence of polyphenols and flavonols (Juliani and Simon, 2002). This finding is consistent with Aryal *et al*. (2019), who also observed a strong correlation between antioxidant activity (DPPH) and total phenolic and flavonoid content, suggesting these compounds as significant sources of natural antioxidants.

In conclusion, *Artemisia afra* cultivated in soil enriched with poultry manure exhibited superior growth compared to other organic amendments, with optimal results achieved at a 30% application rate. Poultry manure also enhanced the production of secondary metabolites such as phenolics and flavonols, and improved antioxidant activities (DPPH, FRAP, and TEAC) in *A. afra*. The findings suggest that using poultry manure for cultivating *A. afra* optimize growth and soil nutrient content, promoting plant development.

2.5 References

Akon, M.O.S., Datta, D.K., Biswas, T., Nakamura, K. & Rahman, M.K. 2018. Influence of organic manures on the growth of diabetes preventive medicinal plant Gynura, *Gynura procumbens*. *Journal of Biodiversity Conservation and Bioresource Management.*, 4(2): 61–66.

Aryal, S., Baniya, M.K., Danekhu, K., Kunwar, P., Gurung, R. & Koirala, N. 2019. Total phenolic content, flavonoid content and antioxidant potential of wild vegetables from Western Nepal. *Plants.*, 8(4): 96.

Asfaw, M.D. 2022. Effects of animal manures on growth and yield of maize (*Zea mays* L.). *Journal of Plant Science and Phytopathology.*, 6: 033–039.

Betty, B., Aziz, S.A. & Suketi, K. 2021. The Effects of different rates of chicken manure and harvest intervals on the bioactive compounds of Bitter Leaf (*Vernonia amygdalina* Del.). *Journal of tropical crop science.*, 8(2): 80–88.

Benzie, I.F. & Strain, J.J. 1996. The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": the FRAP assay. *Analytical biochemistry.*, 239(1): 70–76.

Biratu, G.K., Elias, E., Ntawuruhunga, P. & Nhamo, N. 2018. Effect of chicken manure application on cassava biomass and root yields in two agro-ecologies of Zambia. *Agriculture.*, 8(4): 45.

Campbell, C.R. & Plank, C.O. 1998. Preparation of plant tissue for laboratory analysis, Y.P. Kalra (Ed.). Handbook of reference methods for plant analysis. CRC Press, Boca Raton, 37–49.

Dajic-Stevanovic, Z. & Pljevljakusic, D. 2015. Challenges and decision making in cultivation of medicinal and aromatic plants. In Medicinal and Aromatic Plants of the World. Springer, Dordrecht.

Department of Agriculture. 2009. African wormwood production: essential oil crops. Directorate: Plant Production. Available: https://www.doc-developpement-durable.org/file/Culture/Plantes-Medicinales Aromatiques/FICHES_PLANTES/africanWormwood.pdf. Date: 28/02/2023.

Donalue, R. L., Midler, R. W. & Shiekluna J. C. 1990. Soils. An introduction to soils and plant growth. Prentice Hall of India, Private Ltd. New Delhi, 667.

Ezeocha, V.C., Nwogha, J.S., Ohuoba, A.N. & Chukwu, L.I. 2014. Evaluation of poultry manure application rates on the nutrient composition of *Dioscorea bulbifera* (Aerial yam). *Nigerian Food Journal.*, 32(2): 92–96.

Gutser, R., Ebertseder, T., Weber, A., Schraml., M. & Schmidhalter, U. 2005. Short-term and residual availability of nitrogen after long-term application of organic fertilizers on arable land. *Journal of Plant Nutrition and Soil Science.*, 168, 439–446.

Haddad, M.A., Al-Dalain, S.Y., Al-Tabbal, J.A., Bani-Hani, N.M., DA'SAN MM, J.A.R.A.D.A.T., Obeidat, M. & Al-Ramamneh, E.A.D. 2019. In vitro antioxidant activity, macronutrients, and heavy metals in leaves of maize (*Zea mays* l.) plants grown at different levels of cattle manure amended soil in Jordan valley. *Pakistan Journal of Botany.*, 51(3): 933–940.

Hassan, E.A.H. 2002. Effect of poultry manure and season on the performance and HCN Content of two Forage sorghum cultivar, Ph.D. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

Human Sciences Research Council (HSRC). 2021. Local is lekker: Indigenous knowledge should be encouraged. South African social attitudes survey. Available: http://www.hsrc.ac.za/en/review/november-/local-is-lekker. Date accessed: 22/09/2021.

Ibrahim, M.A. & Jaafar, H.Z.E. 2011. The relationship of nitrogen and C/N ratio with secondary metabolites levels and antioxidant activities in three varieties of Malaysian Kacip Fatimah (*Labisia pumila* Blume). *Molecules.*, 16: 5514–5526.

Ibrahim, M.H., Jaafar, H.Z., Karimi, E. & Ghasemzadeh, A. 2013. Impact of organic and inorganic fertilizers application on the phytochemical and antioxidant activity of Kacip Fatimah (*Labisia pumila* Benth). *Molecules.*, 18(9): 10973–10988.

Javanmardi, J. & Ghorbani, E. 2012. Effects of chicken manure and vermicompost teas on herb yield, secondary metabolites, and antioxidant activity of lemon basil (*Ocimum x citriodorum* Vis.). *Advances in Horticultural Sciences.*, 26(3-4): 151–157.

Jensen, T.L. 2010. Soil pH and the Availability of Plant Nutrients," IPNI Plant Nutrition TODAY, Fall 2010, No. 2. Available: www.ipni.net/pnt. Accessed: 28/02/2023.

Juliani H.R. & Simon, J.E. 2002. Antioxidant activity of basil. In: Janick, J. & Whipkey, A (eds.). Trends in new crops and new uses. ASHS Press, Alexandria, VA.

Kanton, R.A.L., Prasad, P.V.V., Mohammed, A.M., Bidzakin, J.K., Ansoba, E.Y., Asungre, P.A., Lamini, S., Mahama, G., Kusi, F. & Sugri, I. 2016. Organic and inorganic fertilizer effects on the growth and yield of maize in a dry agro-ecology in northern Ghana. *Journal of Crop Improvement.*, 30(1): 1–16.

Katalinić, V., Milos, M., Modun, D., Musić, I. & Boban, M. 2004. Antioxidant effectiveness of selected wines in comparison with (+)-catechin. *Food chemistry.*, 86(4): 593–600.

Liu, N. Q., Van der Kooy, F. & Verpoorte, R. 2009. *Artemisia afra*: A potential flagship for African medicinal plants? *South African Journal of Botany.*, 75(2): 185–195.

Masarirambi, M.T., Mbokazi, B.M., Wahome, P.K. & Oseni, T.O. 2012. Effects of kraal manure, chicken manure and inorganic fertilizer on growth and yield of lettuce (*Lactuca sativa* L. var Commander) in a semi-arid environment. *Asian Journal of Agricultural Sciences.*, 4(1): 58–64.

Mbhele, T. 2020. Traditional healing organization warns against misuse of umhlonyane. Available: https://www.sabcnews.com/sabcnews/traditional-healers-organisation-warns-against-misuse-of-umhlonyane/. Date accessed: 22/09/2021.

Miller, R.O. 1998. High temperature oxidation: Dry ashing, Y.P. Kalra (Ed) Handbook of reference methods for plant analysis. CRC Press, Boca Raton, 53–56.

Mitran, T., Kumar, P., Bandyopadhyay, P.K. & Basak, N. 2018. Effects of organic amendments on soil physical attributes and aggregate-associated phosphorus under long-term rice-wheat cropping. *Pedosphere.*, 28(5): 823–832.

Mohd, H. I., Hawa, Z. E. J., Eshan, K. & Ali, G. 2013. Impact of organic and inorganic fertilizers application on the phytochemical and antioxidant activity of Kacip Fatimah (*Labisia pumila* Benth). *Molecules.*, 18(9): 10973–10988.

Ndzingane, T.S., Masarirambi, M.T., Nxumalo, K.A, Kunene, E.N., Earnshaw, D.M., Mpofu, M., Dlamini, D.V. & Sihlongonyan, S. 2022. Effects of organic fertilisers on growth, yield and nutritional content of sweet basil (*Ocimum basilicum* L.). *Advancement in Medicinal Plant Research.*, 10(1): 1–16.

Oyedeji, S., Animasaun, D.A., Bello, A.A. & Agboola, O.O. 2014. Effect of NPK and poultry manure on growth, yield, and proximate composition of three Amaranths. *Journal of Botany.*, 2014: 1–6.

Raei, Y. & Milani, M. 2014. Organic cultivation of medicinal plants: a review. *Journal of Biodiversity and Environmental Sciences.*, 4 (4): 6−18.

Ramalepe, P. 2020. A 'medical plant' is in hot demand as South Africans seek relief for Covid symptoms. Business Insider South Africa. Available: https://www.businessinsider.co.za/atremisia-plant-and-price-increase-2020-7. Date accessed: 22/09/2021.

Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M. & Rice-Evans, C. 1999. Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free radical biology and medicine.*, 26(9-10): 1231−1237.

SA, T.E. & El Sayed, S.A. 2021. Evaluating biotic elicitation with phenylalanine and/or yeast for Rosemary (*Rosmarinus officinals L.*) sustainable improvement under traditional and organic agriculture. *Agricultural Sciences.*, 12(3): 273−292.

South African National Biodiversity Institute, 2021. Traditional healers discuss sustainable use of medicinal plants. Available: https://www.sanbi.org/news/traditional-healers-to-discuss-sustainable-management-and-use-of-medicinal-plants/. Date accessed: 22/09/2021.

Stewart, A.J., Chapman, W., Jenkins, G.I., Graham, I., Martin, T. & Crozier, A. 2001. The effect of nitrogen and phosphorus deficiency on flavonol accumulation in plant tissues. *Plant, Cell & Environment.*, 24(11): 1189−1197.

Van Wyk, A.S & Prinsloo, G. 2018. Medicinal plant harvesting, sustainability and cultivation in South Africa. *Biological Conservation.*, 227: 335−342.

Wild, S. 2021. Miracles and medicine: how COVID-19 has been changing the traditional remedies game. Available: https://bhekisisa.org/health-news-south-africa/2021-01-18-miracles-and-medicine-how-covid-19-has-been-changing-the-traditional-remedies-game/. Date accessed: 22/09/2021.

Zeid, H.A., Wafaa, H.M., Abou El Seoud, I.I. & Alhadad, W.A.A. 2015. Effect of organic materials and inorganic fertilizers on the growth, mineral composition and soil fertility of radish plants (*Raphine's sativus*) grown in sandy soil. *Middle East Journal of Agriculture Research.*, 4(01): 77−87.

Zeinab, A. S., Farouk, K. E., Alaa, A. G. & Mohamed, F. Z. 2013. Antioxidant activities of phenolics, flavonoids and vitamin C in two cultivars of fennel (*Foeniculum vulgare*) in responses to organic and bio-organic fertilizers. *Journal of Saudi Society of Agricultural Sciences.*, 14: 91−99.

CHAPTER THREE

Traditional healers' perspectives, beliefs, and awareness on the use of cultivated medicinal plants, and plant conservation status.

3.1 Introduction

For decades, the populace of the Western Cape has relied on plant collecting for healthcare purposes. Each year, approximately 279 tonnes of biological material are harvested from the Western Cape wildlands for traditional medicinal uses (Sustainable Livelihoods Foundation, 2018). Traditional healers who practice indigenous medicine predominately source their medicinal material from wild plants (Abiolu, 2018).

Traditional healers are recognized as a crucial component of the national health system (Latif, 2010) and serve as primary healthcare providers within their communities. Suppliers of traditional medicine are categorized into formal and informal sectors. The formal sector comprises herb dealers, including traditional healers, consumers of traditional medicine, and herbal chemists (owners of “muthi” stores) (Williams *et al*., 1997; Mander, 1998; Mhlanga, 2018; Dold and Cocks, 2002). Traditional healers utilize herbal medicine to treat a wide range of ailments. Raw materials for these medicines are primarily gathered from the wild (Rousan & Al-Uzaizi, 2016), with additional sources from street suppliers, medicinal plant shops, and collectors (Nefhere, 2019). According to Mhlanga (2018), traditional medicine practitioners have an average annual income of R38 8491, relying predominately on wild-collected plant materials. This escalating demand for wild-collected medicinal plants exacerbated plant scarcity.

The activities of medicinal plant gatherers and traditional healers considerably impact the remaining stock of wild plants (Mabogo, 1990; Van Wyk *et al*., 2013). The rise in human population and poverty has led individuals beyond diviners or herbalists to engage in the sale and use of medicinal plants, intensifying pressure on wild populations (Mbongwa, 2018). Both traditional healers and traders frequently collect plants from the wild due to shared beliefs among patients and healers that cultivated medicinal plants swiftly lose their therapeutic efficacy and are inadequate in treating certain conditions (Semenya & Potgieter, 2014; Nefhere, 2019). As indicated in a study by Nefhere (2019), traditional healers expressed reservations about cultivating

medicinal plants in home gardens due to associated taboos, ceremonies, and mystical attributes. Despite concerns regarding the perceived diminishing potency of cultivated plants, there is still a paucity of knowledge among scientists regarding the acceptance of cultivated medicinal plants by traditional healers (Nefhere, 2019). Very few comprehensive studies have been carried out on this subject.

Given the above, this study aims to ascertain and document the willingness of the traditional healers in the Western Cape to utilize and accept material from cultivated plants. Furthermore, this research seeks to explore traditional healers' perspectives concerning the conservation status of indigenous medicinal plants, with a particular focus on *Artemisia afra* and identify plants deemed priority by healers.

3.2 Materials and methods

The primary focus of the study was on traditional healers in the Western Cape, as they belong to communities with a long history of using medicinal plants. Therefore, they are likely to be key contributors and beneficiaries in the cultivation of these plants. Understanding the cultural practices related to medicinal plant cultivation, collection and utilization are crucial for promoting and encouraging cultivation by traditional healers and small-scale farmers.

3.2.1 Study area

The study was conducted in the Western Cape province from November 2021 to July 2022. The Western Cape province is situated at the southern end of the African continent (Britannica, 2019), covers an area of 129,449 square kilometres (49,981 square miles) and has a population of 5.8 million, making it the fourth largest province in South Africa in terms of both size and population. Approximately two-thirds of the population resides in the Cape Town metropolitan area, which also serves as the provincial capital (Latitude, 2023). According to Petersen (2014), there are approximately 5 100 full-time practicing traditional healers in the province, operating within 232 township communities, and they sell an estimated 1 300 tonnes of biological plant material annually. The participating traditional healers in the study were from various residential areas across the province, including Mfuleni, Khayelitsha, Green Point, Ceres, Langa, Worcester, Mandela Park, Delft, Killarney Gardens,

Stellenbosch, Hout Bay, Bongweni, Cape Town, Kraaifontein, Nyanga, Paarl, Gugulethu, Philippi, Tafelsig, Driftsands, Mandalay, Makhaza, Summer Greens, Kuils River, Somerset West, Strandfontein, Mitchellsplain, Bellville, Brackenfell and Philadelphia (Figure 3.1).

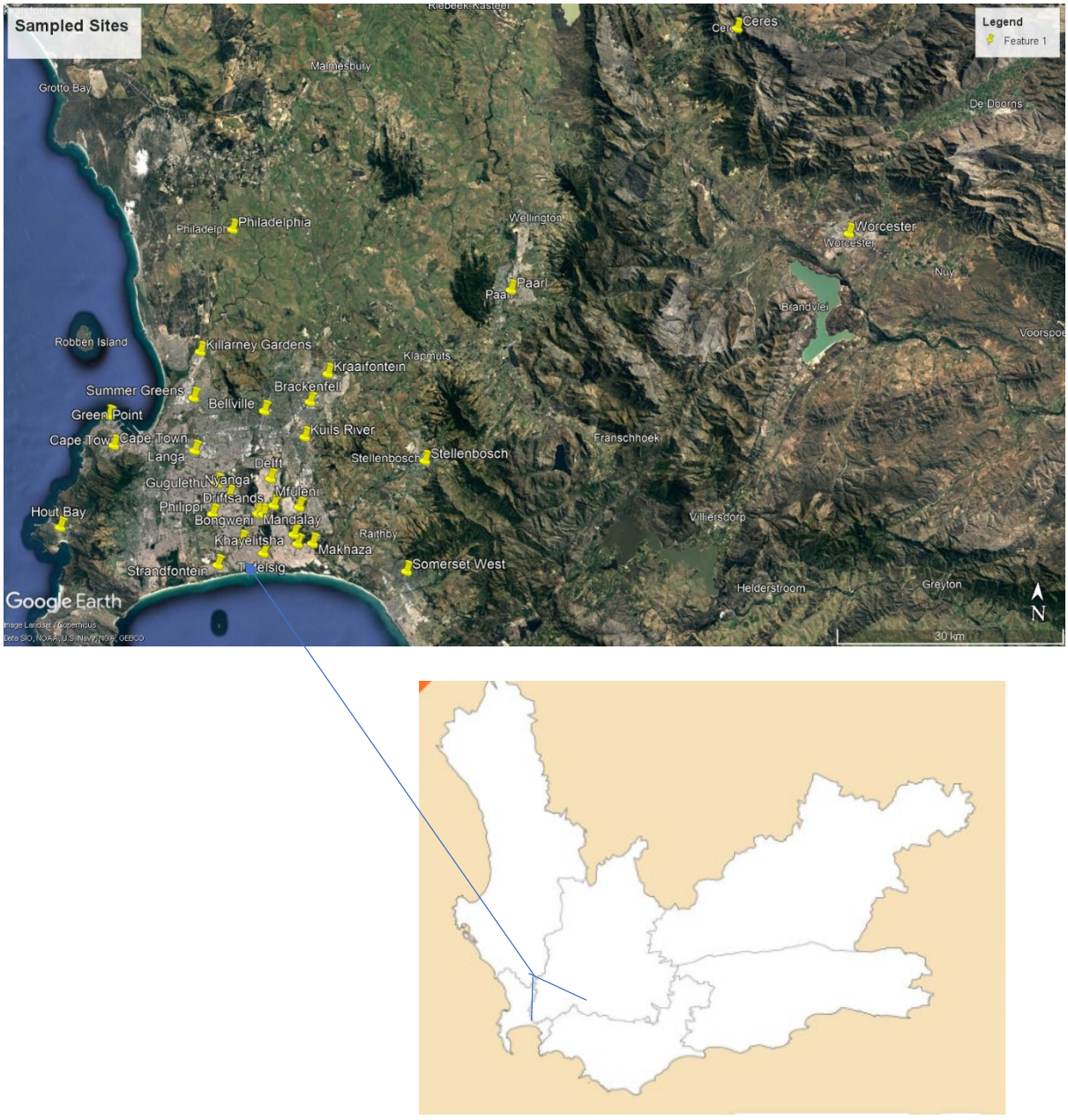


Figure 3.1: A map showing the regions of traditional healers from the Western Cape who participated in the study was generated using Google Earth software.

3.2.2 Methods of data collection

A mixed methods approach was employed, combining qualitative and quantitative research techniques. The primary data collection method involved open-ended and close-ended semi-structured questionnaires, which were administered to randomly selected traditional healers to gather relevant information.

3.2.3 Data collection

100 semi-structured questionnaires (see appendix 4) were distributed to traditional healers, of which 75 agreed to participate in the research. According to Bless and Higson-Smith (2000), the minimum statistical sample size required to provide credible data is at least 30 units. Therefore, the sample size of 75 respondents was deemed sufficient for obtaining accurate data.

3.2.4 Pre-survey interviews

Before distributing the questionnaires to participants, a preliminary survey was conducted to assess the topics' relevance, acceptability and authenticity. In August 2021, ten consenting healers were randomly selected and interviewed to evaluate the questionnaires. Based on the preliminary findings, the questions were refined to align more closely with the study objectives before initiating the research study.

3.2.5 Assembling the survey instruments

As most traditional healers registered under the organizations primarily spoke isiXhosa, the revised questionnaires were translated into isiXhosa to address the language barrier. The questionnaires encompassed various variables with both the quantitative and qualitative components, including: (i) sociodemographic characteristics (i.e., healers sex, age, employment status, source of income, home language, place of residence and involvement category (healer, shop trader or street trader); (ii) Duration of healing/plant-selling activities; mostly requested medicinal plants species, sources of plant materials; (iii) awareness of depletion and preservation of medicinal plants; (iv) perceptions and attitudes towards cultivated medicinal plants; (v) involvement in cultivation activities and willingness to buy cultivated plants from local farmers; and (vi) information specific to *A. afra*, covering

aspects like demand, source of plant material, availability, parts used and medicinal uses of the plant.

3.2.6 Surveys

The Department of Horticultural Sciences at the Cape Peninsula University of Technology, Bellville campus, facilitated two workshops aimed at establishing partnerships with traditional healers. These workshops sought to provide training and initiate collaboration in conserving and cultivating medicinal plants, facilitate constructive discussions, mitigate mistrust, and introduce and elucidate the purpose of the questionnaires to the healers. The workshops were organized in collaboration with the Western Cape Traditional Healers Organizations, namely Ubizo Lwam Institute, Buzani Kubawo Healers Organization, Lupasa and Traditional Healers Organization (THO) (Figure 3.2a). Notably, the workshops were graced by the presence of the Chief of abaThembu and the Cultural Council of the Western Cape (Figure 3.2b). Invitations were extended to the chairpersons of these organizations to disseminate information to their members and relevant stakeholders (Appendix 5).

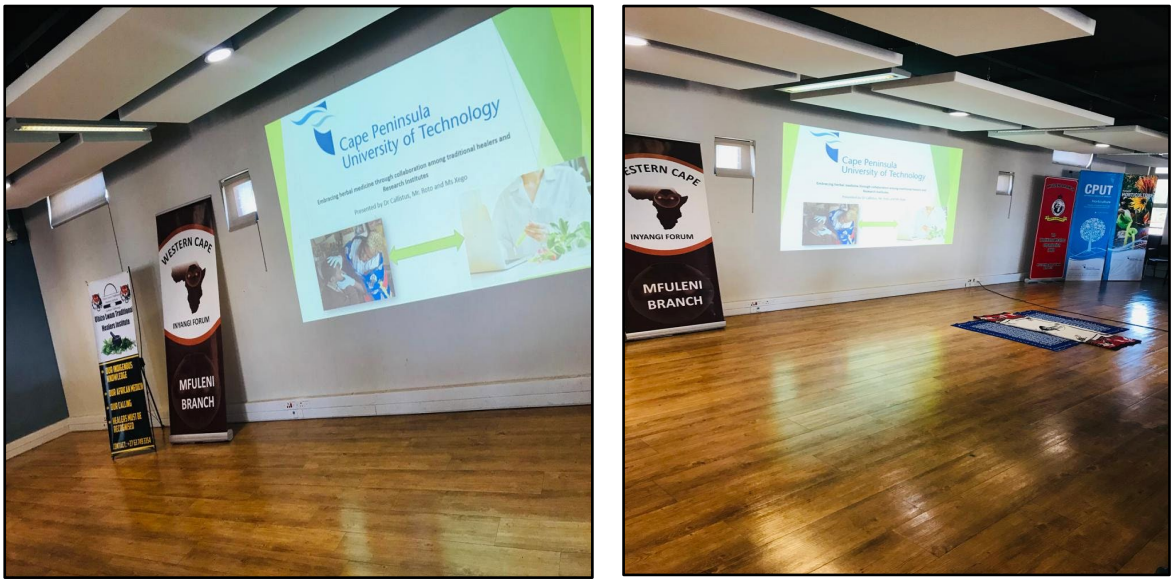


Figure 3.2a: Banners of the traditional healers' organizations at the workshop venue.

Figure 3.2b: Chief of abaThembu and cultural council of the Western Cape.

The leaders of the traditional healer organizations chose the venues of the meetings. Each participant received an information sheet detailing the agenda for the day (Appendix 6). Following the discussions, consent forms and questionnaires were distributed, with researchers providing thorough explanations for each question and addressing any queries from the healer (Figure 3.3). Notably, while some healers completed the surveys immediately with the researchers' assistance, others preferred to take the forms for completion later. As incentives for participation, gift bags adorned with the insignia of Cape Peninsula University of Technology and refreshments were offered (Figure 3.3).

Figure 3.3: Snapshots captured throughout the workshop, including moments from registration, healers paying respect to their ancestors, researchers interacting with participants and filling out the questionnaires.

Some questionnaires were sent via email, while others were personally delivered to traditional healers. Those located in Philadelphia, Houtbay, and Killarney preferred email delivery, while others were visited at home, often upon recommendation from fellow traditional healers (Figure 3.4).

Figure 3.4: Visits to traditional healers' households and places of practice.

Every participant was presented with a written informed consent letter at the outset of each workshop and home visit (Appendix 7a). They were briefed on the study's objectives and its significance to their community, and assured of the confidentiality of their responses, emphasizing that the data would be strictly used for research purposes. Participants were informed of their right to withdraw from the survey at any point, with the understanding that their involvement was voluntary and anonymous. Participants were also given the option to abstain from answering any questions that made them feel uneasy.

3.2.7 Ethical issues

This study adhered to university policies and obtained ethical approval from the Cape Peninsula University of Technology Research Ethics Committee (Ethics reference number: 209199237/10/2020) (Appendix 8). Permission was also sought from the chairpersons of traditional healers' groups to conduct the research with their members.

3.2.8 Processing and analyzing data

All responses to the open-ended questions were translated into English before analysis. The data was then recorded on an Excel spreadsheet and analyzed using the Software Program for Social Science (SPSS) to identify significant differences with a 95% confidence interval. A list of commonly used medicinal plants reported by healers was compiled by matching vernacular names to botanical names from previously published studies (Dold & Cocks, 1999; Williams, 2003; Sewani-Rusike & Mammen, 2014; Bhat. 2014; Mbongwa, 2018; Ndlovu *et al*., 2022). SPSS was used to generate frequency tables for descriptive statistics.

3.3 Results

3.3.1 Location

Traditional healers who participated in the study were from various locations as listed below. Notably, Khayelitsha exhibited the highest participation rate, followed by Mfuleni: Khayelitsha (23%), Mfuleni (8%), Langa (5%), Kraaifontein (5%), Worcester (4%), Delft (4%), Nyanga (4%), Paarl (4%), Ceres (3), Philippi (3%), Gugulethu (3%), Stellenbosch (3%), Hout Bay (3%), Driftsands (3%), Bellville (3%), Strandfontein (3%), Green Point (1%), Mandela Park (1%), Killarney (1%), Bongweni (1%), Tafelseg (1%), Mandalay (1%), Makhaza (1%), Summer Greens (1%), Kuils River (1%), Mitchellsplain (1%), Cape Town (1%), Brackenfell (1%), Philadelphia (1%), Somerset West (1%).

3.3.2 General/demographic information of respondents

The findings from the study on home language indicated the use of Xhosa among traditional healers was predominant (95%; $P < 0.05$) (Table 3.1). However, there were notable instances where participants indicated different home languages, including English (2.5%) and Sesotho (2.5%).

Regarding age distribution (Table 3.1), the age range of 26-45 comprised most participants, with the age range 36-45 having the highest representation (31%; $P < 0.05$). While there was representation in both the younger (15-25) and older (56 & above) age brackets, they constituted smaller proportions of the total participants.

The results further highlighted a significant gender representation, with females, comprising 69% ($P < 0.05$) of the total participants and males accounting for 31%. This underscores a notable presence of females within the group (Table 3.1).

Regarding participants' involvement, the majority (91%) were identified as traditional healers. Although the primary involvement is in traditional healing, some individuals also combined roles, with 4% engaging in street trading and 5% in shop trading (Table 3.1). The participants exhibited diverse experience levels, with a notable portion having less than 5 years of experience (28%) and the 5-10 years range had the greatest participation rate (37%). Other experience categories included 11-15 years (7%), 25-30 years (8%), and 34-40 years (5%), with a few participants having 40 or more years of experience. Notably, a small percentage (15%) did not specify the exact number of years in the field (Figure 3.5).

Table 3.1: Demographic information, linguistic diversity, varied roles and experience levels of the participants.

		Number of participants (%)	**Mean ± standard error**
Language	Xhosa	95%	0.95 ± 0.23^{a}
	Sotho	2.5%	0.03 ± 0.16^{b}
	English	2.5%	0.03 ± 0.16^{b}
Age	15-25	12%	0.12 ± 0.32^{bc}
	26-35	23%	0.23 ± 0.42^{ab}
	36-45	31%	0.31 ± 0.46^{a}
	46-55	24%	0.24 ± 0.43^{ab}
	56-65	1%	0.01 ± 0.11^{c}
	65 & above	9%	0.09 ± 0.29^{bc}
Gender	Male	31%	0.31 ± 0.46^{b}
	Female	69%	0.69 ± 0.46^{a}
Involvement	Traditional healer (TH)	91%	0.91 ± 0.29^{a}
	TH & Street trader	4%	0.05 ± 0.23^{b}
	TH & Shop trader	5%	0.04 ± 0.19^{b}
Years in the field	1-5	28%	
	6-10	37%	
	11-15	7%	
	25-30	8%	
	34-40	5%	
	Not specified	15%	

Means that do not share a letter are significantly different ($P < 0.05$). Values shown are mean ± standard error. Different letters down the same column represent significant differences at $P < 0.05$. (%) indicate a total percentage of respondents for each question.

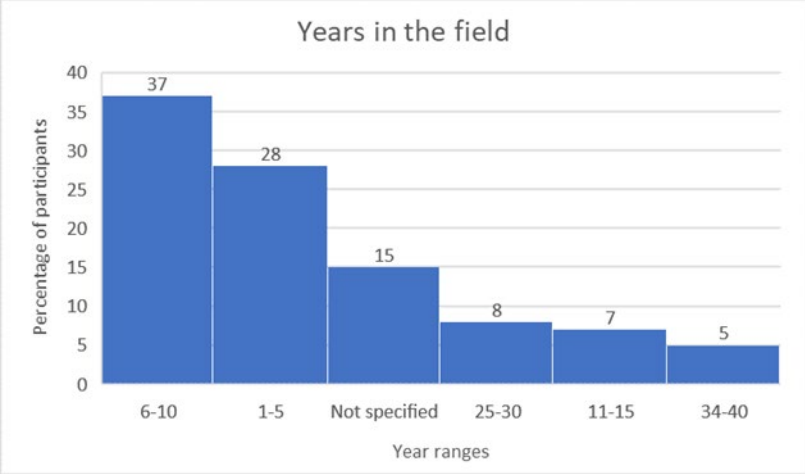


Figure 3.5: Participants' years of experience in the field of traditional healing.

3.3.3 Details regarding the sales, harvesting, cultivation and depletion of medicinal plants.

3.3.3.1 Sales

The data presented in table 3.2a, 3.2b, 3.2c and table 3.3 provides summary statistics concerning the contribution of medicinal plant sales to the income of traditional healers. A significant portion of the surveyed population (52.0%, n= 39) stated that they rely on medicinal plant collection/production as their primary source of income. While nearly half of the respondents (48.0%, n= 36) indicated that medicinal plant collection in not their primary means of earning (Table 3.2a). Only 6 (8.0%) participants provided explanations, shedding light on factors influencing their reliance on medicinal plant collection/production. The reasons provided for "Yes" answers included "*I am unemployed, and I have no other means of income*"; this emphasized the exclusive dependence on medicinal plant-related activities for financial sustenance. Explanations for "No" answers, such as "*I am working part-time and full-time*" indicated diversity in economic activities among the respondents.

Table 3.2b provided data on the frequency and percentage of responses to a question about whether selling medicinal plants contributes to participants' income. The results showed a significant consensus among 69 respondents (92.0%) affirming that the sale of medicinal plants contributes to their income. Conversely, 6 respondents (8.0%) indicated that selling medicinal plants does not contribute to their income. The respondents who answered "Yes" provided additional information.

Specifically, they mentioned reasons such as "*the money I am earning is not enough*" and "*I have a small personal monthly income that requires additional support or supplementation*".

The results presented in Table 3.2c show responses to a question about the sales experiences among the respondents (categorized by different speed levels). The majority of respondents (45.3%, n= 34) indicated that the plants in their shops or practicing residences sell as at a fast pace, while (24.0%, n= 18) mentioned that the sales fluactutes. Smaller percentages were noted on various degrees of slower sales [Very slow (5.3%, n= 4), Moderate slow (10.7%, n= 8) and Slow (14.7%' n= 11).

Table 3.2a, 3.2b and 3.2c: Frequency and percentages**.**

a) Is medicinal plant collection/production the primary means of your earning?

		Frequency	Percent
Valid	Yes	39	52.0
	No	36	48.0
	Total	75	100.0

b) Does selling of medicinal plants contribute to your income?

		Frequency	Percent
Valid	Yes	69	92.0
	No	6	8.0
	Total	75	100.0

c) How well do the plants in your shop sell?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very slow	4	5.3	5.3	5.3
	Moderate slow	8	10.7	10.7	16.0
	Slow	11	14.7	14.7	30.7
	Fast	34	45.3	45.3	76.0
	Fluctuate	18	24.0	24.0	100.0
	Total	75	100.0	100.0	

Frequency: demonstrates number of participants for each response and percentages (%).

Table 3.3: Descriptive statistics for the sales questions.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean	df
Is medicinal plant collection/production the primary means of your earning?	75	1.48	.503	.058	74
Does selling of medicinal plants contribute to your income?	75	1.08	.273	.032	74
How well do the plants in your shop sell?	75	3.72	1.110	.128	74

N= number of participants; Std.= standard; df= degree of freedom.

3.3.3.2 List of mostly demanded medicinal plant species by buyers or users

Appendix 9 is a compilation of 64 diverse and predominantly utilized traditional medicinal plant species identified by respondents. The top ten most used species are highlighted (Table 3.4), with *Artemisia afra* being the most used species (Table 3.4) and the most sought-after with a notable 27% demand, followed closely by *Rhoicissus digitata* at 23% and *Silene undulata* at 18%. *Bulbine abyssinica*, *Hypoxis hemerocallidea*, and *Strychnos henningsii* also demonstrate considerable demand, ranging between 15% and 16%. Conversely, *Talinum caffrum* (12%), *Helichrysum odoratissimum* (11%), *Cissampelos capensis* (11%), and *Synaptolepis oliveriana* (9%) exhibited moderate demand, with percentages ranging from 9% to 12%. This detailed breakdown yields valuable insights into the preferences of buyers or users, aiding informed decision-making regarding cultivation and resource allocation.

Table 3.4: Summary of the top ten medicinal plants frequently mentioned by respondents as the most utilized (n= 75 respondents; total plant species= 64). (Complete species list available in Appendix 9).

Botanical name	Vernacular name	Part(s) used	Condition for treatment	No. of citations (%)
Artemisia afra Jacq. ex Willd	Umhlonyane; wilde Als	Leaves, roots	Flu, blood sugar, worms, respiration, skin ailments, covid, cold	27%
Rhoicissus digitata (L.f.) Gilg & M.Brandt	Chithibunga	Roots, bulbs, leaves	Chase away bad luck	23%
Silene undulata Ainton	Ubulawu	Roots	Facilitate communication with the ancestors (for clear dreams), meditation herb	18%
Many species including *Bulbine abyssinica* A.Rich.	Intelezi	Roots, bulbs	Bring good luck	16%
Hypoxis hemerocallidea Fisch., C.A.Mey. & Avé-Lall.	Inongwe; African potato; Ilabatheka	Bulb, flowers, roots	Immune boosting	15%
Strychnos henningsii Gilg	Umnonono	Bark	To heal poison	13%
Talinum caffrum (Thunb.) Eckl. & Zeyh.	Phunyuka	Stem, roots	Bring peace, wounds	12%
Helichrysum odoratissimum (L.) Sweet	Impepho	Leaves, stem, roots	Incense to communicate with ancestors, swollen lymph, steaming, stomach problems	11%
Cissampelos capensis L.f.	Umayisake	Roots	Unidentified	11%
Synaptolepis oliveriana Gilg	Uvuma omhlophe	Arial parts	Lucky charm	9%

3.3.3.3 Harvesting or collection of medicinal plants

The provided data in Table 3.5a and 3.5b outlines responses from a survey related to the sourcing and harvesting frequency of medicinal plants. The first part (a) addressed the sources of medicinal plants sold by respondents, and the second part (b) focused on the harvesting frequency, particularly for those obtained from the wild.

Regarding the sources of medicinal plants (Table 3.5a), most respondents (53.3%, n= 40) engage in wild harvesting, highlighting a substantial reliance on natural plant species. A significant portion (32.0%, n= 24) relies on purchasing from external suppliers or markets, while a small percentage (6.7%, n= 5) cultivate the plants

themselves. Furthermore, a smaller proportion (8.0%, n= 6) adopts a hybrid approach, both buying and collecting medicinal plants.

The harvesting frequency showed that the most common harvesting frequency is monthly, with 64.0% of respondents reporting this practice. Following closely, 17.3% of respondents selected a seasonal harvesting schedule, aligning with the natural growth cycles of the plants. A smaller but still significant percentage, 16.0%, harvests wild plants on a weekly basis, reflecting a more frequent harvesting practice. Conversely, a minority of respondents (2.7%) harvest wild plants annually, suggesting a less frequent collection from the wild (Table 3.5b and 3.6).

Table 3.5a and 3.5b: Frequency and percentage.

a) Where do you get the medicinal plants that you sell?

		Frequency	Percent
Valid	Grow	5	6.7
	Buy	24	32.0
	Collect from the wild	40	53.3
	Buy and collect	6	8.0
	Total	75	100.0

b) If you harvest from the wild: how often do you harvest your plants?

		Frequency	Percent
Valid	Weekly	12	16.0
	Monthly	48	64.0
	Seasonally	13	17.3
	Annually	2	2.7
	Total	75	100.0

Table 3.6: Descriptive statistics on the responses to the gathering and collection of questions.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean	df	t
Where do you get the medicinal plants that you sell?	75	2.63	.731	.084	74	31.117
If you harvest from the wild: how often do you harvest your plants?	75	3.07	.664	.077	74	39.972

N= number of participants; Std.= standard; df= degree of freedom

3.3.3.4 Cultivation of medicinal plants

Of the total participants (n= 75), nearly half of the participants (48.0%, n= 36) reported actively cultivating medicinal plants and being involved in the cultivation process. In contrast, 34.7% (n= 26) of respondents do not engage in cultivation, relying on alternative sources such as purchasing or wild harvesting. An additional 17.3% (n= 13) falls into the category of cultivating sometimes, indicating an intermittent or occasional involvement in the cultivation activities (Table 3.7a). The reasons why participants do not cultivate medicinal plants were provided by some participants. The responses highlighted a range of challenges and constraints influencing their decision not to engage in cultivation. A notable reason was the limitation of physical space or land, with six participants expressing this as a significant factor. Others cited a preference for purchasing plants from other individuals, emphasizing convenience or access to established sources. Lack of knowledge about cultivation practices and the necessary equipment emerged as a common theme, with six participants specifically mentioning this obstacle. Time constraints, mobility issues, challenges with specific soil types, the cost of seedlings, and water restrictions were additional factors contributing to participants' decisions not to cultivate medicinal plants.

The statistics presented in Table 3.7b, regarding participants' willingness to grow mostly used plants if seeds were freely supplied demonstrated a strong inclination toward cultivation. A significant majority, comprising 96.0% (n= 72) of respondents, expressed a positive response, indicating a high level of interest in engaging in cultivation when seeds are readily available. In contrast, a minimal 4.0% of respondents expressed hesitancy to cultivate these plants, even when seeds and seedlings could be made available.

The results regarding participants' perceptions of differences between cultivated and wild-sourced material (Table 3.7c) indicated that a majority (53.3%) of respondents do not acknowledge any difference between cultivated and wild-sourced material. However, 38.7% of respondents believe there is a distinction between the two sourcing methods. A smaller proportion (8.0%) remained uncertain, expressing a "maybe" response. Among the 38.7% of respondents who perceive differences between cultivated and wild-sourced medicinal plants, four participants provided specific reasons for their beliefs. The respondents stated that (i) cultivated plants,

being home-grown, are considered less potent in their healing properties compared to plants naturally growing in the wild; (ii) another cited reason is the belief that wild-sourced material is organic, in contrast to the non-organic nature of cultivated plants; (iii) the participants stressed the importance of incorporating soil and rocks from the area where the plant naturally grows as part of training for medicinal plants, accompanied by the practice of communicating with the plants; (iv) respondent expressed a belief that plants growing naturally in the wild possess magical qualities derived from their environment, making them more effective when treating various ailments.

The survey results (Table 3.7d) examining participants' willingness to buy or accept cultivated medicinal plants from local farmers revealed a positive inclination toward supporting local cultivation efforts. A substantial 70.7% (n= 53) of respondents expressed a willingness to buy or accept medicinal plants cultivated by local farmers. Conversely, 16.0% (n= 12) of respondents indicated a reluctance to purchase or accept cultivated plants from local farmers, while 13.3% (n= 10) remained uncertain, expressing a "maybe" response. The reasons cited by respondents for not buying cultivated plants from farmers are listed in Appendix 10, providing valuable insights into potential barriers or concerns that may impact their decisions. They also listed a set of beliefs linked to cultivated medicinal plants. The most highlighted responses included: "*Certain rituals must be performed before harvesting some cultivated traditional medicinal plants, as failure to do so may pose a risk to one's life*". "*They wouldn't provide me with the assurance of effective healing"*. "*Because farmers use chemicals*". "*I chose not to purchase it because they incorporate foreign substances to enhance the growth of the plants"*.

Table 3.7e displays the frequency and percentages of responses gathered concerning the existence of community organizations involved in the collection, harvesting, and production of medicinal plants. Among the 75 respondents, only 8.0% acknowledged the existence of such organizations, constituting a total of 6 individuals. In contrast, a substantial 92.0% of respondents (69 individuals), reported the absence of community organizations engaged in these activities.

Table 3.7a, 3.7b, 3.7c, 3.7d and 3.7e: Frequency and percentage.

a) Do you cultivate some of the plants?

		Frequency	Percent
Valid	Yes	36	48.0
	No	26	34.7
	Sometimes	13	17.3
	Total	75	100.0

b) If seeds of mostly used plants can be freely supplied, would you grow them?

		Frequency	Percent
Valid	Yes	72	96.0
	No	3	4.0
	Total	75	100.0

c) Is there any difference between cultivated and wild-sourced material?

		Frequency	Percent
Valid	Yes	29	38.7
	No	40	53.3
	Maybe	6	8.0
	Total	75	100.0

d) If medicinal plants can be cultivated by local farmers, would you buy/accept them?

		Frequency	Percent
Valid	Yes	53	70.7
	No	12	16.0
	Maybe	10	13.3
	Total	75	100.0

e) Is there any community organization dealing with collection, harvesting, trading and producing wild plants?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	6	8.0	8.0	8.0
	No	69	92.0	92.0	100.0
	Total	75	100.0	100.0	

Table 3.8: Descriptive statistics for cultivation questions.

	Do you cultivate some of the plants?	If seeds of mostly used plants can be freely supplied, would you grow them?	Is there any difference between cultivated and wild-sourced material?	If medicinal plants can be cultivated by local farmers, would you buy/accept them?	Is there any community organization dealing with the collection, harvesting, trading and production of wild plants?
Mean	1.69	1.04	1.69	1.43	1.92
Std. Error of Mean	.087	.023	.071	.083	.032
Std. Deviation	.753	.197	.615	.720	.273
T	19.478	45.654	23.863	17.163	60.880
Df	74	74	74	74	74
Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001

3.3.3.5 Depletion of medicinal plant species

The survey data, which analysed responses to the question "Are you aware of the depletion of some medicinal plant species in the wild?" provided valuable insights into the awareness and perceived causes of medicinal plant depletion among the surveyed population (Figure 3.6). The data indicated a significant awareness (66.7%, n= 50) among respondents regarding the depletion of some medicinal plant species, while 33.3% reported not being aware. Furthermore, 50 individuals acknowledged the depletion of medicinal plants and identified various factors contributing to this decline, amounting to a comprehensive list of 26 distinct causes, detailed in appendix 11. Certain participants were not aware of the potential causes of medicinal plant depletion.

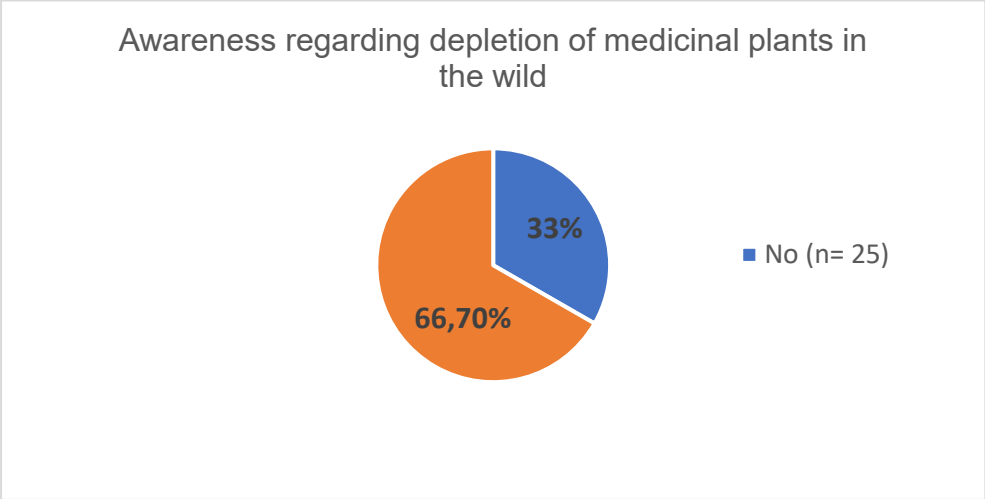


Figure 3.6: The frequency and percentage of responses from participants concerning the depletion of medicinal plants.

3.3.4 Details regarding *Artemisia afra:* demand, availability and uses

The presented data (Table 3.9a) pertains to the usage or sale of the medicinal plant *A. afra*, commonly known as Umhlonyane. The results indicated that an overwhelming majority of 98.7% (n= 74) answered affirmatively, indicating that they use or sell the medicinal plant. Only a minimal 1.3% (n= 1) stated that they do not engage in the utilization or trade of *A. afra*. The high percentage of positive responses suggests a prevalent and widespread association with the medicinal plant within the surveyed group.

The results on the demand for *A. afra* revealed that within the surveyed population, 53.3% (n= 40) of respondents indicate a high demand for the medicinal plant, suggesting a widespread and considerable interest in *A. afra*. Another substantial portion, 40.0% (n= 30), reports a moderate demand, indicating noteworthy but not overwhelming interest. Only a small percentage, 6.7% (n= 5), suggests a low demand (Table 3.9b).

The data on the sources of *A. afra* plant material, categorized by province (Table 3.9c), revealed a varied distribution within the surveyed population. Most of the respondents, comprising 60.0% (n =45), reported obtaining the plant material from the Eastern Cape province, suggesting a significant prevalence or accessibility of *A. afra* within this province. The Western Cape follows with 24.0% (n= 18), indicating another substantial region where respondents source the plant material. A smaller percentage of 10.7% reported obtaining *A. afra* from all provinces, suggesting a more widespread distribution. Durban in KwaZulu-Natal (KZN) and the Northern Cape represent a smaller proportion, at 4.0% and 1.3%, respectively.

According to the data on the methods of obtaining *A. afra*, the majority of respondents (69.3%, n= 52) harvest the plant from the wild. This shows a predominant practice of sourcing *A. afra* directly from its natural habitat. In contrast, 25.3% (n= 19) of respondents reported buying *A. afra*, indicating a market or trade for the plant. While, a smaller percentage, 5.3%, reported growing the plant.

The results on the current availability and accessibility of *A. afra* indicated that most respondents, comprising 80.0% (n= 60), affirm that the plant is still available and easy to access. However, 18.7% (n= 14) of respondents noted that the availability is not like before, implying a perceived change in accessibility over time. Only 1.3% of respondents reported that the plant is not currently available (Table 3.9e).

The information concerning the utilization of various parts of *A. afra* indicated a predominant usage of its leaves, with 68.0% (n= 51) of respondents incorporating them into various practices. The roots are the second most utilized part, reported by 17.3% (n= 13) of respondents, indicating a notable but less common usage. A smaller percentage (4.0%, n= 3) reported using the stem, while 10.7% (n= 8) used the entire plant.

Table 3.9a, 3.9b, 3.9c, 3.9d, 3.9e and 3.9f: Frequency and percentage.

a) Do you use/sell the medicinal plant called *A. afra* (Umhlonyane)?

		Frequency	Percent
Valid	Yes	74	98.7
	No	1	1.3
	Total	75	100.0

b) Is *A. afra* in Demand?

		Frequency	Percent
Valid	Low	5	6.7
	Moderate	30	40.0
	High	40	53.3
	Total	75	100.0

c) Where do you obtain the plant material? (province)

		Frequency	Percent
Valid	All provinces	8	10.7
	Durban- KZN	3	4.0
	Eastern Cape	45	60.0
	Northern Cape	1	1.3
	Western Cape	18	24.0
	Total	75	100.0

d) Do you harvest *A. afra* from the wild or buy it?

		Frequency	Percent
Valid	Buy	19	25.3
	Grow	4	5.3
	Harvest from the wild	52	69.3
	Total	75	100.0

e) Is the plant still available or easy to access?

		Frequency	Percent
Valid	No	1	1.3
	Not like before	14	18.7
	Yes	60	80.0
	Total	75	100.0

f) Which part of the plant do you use?

		Frequency	Percent
Valid	Leaves	51	68.0
	Roots	13	17.3
	Stem	3	4.0
	Whole plant	8	10.7
	Total	75	100.0

Table 3.10: Descriptive statistics for questions associated with *Artemisia afra*.

Statistics

	Do you use/sell the medicinal plant called *A. afra* (Umhlonyane)?	Is *A. afra* in Demand?	Where do you obtain the plant material? (Province)	Do you harvest *A. afra* from the wild or buy it?	Is the plant still available or easy to access?	Which part of the plant do you use?
Mean	1.01	2.47	3.24	2.44	2.79	1.57
Std. Error of Mean	.013	.072	.137	.101	.051	.114
Std. Deviation	.115	.622	1.184	.874	.444	.989
T	76.000	34.322	23.705	24.187	54.357	13.780
Df	74	74	74	74	74	74
Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	<.001
No. of participants	75	75	75	75	75	75

3.3.4.1 Uses of *Artemisia afra.*

The respondents provided a diverse range of 44 uses for *A. afra,* as documented in appendix 12, reflecting the plant's multifaceted significance in traditional practices. Some common applications include using *A. afra* for respiratory issues, such as coughing, asthma, and chest congestion, involving methods like steaming and inhalation. Additionally, the plant is employed for various health concerns, including fever, body pain, high blood pressure, and as an antibiotic. The plant is also associated with cultural and spiritual uses, such as being used for luck and repelling bad spirits. Furthermore, the plant is mentioned for its potential to treat specific ailments, including cancer, fungal infections, and even COVID-19.

Some traditional healers declined to provide a list of the plant's uses, adhering to the belief in preserving confidentiality within traditional healing practices.

"I'm unable to disclose it as it is a confidential matter with my ancestors. Sharing such knowledge as a traditional healer is challenging due to the potential consequences from the ancestors. I apologize for any inconvenience this may cause".

3.4 Discussion

3.4.1 General/demographic information of traditional healers

In accordance with the results, Khayelitsha exhibited the highest rate of participation among respondents who effectively completed the questionnaires. Perhaps, this outcome is linked to the workshop location, which was Khayelitsha, enabling convenient access for participants residing in the area to reach the designated venue.

In the Western Cape province, Afrikaans is the most widely spoken language, followed by Xhosa and English (Britannica, 2024). The findings of the study highlighted a significant prevalence of Xhosa as the home language among traditional healers, constituting 95% of the participants. These results align with the assertion made by Schierenbeck *et al*. (2018) that traditional beliefs are widespread within the Xhosa community, and the use of the traditional healthcare system is a regular and frequent occurrence.

According to Mander *et al*. (2007), approximately 74% of medicinal plant harvesters, street traders and traditional healers are estimated to be women, with 80% residing in rural areas and 20% in urban areas. The demographic data from the surveyed participants in the Western Cape also showed a predominance of females (69%) involved in traditional knowledge and healing practices. This gender distribution corresponds with Mathibela's (2013) findings in Blouberg, where the majority of interviewed traditional healers were females. Similarly, Mayaba's (2019) study revealed female dominance among Mohlontlo traditional healers providing primary health care. However, conflicting reports from other authors, including Bereda (2002), Loundou (2008), Moeng and Potgieter (2011), Davids *et al*. (2016), and Urso *et al*. (2016) suggested male dominance in traditional healing. The diverse evidence demonstrates a potential future dominance of females in the traditional healing sector. The empowerment and recognition of women's roles in traditional healing, coupled with shifts in gender roles, maybe fostering an environment where women feel increasingly empowered to participate in traditional healing practices.

Traditional healing often requires a profound understanding of practices and the accumulation of knowledge. In the study area, a significant majority of traditional healers were in the 36 to 45 age range, followed closely by the 46 to 55 age group. These findings align with previous studies by Nzue (2009) and Semenya and Potgieter (2014), reporting that a majority of male and female Xhosa healers in the Western Cape province were typically between 41 to 50 years old. Similarly, Ndawonde (2006) found that most participants in their study were aged between 45 to 54. As highlighted by Ndawonde (2006), the dominance of this age category may be attributed to the perception that individuals within this range are considered responsible and in a life stage where substantial experience and expertise have been gained. Subedi's findings (2022) also align with the results, indicating that a majority of traditional healers are elderly, and there is a reluctance among the younger generation to learn traditional healing practices. This phenomenon is leading to the loss of valuable health knowledge within the community. A limited number of traditional healers were within the 15 to 25 age range. These individuals expressed a fear that engaging in research or other academic and scientific pursuits would lead to negative perceptions from their peers and elders.

One hundred percent (100%) of the participants were identified as traditional healers, indicating a homogeneous group of participants solely involved in traditional healing practices. The identification of individuals combining traditional healing with other roles, such as street or shop trading, added complexity to their professional profiles. The traditional healers surveyed displayed a diverse range of experience levels; the majority had 6 to 10 years of experience, indicating a substantial presence of practitioners with moderate expertise. Notably, those in the early stages of their careers with 1 to 5 years of experience constituted a significant portion, suggesting a continuous interest and involvement in the field. Furthermore, experienced healers with several decades of practice experience, ranging from 25 to 30 years, contribute valuable knowledge and expertise to the traditional healing community. This diversity in experience levels indicates the richness of perspectives within traditional healing practices. The findings are similar to those reported by Mathibela *et al*. (2015), revealing that twenty-nine percent of healers had less than 10 years of experience, while twenty-one percent had between 11 and 20 years. Additionally, seven percent of respondents reported having 21 to 30 years of healing experience. As stated by Semenya and Potgieter (2014), this balance between experienced and less experienced individuals may contribute to the long-term stability of the profession.

3.4.2 Sales, harvesting, cultivation and depletion of medicinal plants.

In South Africa, the traditional medicine trade is integrated into a multi-million rand 'hidden economy', driven by factors including significant population growth, rapid urbanization, high unemployment rate, and the deep cultural value attached to traditional remedies (Dold and Cocks, 2002). A notable portion of respondents reported relying on medicinal plant collection or production as their primary source of income, showing the economic significance of selling medicinal plants within the traditional healing community. Reasons for this reliance vary, with some participants citing financial necessity due to unemployment, while others seek to supplement their existing income. These reasons align with those highlighted by Schippmann *et al*. (2002) and Ndawonde (2006), indicating that factors such as rapid population growth and high unemployment rates contribute to commercial over-harvesting of medicinal plants by gatherers seeking to generate income. Overall, these findings underline the vital economic role played by medicinal plant collection and sales in supporting the livelihoods of traditional healers.

Regarding sales experiences, most of the respondents reported fast sales, indicating a high demand for medicinal plants. The mention of rapid sales among traditional healers highlights a strong demand for medicinal plants within the market. This indicates that certain products or remedies derived from these plants are highly sought after by consumers. Rapid sales suggest that traditional healers have a competitive advantage in providing health care tailored to meet their patients' needs and expectations (UNAIDS, 2002). According to Khumalo *et al*. (2006), the rising prevalence of practitioners offering herbal remedies and medicinal plants signifies the growing acceptance and popularity of herbal medicine usage.

3.4.3 List of mostly demanded medicinal plant species by buyers or users

The World Health Organization is highly interested in documenting the utilization of medicinal plants by indigenous communities across different global regions (Buragohain, 2011). This study documented 64 diverse medicinal plant species identified by participants as the most frequently utilized or traded traditional medicinal plants in the Western Cape province. This compilation provides valuable insights into buyers' and users' preferences, facilitating in making informed decisions concerning sustainable cultivation and utilization practices of medicinal plants in the region.

Ethnobotanical surveys of medicinal plants have been conducted across various provinces in South Africa, revealing rich traditional knowledge and practices. However, to our knowledge, the current study is the first in the Western Cape to explore plants traditionally utilized by traditional healers across the majority of the investigated communities. In the Western Cape, Philander (2011) identified 205 ethnospecies used in Rastafari ethnobiology, with 181 plants used medicinally, while Nzue (2009) documented 183 plant species used for medicinal purposes in the Cape Peninsula. Additionally, Loundou (2008) found approximately 170 medicinal plant species actively traded and used in the region. In Graaff-Reinet and Murraysburg regions van Wyk *et al*. (2008) recorded 86 medicinal plant species used by elderly people of Khoi-San in the southeastern Karoo. In Limpopo, Mongalo & Makhafola (2018) documented 82 medicinal plants used by Blouberg traditional healers, while Nefhere (2019) recorded 90 medicinal plant species commonly used in the region. Semenya and Potgieter (2014) established 43 species used by Bapedi traditional

healers for the treatment of various ailments, and Rankoana (2016) identified 44 indigenous medicinal plant species from 28 families. In the Nkonkobe Municipality, Eastern Cape, ethnobotanical data on culinary herbs used in the traditional medicinal system was collected highlighting 58 plant species belonging to 29 families (Asowata-Ayodele *et al*., 2016).

In this study, *Artemisia afra* Jacq. ex Willd, *Rhoicissus digitata* (L.f.) Gilg & M. Brandt, *Silene undulata* Aiton, *Bulbine abyssinica* A.Rich., *Hypoxis hemerocallidea* Fisch., C.A.Mey. & Avé-Lall., *Strychnos henningsii* Gilg, *Talinum caffrum* (Thunb.) Eckl. & Zeyh., *Helichrysum odoratissimum* (L.) Sweet., *Cissampelos capensis* L.f., and *Synaptolepis oliveriana* Gilg. were identified as some of the most preferred 'top ten' medicinal plant species used or traded by questioned traditional healers. Among these, *Artemisia afra* emerged as the most sought-after. This finding is consistent with previous studies that have accentuated the significant role of *A. afra* in traditional medicine due to its diverse medicinal properties. Similar ethnobotanical studies by Boadu and Asesa (2017), Semenya and Maroyi (2018), Chakale *et al.* (2022), and Prinsloo *et al*. (2023), have confirmed and emphasized the value and importance of *A. afra* in traditional medicinal practices, identifying it as the most widely used and recognized species among respondents. This study demonstrates an increased demand for *A. afra* during and after the COVID-19 pandemic. This trend aligns with Saruchera and Xaba (2023) assertion that in South Africa, umhlonyane or lengana (*A. afra*) gained popularity as a potential herb for treating COVID-19 symptoms, despite the South African government's insistence on scientific evidence supporting such claims.

Several studies have highlighted the significance and medicinal value of certain plant species identified in this research. In a study by Prinsloo *et al*. (2023), *Helichrysum odoratissimum* emerged as the most recognized plant among the cultural groups interviewed. *Hypoxis hemerocallidea* was ranked fourth in terms of volumes sold in 2007 at the Faraday market in Johannesburg (van Wyk, 2011), it was also among the top 10 most frequently sold medicinal plant species for various ailments in the Eastern Cape, Lesotho and Durban (Dold and Cock, 2002, Ndawonde *et al*., 2007, Mugomeri *et al*., 2016). Philander (2011) similarly identified *H. hemerocallidea*, *Agathosma spp*., and *Helichrysum spp*. as significant contributors to traditional medicine in the Western Cape, aligning with observed demand levels. Whereas

Strychnos henningsii was identified by Wintola *et al*. (2017) as one of the species with the highest use- values for treating stomach diseases. Keirungi and Fabricius (2005) listed the 17 most important medicinal plants used in the Nqabara Administrative Area in the Eastern Cape, with *S. henningsii* being the most important tree species. Some plants such as *A. afra*, *S. henningsii* and *H. odoratissimum* were frequently cited as the most commonly used species by traditional healers, herbalists and across four villages in Seymour (Buwa-Komeren *et al*., 2019). The ethnobotanical survey conducted by de Wet (2005) documented *Cissampelos capensis* as the most widely used medicinal plant species in South Africa and marked as highly important. Additionally, Cocks *et al*. (2004) and Fearon (2010) listed the top 10 medicinal species sold by traditional healers in the Eastern Cape including *H. odoratissimum*, *H. hemerocallidea* and *Rhoicissus digitata*.

3.4.4 Harvesting or collection of medicinal plants in the Western Cape

Concerns regarding the conservation of medicinal plant species have garnered significant attention due to extensive overharvesting and exploitation (van Wyk and Prinsloo, 2018). Thus, understanding medicinal plant sources and harvesting frequencies is crucial for promoting sustainable management strategies and conservation initiatives for medicinal plant resources.

The research findings from this study regarding the origins and harvesting frequencies of medicinal plants in the Western Cape revealed that most respondents rely on wild-harvested species for trade and usage. This observation is aligned with findings by Petersen (2014), who revealed that many traditional practitioners in Cape Town communities heavily depend on plant materials harvested from the wild. Furthermore, this investigation found that the practice of harvesting wild plants for traditional medicine trade is deeply entrenched in townships and informal settlement cultures of the region (Petersen, 2014). Correspondingly, several authors have reported that traditional healers and traders primarily rely on wild populations for sourcing medicinal plants, with the wild collection being the most preferred and widespread method (Srivastava *et al*. 1996; Mander *et al*., 2007; Moeng and Potgieter, 2011; Verma, 2013; Van Wyk and Prinsloo, 2018; Nzue, 2019; Cocks & Dold, 2000). According to Maundu (2006) and Liu *et al*. (2007), these plants are harvested directly from the wild through unsustainable and uncontrolled practices and without cultivation.

The wild harvesting of medicinal plants has significant sustainability implications, necessitating intervention through conservation strategies (Seile *et al*., 2022).

Further analysis of the results showed that not all questioned traditional healers solely depend on wild resources to obtain certain plants; some purchase the plant material from external suppliers or markets. Correspondingly, according to Williams (2003), traditional practitioners relying on these sources believe that markets offer fresh and highly effective materials, while others rely on medicinal plant suppliers due to distant and inaccessible collection sites (Oladele *et al*., 2011). These rationales are aligned with those presented by Kahatano (1997), Hong *et al*. (2015) and Semenya and Maroyi (2019), who argued that time constraints, difficulty in accessing species, and prevalence of diseases might prompt healers to buy medicinal plants from other suppliers or harvesters to ensure consistent availability of these healing plant materials (Semenye & Maroyi, 2019). This indicates that factors such as convenience, the availability of plant species, or urbanization lead to reduced access to natural habitats for wild harvesting. Notably, a small percentage of respondents cultivate the plants, indicating proactive efforts to ensure a sustainable supply of medicinal plants.

According to the traditional healers interviewed, the sourcing practice of collecting plants from the wild is generally conducted on a monthly basis, indicating a systematic approach to plant collection. This finding aligns with Loundou (2008), who discovered that most traded or used species in the study were from wild populations and harvested monthly. Conversely, the results from Semenya *et al*. (2013) and Ndawonde (2015) also indicated that medicinal plants were primarily collected once or three times each month with only a few being harvested twice a week. This frequent harvesting could potentially have detrimental effects on the environment, especially since these plants are sourced from the wild. The manner in which they are collected may also negatively impact the plants, especially considering the frequent harvesting that may not allow sufficient time for regeneration (Ndawonde, 2015). Respondents opting for seasonal harvesting align with the natural growth cycles of plants. According to Semenya *et al*. (2013), seasonality only plays a role when collecting plant parts such as fruits or leaves. Moreover, harvesting on a weekly basis indicates the need for continuous availability of specific remedies or demand for fresh materials.

3.4.5 Cultivation of medicinal plants

The extensive collection of medicinal plants for commercial trade in South Africa poses a significant threat to many species. Thus, cultivation has been considered as a viable alternative to wild harvesting (Keirungi & Fabricius, 2005). Cultivation alleviates harvesting pressure on wild populations, particularly for plants harvested in large quantities (Monakisi, 2007, Mbongwa, 2018). The findings from this study showed that a significant portion of respondents are actively involved in the cultivation of medicinal plants. This outcome reaffirms earlier assertions by Wiersum *et al*. (2006) and Semenye and Potgieter (2014), who noted that the decline in wild medicinal plants has prompted some traditional healers to cultivate plants in their home gardens or source material from other stakeholders involved in cultivation to sustain their practice. There is existing evidence of traditional healers growing medicinal plants in their home gardens, as indicated by Oladele *et al*. (2011) and Amujoyegbe *et al*. (2012).

Reasons for not cultivating medicinal plants varied among participants and included issues such as limited physical space and land, preference for purchasing from established sources for convenience, lack of knowledge about cultivation practices, time constraints, mobility issues, challenges with specific soil types, the cost of seedlings, and water restrictions. These results highlight traditional healers' complex challenges in cultivating medicinal plants and sourcing materials for their practices. The challenges highlighted are consistent with previous research by Crouch and Edwards (2004), Wiersum *et al*. (2006), Oladele *et al*. (2011) and Ndawonde (2015), who found that local cultivation is hindered by several constraints, such as lack of land and water for irrigation, lack of experience and knowledge on how to properly cultivate with respect to soil and light conditions. A study conducted by Nefhere (2019), also revealed that traditional healers expressed interest in cultivating medicinal plants in their backyards; however, they lack the necessary knowledge and training in basic propagation skills. Mbongwa (2018) found that lack of water resources and time were significant barriers to cultivation among healers. Moreover, concerns have been raised concerning the impracticality of cultivating several medicinal plant species due to their extended time to maturity and harvestable size (Botha 2001; Mander and Le Breton, 2006; Lewu *et al*., 2006; Moeng, 2010). It is noteworthy that respondents emphasized

the difficulty of cultivating plants in the soil typical of the Western Cape, suggesting a need for training on composting techniques.

Furthermore, a significant majority of respondents expressed a strong interest and willingness to grow commonly used plants in their gardens if provided with free seeds or planting material, echoing the suggestion by Botha (2001) to provided healers or traders with propagation material and encourage the development of medicinal gardens. Louw's (2016) study also found that some respondents were willing to purchase seeds if unable to obtain propagation material from wild populations' cuttings.

According to Botha (2001) the success of medicinal plant conservation depends strongly on people's attitudes, values and perceptions regarding natural resources. In line with this, in this study participants were asked to specify their perceptions regarding the difference between cultivated and wild-sourced plants. The majority of respondents claimed that there is no distinction between the two sourcing methods. The results are very similar to those reported by Manzini (2005), where the majority (77%) of participants shared similar views. Corresponding findings have widely reported that products cultivated through in situ domestication are either better or have comparable quality to those gathered from the wild (Wang *et al*., 1990; Guo *et al*., 2001; Liet *et al.*, 2007; Xego, 2016). This suggests that the effectiveness of a medicinal plant may be attributed more to its inherent nature than its cultivation method. Through their experience traditional healers' may have consistently observed therapeutic effects from both cultivated and wild-sourced plants, reinforcing their belief in the equivalence of the two sourcing methods.

On the contrary, a notable number of respondents (39 percent) perceived a distinction between cultivated and wild-sourced plants. Reasons cited included beliefs in the superior potency of the wild-sourced plants due to their environment and organic nature, as well as the importance of incorporating elements from the plant's habitat and communicating with the plants. Respondents emphasized the cultural and spiritual importance of cultivation and harvesting practices stating that, "*certain rituals must be performed before harvesting as the failure to do so may pose a risk to the user's life*" and some concerns highlighted scepticism towards cultivated medicinal plants stating, "*They wouldn't provide me with the assurance of effective healing*". This perspective

suggests that for some participants, traditional medicine is deeply rooted in spiritual and cultural beliefs. It further highlights a potential barrier to the acceptance of commercial cultivated medicinal plants, as some users perceive them as less potent or effective compared to wild-harvested plants. The findings are supported by Mathibela *et al*. (2015), who found that the minority of participants regarded cultivated plants as inferior to wild gathered specimens. Traditional healers view cultivated material as unacceptable, believing it lacks the same potency as wild collected material (Cunningham, 1998). Medicinal plant users often opt for wild-sourced plants due to perceptions among both patients and healers that cultivated medicinal plants lose their healing power quickly and may be ineffective for certain illnesses (Semenya and Potgieter, 2014). They also believe that collecting medicinal plants from the mountain saturates them with purity and natural powers (Louw, 2016).

According to Kelatwang and Abbot (2002), healers perceive that the toxicity of a species is influenced by harsh natural environments, and they believe that the more a species is protected from such environments, the less effective it becomes. Concerns also arise regarding whether cultivated plants can fulfil traditional or ritual requirements (Monakisi, 2007; Ndawonde, 2015). Kelatwang and Abbot (2002) asserted that the lack of adoption is also linked to the rituals that must be conducted before species are harvested. These findings highlight the cultural and spiritual dimensions inherent in traditional healing practices, emphasize the importance of considering cultural perspectives in medicinal plant research and conservation efforts. Ultimately, the success of cultivation depends on the attitudes of the traders, healers and customers towards cultivated material (Cunningham, 1997).

3.4.6 Cultivation of medicinal plants by local farmers

Farming overharvested species can serve as a conservation strategy to meet increasing market demands while simultaneously protecting wild populations of the targeted species (Liu *et al*. 2019). The survey results of the study indicated a prevalent positive attitude among participants toward supporting cultivation efforts of medicinal plants, with the majority expressing willingness to purchase or accept plants cultivated by local farmers. This sentiment aligns with findings from Mbongwa's (2018) study, where most traditional healers and traders recommended farmers for commercialising medicinal plant cultivation. This presents an opportunity to promote local agriculture

and sustainable practices in medicinal plant production. As highlighted by Mofokeng *et al.* (2022) cultivation of medicinal plants provides emerging farmers an opportunity to cultivate these plants as new and alternative crops, thereby mitigating unsustainable wild harvesting and competition.

However, it is essential to acknowledge that a minority of the participants exhibited reluctant to purchase or accept cultivated plants from local farmers. Their hesitancy stemmed from various concerns including doubt about the efficacy and safety of cultivated plants due to potential deviations from traditional rituals and the use of chemicals. Some traditional healers preferred cultivating the plants themselves to ensure control over the process and avoid potential unknown substances. Additionally, they had reservations regarding the authenticity and purity of cultivated plants, along with cultural beliefs dictating who should handle the medicinal plants. For instance, in South Africa and Swaziland, cultural norms stipulate that menstruating women should refrain from collecting medicinal plants due to beliefs about diminishing their healing power (Cunningham, 1993). Cost considerations also factored into their decision-making process.

It is also worth mentioning that in South Africa, there has been limited progress in the cultivation of medicinal plants by farmers (Jager & van Staden, 2000). This stands in stark contrast to countries like India and China, where over 700 farmers were reported to be actively involved in medicinal plant cultivation (Lambart *et al*., 1997).

3.4.7 Awareness (active community organizations)

Cultivation of medicinal plants should be undertaken by the communities that depend on them (Mander 1998), and this can be facilitated through the establishment of community-based natural resource management projects (Moeng, 2010). The survey results indicated a significant absence of community organizations engaged in the collection, harvesting, and production of medicinal plants, with ninety-two percent of respondents acknowledging this gap. This observation aligns with the research conducted by Nefhere (2019), where the majority of traditional healers highlighted a prevailing lack of awareness regarding medicinal plant conservation and sustainability. The absence of collective initiatives highlights a critical gap in addressing medicinal plant-related activities within the Western Cape.

This disparity signifies a need for greater awareness, support, or collaboration to foster the establishment and empowerment of community organizations aimed at sustainable management and utilization of medicinal plant resources. According to Rahman *et al*. (2022) raising community awareness about sustainable harvesting and cultivation practices at both homestead forests and commercial levels, could lead to sustainable conservation of these valuable plant species. Awareness campaigns are part of community-based initiatives to educate medicinal plant users about the existing challenges and mobilize them to manage and conserve these plants effectively (Motaleb, 2010). As proposed by Semenya and Maroyi (2019), the primary conservation initiative should involve educating traditional healers and other local harvesters about the importance of cultivating and conserving medicinal plant species.

3.4.8 Awareness regarding depletion of medicinal plants in the wild

Due to rapid population growth, the demand for medicinal plants has exceeded their availability in the wild which resulted in scarcity and, in some instances, local extinction of important plant species (Dawa *et al*., 2018; SANBI, 2018). According to Shukla (2023) the main challenge with conserving medicinal plants is the lack of awareness among local people about medicinal plant importance and the dangers that pose a threat to them. Concerning the decline of medicinal plant species in their natural areas, a notable number of respondents admitted awareness of this phenomenon. These findings corroborate results by Nzue (2009) and Nefhere (2019) that a significant number of traditional healers are aware and concerned about the decline of certain medicinal plant species.

Traditional healers identified various factors contributing to the depletion of medicinal plants, as seen in appendix 11. Major factors include the unsustainable harvesting practices such as careless harvesting, uprooting of plants, and continuous harvesting without allowing for regeneration. Environmental pressures, such as habitat destruction and climate change, also play a significant role. Cultural factors such as inadequate rituals before harvesting and limited knowledge about sustainable practices, exacerbate the problem. Additionally, limited land availability for cultivation, absence of replanting practices, unrestricted nature of harvesting, lack of designated oversight, and widespread use for commercial purposes further strains wild populations. Nzue (2009), Magoro *et al*. (2010), Dubey and Dubey (2010), Kayombo

et al. (2013), Dawa *et al*. (2018) and Strydom and Dunn (2019), have also highlighted factors such as unsustainable harvesting practices, urbanisation, overharvesting, climate change, explosion of human population, habitat alteration, and socio-economic constraints as significant contributors to plant depletion.

The decline in medicinal plants is recognized by both conservationists traditional healers and traders, emphasizing the need for intervention (Kelatwang & Abbot, 2002). Increasing awareness about the depletion of wild medicinal plants can promote the cultivation and utilization of cultivated varieties, thereby enhancing accessibility compared to the less available wild plants.

3.4.9 Details regarding *Artemisia afra:* demand, availability and uses

The data provided displayed valuable insights into the use, demand, sources, methods of obtaining, availability, and utilization of *A. afra*, also known as ‘’umhlonyane’’. The findings revealed that nearly all respondents are either using or selling this medicinal plant, underscoring its significance within the community. These results align closely with previous studies by Williams (1996), Abrahams (1997) and Thring and Weitz (2006), which also identified *A. afra* as the most commonly stocked plant among local traditional healers for treating various ailments. Additionally, numerous studies have highlighted that *A. afra* is one of the oldest, most well-known, and most frequently used medicinal plant across all cultures in South Africa (Moteetee & van Wyk, 2011; du Toit & van der Kooy, 2019; Sotenjwa, 2020; Tsumbedzo *et al*., 2020).

The demand for *A. afra* varies, with a significant number of respondents indicating a high demand for the plant, while others reported a moderate demand. This widespread demand highlighted the plant’s importance and its significant role in the community for medicinal purposes. Although it was classified as least concern by SANBI in 2005 (Raimondo *et al*., 2009), recent observation by Letsoalo (2002) indicated that the high demand for *A. afra* over the years has led to overharvesting, putting the plant at risk of depletion.

The majority of respondents sourced *A. afra* from the Eastern Cape, followed by the Western Cape. Harvesting from the wild was the predominant method of obtaining the plant, though some respondents reported purchasing it. Notably, very

few respondents grew the plants in their home gardens, underscoring a reliance on natural habitats. These results align with Xaba (2008) statement that the popularity of *A. afra* has led to extensive wild harvesting to support a rapidly growing population. Regarding availability, respondents affirmed the continued availability and accessibility of *A. afra*, although some noted perceived decrease over time. The plant has become more difficult to find as demand and prices have risen due to its recent use in treating Covid-19 symptoms (Letsoalo, 2022). Before the pandemic, *A. afra* was easily accessible from street vendors and various traditional markets. However, public reaction to the pandemic led to an increase in the harvesting and sale of the plant (Tsumbedzo *et al*., 2020).

3.4.10 Uses of *Artemisia afra*

Traditional healers indicated a wide range of uses for *A. afra*. It is commonly used to treat respiratory issues and flu-related illnesses such as coughing, colds, sinus problems, dry throat, asthma, fever, tuberculosis, bronchial ailments, chest congestion, and Covid-19. Additionally, it is used for digestive and gastrointestinal issues including stomach aches, intestinal worms, colic, gastritis, rectal laxative, vomiting, and loss of appetite. *A. afra* is also employed for pain relief from body pain, arthritis, gout, rheumatic diseases, and headaches. Other uses include treating high blood pressure, cancer, fungal infections, bladder problems, swelling, blood purification, immune boosting, antibiotic, skin application, and fertility treatments. Healers also use it for steaming to bring luck and chase away bad spirits. Numerous studies have substantiated many of the aforementioned uses (Williams, 1996; Abrahams, 1997; Thring & Weitz, 2006; Xaba, 2008; Moteetee & van Wyk, 2011; Patil *et al*., 2011; Bekele & Reddy, 2015; du Toit & van der Kooy, 2019; Sotenjwa, 2020; Tsumbedzo *et al*., 2020; Letsoalo, 2022; Setshedi *et al*., 2022).

3.5 Recommendations

The study elicited the following recommendations from traditional healers:

Firstly, they advised against excessive consumption of *A. afra*, cautioning that it could interfere with other medications in the body. Secondly, there was a call for promotion of traditional medicinal plant cultivation. It was emphasized that availability

of medicinal plants from diverse stakeholders, coupled with their cultivation for resale or herbal medicine preparation, represents a practical approach to address the decline of wild medicinal plants nearing extinction. According to the traditional healers, this approach will not only ensure sustainable access to medicinal resources but also provides a source of income for low-income traditional healers. Thirdly, they encouraged farmers to cultivate more medicinal plants, utilizing their available land resources. Lastly, they highlighted that accessing medicinal plants in regions like the Western Cape poses challenges due to government restrictions, advocating for registered traditional healers to be granted access to these protected areas.

3.6 Conclusion

In the Western Cape, the traditional medicine trade is a significant component of the economy, driven by population growth, urbanization, and unemployment. Medicinal plant collection is vital for the livelihood and healthcare purposes of traditional healers, with rapid sales indicating high demand. However, the reliance on wild harvested plants poses sustainability challenges, emphasizing the need for conservation and cultivation practices. The cultivation of medicinal plants is hindered by a number of constraints, yet it presents a viable solution to reduce pressure on wild populations. Increasing awareness and community involvement are crucial for sustainable management. *A. afra* exemplifies the importance and demand for medicinal plants. It is a highly significant plant within the community, widely used and sold for its diverse health benefits. Despite its current accessibility, the plant faces risks from overharvesting due to high demand, particularly during the Covid-19 pandemic. Sustainable cultivation efforts are crucial to ensure its continued availability for future generations.

3.7 References

Abiolu, O.A., 2018. Ethnobotanical study of medicinal plants in southwestern Nigeria and traditional healers' perception of indigenous knowledge digitisation. Inkanyiso: *Journal of Humanities and Social Sciences.*, 10(1): 90–102.

Abrahams, M.A. 1997. Bioassay-guided fractionation of Artemisia afra for in vitro antimalarial activity against *Plasmodium falciparum*. A project submitted to the Department of Pharmacology, University of Cape Town in fulfilment of the requirements for the degree Master of Science (MEDICINE).

Amujoyegbe, B.J., Agbedahunsi, J.M. & Amujoyegbe, O.O. 2012. Cultivation of medicinal plants in developing nations means of conservation and poverty alleviation. *International Journal of Medicinal and Aromatic Plants.,* 2: 345–353.

Asowata-Ayodele, A.M., Afolayan, A.J. & Otunola, G.A. 2016. Ethnobotanical survey of culinary herbs and spices used in the traditional medicinal system of Nkonkobe Municipality, Eastern Cape, South Africa. *South African Journal of Botany*, 104: 69–75.

Bekele, G. & Reddy, P.R. 2015. Ethnobotanical study of medicinal plants used to treat human ailments by Guji Oromo tribes in Abaya District, Borana, Oromia, Ethiopia. *Universal Journal of Plant Science*., 3(1):1–8.

Bereda, J.E. 2002. Traditional healing as a health care delivery system in a transcultural society (Doctoral dissertation).

Bhat, R.B. 2014. Medicinal plants and traditional practices of Xhosa people in the Transkei region of Eastern Cape, South Africa. *Indian Journal of Traditional Knowledge.,* 13(2): 292–298.

Boadu AA. & Asase, A. 2017. Documentation of herbal medicines used for the treatment and management of human diseases by some communities in southern Ghana. *Evidence-Based Complement Alternative Medicine*., 2017: 3043061.

Botha, J. 2001. Perceptions of Species Availability and Values of Medicinal Plants Traded in Areas Adjacent to the Kruger National Park. MSc. University of the Witwatersrand, Johannesburg.

Britannica, 2024. The Editors of Encyclopaedia. “Western Cape”. *Encyclopedia Britannica*, 29 Jan. https://www.britannica.com/place/Western-Cape. Accessed 30 January 2024.

Buragohain J. 2011. Ethnomedicinal plants used by the ethnic communities of Tinsukia district of Assam, India. *Research in Science and Technology*., 3:31–42.

Buwa-Komoren, L.V. Mayekiso, B. Mhinana, Z. & Adeniran, A.L. 2019. An ethnobotanical and ethnomedicinal survey of traditionally used medicinal plants in Seymour, South Africa: An attempt toward digitization and preservation of ethnic knowledge. *Pharmacognosy Magazine*, 15(60): 115–123.

Chakale, M.V., Asong, J.A., Struwig, M., Mwanza, M., Aremu, A.O. 2022. Ethnoveterinary practices and ethnobotanical knowledge on plants used against cattle diseases among two communities in South Africa. *Plants*., 11(13): 1784.

Cocks, M. & Dold, T. 2000. The medicinal plant trade in the Eastern Cape Province. Research Report (Unpublished). Institute for Social and Economic Research. Rhodes University. Grahamstown.

Cocks, M.L., Dold, A.P. & Grundy, I.M. 2004. The trade in medicinal plants from forests in the Eastern Cape Province. In: LAWS, M.E., Shackleton, C.M. and Geach, B. (eds). Indigenous forests and woodlands in South Africa: policy, people and practice. University of KwaZulu-Natal Press, Pietermaritzburg. pp 473–492.

Crouch, N.R. & Edwards, T. 2004. Ethnomedicinal (muthi) plant nurseries. In: Lawes, M.J., Eeley, H.A.C., Shackleton, C.M., et al. eds. Indigenous forests and woodlands in South Africa: policy, people and practice. University of KwaZulu-Natal Press, Scottsville, 658–661.

Cunningham, A.B. 1993. African medicinal plants: setting priorities at the interface between conservation and primary healthcare. Paris: UNESCO, Division of Ecological Sciences, People and Plants Initiative. (People and plants working paper 1, March 1993.)

Cunningham, A.B. 1997. An Africa-wide overview of medicinal plant harvesting, conservation and health care. pp 116-129. In: G. Bodeker, K.K.S. Bhat, J. Burley & P.

Vantomme (eds), Medicinal Plants for Forest Conservation and Health Care. Non-Wood Forest Products Series No. 11. FAO, Rome. pp 158.

Cunningham, A.B. 1998. an investigation of the herbal medicine trade in KwaZulu-Natal. Investigation Report no. 29. Pietermaritzburg. Institute of Natural resources. University of Natal.

Davids, D., Gibson, D. & Johnson, Q. 2016. Ethnobotanical survey of medicinal plants used to manage high blood pressure and type 2 diabetes mellitus in Bitterfontein, Western Cape Province. *Journal of Ethnopharmacology*., 194: 755–766.

Dawa, S., Gurmeet, P., Dolma, T., Angdus, T., Stobgais, T. & Tharpa, T. 2018. Status of medicinal and aromatic plants in the state of Jammu and Kashmir, India. *International Journal of Current Microbiology and Applied Sciences.*, 7: 2597–2615.

De Wet, H. 2005. An ethnobotanical and chemotaxonomic study of South African Menispermaceae (Doctoral dissertation, University of Johannesburg).

Dold, A.P. & Cocks, M.L., 1999. Preliminary list of Xhosa plant names from Eastern Cape, South Africa. *Bothalia.*, 29(2): 267–292.

Dold, A.P. & Cocks, M.L. 2002. The trade in medicinal plants in the Eastern Cape Province, South Africa. *South African Journal of Science*., 98: 589–597.

Dubey, K.P. & Dubey, K. 2010. Conservation of medicinal plants and poverty alleviation. In National conference on biodiversity, development and poverty alleviation. Souvenir (pp. 89–92).

Du Toit, A. & van der Kooy, F. 2019. *Artemisia afra*, a controversial herbal remedy or a treasure trove of new drugs?, *Journal of Ethnopharmacology*., 244: 112127.

Fearon, J.J. 2010. Population assessments of priority plant species used by local communities in and around three Wild Coast reserves, Eastern Cape, South Africa (Doctoral dissertation, Rhodes University).

Guo, M., Gao, H.Q., Yu, X.H., Li, Z.H., Zhang, Y.X., Sheng, K.H. & Gao, C.Y. 2001. Quality comparison between cultivated and wild materials of *Tussilago farfara* L. *Journal of Chinese Med Materials.*, 24(11): 787–8.

Hong, L., Guo, Z., Huang, K., Wei, S., Liu, B., Meng, S. & Long, C. 2015. Ethnobotanical study on medicinal plants used by Maonan people in China. *Journal of ethnobiology and ethnomedicine.*, 11(1): 1–35.

Jäger, A.K. & van Staden J. 2000. The need for cultivation of medicinal plants in southern Africa. *Outlook on Agriculture*, 29(4): 283–284.

Kahatano, D.E., 1997. Trade in Wildlife medicinal in Tanzania. Report prepared for TRAFFIC East/Southern Africa (Unpublished).

Kayombo, E.J., Mahunnah, M.L.A. & Uiso, F.C. 2013. Prospects and challenges of medicinal plants conservation and traditional medicine in Tanzania. *Anthropology*, 1:108–115.

Keirungi, J. & Fabricius, C. 2005. Selecting medicinal plants for cultivation at Nqabara on the Eastern Cape Wild Coast, South Africa. *South African Journal of Science*., 101: 497–501.

Kelatwang, S. & Abbot, P.G. 2002. Medicinal plant gardens: Promoting plant conservation or rural economic development. In Multiple Use Management of Natural Forests and Savanna Woodlands: Policy Refinements and Scientific Progress: Natural Forests and Savanna Woodlands Symposium III Symposium Proceedings (p. 367). Department of Water Affairs and Forestry, Indigenous Forest Management.

Khumalo, S.G., Fröde, A. & Sola, P. 2006. Guidelines for the sustainable harvesting of traditional medicinal plants in Zimbabwe. Southern Alliance for Indigenous Resources.

Lambart, J., Sricastaca, T. & Vietmaye, N. 1997. Medicinal plants: Rescuing a Global Heritage. The World Bank Washington DC.

Latif, S.S., 2010. Integration of African traditional health practitioners and medicine into the health care management system in the province of Limpopo. Thesis presented in partial fulfilment of the requirements for the Degree of Master of Public Administration University of Stellenbosch, Stellenbosch.

Letsoalo, M.M. 2022. The effect of scarification, temperature and light conditions on seed germination of *Artemisia afra* Jacq. Ex Willd. Dissertation submitted in fulfilment

of the requirements for the degree of Master of Agricultural Management in Plant production in the Faculty of Science and Agriculture at the University of Limpopo.

Lewu, F. B., Grierson, D. S. & Afolayan, A. J. 2006. Clonal propagation of *Pelargonium sidoides*: a threatened medicinal plant of South Africa. *African Journal of Biotechnology.*, 5: 123–125.

Liu, F., Vind, J., Promchote, P. & Ly, P. 2007. Medicinal plants, its condition and Socio-Economic Impacts: A Case Study in Makomereng and Pepela, South Africa. Interdisciplinary Land Use and Natural Resource Management. Faculty of Life Sciences.

Liu, H., Gale, S.W., Cheuk, M.L. & Fischer, G.A. 2019. Conservation impacts of commercial cultivation of endangered and overharvested plants. *Conservation Biology.*, 33(2): 288–299.

Loundou, P.M. 2008. Medicinal plant trade and opportunities for sustainable management in the Cape Peninsula, South Africa (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Louw, M. 2016. The social practices of cultivation and gathering of medicinal plants in Ebenhaezer, Matzikama, Western Cape, South Africa (Doctoral dissertation, University of the Western Cape).

Mabogo, D.E.N. 1990. The ethnobotany of the Vhavenda. Submitted in partial fulfilment of the requirements for the degree Magister Scientiae in the Faculty of Science (Department of Botany) University of Pretoria.

Magoro, M.D., Masoga, M.A. & Mearns, M.A. 2010. Traditional health practitioners' practices and the sustainability of extinction-prone traditional medicinal plants. *International Journal of African Renaissance Studies.*, 5(2): 229–241.

Mander, M. 1998. Medicinal plant marketing in Bushbuckridge and Mpumalanga: A market survey and recommended strategies for sustaining the supply of plants in the region. Unpublished report. Darudec and DWAF, South Africa.

Mander, M. 1998. Marketing of indigenous medicinal plants in South Africa: a case study in KwaZulu-Natal.

Mander, M. & Le Breton, G. 2006. Overview of the medicinal plants industry in southern Africa. In: Diederichs, N (Ed), Commercialising Medicinal Plants: A Southern African Guide. Sun Press, Stellenbosch, 1–9.

Mander, M., Ntuli, L., Diederichs, N. & Mavundla, K. 2007. Economics of the traditional medicine trade in South Africa care delivery. *South African Health Review*., 2007(1): 189–196.

Manzini, T.Z. 2005. Production of wild ginger (*Siphonochilus aethiopicus*) under protection and indigenous knowledge of the plant from traditional healers. University of Pretoria (South Africa).

Mathibela, K.M. 2013. An investigation into aspects of medicinal plant use by traditional healers from Blouberg Mountain, Limpopo Province, South Africa (Doctoral dissertation, University of Limpopo (Turfloop Campus).

Mathibela, M.K., Egan, B.A., Du Plessis, H.J. & Potgieter, M.J. 2015. Socio-cultural profile of Bapedi traditional healers as indigenous knowledge custodians and conservation partners in the Blouberg area, Limpopo Province, South Africa. *Journal of ethnobiology and ethnomedicine*., 11: 1–11.

Maundu, P., Kariuki, P. & Eyog-Matig, O. 2006. Threats to medicinal plant species—an African perspective. Conserving Medicinal Species: Securing a Healthy Future. International Union for Conservation of Nature and Natural Resources. Ecosystems and Livelihoods Group, pp.47–63.

Mayaba, N. 2009. Gender Stereotyping in traditional healing practices. A dissertation submitted in fulfilment of the requirements for degree of Master of Science (Geography) at Walter Sisulu University.

Mbongwa, N.S. 2018. The perceptions, attitudes and knowledge of traditional healers and traders about using cultivated plants in South Africa (MSc dissertation). Johannesburg: University of the Witwatersrand.

Mhlanga, S. 2018. An exploration into the Utilisation of Indigenous Knowledge by Medicinal Plant Vendors as a Livelihood Strategy in Thohoyandou, Vhembe District of Limpopo, South Africa. Thesis submitted in fulfilment of the requirement of the degree of Master of Arts in African Studies. University of Venda.

Moeng, T.E. 2010. An Investigation into the Trade of Medicinal Plants by Muthi Shops and Street Vendors in the Limpopo Province, South Africa. MSc. University of Limpopo, Polokwane.

Moeng, ET. & Potgieter, M.J. 2011. The trade of medicinal plants by muthi shops and street vendors in the Limpopo Province, South Africa. *Journal of Medicinal Plants Research.*, 5(4): 558–564.

Mofokeng, M.M., Du Plooy, C.P., Araya, H.T., Amoo, S.O., Mokgehle, S.N., Pofu, K.M. & Mashela, P.W. 2022. Medicinal plant cultivation for sustainable use and commercialisation of high-value crops. *South African Journal of Science.*, 118(7-8): 1–7.

Monakisi, C.M. 2007. Knowledge and use of traditional medicinal plants by the Setswana-speaking community of Kimberley, Northern Cape of South Africa [MS dissertation]. University of Stellenbosch.

Mongalo, N.I. & Makhafola, T.J. 2018. Ethnobotanical knowledge of the lay people of Blouberg area (Pedi tribe), Limpopo Province, South Africa. *Journal of ethnobiology and ethnomedicine.*, 14(46): 1–23.

Motaleb, M. A. 2010. Approaches to Conservation of Medicinal Plants and Traditional Knowledge: A Focus on the Chittagong Hill Tracts. IUCN (International Union for Conservation of Nature), Bangladesh Country Office, Dhaka, Bangladesh, pp viii+30.

Moteetee, A. & Van Wyk, B.E. 2011. The medical ethnobotany of Lesotho: a review. *Bothalia*., 41(1): 209–228.

Mugomeri, E., Chatanga, P., Raditladi, T., Makara, M. & Tarirai, C. 2016. Ethnobotanical study and conservation status of local medicinal plants: towards a repository and monograph of herbal medicines in Lesotho. *African Journal of Traditional, Complementary and Alternative Medicine*., 13: 143–156.

Ndawonde, B.G. 2006. Medicinal Plant Sales: A Case Study in Northern Zululand M. A mini dissertation submitted in partial fulfilments for the degree of Master of Environmental Education in the department of Comparative and Science Education at the University of Zululand.

Ndawonde, B.G., Zobolo, A.M., Dlamini, E.T. & Siebert, S.J. 2007. A survey of plants sold by traders at Zululand muthi markets, with a view to selecting popular plant species for propagation in communal gardens. *African Journal of Range and Forage Science.*, 24(2): 103–107.

Ndawonde, B.G. 2015. Education for sustainable development of medicinal plant sellers-challenges in relation to marketing, sales, storage and conservation (Doctoral dissertation, University of Zululand).

Ndhlovu, P.T., Omotayo, A.O., Otang-Mbeng, W. and Aremu, A.O. 2021. Ethnobotanical review of plants used for the management and treatment of childhood diseases and well-being in South Africa. *South African Journal of Botany.*, *137*: 197-215.

Nefhere, K.V. 2019. Perceptions of traditional healers regarding ethnobotanical importance and conservation status of indigenous medicinal plants of Thulamela, Limpopo. Pretoria: University of Pretoria.

Nzue, A.P. 2009. Use and conservation status of medicinal plants in the Cape Peninsula, Western Cape Province of South Africa. MSc dissertation, University of Stellenbosch.

Oladele, A.T., Alade, G.O. & Omobuwajo, O.R. 2011. Medicinal plants conservation and cultivation by traditional medicine practitioners (TMPs) in Aiyedaade Local Government Area of Osun State, Nigeria. *Agriculture and Biology Journal of North America.,* 2(3): 476–487.

Patil, G.V., Dass, S.K. & Chandra, R. 2011. *Artemisia afra* and Modern Diseases. *Journal of Pharmacogenomics & Pharmacoproteomics*., 2(3):105.

Petersen, L. 2014. Cape Town's trade in wild medicines: ecological threat or essential livelihood resource. Sustainable Livelihoods Foundation: Cape Town, South Africa.

Philander, L.A. 2011. An ethnobotany of Western Cape Rasta bush medicine. *Journal of ethnopharmacology.*, 138(2): 578–594.

Prinsloo, K.L., Kleynhans, R. & Jansen, R. 2023. Medicinal ethnobotanical knowledge across urban cultural groups: A case study in a South African township. *Ethnobotany Research and Applications.*, 26: 1–10.

Rahman, M.H., Roy, B., Chowdhury, G.M., Hasan, A. & Saimun, M.S.R. 2022. Medicinal plant sources and traditional healthcare practices of forest-dependent communities in and around Chunati Wildlife Sanctuary in southeastern Bangladesh. *Environmental Sustainability*., 5(2): 207–241.

Raimondo, D., von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. & Manyama, L. 2009. Red List of South African Plants. Strelitzia 25. South African National Biodiversity Institute, Pretoria.

Rankoana, S.A. 2016. Sustainable use and management of indigenous plant resources: a case study of Mantheding community in Limpopo province, South Africa. *Sustainability.*, 8: 221–233.

SANBI. 2018. Scoping process for the development of biodiversity management plans for threatened medicinal plant species in Mpumalanga as part of the GEF funded biodiversity and land use project. Report, Available: https://inr.org.za/wp-content/uploads/2024/03/Ehlanzeni-medicinal-plants-final-report-18.08.pdf.

Saruchera, M. & Xaba, M.B. 2023. Embracing African Traditional Knowledge Health Systems in a HIV/AIDS and COVID-19 Pandemic Era. *Journal of Black Studies*., 55(10): 1–22.

Schierenbeck, I., Johansson, P., Andersson, L.M., Krantz, G. & Ntaganira, J. 2018. Collaboration or renunciation? The role of traditional medicine in mental health care in Rwanda and Eastern Cape Province, South Africa. *Glob Public Health*., 13(2): 159–172.

Schippmann, U., Leaman, D.J. and Cunningham, A.B. 2002. Impact of cultivation and gathering of medicinal plants on biodiversity: global trends and issues. Biodiversity and the ecosystem approach in agriculture, forestry and fisheries.

Seile, Boinelo P., Sechaba Bareetseng, Motheo T. Koitsiwe. & Adeyemi O. Aremu. 2022. "Indigenous Knowledge on the Uses, Sustainability and Conservation of African

Ginger (*Siphonochilus aethiopicus*) among Two Communities in Mpumalanga Province, South Africa". *Diversity*., 14(3): 192.

Semenya, S.S., Potgieter, M.J. & Erasmus, L.J.C. 2013. Indigenous plant species used by Bapedi healers to treat sexually transmitted infections: Their distribution, harvesting, conservation and threats. *South African Journal of Botany.*, 87: 66–75.

Semenya, S.S. & Potgieter, M.J. 2014. Medicinal plants cultivated in Bapedi traditional healer's home gardens, Limpopo Province, South Africa. *African journal of traditional*, *complementary and alternative medicines*., 11(5): 126–132.

Semenya, S.S. & Maroyi, A. 2018. Ethnobotanical study of curative plants used by traditional healers to treat rhinitis in the Limpopo Province, South Africa. *African Health Sciences.*, 18(4): 1076–1087.

Semenya, S.S. & Maroyi, A. 2019. Source, harvesting, conservation status, threats and management of indigenous plant used for respiratory infections and related symptoms in the Limpopo Province, South Africa. *Biodiversitas Journal of Biological Diversity.*, *20*(3): 789–810.

Setshedi, K.T., Newete, S.W. & Witkowski, E.T. 2022. The threat of an indigenous medicinal plant encroacher: *Artemisia afra* in Klipriviersberg Nature Reserve, Johannesburg, South Africa. *African Journal of Ecology*., 60(4): 1133–1142.

Sewani-Rusike, C.R. & Mammen, M. 2014. Medicinal plants used as home remedies: A family survey by first year medical students. *African Journal of Traditional, Complementary and Alternative Medicines.*, *11*(5): 67–72.

Shukla, S.K. 2023. Conservation of medicinal plants: challenges and opportunities. *Journal of Medicinal Botany.*, 7: 5–10.

Sotenjwa, V.Z. 2020. Phytochemical variation and quality control of non-volatile constituents of *Artemisia afra* (Doctoral dissertation, Tshwane University of technology).

Srivastava, J., Lambert, J. & Vietmeyer, N. 1996. Medicinal plants: An expanding role in development (Vol. 320). World Bank Publications.

Strydom, A. & Dunn, A. 2019. Traditional medicine for today: Why we should pay attention? Sustainability Institute: News.

Subedi, B. 2022. Whose Knowledge Counts? A reflection on the field narratives of indigenous health knowledge and practices. Dhaulagiri: *Journal of Sociology & Anthropology.*, 16.

Sustainable Livelihoods Foundation. 2018. The wild harvesting of plant medicines in Cape Town. An overview and checklist for protected area managers. Available: http://livelihoods.org.za/wp-content/uploads/2018/05/Wild-resource-harvesting-report-final-070814.pdf. Date accessed: 24/05/2021.

Thring, T.S.A. & Weitz, F.M. 2006. Medicinal plant use in the Bredasdorp/Elim region of the Southern Overberg in the Western Cape Province of South Africa. *Journal of ethnopharmacology.*, 103(2): 261–275.

Tsumbedzo, R., Dave, T. & Ndlovu, N. 2020. Global Covid-19 pandemic adds to the pressures faced by natural resources: Using SAEON data to inform the sustainable management of lengana. National Research Foundation eNews. Available: https://www.businessinsider.co.za/life/atremisia-plant-and-price-increase-2020-7.

UNAIDS, 2002. Ancient Remedies, New Disease: Involving traditional healers in increasing access to AIDS care and prevention in East Africa. UNAIDS Case Study.

Urso, V., Signorini, M.A., Tonini, M. & Bruschi, P. 2016. Wild medicinal and food plants used by communities living in Mopane woodlands of Southern Angola: results of an ethnobotanical field investigation. *Journal of Ethnopharmacology*., 177: 126–139.

Van Wyk, B.E., De Wet, H. & Van Heerden, F.R. 2008. An ethnobotanical survey of medicinal plants in the southeastern Karoo, South Africa. *South African Journal of Botany.*, 74(4): 696–704.

Van Wyk, B.E. 2011. The potential of South African plants in the development of new medicinal products. *South African Journal of Botany.*, 77(4): 812–829.

Van Wyk, B.E. & Van Oudshoorn, B. & Gericke, N. 2013. 3rd ed. Medicinal plants of South Africa. Pretoria: Briza Publications.

Van Wyk, A.S. & Prinsloo, G. 2018. Medicinal plant harvesting, sustainability and cultivation in South Africa. *Biological Conservation.*, 227: 335–342.

Verma, H.K. 2013. Concepts in Horticulture. New Delhi: Anmol Publication.

Wang, S.M., Yang, Y. & Zhang, S.H. 1990. Comparison of chemical compounds between materials of wild and cultivated *Codonopsis pilosula* (Franch.) Nannf. Shanxi *Journal of Traditional Chinese Medicine*., 6(8): 35–6.

Wiersum, K. F., Dold, A. P., Husselman, M., & Cocks, M. L. 2006. Cultivation of medicinal plants as a tool for biodiversity conservation and poverty alleviation in the Amatola region, South Africa, in Bogers, R. (Ed.), Medicinal and Aromatic Plants. Springer, Dordrecht.

Williams, L. 1996. THE WITWATERSRAND MUTI TRADE. Department of Botany, University of Witwatersrand. Veld and Flora.

Williams, V.L., Balkwill, K. & Witkowski, E.T.F. 1997. Muthi traders on the Witwatersrand, South Africa-an urban mosaic. *South African Journal of Botany.*, 63(6): 378–381.

Williams, V.L. 2003. Hawkers of health: The faraday street traditional medicine market in Johannesburg, Gauteng. Technical Report. Gauteng Department of Nature Conservation, Johannesburg.

Wintola, O.A. Otang, W.M. & Afolayan, A.J. 2017. The prevalence and perceived efficacy of medicinal plants used for stomach ailments in the Amathole District Municipality, Eastern Cape, South Africa. *South African Journal of Botany.*, 108: 144–148.

Xaba, P. 2008. African wormwood: gardening with traditionally useful plants. SANBI, Kirstenbosch, pp 102-103.

Xego, S. 2017. Hydroponic propagation of *Siphonochilus aethiopicus*: an endangered medicinal plant. Thesis submitted in fulfilment of the requirements for the degree Master of Technology: Horticultural Sciences in the Faculty of Applied Sciences at the Cape Peninsula University of Technology).

Chapter Four

Bridging knowledge and practice: traditional healers and small-scale farmers' training workshops to improve sustainable practices.

4.1 Introduction

The increasing demand for indigenous medicinal plants has encouraged greater awareness in their cultivation (Nwafor, 2020). Cultivation of medicinal plants serves as a conservation measure for species that are at-risk and is encouraged by the need to ensure a consistent source of these plants, reduce the pressure on natural populations, and take advantage of their potential for economic and remedial benefits (Schippmann *et al*., 2002). In addition, cultivation is an essential strategy to conserve biodiversity and solve issues with quality control and commercialization of medicinal plant material (Tanga *et al*., 2018).

The lack of public support for conservation initiatives hinders resource mobilization for the successful implementation of programs involving cultivation of medicinal plants (Ibrahim *et al*., 2023). To address this issue, it is crucial to raise awareness through education, public campaigns, and community involvement (Shukla, 2023). In order to promote the conservation of herbal medicine sources, it is essential to conduct effective awareness campaigns (Khan *et al*., 2005). Fostering collaborations, integrating traditional knowledge, encouraging sustainable harvesting, and executing educational programs are key to developing effective and sustainable conservation strategies for medicinal plants (Shukla, 2023). Furthermore, increasing the production of medicinal and aromatic plants within the country depends on well-structured training programs focused on sustainable harvesting and cultivation methods (Hamdane *et al*., 2023).

Traditional healers involvement is vital in identifying native medicinal plant species, their uses, and the necessary conservation efforts. Developing medicinal plant gardens at the community level can ensure a reliable local supply of raw materials for herbal medicines and serve as an alternative source of income (Khan *et al*., 2005; Motaleb, 2010). It is essential to provide traditional healers with practical and efficient methods of propagating medicinal plants to ensure successful establishment of medicinal plant gardens. Equally important is equipping farmers with knowledge on

conservation, propagation, cultivation, maintenance, and sustainable commercial utilization of these natural resources (Hamdane *et al*., 2023). Transferring forest plant species to farms and common lands as a conservation strategy can reduce exploitation pressure on wild species and alleviate the extinction risk for vulnerable species (Kideghesho & Msuya, 2010). Cultivation of medicinal plants in farmers' fields offers several advantages, including a steady supply of herbal medicinal products, additional income, integration into existing agricultural systems, reducing pressure on wildlife population and cultivation on degraded or marginal soils, as many medicinal plants are drought-tolerant (Karhagomba *et al*., 2013; Paroda *et al*., 2014; Kling, 2016; Noorhosseini *et al*., 2019; Reddy, 2020). An in-depth knowledge of propagation methods, harvesting and processing techniques, and marketing strategies is necessary to encourage farmers to cultivate medicinal plants.

For environmental community-based projects, it is essential to engage stakeholders from the target community throughout all phases of planning and execution (Khan *et al*., 2005). The main purpose of this chapter was to facilitate training sessions to provide traditional healers and small-scale farmers with fundamental conservation techniques and medicinal plant cultivation skills. The aim of the workshop was to amalgamate traditional knowledge with hands-on horticultural skills, to promote sustainable farming methods, to transfer skills and enable participants to successfully cultivate medicinal plants in their communities.

4.2 A conceptual model for community education on cultivation of medicinal plants

The objective of this outline was to increase the knowledge and skills of traditional healers and small-scale farmers in the cultivation of medicinal plants by integrating formal and non-formal learning approaches. This system of education was designed based on three major theoretical lenses: agricultural extension, indigenous knowledge, and university collaborations and community participation. There are two learning models relevant for this study: the concept of collaborative learning and the concept of two-way learning. Collaborative learning foundations include problem-based learning, action learning, research on action, and enterprise in higher education (Rae *et al*., 2006). Collaborative learning communities use common representations

of issues to create knowledge and understanding together. Deep and shared learning is an essential part of this cooperation process, fostering synergies through concepts, actions and initiatives. This enhances critical thinking and problem-solving abilities by encouraging participants to evaluate other viewpoints, question preconceived notions, and challenge conventional knowledge (Huri *et al*., 2024). Each theoretical concept helped to create a more collaborative, sustainable, and culturally acceptable approach to training.

4.2.1 Agricultural extension

Training in new sets of skills applicable to farming is an essential source of livelihood assistance. According to research, farmers can profit from agricultural training. There is compelling evidence that failing to address farmers' agricultural requirements, including training needs, has constrained agricultural expansion (Collett & Gale, 2009). For these reasons, the study involved small-scale farmers in medicinal plant cultivation to provide them with new and alternative crops for additional revenue while simultaneously reducing wild harvesting of medicinal plants and potentially serving as marketplaces for traditional healers. According to van de Ban and Hawkins (1996), agricultural extension is broadly described as the development of agricultural knowledge and skills among farmers with the goal of boosting productivity and bringing about other desirable developments, such as the construction of cooperative marketing arrangements. Agricultural extension's numerous purposes include disseminating knowledge from global, national, and local researchers to farmers; assisting farmers in clarifying their own goals and assessing possibilities; teaching them about decision-making processes; and supporting desirable agricultural growth.

4.2.2 Indigenous knowledge

According to Yacoub (1998), learning from indigenous knowledge, or examining what local cultures know and have, helps increase understanding of agriculture and issues related to healthcare, food security education and natural resource management. Modern science cannot live exclusively through complex machinery led by human conscience and cannot be separated from the framework and structure of indigenous knowledge, which contains concepts, ideas, philosophies and principles that are also used in science operations. Indigenous knowledge is important for practical reasons. It connects every human being's survival to the entirety of nature

and its life-sustaining components. It presents actual examples of community situations in connection to the environment, as well as practical solutions to people's challenges (Senanayake, 2006). This study conceptual framework for teaching medicinal plant cultivation relied heavily on indigenous knowledge since it supported sustainable methods to avoid overharvesting of wild plants while preserving biodiversity and promoting the regeneration of native species that are essential in the Western Cape.

4.2.3 University collaborations and community participation

Community interaction has developed as a key priority at universities, with the goal of collaborating and facilitating the mutually beneficial flow of information and resources between institutions and communities (Jadhav & Suhalka, 2016). Cooper and Orrell (2016) defined university-community engagement as partnership between universities and the community that promotes research and learning through teaching practice, community service, and other forms of public involvement (Ruforum, 2017; Sathorar & Geduld, 2021). This study implemented a community-based learning and information-sharing methodology, with academics applying their knowledge and skills to improve the lives of traditional healers and small-scale farmers through a university supported practical program. This kind of engagement made academics' information available to the local community through surveys and trainings, taking "knowledge'' out of the institution and extending it in communities where it might be used for their well-being and other activities.

4.3 Materials and methods

4.3.1 Workshop planning and participant selection

A training workshop on medicinal plant cultivation was planned and scheduled on a day that was deemed appropriate for all the stakeholders. It was facilitated by the researcher at facilities of the Department of Horticultural Sciences, Cape Peninsula University of Technology, Bellville campus, Cape Town. The target population included traditional healers and small-scale farmers from the Western Cape region. Invitations were distributed to organizations representing traditional healer's and small-scale farmers, with the chairperson of each organization selecting three

representatives to attend the workshop (Appendix 13). The selected individuals were expected to acquire practical cultivation skills and to share the knowledge with other healers and farmers within their networks.

The workshop was originally designed to accommodate 30 participants, comprising 15 healers from four organizations and 15 small-scale farmers interested in medicinal plant cultivation. However, due to high demand, 58 participants attended the workshop. Additionally, more than 50 individuals expressed interest in attending but could not participate due to venue capacity limitations.

4.3.2 Briefing and introduction

Upon arrival, participants were required to sign a registration log to document attendance formally. Following this, they were welcomed with an introductory briefing session. The session commenced with a detailed explanation of the workshop's objectives, emphasizing the specific goals related to the cultivation of medicinal plants. This was followed by an overview of prior workshops conducted by the researchers, highlighting the department's ongoing efforts to support medicinal plant cultivation and its relevance to local communities.

4.3.3 Workshop structure and materials distribution

Handbooks containing detailed step-by-step instructions on various cultivation techniques were distributed to the attendees (Appendix 14). These guides covered the detailed methods, from seed sowing and propagation by cuttings to transplanting and maintenance. Special emphasis was placed on using recyclable materials like containers for plant growth, aligning with sustainable and low-cost farming practices (Figure 4.1).

Figure 4.1: Recyclable materials were utilized for seed propagation and cuttings prior to the transplanting stage.

4.3.4 Practical training session

Following the registration and the briefing session, participants were directed to the department's nursery, where designated workstations had been set up (Figure 4.2). Each workstation was equipped with essential tools and materials, including a growing medium of sand and manure, seeds, plant material, watering cans, hand spades and propagation pots. The selected plant species for the hands-on training included *Artemisia afra*, *Leonotis leonurus*, *Lippia javanica* and *Helichrysum spp. A. afra* was specifically chosen because they are widely utilized medicinal plants by traditional healers in the Western Cape province, (detailed in chapter 3) (Figure 4.3). *A. afra* plant material (9cm pots) along with poultry manure were purchased from Stodels Garden Nursery, Bellville, South Africa. While *L. leonurus*, *L. javanica* (seeds) and *Helichrysum spp.* were obtained from the nursey of the Department of Horticultural Sciences, Bellville campus.

The workshop commenced with a demonstration of seed-sowing techniques, followed by instructional sessions on taking stem and leaf cuttings (Figure 4.4). Participants were then shown transplanting techniques, under the supervision of facilitators. The training emphasised organic cultivation practices using organic manure based on feedback from Chapter 3 questionnaires, where healers had indicated their preference for organically grown medicinal plants.

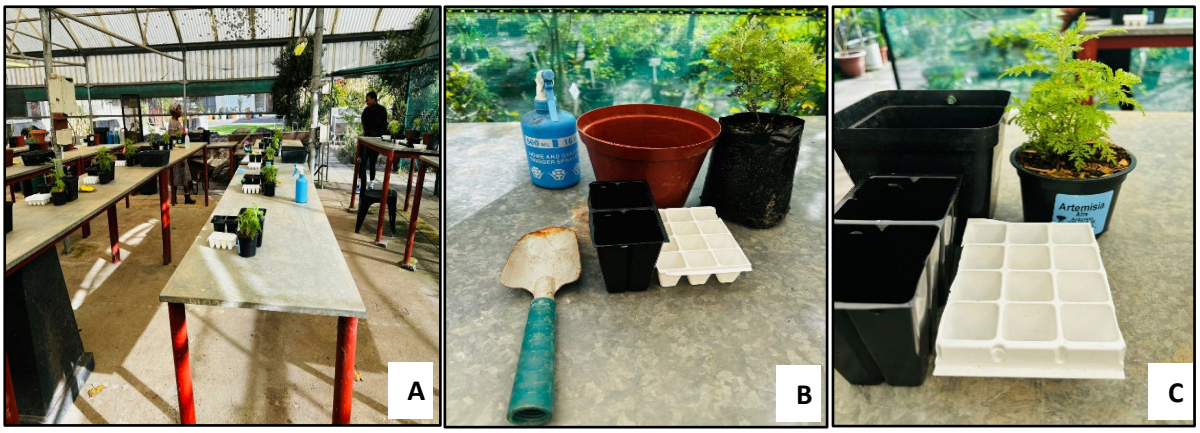


Figure 4.2 & 4.3: A & B: Workstations with all the required materials; C: *Artemisia afra.*

Figure 4.4: Participants engaged in propagation techniques under the guidance of facilitators.

4.3.5 Post-training session and feedback

After the practical session, participants reconvened at the venue to complete feedback questionnaires assessing their experiences and perspectives regarding the workshop. The questionnaires comprised open-ended questions that solicited

personal information with their consent (Appendix 7b), the relevance of the topics covered, suggestions for future training, cultivation skills acquired, the usefulness of organic farming information, and general comments (Appendix 15). Upon completion of the questionnaire session, refreshments were provided to the participants.

4.3.6 Ethical issues (declaration on validation of the questionnaire and study confidentiality compliance).

Prior to the initiation of the workshop and during the feedback session, informed consent was obtained from all participants, ensuring that they were fully aware of the study's objectives and their right to withdraw at any time without consequence. At the end of the workshop, a questionnaire was used to evaluate feedback from participants, insights into medicinal plant cultivation and to highlight areas for improvement. The procedure was conducted with the highest ethical standards to ensure the integrity of research and the welfare of all participants. Strong measures were implemented to protect the personal data of the participants' in line with the rules on confidentiality and the law on the protection of personal data. In order to avoid identification, all responses were anonymised and only authorized persons had access to the data.

The questionnaires used in this study were carefully validated to ensure that the data obtained was reliable and accurate. This included pilot testing to identify and resolve any biases or ambiguities, as well as validation of the content through feedback from experts on the subject.

Additionally, this investigation was conducted in compliance with university protocols. The Cape Peninsula University of Technology Research Ethics Committee granted the study ethical approval. Representatives of traditional healers groups (Chairpersons) were approached to obtain permission for the research to be conducted with members of their organization.

4.3.7 Processing and analyzing data

The data was recorded on an Excel spreadsheet and analyzed using Software Program for Social Science (SPSS) to identify significant differences with a 95% confidence interval. SPSS was used to create frequency tables to display the descriptive statistics.

4.4 Results

4.4.1 Organizations represented by traditional healers and small-scale farmers at the workshop.

A combined total of 58 traditional healers and small-scale farmers from various organizations participated in the workshop as listed in table 4.1a and 4.1b. The data presented in the tables display attendance information for small-scale farmers associations (Table 4.1a) and traditional healers associations (Table 4.1b) at the workshop. It is worth noting that 46 out of the 58 attendees completed the questionnaires, with the results showing responses from 17 healers and 29 farmers.

The sector of small-scale farmers organizations (Table 4.1a) was presented by a variety of groups, with 29 distinct organizations in attendance. A total of 38 farmers participated in the workshop, however only 29 farmers completed the feedback questionnaires. Furthermore, 3 out of the 29 farmers who submitted feedback questionnaires following the workshop were categorized as unspecified because they did not disclose their affiliations. Boya Environmental Growth and Yiza Mfazi waseMzantsi had the highest attendance with 3 participants each. While Abalimi Bezekhaya, Abathethi food garden and Sunshine organic nursey each had 2 participants in attendance.

The results for traditional healers groups (Table 4.1b) revealed that participants represented 6 distinct Western Cape-based traditional healers organizations. Among these, Ubizo Lwam Traditional Healers Institute and Buzani kuBawo Inyanga's Association had the highest representation, with 5 attendees each. The Traditional Healers Organization (THO) followed represented notably by 4 attendees. Smaller groups including Indigenous Healers, Khoena Exchange, and Lupasa each had 1 attendee. All the organizations that participated in the study except Indigenous Healers and Khoena Exchange had been part of the study from its initiation phase through to the practical workshop. Of the 20 traditional healers present at the workshop, 17 completed the questionnaires, while 3 participants did not submit any responses.

Overall, small-scale farmers organizations had a greater number of distinct organizations, and farmers group participation was more evenly dispersed, whereas healers' organizations were fewer but had stronger representation per group.

Table 4.1a: A record of farmers organizations in attendance during the workshop.

Small-scale farmers organizations	No. of attendees
Abalimi Bezekhaya	2
Abathethi food garden	2
Avee gardens	1
Bongubuntu Youth Development	1
Boya environmental growth	3
BSB Empire	1
Empilweni food gardens	1
Happy by Nature Indigenous nursery	1
Home, herbs and fruit tree growers	1
Housefive gardener	1
Ikhaya loxolo home	1
Khompela farming	1
Lumanyano community garden	1
Mbonombini health and wellness organization	1
Mtonga foundation	1
Sinethemba lesivuno community garden	1
Sunshine organic nursery	2
Thanda Bantu	1
Yiza Mfazi waseMzantsi	3
Unspecified	3

Participants who did not disclose their organizations are considered as unspecified

Table 4.1b: A record of traditional healer organizations in attendance during the workshop.

Traditional healers organizations	No. of attendees
Indigenous Healers	1
Khoena Exchange	1
Lupasa	1
Traditional Healers Organization (THO)	4
Ubizo Lwam Traditional Healers Institute	5
Buzani kuBawo Inyanga's Association	5

4.4.2 Participants' demographic information

The results provide an overview of the distribution of age, gender and role in this population. The dataset consists of three primary roles: traditional healer, small-scale farmer, and dual role as both healer and farmer.

4.4.2.1 Gender

The gender breakdown displays an equal distribution, with males and females each accounting for 50.0% of the population (n= 46) (Table 4.2).

4.4.2.2 Age

The age range across all categories was 17 to 77 years (Table 4.2). The majority of participants were of the ages between 20 and 40 years, with a few over 60 years. 48.0% of the population, encompassing all roles ranged between the ages of 16 and 35, with small-scale farmers accounting for the most participation (26.0%) aged 16 to 35. Individuals aged 36 to 55 collectively placed second in the ranking, comprising 41.0% of the population. Overall, the majority of attendees were between the ages of 16 and 35, with a gradual decline in representation as age increased, implying that younger adults were more represented in this dataset.

4.4.2.3 Role distribution by gender (Gender vs Role)

The population's highest contributor (59.0%) was small-scale farmers, followed by traditional healers (33.0%) and a small percentage of individuals who merged the roles of "traditional healer and farmer" (9%), as shown in Table 4.2. Regarding the gender-specific role distribution (Figure 4.5), the results indicated that the majority of the small-scale farmers (39.0%, n= 18) were male participants, while the proportion of females in this capacity was lower at approximately 20.0% (n= 9). Female participants dominated the traditional healers' role, accounting for approximately 26.0% (n= 12) of the populace, while male representation was significantly lower at only 7.0%. The dual role had a low representation, with only two individuals per gender, suggesting that combining these responsibilities may be less common among participants.

Table 4.2: Participants categorized by gender and age.

	Traditional Healers	Small-scale farmers	Healer and Farmer
Gender			
Female	12 (26%)	9 (20%)	2 (4%)
Male	3 (7%)	18 (39%)	2 (4%)
Age			
16-25	3 (7%)	8 (17%)	0
26-35	3 (7%)	4 (9%)	2 (4%)
36-45	4 (9 %)	5 (11%)	1 (2%)
46-55	2 (4 %)	6 (13%)	1 (2%)
56-65	3 (7 %)	3 (7%)	0
66-75	0	1 (2 %)	0
No. of participants per category	15 (33%)	27 (59%)	4 (9%)

The total number of participants (frequency; N= 46) is accompanied by the percentage of that number in parentheses.

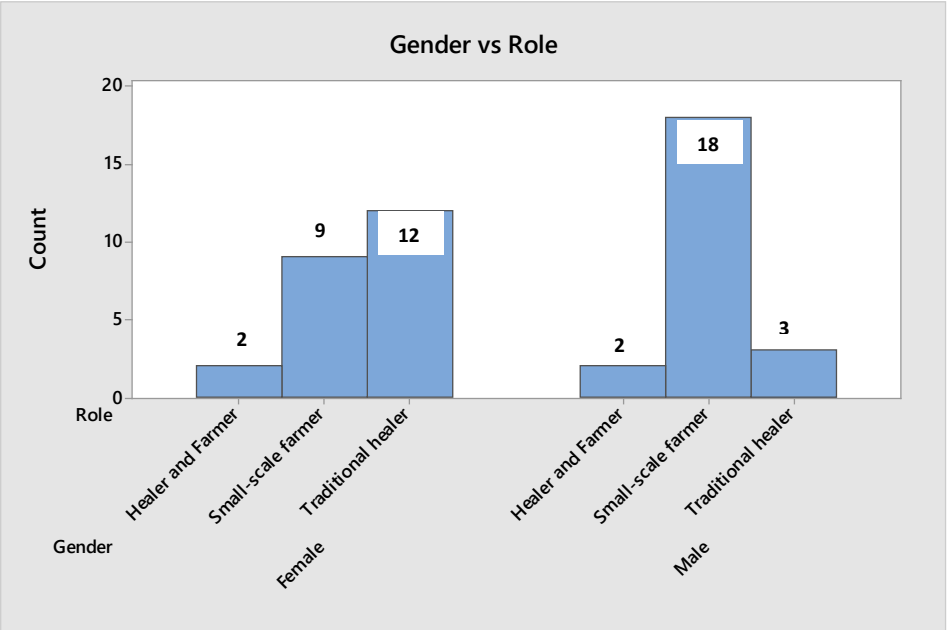


Figure 4.5: Breakdown of participant gender by role.

4.4.3 Responses to the feedback questionnaire

4.4.3.1 Workshop content's relevance, usefulness and potential areas for future focus.

The findings presented in table 4.3a and 4.3b showed that all participants (n= 46; 100%) acknowledged that the workshop content was pertinent to their needs,

demonstrating complete alignment with participants expectations. Attendees highlighted several factors contributing to their satisfaction with the workshop's content (Table 4.4). Particularly, 17% (n= 8) expressed satisfaction with the use of organic composts in growing medicinal plants, noticing its dual benefit for personal use and income generation. Similarly, 17% found the nursery practical session valuable, as it offered a hands-on learning experience and facilitated the application of the cultivation handbook's lessons. Moreover, 13% (n= 6) identified vegetative propagation, transplanting, and plant maintenance techniques as crucial aspects of the workshop. Overall, the results suggest that the workshop successfully addressed the needs of the participants and emphasized 13 impactful themes that improved their learning and practical skills (Table 4.4: Q1).

Participants reported finding a variety of topics useful and insightful (Table 4.4), with 39% expressing appreciation for lessons and practical sessions on planting techniques, especially vegetative propagation. Other significant topics included composting and fertilization (11%) and soil preparation (11%), followed by seed sowing (9%) and transplanting (9%), respectively. Watering was also considered essential however it was mentioned less frequently. It is noteworthy that 7% of participants expressed an interest to acquire more knowledge about vegetative propagation of *A. afra*. In general, the results suggest that while vegetative propagation was the most popular subject, various beneficial horticulture techniques such as composting, transplanting, and soil preparation also greatly enhanced participants' learning experiences.

A *t*-test (t= 20.787; p= < 0.001) showed a statistically significant difference in the responses concerning the identified gaps in topics. A substantial majority (n= 25, 54.3%) stated that the session addressed all of the relevant subjects. Whereas almost half of the participants (n= 21, 45.7%) suggested that future trainings and workshops incorporate additional topics (see table 4.4). The analysis of responses highlighted the most and least preferred topics for future workshops. The top suggestion, mentioned by 9% (n= 4), was herb preservation, emphasizing the importance of maintaining the quality and value of medicinal plants. Other interest was on vegetative propagation of underground (subterranean) stems and propagation methods for plants such as *Helichrysum odoratissimum* (*Impepho*), *Hypoxis hemerocallidea* (African potato), and *Agathosma betulina* (Buchu) each mentioned by 7% of participants (n= 3), indicating

a need for enhanced propagation techniques. In contrast, topics such as first aid uses of medicinal plants, use of alternative plant parts, and the impact of alien weeds were least mentioned (2%, n= 1 each), indicating potential niche interest. These findings highlight a strong participant interest in propagation techniques and herb preservation.

Table 4.3a: Descriptive statistics on the relevance and areas of focus for future topics.

Q1 & Q3 One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Where the topics covered relevant to your need?	46	1.00	.000[a]	.000	0	0	.000
Missing topics that should be included in future	46	1.54	.504	.074	20.787	45	.000

a. t cannot be computed because the standard deviation is 0.

Table 4.3b: Frequency and percentages

Q1: Where the topics covered relevant to your need?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	46	100.0	100.0	100.0

Q3: Missing topics that should be included in future

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	21	45.7	45.7	45.7
	No	25	54.3	54.3	100.0
	Total	46	100.0	100.0	

Table 4.4: Explanatory responses for Questions 1, 2 and 3 (relevance and usefulness of topics covered, as well as areas of focus for future topics).

Questions	Responses	Frequency [n (%)]
Q1: Where the topics covered relevant to your needs?	• They addressed the need for cultivating organic medicinal plants for personal use and as a potential source of income.	8 (17%)
	• The information enhanced my farming skills and propagation techniques.	2 (4%)
	• We learned how and when to plant medicinal plants.	1 (2%)
	• No answers provided	7 (15%)

	• I now understand how to propagate plants using minimal planting material.	1 (2%)
	• I have acquired knowledge on the proper way to sow seeds and effective methods of propagating medicinal plants.	5 (11%)
	• I have acquired vegetative propagation techniques, transplanting and ways to maintain propagated plants.	6 (13%)
	• The workshop was highly relevant, it provided us with simple, and cheaper cultivation methods to grow plants.	1 (2%)
	• The practical session at the nursery was the highlight, we were able to apply the acquired knowledge.	8 (17%)
	• The workshop was helpful, informative and covered all relevant topics.	4 (9%)
	• I have learned how to plant correctly using the right container and recycling available containers at home.	1 (2%)
	• We are now recognised as healers and farmers.	1 (2%)
	• The knowledge shared on local herbs was exceptional and the information reinforced some of my existing horticulture experience.	1 (2%)
Q2: The topics/subjects that were most helpful to the participants.	• Soil mixing (preparation of soil mixes) and use of spray bottles to water plants.	5 (11%)
	• Planting techniques: vegetative propagation (stem and tip cuttings).	18 (39%)
	• Composting and use of fertilizers.	5 (11%)
	• Participants stated that all the topics covered were crucial.	5 (11%)
	• Seed sowing.	4 (9%)
	• Watering.	2 (4%)
	• Transplanting.	4 (9%)
	• Vegetative propagation of *Artemisia afra.*	3 (7%)
Q3: Topics to be covered in future training workshops.	• Vegetative propagation focusing on underground stem.	3 (7%)
	• Compost composition and list of effective organic fertilizers.	2 (4%)
	• How to use medicinal plants as basic first aid at home.	1 (2%)
	• Harvesting techniques.	2 (4%)
	• How to preserve quality of herbs.	4 (9%)
		1 (2%)

• Information on alternative plant parts that can be used as substitutes, excluding underground parts.	2 (4%)
• Edible medicinal weeds in Southern Africa (Advantages and disadvantages of alien weeds and invasive plants.	2 (4%)
• Techniques for growing plants in urban areas with predominantly sandy soil.	3 (7%)
• Include propagation methods of other commonly used herbs, such as *Helichrysum odoratissimum* (Impepho), *Hypoxis hemerocallidea* (African potato) and *Agathosma betulina* (Buchu).	

4.4.3.2 Responses regarding medicinal plant cultivation and the development of home gardens.

Following the practical session, a significant number of participants (n= 33, 71.7%) reported feeling very confident in their abilities to cultivate medicinal plants. An additional 21.7% (n= 10) were confidence and satisfied with the information provided, while a small portion (n= 3, 6.5%) remained neutral, indicating uncertainity about the information provided (Table 4.5) and (Table 4.10a). Participants provided several reasons for feeling very confident regarding medicinal plant cultivation subsequently to the workshop, with many citing the combination of practical and theoretical knowledge shared as the key reason for their high confidence and satisfaction. Several individuals reported increases confidence in cultivating medicinal plants, highlighting their improved understanding of step-by-step processes involved in seed sowing, propagation and other planting techniques. The hands-on practical session was highly mentioned for enabling participants to apply their knowledge, ask questions, and receive direct feedback. Some expressed interest in acquiring parent material to commence their propagation projects, while others appreciated the opportunity to network with small-scale producers and experts, gaining valuable insights into sustainable and organic agriculture practices. Overall, the workshop was regarded as a valuable experience that significantly enhanced participants confidence, knowledge and practical skills in medicinal plant production.

The workshop had a significant impact on participants, with all attendee (n= 46, 100%) stating that it inspired them to cultivate their own medicinal plants (Table 4.6 &

Table 4.10b). This highlights the workshops effectiveness in inspiring participants to implement the acquired knowledge and take practical actions toward medicinal plant cultivation. A total of 31 responses (67%) (Appendix 16) supported this, with several participants highlighting that the workshop equipped them with valuable skills and information that fostered their interest in growing medicinal plants. They also noted that utilizing readily available materials, such a recycling household items, would allow them to save money and establish their own soil mixes. The participants further explained that the provided handbook simplified the process and will serve as a useful guide when starting their own gardens. Furthermore, the farmers highlighted that the knowledge acquired at the workshop has motivated them to start their own indigenous medicinal plant nurseries. The attendees expressed optimism about the skills acquired to start their own gardens and intend to utilize the plant material and instructons provided. Overall, 67% (n= 31) of participants who provided additional feedback affirmed that the workshop offered valuable insights and inspired them to start and continue cultivating, and conserving medicinal plants (Appendix 11).

Lastly, the results showed that the workshop enhanced attendees' knowledge and preparedness for cultivating medicinal plants. A substantial proportion of the participants (n= 43, 93.5%) reported an increased understanding of the conservation and cultivation of indigenous medicinal plants, validating the workshop's success in raising awareness regarding the challenges associated with their preservation (Table 4.7). Furthermore, 95.7% (n= 44) of participants stated that they were prepared to face common challenges in medicinal plant cultivatiion, demonstrating the trainings practical value (Table 4.8). Moreover, in terms of organic agricultural techniques (Table 4.9), an overwhelming 87% (n= 40) evaluated the workshop content as very useful, while the remaining 13% (n= 6) considered it beneficial. These findings indicate that the workshop provided an excellent platform for participants to confidently engage in susstainable medicinal plant cultivation.

Tables 4.5 and 4.6: Frequency and percentage distribution of responses for question 4 and 5.

Q4: How confident do you feel about cultivating MP's after the practical?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Confident	10	21.7	21.7	21.7
	Neutral	3	6.5	6.5	28.3
	Very confident	33	71.7	71.7	100.0
	Total	46	100.0	100.0	

Q5: Did the workshop encourage you to grow your own medicinal plants?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	46	100.0	100.0	100.0

Tables 4.7 and 4.8: Frequency and percentage distribution of responses for question 6 and 7.

Q6: Are your more informed about conservation and indigenous medicinal plants?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	43	93.5	93.5	93.5
	No	3	6.5	6.5	100.0
	Total	46	100.0	100.0	

Q7: Do you feel prepared to deal with common challenges associated with MP's cultivation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	44	95.7	95.7	95.7
	No	2	4.3	4.3	100.0
	Total	46	100.0	100.0	

Table 4.9: Frequency and percentage distribution of responses and for question 8.

Q8: How useful was the information provided about organic farming methods?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Useful	6	13.0	13.0	13.0
	Very useful	40	87.0	87.0	100.0

Table 4.10a: Descriptive statistics for question 4,6,7 and 8.

One-Sample Test

	Test Value = 0						
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper	Std. Error Mean
Q4: How confident do you feel about cultivating MP's after the practical?	28.373	45	.000	3.500	3.25	3.75	.123
Q6: Are your more informed about conservation and indigenous medicinal plants?	28.941	45	.000	1.065	.99	1.14	.037
Q7: Do you feel prepared to deal with common challenges associated with MP's cultivation?	34.325	45	.000	1.043	.98	1.10	.030
Q8: How useful was the information provided about organic farming methods?	37.239	45	.000	1.870	1.77	1.97	.050

Table 4.10b: Descriptive statistics for question 5.

One-Sample Test

	N	Mean	Std. Deviation	Std. Error Mean
Q5: Did the workshop encourage you to grow your own medicinal plants?	46	1.00	.000[a]	.000

a. t cannot be computed because the standard deviation is 0.

It is worth noting that as a token of appreciation for their involvement, each participant was presented with a 9cm pot of *A. afra* for personal cultivation, a potting mixture, and seeds for further cultivation in their own gardens.

4.5 Discussion

4.5.1 Overall attendance by traditional healers and small-scale farmers

Currently, there exists a pressing imperative to effectively educate individuals to ensure that both present and future actions and decisions are executed with an educated and skilled approach (Corrochano *et al*., 2022). A study conducted by Gonfa *et al*. (2020) revealed that communities are highly motivated to enhance awareness of and access to the plants utilized for treating ailments within their natural surroundings.

This assertion is corroborated by the participation observed during the workshop, which initially extended invitations to a limited number of 30 participants, yet ultimately attracted 58 individuals from various backgrounds, including small-scale farmers and traditional healers. Both sectors demonstrated significant levels of participation, effectively doubling the expected number of attendees, with a substantial number of interested individuals unable to attend due to venue capacity restrictions.

The pronounced interest and high participation levels demonstrate a significant willingness among healers and farmers in the Western Cape to engage in conservation initiatives and adopt the use of cultivated medicinal plants. The inclination of healers was also confirmed by a study conducted by Nfhere (2019), in which an overwhelming majority of traditional healers (83%) expressed interest in growing medicinal plants in their home gardens, albeit lacking the necessary expertise and skills related to the cultivation practices of such plants. As recommended by Nfhere's research, the workshop enabled healers in the Western Cape to acquire essential cultivation skills. As described in chapter three, data obtained from the questionnaires illustrated that a significant number of traditional healers (70.7%) were willing to buy medicinal plants produced by local farmers. It is noteworthy that a remarkable 66% of farmers representing 29 organizations, expressed their willingness to engage in the cultivation of medicinal plants, positioning themselves as prospective suppliers for traditional healers who might be interested in utilizing cultivated plants. This result aligns with the findings of Liyanagamage *et al*. (2016) who found that approximately 73% of farmers recognized a significant demand for medicinal plants, with 58% expressing their willingness to adopt and engage in the cultivation practices of medicinal plants.

4.4.1 Participants demographic information

The overall participation, including both farmers and healers, showed an even gender distribution (50:50). This balanced gender representation in medicinal plant cultivation activities shows inclusivity and impartial involvement of men and women in this endeavour. Furthermore, equal gender participation not only ensures that both genders contribute meaningfully to sustainable agricultural practices but also helps to reduce gender bias and promote greater equality within the framework of initiatives that promote sustainability (FAO, 2019).

According to Oladele and Mudhara (2016), there is a "gender gap" in South Africa that prevents women from participating in subsistence farming due to limited access to resources and opportunities. This observation is consistent with the findings of this study, which found that participants in smallholder farming were predominantly male-dominated. In contrast, traditional healers were predominately female-dominated, which is consistent with the findings of Fassil (2004) and Menze *et al*. (2018), who reported a higher proportion of women among traditional healers. The contrasting gender participation between these two groups emphasises the need to address gender inequalities, particularly in agriculture, as closing these gender gaps could significantly increase agricultural productivity.

A significant proportion of participants (48%) were aged between 16 and 35, followed by 41% in the 36-55 age group, indicating a strong interest in traditional healing and agricultural practices among the younger generations. This highlights the importance of imparting indigenous knowledge and education to young traditional healers and farmers so that future generations can also benefit from it. Therefore, documentation of such practices is crucial to ensure that the chain of transmission is not broken. Emerging discoveries suggest a growing interest in understanding and promoting youth engagement in agriculture, which is influenced by concerns such as rural development, unemployment, and food insecurity. Youth engagement is motivated by various factors, including economic incentives, cultural traditions, preservation of indigenous knowledge, social factors and environmental awareness (Kote *et al*., 2024).

4.4.2 Feedback on the execution of the workshop

4.4.2.1 Workshop content and its usefulness

All attendees rated the content of the workshop as exceptionally relevant to their needs, indicating a significant alignment with their expectations. The positive feedback emphasized the participants' satisfaction with the focus on the utilization of organic compost for growing medicinal plants, which was identified as an important area of significance. As Macilwain (2004) noted, the organic cultivation of medicinal plants is increasingly recognized as crucial for the sustainable development and conservation of these species. This perspective also aligns with Chen's (2016) assertion that organic farming methods for medicinal plants not only improve the

quality of materials produced but also increase productivity while promoting conservation and sustainable practices.

Participants also considered practical session in the nursery beneficial, as it provided a hands-on learning experience that enabled them to effectively apply the knowledge they have received. They highlighted that techniques such as vegetative propagation, transplanting and plant care were essential components of the workshop. These observations are consistent with the findings of O'Donovan *et al*. (2020), who indicated that a significant number of participants valued the workshop for its emphasis on active participation. Furthermore, these findings support Pushpangadan's (2004) assertion that environmental programs should evolve into a proactive conservation initiative aimed at protecting the country's fragile biodiversity.

Moreover, the participants emphasized that the workshop had significantly improved their agricultural and propagation skills and enhanced the horticultural expertise of small-scale farmers. The implementation of participatory strategies to promote the cultivation of medicinal and aromatic plants offers farmers and users of medicinal plants the opportunity to improve their skills, broaden their knowledge, and contribute to the conservation of the diversity of medicinal plants in their natural habitats (Phondani, *et. al*., 2016). Overall, participants found several topics useful and insightful, especially the practical sessions on propagation techniques, composting, soil preparation, sowing and transplanting. They also reported an avid interest in the cultivation of *A. afra* and considered the watering requirements lessons essential.

4.4.2.2 Areas for improvement

With regard to the gaps identified in workshop topics, almost half of the participants recommended expanding the scope of future training and addressing a broader range of topics. Areas of interest included the preserving medicinal plants, maintaining the quality and value of these plants, and exploring the use of alternative plant parts, such as above-ground parts, to substitute below-ground components. Various strategies have been proposed to address the problem of overharvesting of at-risk plants, with the most promising being the use of renewable plant parts as substitutes for bark, roots and rhizomes. Jena *et al*. (2017) emphasized that substituting roots with leaves, a renewable plant part, is an effective strategy to conserve bioresources while promoting sustainable bioprospecting. Research has

continued to investigate the potential of substituting above-ground parts with below-ground plant parts as a conservation strategy. Studies on species such as *Eucomis autumnalis*, *Siphonochilus aethiopicus* (Xego, 2016), *Ocotea bullata*, *Warburgia salutaris* (Zschocke *et. al*., 2000) and *Aegle marmelos* (Sulaiman & Balachandran, 2013; Srivastava *et al*., 2016) underscore the feasibility of this approach.

The participants also demonstrated a keen interest in acquiring knowledge about propagation methods for various plant species, including *Helichrysum odoratissimum*, *Hypoxis hemerocallidea* and *Agathosma betulina*. It is worth noting that they further highlighted the need for more regular workshops and proposed that the institution should offer short courses to train prospective farmers and traditional healers. These suggestions are consistent with the findings presented by (O'Donovan, 2020).

4.4.2.3 Cultivation

After the workshop, participants reported a strong confidence in their proficiency to grow medicinal plants. This confidence was influenced by the integration of practical and theoretical knowledge imparted during the training. Particularly valuable were the practical exercises, which reinforced theoretical learning through interactive discussions between participants and facilitators. Correspondingly, a survey conducted by Alabama (2018) showed that 83% of participants in gardening and propagation workshops at five different locations confirmed that practical activities significantly enhanced their knowledge and skills. Furthermore, participants intended to use their newly acquired skills by experimenting with different plant varieties, participating in group plantings, and optimizing the timing of their production. Encouragingly, all workshop participants in this study expressed a strong motivation to cultivate their own medicinal plants. Small-scale farmers in particular were encouraged to establish nurseries for indigenous medicinal plants. Furthermore, the workshop not only imparted essential skills and knowledge but also fostered enthusiasm and proactive initiatives for the cultivation of medicinal plants.

Various factors, including practical sessions demonstrating step-by-step procedures for sowing, propagation and planting, encouraged participants to engage in the cultivation of medicinal plants. This was particularly evident in the emphasis on using readily accessible materials such as empty household containers, bottles, egg

trays, and eggshells for growing plants. This approach not only promotes cultivation efforts but also fosters cost savings through the reuse of recycled materials. As stated by Nagase and Lundholm (2021), container gardens play a significant role in sustainable development, as they provide several direct and indirect benefits to urban communities. Moreover, promoting the cultivation of medicinal plants in urban areas necessitates systems that emphasize both accessibility and affordability. Key features of effective home gardens include the innovative reuse of locally sourced materials and composted growing media (De Zeeuw *et al*., 2017).

The handbook provided was also substantially commended as it simplified the process and served as a valuable guide for individuals embarking on their gardening endeavours.

Both groups expressed their appreciation for the networking opportunities, emphasizing that the exchange of knowledge among researchers, users of medicinal plants, and small-scale farmers promoted relationships that are beneficial for collaboration in conservation initiatives and the establishment of trust. It is essential for conservationists working with medicinal plants to collaborate with the users of these plants. Engaging with these stakeholders fosters a more profound comprehension of the cultural importance attributed to medicinal plants (Hamilton, 2004). Establishing connections among researchers, local communities, and stakeholders at the start of sustainability initiatives is vital, as collaboration in medicinal plant conservation builds trust and fosters confidence among participants (Hamilton, 2004).

4.6 Recommendations

The participants provided the following recommendations/additional comments:

To improve training and approachability, it is essential to strategically organize workshops within local communities, such as Khayelitsha and Mfuleni to enhance outreach and inclusivity. Also, facilitate short courses for convenient learning opportunities about medicinal plants, while offering advanced knowledge and skills. A strong emphasis on practical learning is vital, incorporating hands-on sessions that focus on planting techniques and the entire seed-to-transplanting process. It was also significantly emphasized that incorporating organic farming practices is fundamental

to promoting biodiversity and sustainable farming. The participants also highlighted the importance of encouraging collaboration between indigenous knowledge systems and academia framework to strengthen conservation efforts and optimize cultivation practices.

Additionally, platforms should also be established for participants to exchange knowledge and engage the youth in their community-based activities. It was also emphasized that expanding the scope of the workshops include topics such as healing herbs, indigenous plants, and sustainable practices such as soil enhancement, water conservation, and chemical-free farming will significantly increase medicinal plants' value. Most participants were in favour of a higher frequency of training workshops, where some members of the community who are knowledgeable about some crucial topics could also act as facilitators.

Participants also mentioned that workshops should be extended to other regions such as the Eastern Cape Province, where many traditional healers reside to ensure regional integration. Furthermore, participants should be empowered to assist their communities, especially the elderly. It is equally important to educate the youth, while also capitalizing on the economic benefits of cultivating medicinal plants to alleviate poverty. Lastly, workshops should continue to be engaging and responsive to participant feedback, with a focus on retention and integration of shared knowledge to ensure continuous improvement.

4.7 Conclusion

This chapter concludes by providing a significant and practical context for understanding and implementing initiatives aimed at promoting the sustainability and conservation of medicinal plants through cultivation. The success of the workshop is due to the active engagement of a diverse group of stakeholders, including researchers, small-scale farmers and traditional healers, which facilitated a dynamic exchange of knowledge and collective progress in the cultivation of medicinal plants. By fostering collaboration and providing actionable insights, the workshop has laid a solid foundation for improving future initiatives of a similar nature.

To ensure the long-term sustainability and conservation of medicinal plants, it is crucial to consider both environmental and community needs. The effectiveness of the workshop in engaging communities, promoting sustainable practices, and supporting the conservation of medicinal plants highlights the significance of collaboration and shared commitment. This approach serves as a persuasive model for achieving both environmental and social benefits in the field of medicinal plant conservation.

References

Alabama, 2018. Annual Report, 567.12 KB. 2018 University of Alaska Combined Research and Extension Annual Report of Accomplishments and Results,

Chen, S.L., Yu, H., Luo, H.M., Wu, Q., Li, C.F. & Steinmetz, A. 2016. Conservation and sustainable use of medicinal plants: problems, progress, and prospects. *Chinese medicine.*, 11: 1–10.

Collett, K. & Gale, C. 2009. Training for rural development: Agricultural and enterprise skills for women smallholders. *City and Guilds Centre for Skills Development*, pp.24-30.

Cooper, L. & Orrell, J. 2016. University community engagement: Towards a partnership based on deliberate reciprocity. In F. Trede & C. McEwen (Eds.), Education the deliberate professional: Preparing for future practices (pp.107-138). Springer.

Corrochano, D., Ferrari, E., López-Luengo, M.A. and Ortega-Quevedo, V. 2022. Educational gardens and climate change education: an analysis of Spanish preservice teachers' perceptions. *Education Sciences*., 12(4): 275.

De Zeeuw, H., Komisar, J., Sanyé-Mengual, E., Kahane, R., Gianquinto, G., Geoffriau, E., Sia, C.S., Rodríguez-Delfín, A., Tawk, S.T., El Omari, H. 2017. "A geography of rooftop agriculture in20 projects." in: Rooftop Urban Agriculture, Springer, pp. 309–382.

FAO and Care, 2019. Good Practices for Integrating Gender Equality and Women's Empowerment in Climate-Smart Agriculture Programmes.

Fassil, H. 2004. Building on traditional medicinal plant knowledge and home-based health care efforts in rural Malawi. http:// www.worldbank.org/afr/ik/ default.htm.

Gonfa, N., Tulu, D., Hundera, K. & Rag, D. 2020. Ethnobotanical study of medicinal plants, its utilization, and conservation by indigenous people of Gera district, Ethiopia, Cogent Food & Agriculture., 6:1. Article ID, 1852716.

Hamdane, S., Marcelino, S., Gaspar, P.D. & Paço, A. 2023. Sustainable Agricultural Practices for the Production of Aromatic and Medicinal Plants: Evidence and Recommendations.

Hamilton, A.C. 2004. Medicinal plants, conservation and livelihoods. *Biodiversity & Conservation.*, 13: 1477–1517.

Huri, A.S., Sahae, J.P., Prince, A.M. & Srivastava, R. 2024. Collaborative learning communities: enhancing student engagement and academic achievement. *Educational Administration: Theory and Practice.*, 30(5): 7031−7036.

Ibrahim, M.S.N., Assim, M.I.S.A., Johari, S., Mohammad, S.K.W., Afandi, S.H.M. & Hassan, S. 2023. Public awareness on biodiversity conservation and well-being: case of Gunung Mulu National Park, Sarawak. *GeoJournal*., 88(3): 3471−3496.

Jadhav, J. U. & Suhalka, V. 2016. University community engagement: Insights from field work practices. *Indian Journal of Sustainable Development.*, 2(1): 22−28.

Jena, A.K., Karan, M. & Vasisht, K. 2017. Plant parts substitution-based approach as a viable conservation strategy for medicinal plants: A case study of Premna latifolia Roxb. *Journal of Ayurveda and integrative medicine.*, 8(2): 68–72.

Karhagomba, I.B., Mushagalusa, T.B., Nabino, V.B., Koh, K. & Kim, H.S. 2013. The cultivation of wild food and medicinal plants for improving community livelihood: The case of the Buhozi site, DR Congo. *Nutrition Research and Practice*., 7(6): 510−518.

Khan, M., Mannan, M.A., Chowdhury, M.T.I., Irfanullah, H.M. & Nishat, A. 2005. Medicinal plant conservation through community participation.

Kideghesho, J.R. & Msuya, T.S. 2010. Gender and socio-economic factors influencing domestication of indigenous medicinal plants in the West Usambara Mountains, northern Tanzania. *International Journal of Biodiversity Science, Ecosystem Services & Management*., 6(1-2): 3−12.

Kling, J. 2016. Protecting medicine's wild pharmacy. *Nature plants.*, *2*(5): 16064.

Kote, P., Jabeen, A., TN, S., Prabhavathi, S.J., Ramasamy, M., Dhanalakshmi, K., Chitra, K. & Malathi, G. 2024. A Scoping Review on Youth Participation in Agriculture:

Sustainable Development, Food Security, and Economic Growth. *Journal of Scientific Research and Reports*., 30(5): 947–958.

Liyanagamage, T.M., Hettiarachchi, I.C., Sivashankar, P. & Mahaliyanaarachchi, R.P. 2015. Farmers perception on cultivating medicinal plants as an agribusiness venture: a study at Pambahinna agrarian services division. Technical Session-Export Agriculture, p.85.

Macilwain, C. 2004. Organic: is it the future of farming? *Nature*., 428: 792–3.

Menze, N., Van der Watt, A.S., Moxley, K. & Seedat, S. 2018. Profiles of traditional healers and their healing practices in the Eastern Cape province of South Africa. *South African Journal of Psychiatry*., 24(1): 1–1.

Motaleb, M. A. 2010. Approaches to Conservation of Medicinal Plants and Traditional Knowledge: A Focus on the Chittagong Hill Tracts. IUCN (International Union for Conservation of Nature), Bangladesh Country Office, Dhaka, Bangladesh, pp viii+30.

Nagase, A. & Lundholm, J. 2021. Container gardens: Possibilities and challenges for environmental and social benefits in cities. *Journal of Living Architecture*., 8(2): 1–19.

Nefhere, K.V. 2019. Perceptions of traditional healers regarding ethnobotanical importance and conservation status of indigenous medicinal plants of Thulamela, Limpopo. Pretoria: University of Pretoria.

Nwafor, C. 2020. Cultivation of Medicinal Plants by Smallholder Farmers in South Africa: Constraints to Commercialization.

Noorhosseini, S.A., Fallahi, E. & Damalas, C.A. 2019. Promoting cultivation of medicinal and aromatic plants for natural resource management and livelihood enhancement in Iran. *Environment, Development and Sustainability.,* 22: 4007–4024.

O'Donovan, J., Thompson, A., Stiles, C., Opintan, J.A., Kabali, K., Willis, I., Mutimba, M.E., Nalweyiso, E., Mugabi, H., Kateete, D.P. & Ameniko, M. 2020. Participatory approaches, local stakeholders and cultural relevance facilitate an impactful community-based project in Uganda. *Health Promotion International.*, 35(6): 1353–1368.

Oladele, O.I. & Mudhara, M. 2016. Empowerment of women in rural areas through water use security and agricultural skills training for gender equity and poverty reduction in KwaZulu-Natal and North West Province: report to the Water Research Commission. Water Research Commission.

Paroda, R., Dasgupta, S., Bhag Mal., Ghosh, S.P. & Pareek, S.K. 2014. Expert consultation on promotion of medicinal and aromatic plants in the Asia-Pacific Region: Proceedings, Bangkok, Thailand; 2-3 December 2013.

Phondani, P.C., Bhat, I.D., Negi, V.S., Kothiyari, B.P., Bhatt, A. & Maikhuri, R.K. 2016. Promoting medicinal plant cultivation for livelihood enhancement and biodiversity conservation in the Indian Himalayan region. *Journal of Asia-Pacific Biodiversity*., 9: 39–46.

Pushpangadan, P., Nair, K.N. & Ahmad, M.R. 2004. Biodiversity and medicinal plant wealth of South Asian countries: country reports of Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka.

Rae, J.M., Roberts, C.A. & Taylor, G.D. 2006. Collaborative learning: A connected community approach. *Issues in Informing Science and Information Technology.*, 3(3).

Reddy, J. 2020. Medicinal plants cultivation, farming guide, training. Agri Farming. Available: https://www.agrifarming.in/medicinal-plants-cultivation-farming-guide-training. Date accessed: 17/11/2021.

Ruforum, 2017. University Community engagement framework and strategy study report, Kampala-Uganda. Reginal Universities Forum for capacity building in Agriculture. Study report.

Sathorar, H. & Geduld, D. 2021. A Critical Approach to University-Community Partnerships: Reflecting on the Diverse Realities. *Educational Research for Social Change.*, 10(2): 88–104.

Schippmann, U., Leaman, D.J. & Cunningham, A.B. 2002. Impact of cultivation and gathering of medicinal plants on biodiversity: global trends and issues. Biodiversity and the ecosystem approach in agriculture, forestry and fisheries. Satellite event on the occasion of the Ninth Regular Session of the Commission on Genetic Resources for Food and Agriculture. Rome.

Senanayake, S.G.J.N. 2006. Indigenous knowledge as a key to sustainable development. *Journal of Agricultural Sciences–Sri Lanka.*, 4: 2(1).

Shukla, S.K. 2023. Conservation of medicinal plants: challenges and opportunities. *Journal of Medicinal Botany*., 7: 5−10.

Srivastava, B., Sharma, V.C., Pant, P., Pandey, N.K. & Jadhav, A.D. 2016. Evaluation for substitution of stem bark with small branches of Myrica esculenta for medicinal use–A comparative phytochemical study. *Journal of Ayurveda and integrative medicine.*, 7(4): 218–223.

Sulaiman, C.T. & Balachandran, I. 2013. Plant part substitution for medicinal use in Aegle marmelos-a phytochemical approach. *Journal of Tropical Medicinal Plants.*, 14(1/2): 19–22.

Tanga, M., Lewu, F.B., Oyedeji, O.A. & Oyedeji, O.O. 2018. Cultivation of medicinal plants in South Africa: a solution to quality assurance and consistent availability of medicinal plant materials for commercialization. *Academia Journal of Medicinal Plants.*, 6(7): 168−177.

van den Ban, A. & Hawkins, H. 1996. Agricultural Extension, 2nd ed. Oxford: Blackwell.

Xego, S. 2016. Hydroponic propagation of Siphonochilus aethiopicus: an endangered medicinal plant. Thesis submitted in fulfilment of the requirement for the degree Master of Technology: Horticultural Sciences in the faculty of Applied Sciences at the Cape Peninsula University of Technology.

Yacoub, H. 1998. Indigenous Knowledge Definitions, Concepts and Applications [online].

Zschocke, S., Rabe, T., Taylor, J.L., Jäger, A.K. & Van Staden, J. 2000. Plant part substitution–a way to conserve endangered medicinal plants?. *Journal of ethnopharmacology*., 71(1-2): 281–292.

Chapter Five

General discussion, conclusions and recommendations

5.1 General discussion

The cultivation of high-priority medicinal species outside of designated conservation areas is imperative for the advancement of sustainability initiatives. Conservation strategies must integrate both *in-situ* and *ex-situ* approaches, alongside educational and research components. A range of stakeholders, comprising agricultural producers, traditional healers, gatherers, as well as street and shop traders, possess the capability to cultivate endangered species through organic practices. *Artemisia afra*, a medicinal herb of considerable significance, lacks comprehensive cultivation data. Consequently, further research is essential to establish optimal cultivation practices for this species. Furthermore, assessing medicinal plant users' willingness to procure raw materials from smallholder farmers is crucial for fostering cultivation practices among traditional healers and farmers. This approach aims to diminish reliance on wild harvesting and promote sustainability in the ecosystem.

Chapter 2 focused on assessing the effect of various organic amendments on the growth, secondary metabolites production and antioxidant capacity of *A. afra*, a plant significant to local communities and highlighted during the COVID-19 outbreak in South Africa. The study found that the plants treated with poultry manure exhibited higher growth compared to those receiving other organic matter, attributed to poultry manure’s high phosphorus and adequate nitrogen content which are crucial for plant development. Furthermore, poultry manure enhanced secondary metabolites and antioxidant activity in *A. afra*, with a positive correlation between polyphenols and flavonoids and the overall antioxidant activity. This indicates that the plant’s total antioxidant activity is attributed to the presence of polyphenols and flavonols. Given the sandy soils of the Western Cape, improving soil quality through organic amendments is essential, and the results suggest that poultry manure significantly enhances both growth and soil nutrient profile for *A. afra* cultivation.

Chapter 3: Previous studies highlight concerns about the remarked reduced potency of cultivated medicinal plants, however scientific evidence on traditional

healers' acceptance remains limited. Firstly, the findings showed that a notable portion of respondents rely on the collection of medicinal plants as their primary source of income, driven primarily by unemployment and financial challenges. The rising demand and rapid sales further intensify the problem of commercial over-harvesting, underscoring critical need for sustainable cultivation practices.

In relation to trade and usage, the study documented 64 diverse medicinal plant species recognized as the most frequently utilized or traded traditional medicinal plants in the Western Cape. Among these, *Artemisia afra*, *Rhoicissus* digitata, *Silene undulata*, *Bulbine abyssinica*, *Hypoxis hemerocallidea*, *Strychnos henningsii*, *Talinum caffrum*, *Helichrysum odoratissimum*, *Cissampelos capensis*, and *Synaptolepis oliveriana* were identified as the most preferred 'top ten' medicinal plant species used or traded by the surveyed traditional healers. Notably, *A. afra* recognized as the most sought-after, reflecting a heightened interest in *A. afra* during and following the COVID-19 pandemic.

The research findings regarding the origins and harvesting frequencies of medicinal plants in the Western Cape revealed that significant proportion of participants rely on species sourced from the wild for both trade and personal use. The sourcing practice from the wild is mostly conducted on a monthly basis, adversely affecting the sustainability of wild population, and availability of valuable plant species. Therefore, implementing cultivation practices could alleviate the pressure exerted on wild stock. A substantial number of participants engage in cultivation while others face challenges such as limited space and land, insufficient knowledge about cultivation practices, challenges with specific soil type and water availability. It is worth noting that a majority of respondents expressed willingness to cultivate commonly utilized plants in their gardens and demonstrated a supportive attitude towards initiatives aimed at promoting cultivation. Nevertheless, a small segment of the population expressed reluctance to purchase or accept cultivated plants, citing concerns regarding efficacy and safety.

Traditional healers indicated that they are concerned about the declining populations of certain medicinal plants, which are threatened by unsustainable harvesting practices, habitat destruction, and climate change. Cultural factors, such as inadequate rituals before harvesting and lack of sustainable practices, exacerbate

the problem. Moreover, restricted land for cultivation, lack of replanting practices, and unregulated harvesting practices further intensifies the problem.

The study further revealed that *A. afra* is widely used and sold within the community, however few respondents cultivate it, relying instead on wild populations. Traditional healers use *A. afra* primarily for respiratory issues and flu-related ailments, including coughs, colds, sinus problems, dry throat, asthma, fever, tuberculosis, bronchial ailments, chest congestion, and Covid-19. It also addresses digestive complaints like stomach aches, intestinal worms, colic, gastritis, rectal laxative, vomiting, and loss of appetite. Additional uses include treating hypertension, cancer, fungal infections, and enhancing immunity, as well as in rituals for good fortune.

Chapter 4 revealed a strong willingness among traditional healers and small-scale farmers to cultivate medicinal plants, underscoring the necessity for educational initiatives, and collaborative efforts with communities and relevant stakeholders to support sustainable cultivation and conservation practices. A training workshop was facilitated for traditional healers' and local farmers to impart essential skills for cultivating organic medicinal plants. The workshop experienced a remarkable doubling of participation compared to initial registration numbers, highlighting the community's enthusiasm for awareness and the considerable interest exhibited by healers and farmers in the Western Cape regarding the cultivating, maintenance, and sustainable utilization of medicinal plants. The workshop's content was notably pertinent, with attendees expressing a strong appreciation for the incorporation of organic compost and the demonstration of practical and attainable gardening materials. The practical nursery session was valued for its hands-on approach, covering techniques like vegetative propagation, transplanting, and plant maintenance. Future workshops were suggested to address medicinal plant preservation and use of alternative plant parts, such as aerial components, as substitutes for underground parts. Participants also requested more frequent workshops and short courses for emerging farmers and healers, emphasizing the importance of networking for collaborative conservation efforts.

5.2 Conclusions and recommendations

Despite the extensive information available regarding medicinal plants, it is regrettable that conservation efforts aimed at practitioners, collectors, and cultivators remain largely disregarded. This study underlines the importance of collaboration, knowledge sharing, and local conservation initiatives. Acknowledging the decline of certain species, traditional healers and farmers expressed willingness to cultivate medicinal plants. Collaboration channels have been established, and list of important plants in the Western Cape has been compiled to assist researchers in identifying plants of interest for research. Moreover, soil that is supplemented with 30% poultry manure has the capacity to enhance the growth of *A. afra*, as well as increase the production of phenolic compounds, flavonols and antioxidants.

Recommendations for future action include exploring the effect of poultry manure on additional species. It is also recommended that training workshops be conducted more frequently and incorporate significant topics, such as harvesting techniques and the importance of replacing underground components with aerial parts. Furthermore, promote academic collaborations and provide short courses aimed at improving livelihoods and facilitating skill development. For conservation efforts to be effective in the long-term, it is crucial to promote community awareness and engagement.

5.3 Appendices

Appendix 1

Publication 1 (Published review paper)

Journal of Medicinal Plants for Economic Development
ISSN: (Online) 2616-4809, (Print) 2519-559X

Recognising the impact of traditional herbal medicine in managing cancer: The South African context

Authors:
Sibusiso Xego[1]
Learnmore Kambizi[1]
Felix Nchu[1]

Affiliations:
[1]Department of Horticultural Sciences, Faculty of Applied Science, Cape Peninsula University of Technology, Cape Town, South Africa

Corresponding author:
Learnmore Kambizi,
kambizil@cput.ac.za

Dates:
Received: 07 May 2021
Accepted: 07 Aug. 2021
Published: 29 Nov. 2021

How to cite this article:
Xego, S., Kambizi, L. & Nchu, F., 2021, 'Recognising the impact of traditional herbal medicine in managing cancer: The South African context', *Journal of Medicinal Plants for Economic Development* 5(1), a121. https://doi.org/10.4102/jomped.v5i1.121

Background: The increasing prevalence of cancer is placing enormous pressure on health infrastructure globally. The ever rising cancer burden is not unique to South Africa but also to many low- and middle-income countries. Natural plant-based products have for long have been used traditionally for treating cancer. Approximately 7% – 48% of cancer diagnosed patients take herbal medicines post diagnosis. As herbal remedies are also used by South Africans, it is justifiable to investigate herbal medicinal use in the prompt detection as well as prevention of cancer.

Aim: The aim of this article is to highlight the potential of South African medicinal plants to combat cancer.

Method: This review summarises previous research (1991–2020) on the impact of traditional herbal medicine in managing cancer, and identifies the context between traditional and conventional medicines. Scientific databases such as Science Direct, PubMed, Research Gate, and Google Scholar were used to source primary and secondary data for this review.

Results: The findings of the present study call for the integration of herbal medicines into the existing healthcare systems to encourage the open use of herbal medicines by cancer patients. In addition, this study revealed 19 medicinal plant species from 15 families that are commonly used for the management of cancer in South Africa's nine provinces.

Conclusion: It is crucial to enhance collaboration between the existing healthcare systems and herbal traditional medicines in the provision of better care to patients at risk of, or who have been diagnosed with, cancer.

Keywords: medicinal plants; combat cancer; healthcare; conventional medicine; traditional medicine; anti-cancer therapies.

Appendix 2

Publication 2 (Published review paper)

Plant Archives Vol. 21, No. 2, 2021 pp. 632-638 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.096

EMBRACING HERBAL MEDICINE THROUGH COLLABORATION AMONG TRADITIONAL HEALERS, BIOMEDICAL HEALTH PRACTITIONERS AND RESEARCH INSTITUTES: A REVIEW

Sibusiso Xego, Learnmore Kambizi* and Felix Nchu
Department Of Horticultural Sciences, Cape Peninsula University of Technology, Symphony Way, P.O Box 1906, Bellville 7535, South Africa.
*Corresponding author: kambizil@cput.ac.za
(Date of Receiving : 06-12-2020; Date of Acceptance : 16-08-2021)

ABSTRACT

There are nearly 200 000 traditional health practitioners practicing in South Africa catering for approximately 80 percent of the country's population that is thought to use traditional medicine for their physical and spiritual well-being. The cumulative occurrence of diseases of unidentified etiology, customary beliefs and fatal diseases has led to traditional healer's assisting more patients. In many countries, collaborative initiatives between traditional African medicine and western medicine are taking place at a national level. However, in South Africa traditional healers are not formally recognized as health care professionals. Traditional and allopathic health practitioners experience negative attitudes towards each other and very little effort has been executed to incorporate westernized medicine and traditional healing. The main problem is the way to instigate corporation between traditional healers and Western biomedicine which vary in theory of disease management and causation. The purpose of this paper was to assess and address problems adjourning incorporation of traditional and biomedical practitioners, while recognizing opportunities and contemporary initiatives or interventions. Recommendations were provided on how to facilitate collaboration of traditional healers into recognized health care system and research developments to reduce the risks of their practices.

Keywords: Biomedical practitioners, collaboration, traditional healers, traditional medicine, research institutes.

Appendix 3

Published paper (Chapter Two)

Medicinal Plants
Vol. 16 (2), June 2024, 300-310

doi : 10.5958/0975-6892.2024.00031.X

Research Article

The effect of different organic amendments on growth, secondary metabolites and antioxidant properties of *Artemisia afra*

Sibusiso Xego, Learnmore Kambizi and Felix Nchu*
Department of Horticultural Sciences, Cape Peninsula University of Technology, Cape Town, South Africa

Received: March 10, 2024; Accepted: May 17, 2024

ABSTRACT

Traditional medicine plays a crucial role in treating various ailments and is frequently used as a primary or supplementary therapy. The increased demand for commonly used medicinal plants, such as *Artemisia afra*, has put pressure on wild populations and threatens their survival. During the first COVID-19 outbreak, there was a surge in demand for *A. afra* as a remedy, leading to increased prices and maximum harvesting rates. To address the risk of over-exploitation, this study investigated the effects of different organic amendments on the growth, secondary metabolites, and antioxidant properties of *A. afra*, aiming to establish a sustainable and feasible cultivation approach. Four organic amendments were selected in response to the increasing demand for organically cultivated medicinal plants. These included vermicompost, mushroom compost, poultry and kraal manure, mixed with coarse river sand at a ratio of 70% sand and 30% organic amendments. The results highlighted a significant improvement in growth parameters with the use of poultry manure, likely due to its rich nutrient content compared to other organic amendments studied. Poultry manure also exhibited the highest concentration of secondary metabolites (polyphenols and flavonols) and antioxidant activities in *A. afra*, including (ferric reducing antioxidant power (FRAP), 1,1-diphenyl-2-picrylhydrazyl (DPPH) and Trolox equivalent antioxidant capacity (TEAC). Furthermore, there was a strong correlation between secondary metabolites and antioxidant activity, suggesting that the presence of secondary metabolites influenced the overall antioxidant activity of the plant. Substantially, the application of poultry manures positively influenced the growth, secondary metabolites and antioxidant activities of *A. afra*.

Keywords: *Artemisia afra*, organic amendments, traditional medicine, secondary metabolites, antioxidants.

Appendix 4

Sample of semi-structured survey questionnaire

Traditional healers will be interviewed at their homes or at practice place and during traditional healers' workshops; for those who will be interviewed at their practice place, the researcher will comply with traditional practitioner's beliefs and rules.

1. General information of respondent

1.1 Where do you live?

1.2 Home Language

1.3 Age

15-25	26-35	36-45	46-55	56-65	65 and above

1.5 Gender

Female	Male

1.6 Involvement category

Traditional healer	Street trader	Shop trader

2. Medicinal plants

2.1 How long have you been healing people or selling plants?

2.2 Is medicinal plant collection/production the primary means of your earning? Explain

2.3 Does selling medicinal plants contribute to your income?

Yes	No

Explain 2.3

2.4 How well do the plants in your shop sell?

Very slow	Moderate slow	Slow	Fast	Fluctuate

2.5 List five mostly demanded medicinal plant species by buyers or users

Plant name	Parts used	Price/unit	Uses

2.6 Where do you get the medicinal plants you sell (sources of medicinal plants)?

Grow	Buy	Collect from the wild

2.7 If you harvest from the wild, how often do you harvest your plants?

Daily	Weekly	Monthly	Seasonally	Annually

2.8 Do you cultivate some of the plants?

Yes	No	Sometimes

If not, why don't you cultivate your own plants?

2.9 If seeds of the mostly used medicinal plant species could be freely supplied would you grow them?

Yes	No

2.10 Is there any difference between cultivated material and wild sourced material? Explain

Yes	No	Maybe

2.11 If medicinal plants can be grown by local farmers would you buy/accept them?

Yes	No	Maybe

If not, please state the reasons

2.12 Are there any beliefs associated with cultivated medicinal plants? Specify

2.13 Is there any community organization at your area that deals with collection, harvesting, trading and production of wild plants?

2.14 Are you aware of the depletion of some medicinal plant species in the wild?

If yes, what do you think are the causes?

3. Artemisia Afra

3.1 Do you use/sell the medicinal plant *A. afra* (wild wormwood) commonly known as umhlonyane/mhlonyane?

If yes, is it in demand?

Low	Moderate	High

3.2 Where do you obtain the plant material? (Province)

3.3 Do you harvest it from the wild or buy it?

3.4 Is the plant still available/easy to access?

3.5 Which parts of the plant do you use?

3.6 List the uses of the plant that you know?

4. Any other relevant information you would like to share

……

……

5. Is there something else you think we should have included in such a survey?

……

……

THANK YOU FOR PARTICIPATING

Appendix 5a

Workshops invitations

Invitation 1: to introduce the project to the healers and initiate collaboration and build trust between the healers and University reserachers

Embracing herbal medicine through collaboration among traditional healers and Research Institutes

Cape Peninsula University of Technology (Department of Horticultural Sciences)

Inviting you to join the

Traditional medicine and indigenous knowledge preservation workshop

18 March 2022

Friday I 10:00 – 13:00

Venue: KESS (Khayelitsha Shared Service office)

Next to KDH

RSVP

Miss Xego: 0678838583

Mr. Vulikhaya Sihluku: 0670418938

Appendix 5b

Invitation 2: Recap and data collection

Cape Peninsula University of Technology

Embracing herbal medicine through collaboration among traditional healers and Research Institutes

Cape Peninsula University of Technology (Department of Horticultural Sciences)

Inviting you to join the

Traditional medicine and indigenous knowledge preservation workshop (recap and data collection)

19 April 2022

Tuesday I 09:30 – 14:00

Venue: KESS (Khayelitsha Shared Service office)

Next to KDH

RSVP

Miss Xego: 0678838583

Mr. Vulikhaya Sihluku: 0670418938

Appendix 6a

Traditional healers workshops schedules

Workshop 1

ONE DAY TRADITIONAL HEALERS WORKSHOP AGENDA

Summary: Embracing herbal medicine through collaboration among traditional healers and Research Institutes (CPUT).

Programme Director: Noxolo Sekhobo

10:00- 10:15 Welcoming and introduction to the workshop- **Vulikhaya Sihluku (THO Western Cape Chairperson).**

10:15- 10:45 Collaboration among TH's and research institutes (CPUT)**- Dr. Callistus**

10:45- 11:00 Accepting, supporting and preserving indigenous knowledge- **Mr. P Roto**

11:00- 12:30 Conservation of medicinal plants (saving endangered medicinal plants)- **FILLING IN QUESTIONNAIRES- Ms S. Xego (PhD Candidate)**

12:30- 12:45 Closing- **Mkhulu Hlophe (Western Cape THO Co-Ordinator)**

13:00 Lunch

CAMAGU/THOKOZA MAKWANDE!!!!!!!!!

Appendix 6b

Workshop 2

TRADITIONAL HEALERS WORKSHOP (RECAP) AGENDA

Summary: Embracing herbal medicine through collaboration among traditional healers and Research Institutes (CPUT).

Programme Director: Gogo Noxolo Sekhobo

09:00-10:00 Registration

10:00- 10:30 Welcoming and workshop outline**- Mkhulu Zanemvula (Vulikhaya Sihluku) (THO Western Cape Chairperson).**

10:30- 11:00 Collaboration among TH's and research institutes (CPUT)**- Prof. Kambizi (HOD of Horticulture Department).**

11:00- 11:15 Benefits/advantages of collaboration between TH's & research institutes**- Dr. Callistus (Cape Peninsula University of Technology)**

11:15- 11:45 Conservation of medicinal plants (saving endangered medicinal plants)**- CLARIFICATION OF QUESTIONNAIRES- Ms S. Xego (PhD Candidate: CPUT)**

11:45- 12:15 Questions and answers session (Q&A)

12:15- 13:15 Filling of Questionnaires

13:15- 13:30 Closing**- Gogo Mamtshabalala (THO executive)**

Word of Thanks- **Mr. Roto (Cape Peninsula University of Technology)**

13:30 Lunch

CAMAGU/THOKOZA MAKWANDE!!!!!!!!!!

Appendix 7a

Cover letters and consent forms

CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

Symphony Way, Bellville, Cape Town, 7535

Department of Horticultural Sciences

0219596479/0609134297

COVER LETTER AND CONSENT FORM FOR PARTICIPATION IN THE STUDY

Dear Participant

My name is Sibusiso Xego, and I am a post-graduate student in the Department of Horticultural Sciences at the Cape Peninsula University of Technology. The study is in fulfilment of my PhD which I am pursuing, the research questionnaires will be devised to get information about various aspects of medicinal plants, participant's willingness to buy cultivated plants and willingness to cultivate medicinal plants. Additionally, get information on farmer's perceptions towards cultivation of medicinal plants.

Benefits: This study will assist individuals, farmers and community-based organizations to initiate and maintain permanent medicinal plants and nature conservation projects as the basis for sustainable lifestyle, poverty alleviation, job creation and environmental renewal. Additionally, it will provide technical skills to farmers through training and motivation to promote cultivation of medicinal plants in the farmer's field and ensure a continuous and regular supply of medicinal plants for pharmaceutical industry.

The information you will give will be kept private and confidential and will only be used for research purposes. The duration of the interview will take approximately 30 minutes of your time. You will not receive any financial gift or payment of any kind for participation in this research study. You do not pay anything to participate in the study. All questionnaires are coded to facilitate recording, but no names will be written on the questionnaires. The list of participant's names and their corresponding research number will be kept on the computer which only the researcher has the password to access the information.

Your participation is voluntary, and you are free to withdraw at any time if you wish to do so without it being held against you in any way. I intend to tape record the interview with your permission, please note that your participation is entirely voluntary and if you wish not to answer any question you are free to do so at any point. If you are interested in the results of the study, I will be only too willing to share the findings with you. Should you require any further information, please do not hesitate to contact me on 0678838583/ 0711183054.

The study was approved by the research committee of the university, and I hope with all your help this study will become a success. Thank you for agreeing to participate in this study.

Any queries regarding research, your participation and rights can be addressed to Prof L. Kambizi and Prof F. Nchu who are my supervisors (0219596479/0219596473).

If you agree to all the conditions mentioned above and have no further questions, I will then ask you to sign below to show that you have given your consent.

CONSENT FORM

I hereby consent to participation in this research project and to have the interview tape recorded. Furthermore, I give Sibusiso Xego permission to use my responses in the write up of the study, and any future publications or presentations.

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study. I am aware that the results of the study, including personal details regarding my sex, age, date of birth, and diagnosis will be anonymously processed into a study report. In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher. I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

Participant's signature: _____

Date: _____

I, Sibusiso Xego (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Researcher's signature _____

Date _____

Appendix 7b

CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

Symphony Way, Bellville, Cape Town, 7535

Department of Horticultural Sciences

0219596913/0678838583

COVER LETTER AND CONSENT FORM FOR PARTICIPATION IN THE WORKSHOP

Dear Participant

This questionnaire is designed to gather information about your experience during the workshop, identify areas for improvement, and seek suggestions for other topics or workshops that could benefit you.

Benefits: This training will assist individuals, farmers and community-based organizations to initiate and maintain permanent medicinal plants and nature conservation projects as the basis for sustainable lifestyle, poverty alleviation, job creation and environmental renewal. Additionally, it will provide technical skills through training and motivation to promote cultivation of medicinal plants to ensure a continuous and regular supply.

The information you will give will be kept private and confidential and will only be used for research purposes. The duration of the interview will take approximately 20 minutes of your time. You will not receive any financial gift or payment of any kind for participation in this survey. All questionnaires are coded to facilitate recording, but no names will be written on the questionnaires. Your participation is voluntary, and you are free to withdraw at any time if you wish to do so without it being held against you in any way, and if you wish not to answer any question you are free to do so at any point.

CONSENT FORM

I have received, read and understood the above written information (Participant Letter of Information) regarding the feedback questionnaires. In view of the requirements of research, I agree that the data collected during this workshop can be processed in a computerised system by the researcher. I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to complete the feedback questionnaire.

Participant's signature: _____ Date: _____

Appendix 8

Ethics approval

Cape Peninsula University of Technology

Statement of Permission

Data/Sample collection permission is required for this study.

Reference no.	209199237/10/2020
Surname & name	Xego, S.
Student Number	209199237
Degree	Doctor of Horticulture
Title	Development of a sustainable cultivation protocol for *Siphonochilus aethiopicus* in the Western Cape
Supervisor(s)	Prof Learnmore Kambizi
FRC Signature	
Date	2020 Oct 04

Cape Peninsula University of Technology

P.O. Box 1906 · Bellville 7535 South Africa ·Tel: +27 21 953 8677 (Bellville), +27 21 460 4213 (Cape Town)

Ethics Approval Letter **Reference no: 209199237/10/2020**

Office of the Chairperson **Research Ethics Committee**	**Faculty of Applied Sciences**

On 02 October 2020, the Faculty Research Ethics Committee of the Faculty of Applied Sciences granted ethics approval to Xego, S. for research activities related to a project to be undertaken for a degree (Doctor of Horticulture) at the Cape Peninsula University of Technology.

Title of project:	Development of a sustainable cultivation protocol for *Siphonochilus aethiopicus* in the Western Cape

Comments (Add any further comments deemed necessary, e.g. permission required)

1. Human subjects are involved in the study.
2. This permission is granted for the duration of the study.
3. Research activities are restricted to those detailed in the research proposal.
4. The research team must comply with conditions outlined in AppSci/ASFREC/2015/1.1 v1, CODE OF ETHICS, ETHICAL VALUES AND GUIDELINES FOR RESEARCHERS.

Signed: Dr Elie Itoba Tombo on behalf of Chairperson: Faculty Research Ethics Committee	**03/10/2020** **Date**

Appendix 9

Species identified by respondents as the most popular plant species among purchasers and consumers.

Botanical name	Vernacular name	Part(s) used	Condition for treatment	No. of citations (%)
Artemisia afra Jacq. ex Willd	Umhlonyane; wilde Als	Leaves, roots	Flu, blood sugar, worms, respiration, skin ailments, covid, cold	27%
Psoralea pinnata L.	Bloukeur; fountain bush	Leaves, flowers	Anxiety, stress	1%
Leonotis leonurus (L.) R.Br.	Wilde dagga	Leaves, flowers	Bloods and flu	1%
Helichrysum odoratissimum (L.) Sweet	Impepho	Leaves, stem, roots	Incense to communicate with ancestors, swollen lymph, steaming, stomach problems	11%
Euclea undulata Thunb	Common guarri	Leaves	Heart problems, luck	1%
Sutherlandia frutescens (L.) R.Br.	Umnwele; cancer bush	Leaves, flowers	Respiratory problems, stomach, immune boosting	1%
Symphytum officinale L., radix	Comfrey	Root, leaves, flowers	Respiratory problems, skin ailments	1%
Hypoxis hemerocallidea Fisch., C.A.Mey. & Avé-Lall	Inongwe; African potato; Ilabatheka	Bulb, flowers, roots	Immune boosting	15%
Bulbine natalensis Baker	Rooiwortel	Roots	Men's ailments, immune booster	1%
Silene undulata Aiton	Ubulawu	Roots	Facilitate communication with the ancestors (for clear dreams), meditation herb	18%
Acacia xanthophloea (Benth.) P.J.H.Hurter	umKhanyakude	Bark, leaves, roots	Lucky charm	8%
Ocotea bullata (Burch.) Baill.	Umnukani	Bark	Headache, treat pimples	7%
Many species including *Bulbine abyssinica* A.Rich.	Intelezi	Roots, bulbs	Bring good luck	16%
Rhoicissus digitata (L.f.) Gilg & M. Brandt.	Chithibunga	Roots, bulbs, leaves	Chase away bad luck	23%
Unidentified species	Gobela eliweni	Roots, stems	Unidentified	1%
Talinum caffrum (Thunb.) Eckl. & Zeyh.	Phunyuka	Stem, roots	Bring peace, wounds	12%
Albuca setosa Jacq.	Inqwebeba	Stem	Stomach poison, wash away bad luck, restless body	3%
Afzelia quanzensis Welw.	Mdlavuza	Stem, bark	Ward off attack and bad lucks	3%
Unidentified species	Ndakhomba	Stem	Unidentified	1%
Rapanea melanophloeos (L.) Mez	Itshongwe	Stem	Pimples	1%
Strychnos henningsii Gilg	Umnonono	Bark	To heal poison	13%
Croton sylvaticus Hochst.	Umahlabekufeni	Bark	Unidentified	3%
Asclepias fruticose L.	Igwada	Bark	Headache	1%
Eucomis autumnalis (Mill.) Chitt	Umathunga	Roots	After operation for wound healing	5%
Curtisia dentata (Burm.f.) C.A.Sm.	Umlahleni	Unidentified	For luck/charm	4%
Anthospermum rigidum Eckl. & Zeyh.*; Argyrolobium tomentosum* (Andrew) Druce	Umlomomnandi	Stem, bark, roots	Chewing for good fortune/luck, ways opener-it makes people like you	8%
Sansevieria spp.	IsiKholokholo	Bark	Health booster	1%
Vernonia adoensis Sch. Bip. ex Walp.	Inyathelo	Roots	Wounds, diarrhoea	1%
Osyridocarpus schimperianus (Hochst. ex A.Rich.) A.DC.	Malala	Bark	Unidentified	1%

Elaeodendron transvaalense (Burtt Davy) R.H.Archer	Ingwavuma	Bark	Unidentified	1%
Haworthiopsis limifolia (Marloth)	Umathithibala	Roots	Sores, purifying blood	1%
Unidentified species	Dlulabehleli	Stem	Unidentified	1%
Siphonochilus aethiopicus (Schweif.) B.L. Burt	Isiphephetho	Rhizomes	Cough, pain, inflammation	5%
Alepidea amatymbica Eckl. & Zeyh.	Iqwili	Stem, roots	Respiratory problems	5%
Elephantorrhiza elephantine (Burch.) Skeels	Intolwane	Roots	Stomach ache	1%
Pittosporum viridiflorum Sims	Umkhwenkwe	Roots, leaves	Stomach ache	3%
Ipomoea oblongata E.Mey. ex Choisy	Ubhoqo	Roots	Womb problems	5%
Aloe ferox Mill.	Ikhala	Leaves, stem	Stomach ache, acne, congestion	3%
Cinnamomum camphora (L.) Nees & Eberm.	Uroselina	Bark, roots, leaves	Fever, pain	3%
Olea europaea subsp. Africana (Mill.) P.S.Green	Umnquma	Bark, leaves	Steam for protection from the evil spirit, used as an enema, taken as emetic to clean stomach	1%
Cissampelos capensis L.f.	Umayisake	Roots	Unidentified	11%
Unidentified species	Mqaqoba	Stem	Unidentified	1%
Unidentified species	Isixhonxo	Leaves	Repels evil spirit	1%
Hermannia hyssopifolia L.	Inceba	Roots	Lucky charm	5%
Unidentified species	Isonka sehlathi	Arial parts	Unidentified	3%
Synaptolepis oliveriana Gilg	Uvuma omhlophe	Arial parts	Lucky charm	9%
Unidentified species	Vula kuvaliwe	Bark	Unidentified	4%
Bersama lucens (Hochst.) Szyszyl.	Isindiyandiya	Bark	Unidentified	1%
Araujia sericifera Brot.	Impinda	Bark	Unidentified	5%
Viscum spp. (V. verrucosum Harv*)*	Iphakama	Bark	Unidentified	1%
Acokanthera spp. (A. oblongifolia, A. oppositifolia)	Intlungunyembe	Leaves	Stomach ache	1%
Rapanea melanophloeos (L.) Mez	Maphipha	Bark	Respiratory problems	1%
Cassipourea spp. (C. flanaganii, C. gerrardii, C. malosana)	Umemezi-obomvu	Leaves	Skin lightning	4%
Unidentified species	Tswelana	Roots	Unidentified	1%
Dioscorea sylvatica Eckl.	Usikolipati	Roots	Cure for skin problems, charm	1%
Acalypha villicaulis; Celosia trigyna; Crotalaria spp.; Cyrtanthus breviflorus	Velabahleke	Bark	Lucky charm	4%
Unidentified species	Nkunzebomvu	Roots	Unidentified	1%
Tulbaghia spp.	Umwelela	Bark, roots	Fever, worms	4%
Harpagophytum procumbens (Burch.) DC ex Meisn.	Devil's claw	Root, bulb	Fever, pain	1%
Moringa oleifera Lamk	Moringa	Leaves	Energy, stamina	1%
Withania somnifera (L.) Dunal	Ubuvimba	Rhizome, roots	Skin ailments	1%
Hydnora spp; (H .africana; H. abyssinica); Sarcophyte sanguinea	Mavumbuka	Roots	Stomach problems	3%
Ptaeroxylon obliquum (Thunb.) Radlk.	Umthathi	Stem	Chasing away evil spirits	1%
Gunnera perpensa L.	iGobho	Roots	Cleansing the body	1%

Appendix 10

Compilation of reasons provided by respondents for their unwillingness to purchase cultivated plants from farmers:

1. "Certain rituals must be performed before harvesting some cultivated traditional medicinal plants, as failure to do so may pose a risk to one's life."
2. "They wouldn't provide me with the assurance of effective healing."
3. “Because farmers use chemicals”.
4. "I chose not to purchase it because they incorporate foreign substances to enhance the growth of the plants."
5. "Traditional medicinal plants should only be handled by individuals considered clean or pure, specifically those who do not have 'umlaza,' meaning they have abstained from sexual intercourse prior the harvesting time"
6. "It is crucial for a traditional healer to be familiar with the authentic leaves and roots of a plant rather than relying on pre-prepared samples. Depending on ready-made samples may result in a lack of knowledge about medicinal plants, and there is a risk of purchasing plants that do not align with the healer's specific requirements."
7. "I aim to cultivate plants on my own to have complete knowledge of every substance applied to them."
8. “They may be expensive”.

Beliefs associated with cultivated medicinal plants

1. “There are certain herbs that only grow their medicinal properties in the climatic zone they originate from. An inter-provincial online nursery would me amazing”.
2. “Cultivated plants don’t have the same strength medicinally and magically as wild grown plants”.
3. “Medicinal plants require reverence, and it is essential to show respect towards them. Certain medicinal plants should not be cultivated alongside others that might be impure or contaminated. The potency of wild medicinal plants is believed to be higher due to their self-sufficiency”.
4. “I am unaware of the components they may have blended or whether any mixing has occurred”.
5. “We don’t know how they are cultivated, and others are old (or not fresh)”.

6. “They are guided to their specific location or unveiled to you by ancestral forces”.
7. “Certain medicinal plants are prohibited for cultivation by women or within our domestic spaces”.
8. “You should speak to the medicinal plant”.
9. “Only the traditional healer who intends to use the plant is allowed to handle it”.
10. “The time for harvesting cultivated plants differs from that of naturally grown plants.”
11. “I believe in going to the bush/wild and dig”.
12. “They are regarded as weak or lesser healing properties”.
13. “There are medicinal plants that cannot or should not be grown at home”.
14. “Harvesting these traditional medicinal plants from the wild is not a task that can be undertaken by just anyone; it requires specific knowledge and skills”.
15. “Plants collected from the wild are fresher compared to cultivated plants”.
16. “Traditional medicinal plants do not have chemicals; wild plants grow naturally but the cultivated have fertilizers added”.
17. “The healing powers are not the same as those that grow naturally in the wild; natural growing medicinal plants are stronger than the cultivated ones, sometimes or certain plants”.
18. “When gathering traditional medicines, it is essential to practice "ukurhuma" and give back to Mother Earth”.
19. “Some medicinal plants cannot be harvested at any time or season”.
20. “The wild plants have enough time to grow fully and suitably, and it is not the same for cultivated plants”.

Appendix 11

Factors contributing to the depletion of medicinal plants as reported by the participants.

1. “Careless harvesting”.
2. “Uproot the plants or harvest the whole plant from the roots”.
3. “Incorrect method of harvesting and overharvesting”.
4. “Demand and harvesting the whole plant”.
5. “Continuous harvesting”.
6. “Harvested in an unmeasurable or uncontrolled manner”.
7. “Bark removal from trees”.
8. “Plants eaten by animals in the wild”.
9. “Habitat destruction”.
10. “Poor conditions/environment, rain and harvesting techniques”.
11. “Harvesters exhibit a lack of protection and can be destructive towards the available resources in the wild”.
12. “The root cause lies in the people's excessive greed; they harvest large quantities without implementing replanting practices”.
13. “Excessive harvesting without consideration for the future”.
14. “Not preserving or conserving the plants”.
15. ”Insufficient knowledge about harvesting, and individuals who refrain from "ukurhuma"- perform specific rituals before engaging in the harvesting process”.
16. “There are no designated individuals responsible for overseeing, protecting and caring for the plants”.
17. “Climate change”
18. “There is no available land for cultivation to replace the wild plants”.
19. “Over population and limited number mountains containing medicinal plants, upon which dependency is high”.
20. “Harvesting is conducted by everyone, including individuals who are not healers”.
21. “Due to the unrestricted nature of harvesting, anyone can harvest at any time”.
22. “Individuals harvest without replenishing a portion of the plant back to nature”.
23. “The uprooting of plants prevents new growth from occurring”.
24. “Lack of knowledge in harvesting practice. For example, African potato should always have some of the bulb left to resprout”.

25. “Other plants take 2-3 years to regrow”.
26. “Major source of income for people, resulting to overharvesting”

Appendix 12

Uses of *Artemisia afra* as specified by the respondents

1. Coughing, boil and drink it warm
2. Asthma, boil and drink it warm
3. Fever, boil, steam with it and steam inhalation
4. Enema or rectal laxative
5. Emetic or induce vomiting
6. Spitting
7. Nose congestion/sinus
8. High blood
9. Chest congestion (half a cup 3 times a day)
10. Body pain
11. For luck
12. Cancer
13. Fungal infection
14. Antibiotic
15. Get rid of phlegm
16. Cold
17. Chest problems (steam)
18. Steaming
19. Apply or smear on skin
20. Malaria
21. Boil and take as hot drink
22. Dry throat
23. Chase away bad spirits
24. Heals respiratory problems
25. Bladder problems
26. Relieve swelling
27. When you struggle to urinate
28. Tuberculosis
29. Stomach ache
30. Headache

31. Purify the blood
32. Vaginal discharge
33. COVID 19
34. Gout
35. Rheumatic disease
36. Arthritis
37. Loss of appetite
38. Colic
39. Intestinal worms
40. Bronchial ailments
41. Blood sugar
42. Gastritis
43. Immune booster
44. Fertility treatment

Appendix 13

Invitations to organizations representing traditional healers and small-scale farmers.

Appendix 14

Handbooks containing detailed step-by-step instructions on various cultivation techniques.

Handbook for Cultivation of medicinal plants
Prepared by Sibusiso Xego
Department of Horticultural Sciences

A Comprehensive Guide to Growing, transplanting and Caring for Medicinal Plants

Contents Include:

Seed Sowing Techniques, Stem and Tip Cutting Methods

Transplanting Procedures

Care and Maintenance Guidelines

Enhance Your Knowledge:

This handbook is designed to equip traditional healers, small-scale farmers, and gardening enthusiasts with practical knowledge and techniques for cultivating medicinal plants. Learn the best practices for ensuring healthy growth and maximizing the therapeutic potential of your plants.

Handbook for Cultivation of medicinal plants
Prepared by Sibusiso Xego
Department of Horticultural Sciences

Table of Contents

Handbook for Cultivation of medicinal plants
Prepared by Sibusiso Xego
Department of Horticultural Sciences

Introduction

The cultivation of medicinal plants is an essential practice for maintaining the availability of traditional medicines. This handbook provides practical guidelines for growing medicinal plants through seed sowing, stem and tip cuttings, and the process of transplanting. Whether you are a beginner or an experienced cultivator, this guide will help you cultivate your plants effectively.

Empower Your Community:

Join us in promoting sustainable healthcare practices through the cultivation of medicinal plants. Let's work together to conserve our natural resources and ensure the continued availability of traditional medicines.

Handbook for Cultivation of medicinal plants
Prepared by Sibusiso Xego
Department of Horticultural Sciences

Cultivation methods:

1. Seed sowing

Materials Needed

- Seeds of the chosen medicinal plant
- Seed trays (Egg trays, ice cream containers, plastic bottles, etc.)
- Soil mixing: sand 80% and compost 20%
- Spray bottle

Recyclable material you can use

Yoghurt, ice-cream, eggs and plastic containers

Steps for Seed Sowing

1. Preparation: Fill seed trays or pots soil. Ensure the soil is moist but not waterlogged.
2. Sowing Seeds: Sow the seeds according to the recommended depth and spacing for each plant. Smaller seeds should be sown on the surface and lightly covered with soil, while larger seeds can be planted deeper.
3. Watering: Gently water the seeds using a watering can or spray bottle to avoid moving the seeds.
4. Germination: Place the trays in a warm, bright location. Keep the soil moist until the seeds germinate.

Seed sowing process:

Steps: Mix soil; fill your container with soil; big seed open a hole with your finger not too deep and place your seeds, small seed spread on top of your soil and lastly cover with a thin layer of soil.

2. Cuttings

Materials Needed

- Healthy parent plant
- Sharp, sterile knife
- Pots or recycled containers
- Soil- mixture of sand and compost
- Plastic bags to cover the pot or make a structure to cover the cuttings

Steps for Stem Cuttings

1. Selecting Cuttings: Choose a healthy stem from the plant. The cutting should be free of flowers.
2. Cutting Preparation: Cut the stem just below a node (where the leaf joins the stem). Remove the lower leaves, leaving only a few at the top.
3. Planting Cuttings: Insert the cutting into a pot filled with moistened soil. Firm the soil around the cutting.
4. Cover the pot with a plastic bag to maintain temperature.
5. Rooting: Place the cuttings in a bright, indirect light location. Keep the soil moist and remove the cover once roots develop (around 2-4 weeks).

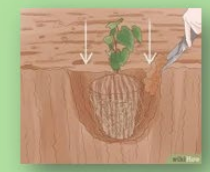
As soon the roots develop transplant your cutting to a bigger container or directly to the ground.

Note: You can also place the cutting in a clean container of water, ensuring that the nodes (where roots will grow) are underwater while the leaves are above water. Use clear containers to easily monitor root growth. Change the water every few days to prevent the growth of bacteria or algae.

3. Transplanting

Materials Needed

- Seedlings or rooted cuttings
- Larger container or garden bed
- Compost or well-draining soil
- Watering container



Steps for Transplanting

1. Preparation: Choose a suitable location for transplanting, ensuring it has enough sunlight and well-draining soil.
2. Soil Preparation: Amend the soil with compost to enhance fertility and drainage.
3. Transplanting: Carefully remove the seedlings or cuttings from their containers, being mindful of the roots.
4. Inspect the roots and tease them gentle.
5. Dig a hole in the new location and place the plant at the same depth it was growing before.
6. Watering: Water the transplanted plant thoroughly to settle the soil around the roots.

Planting seedlings (seed that germinated or rooted cuttings) stages

Care and Maintenance

Watering

- Keep the soil consistently moist but not soaked.
- Water in the early morning or late afternoon to minimize loss of water.

Fertilizing

- Use organic manure or compost to provide needed nutrients. (Garden waste, fallen leaves, vegetable and fruit scrabs etc.)

Pest and Disease Management

- Inspect plants regularly for signs of pests and diseases.
- Use natural remedies to manage infestations such as garlic and dish soap.

Conclusion

Cultivating medicinal plants is a rewarding effort that contributes to sustainable healthcare practices. By following the guidelines in this handbook, you can successfully grow and care for a variety of medicinal plants, ensuring a continuous supply for your needs.

Acknowledgments:

Special thanks to all the traditional healers, small-scale farmers, and community members who contributed their knowledge and experience to this handbook. The Department of Horticultural Sciences for workshop facilities and support.

Some of the Medicinal Plant Cultivation Projects Conducted by Our Department

Prepared by:

Cape Peninsula University of Technology

For more information contact:

Department of Horticultural Sciences,
Bellville campus

Appendix 15

Feedback questionnaire

Workshop Feedback Questionnaires

Traditional healers and small-scale farmers will be asked to complete questionnaires to provide feedback and recommendations about the workshop.

Personal information

1. Age:
2. Gender:

Male	Female

3. Role

Traditional healer	Small-scale farmer

4. Name of organization

……

Workshop content

1. Were the topics covered in the workshop relevant to your needs? Yes/No and explain

……
……

2. Which topics did you find most useful?

……
……

3. Were there any topics you felt were missing or should they be included in future workshop?

……
……

4. How confident do you feel about your ability to cultivate medicinal plants after attending this workshop? Very confident, confident, Neutral, not very confident. Explain

……
……

5. Did this workshop encourage you to grow your own medicinal plants? Explain

……
……

6. Do you feel more informed about the conservation of indigenous medicinal plants after attending this workshop?

……
……

7. Do you feel prepared to deal with common challenges in cultivating medicinal plants (e.g., soil issues, watering)?

……
……

8. How useful was the information provided about organic farming methods during the workshop?

……
……

9. Any additional comments or feedback?

……
……
……

Thank you for your participation and valuable feedback!

Appendix 16

Factors motivating attendees to cultivate medicinal plants:

1. “The acquired skills from the workshop encouraged me to grow my own medicinal plants using feasible material available at home”.
2. “Growing my own medicinal plants will save money by providing access without the cost of purchasing them”.
3. “I can now create my own soil mixes and recycle containers as pots for growing plants”.
4. “With the knowledge I've gained from the workshop, I will start my own indigenous plant nursery”.
5. “This workshop encouraged me to grow my own plants and provided me with the necessary information”.
6. “After learning about the benefits of growing our own plants, particularly in conserving wild stocks, I was inspired to start my own garden using available resources”.
7. “I’m excited to start my own garden, and the handbook provided will make the process much easier for me”.
8. “I now have the knowledge and confidence to grow plants and start my own garden”.
9. “Due to the important information that was shared during the workshop I am now confident to grow my own plants”.
10. “I have a guide (handbook) that will help me cultivate my plants successfully”.
11. “Our country is approaching a time when certain plant species may become scarce, so I’m inspired to grow my own plants to preserve them for future generations”.
12. “Confident to start medicinal gardening in my farm and interested to know more”.
13. “With the planting material provided, I will start planting *Artemisia afra* as soon as I get home”.
14. “I’ve gained a lot of knowledge, and I’m certain I will apply everything I’ve learned into practice to ensure success of my garden”.
15. “There is still much to learn about medicinal plants, and I’m eager to receive more training from the university in the future”.
16. “Thanks to the information provided, I can now confidently start my own garden”.

17. “This practical workshop encouraged me a lot include cultivation of medicinal plants in my farm activities”
18. “I can now start planting medicinal plants because I know the proper techniques”.
19. “I already grow them as a home gardener, and the information I've gained will help me improve my garden”.
20. “The information has encouraged me to continue cultivating medicinal plants and conserve them more”.
21. “I have learnt a lot in this workshop, and I feel confident in starting my garden”.
22. “The experience I gained has inspired to grow my own medicinal plants. I also learned that household items like egg trays and ice cream containers, can be recycled for planting”.
23. “I have plenty of space to plant, but I lacked the knowledge. Now, with what I’ve learned, I feel confident to start”.
24. “I will start my garden and use the existing plants to make cuttings”
25. “I have my own small garden, and the workshop was a great help in improving it”.
26. “I now have a better understanding of planting medicinal plants and can start my own small garden”.
27. “The workshop has given me valuable insight into starting my own medicinal plant garden”.
28. “I've always wanted to start my own garden, and with all the information and training from today’s workshop, I’m ready to begin”.
29. “At first, I did not have any confidence to start a garden but now I do”.
30. “It was a very informative workshop; I plan to improve my small farm by experimenting with growing medicinal plants”.
31. “As a grower, I already have a garden, but I needed more knowledge to improve it”.

Appendix 17

News article (Chapter Four: Practical workshop)

Full article available: https://www.cput.ac.za/newsroom/news/article/4995/horticultural-sciences-commits-to-medicinal-plant-conservation.

Horticultural Sciences commits to medicinal plant conservation

PROMOTING ORGANIC CULTIVATION OF ENDANGERED AND EXTINCT MEDICINAL PLANTS: The Department of Horticultural Sciences recently hosted a successful training workshop on medicinal plants cultivation.

In an effort to enhance a relationship between traditional healers, small scale farmers and CPUT, the Department of Horticultural Sciences recently held a training workshop for these stakeholders.

The workshop was also held to conserve endangered and extinct medicinal plants and promote the organic cultivation of these plants by traditional healers and small-scale farmers,

Professor in Horticultural Science, Learnmore Kambizi said the workshop on Training on Medicinal Plants Cultivation was a huge success. The response from the community members was overwhelming. "We envisaged training a total of 30 traditional healers and small-scale farmers, but the workshop was over-subscribed with some [interested individuals] being turned down. The active participation by PhD students is worth noting," said Kambizi. He added that during the discussion session after practical demonstrations, there was a huge request by the community for "our department to offer a short course on medicinal plant cultivation. Academics who attended the workshop included Prof Felix Nchu and Dr John October, the head of department.

- Academic
- Alumni and Advancement
- Awards
- Campus life
  - Sport
- Community engagement
- Event
- Facilities
- Faculty of Applied Sciences
- Faculty of Business and Management Sciences
- Faculty of Education
- Faculty of Engineering and the Built Environment
- Faculty of Health and Wellness Sciences
- Faculty of Informatics and Design
- Fundani
- Institutional memos
  - Campus update
- Library
- Partnerships
- Research and innovation
- Staff