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THREATENED MEDICINAL PLANTS OF SOUTH AFRICA: CASE OF THE FAMILY HYACINTHACEAE

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Abstract

Background: Traditional medicine plays a major role in the primary health care of many people living in rural areas. South Africa is a home to over 30,000 species of higher plants and 3,000 of these species have been found to be used in traditional medicine across the country. South African medicinal plants are decreasing at an alarming rate as a result of over exploitation. Today many medicinal plants face extinction but detailed information is lacking. The purpose of this paper was to review current and proposed cultivation strategies that could be used to improve plant conservation statuses, livelihoods of the people involved in medicinal plant industry and sustainability of this industry.

Material and Method: In this review, emphasis was on the members of Hyacinthaceae family and the species *Siphonochilus aethiopicus* (Schweinf) B.L. Burtt (Zingiberaceae), which are some of the most traded and used in traditional herbal medicine. Detailed literature search was conducted on the current strategies that are being used for the cultivation of medicinal and food crops and a conceptual analysis of how technologies used for the cultivation of non-medicinal crops could be adopted for cultivation of medicinal plants in Africa. *Siphonochilus aethiopicus* was used as a case study to demonstrate the potential of using alternative cultivation strategy such as hydroponics in the cultivation of medicinal plants.

Result and Conclusion: The results showed that hydroponics has the potential to improve plant growth and yield of desired plant parts even in areas where these plants do not normally grow under natural conditions. This was the case with *Siphonochilus aethiopicus.* There is potential for growth in the medicinal plant industry if optimum cultivation technologies such as hydroponics are implemented despite the perception that Africans have an ingrained traditional preference of wild harvested plants, on the contrary many Africans have no issues with cultivated medicinal plants.

Key words: Medicinal plants; Hyacinthaceae; *Siphonochilus aethiopicus* micropropagation; hydroponics; cultivation; conservation**.**

Introduction

Herbal medicine usage is one of the most remarkable uses of plant based biodiversity. As many as 75% to 90% of the world's rural people rely on herbal medicine for their primary health care (Debnath *et al*., 2006). According to recent estimates by the World Health Organisation (WHO), more than 3.5 billion people in the developing world rely on plants as components of their primary health care (Balick and Cox, 1996; Bodeker *et al*., 1997). In Africa, traditional healers and remedies made from plants play an important role in the health of millions of people (Monitor, 2002).

South Africa is home to over 30,000 species of higher plants and 3000 of these species have been found to be used in traditional medicine across the country (Van Wyk *et al*., 1997) and about 350 species are the most commonly used and traded medicinal plants (South African National Biodiversity Institute, 2006). The local trade in medicinal plants amounted to an estimated 20 000 tons a year, involving 574 species (South African Press Association, 2013; Liphadzi, 2013). There are an estimated 200 000 indigenous traditional healers in South Africa and up to 80% of South Africans consult these healers, usually in addition to using modern biomedical services (SANBI, 2006). In South Africa, the national value of trade in medicinal plants alone (approximately 20 000 tonnes), is estimated at R270 million annually (Department of environmental affairs, unpublished). An estimated 30 million people make regular use of the services of the country's 200 000 traditional health care practitioners, all of whom apply indigenous and exotic plants in their remedies (SAPA, 2013; Liphadzi, 2013). It has been assessed that 35000-70000 species of plants have been harvested and used at one time or another for medicinal purposes (Mujuni, 2014). At least 40 South African plant species on the International Union for Conservation of Nature (IUCN) Red List are threatened in part by international trade (Moeng, 2010).

South Africa has the richest plant biodiversity in the world, many of which are medicinally useful (Afolayan and Adebola, 2004). The rich resource is decreasing at an alarming rate as a result of over- exploitation. It is estimated that over half a million people are directly involved in medicinal plant trade in the country. With the current rate of harvesting, the plant supplies will, in time decline and many of the species will eventually become extinct (Afolayan and Adebola, 2004). Increasing numbers of species are believed to have become extinct or are under pressure, as habitats throughout the subcontinent are transformed to meet the needs of people: 62 southern African plant taxa are believed to be extinct, 277 endangered, 445 vulnerable and 1446 rare (Hilton-Taylor, 1997; Botha *et al*., 2004).

In Africa for example, *Warburgia salutaris* (Bertol. f.) Chiov. and *Siphonochilus aethiopicus* are two species in high demand and very scarce supply (Kuipers, 1997; Bodeker *et al*., 1997). Cunningham (1998) and Liphadzi (2013) also reported that several plant species, such as wild ginger (*S. aethiopicus*) and the pepper-bark tree (*W. salutaris*) have been exploited to such an extent that they are seldom found in unprotected areas in South Africa (Moeng, 2010). With respect to individual species, Williams *et al*. (2001) reported that *S. aethiopicus* is already extinct from natural areas of KwaZulu Natal, and possibly with time this will also happen in the Limpopo province as the species has been recorded as the most used, most traded and the most scarce medicinal plant in the *muthi* market and communal lands around the province. It is also decreasing at an alarming rate at local level (Moeng, 2010).

Medicinal plants (locally called *amayeza* and *muthi* in Xhosa and Zulu languages respectively) are still widely used in the health-care system of South Africa, particularly by the African population (Wiersum *et al*., 2006). Traditional medicine has demonstrated its contribution to the reduction of excessive mortality, morbidity and disability in the treatment of diseases such as HIV/AIDS, malaria, tuberculosis, sickle-cell anaemia, diabetes and mental disorders (Elujoba *et al.*, 2005; Mathibela, 2013). The documentation of medicinal uses of African plants is becoming increasingly urgent because of the rapid loss of the natural habitat for some of these plants due to anthropogenic activities (Monitor, 2002). Today, many medicinal plants face extinction or severe genetic loss, but detailed information is lacking (Akerele *et al*., 1991). The purpose of this review paper is to assess the risks and opportunities arising from the uses of medicinal plants in relation to conservation and investigate cultivation strategies that can be used to improve their conservation status. In this review, emphasis is on the *Hyacinthaceae* family and species *S. aethiopicus* which are some of the most traded and used in traditional herbal medicine.

Some of the Major Causes of Medicinal Plants Scarcity

Medicinal plants have come under increasing pressure due to a number of factors, which have resulted in the decline of certain species, extinction in others, and a general decrease in biodiversity of high use areas of South Africa (Mathibela, 2013). According to Mathibela (2013), knowledge of the threats to medicinal plants is essential to conserve this important natural resource. Medicinal plants have significant roles in the livelihoods of people in South Africa especially for rural community as, firstly, it can provide a source of income, secondly, is important in primary health care delivery system in rural areas and, thirdly, it has an important cultural value (Liu *et al*., 2007).

Over-harvesting and harvesting methods have often been cited among causes of medicinal plant scarcity (Loundou, 2008). It is believed that habitat destruction and unsustainable harvesting practices are the main causes for the loss of medicinal plants (WHO, IUCN, WWF, 1993). Excessive harvesting of plant parts from the wild is causing loss of genetic diversity and habitat destruction (Debnath *et al*., 2006), most of the plants traded in South African markets are observed to be harvested from wild population and are not cultivated (Liu *et al*, 2007). Removal of rhizomes and roots automatically results in the removal of the whole plant, thereby killing the plant. This type of unsustainable harvesting of plants has resulted in the depletion of many medicinal species which are mostly collected from the wild (Bodeker, 2005).

Many Africans, especially rural people and the urban poor, rely on the use of herbal medicine when they are ill. In fact, many rural communities in Africa still have areas where traditional herbal medicine is the major and in some cases the only source of health care available (Monitor, 2002). The lack of health care systems in rural areas forces local people to treat themselves using medicinal plants. In the rural areas, as a whole, people begin by treating themselves before going to a traditional practitioner or a modern doctor (Monitor, 2002). Besides being the primary source of medicine plants are increasingly being harvested for income generation. According to Magoro (2008) cited by Mathibela (2013), unemployment and poverty are forcing rural communities in South Africa to generate income by selling traditional medicinal material.

A high population growth often leads to increased demand for natural resources, including medicinal plants (Loundou, 2008). As a result of rising numbers of people and of an aging populace many medically important species are becoming scarce; some are facing the prospect of extinction (Srivastava *et al*., 1996). Many plant species, possessing medicinally important compounds, are disappearing at an alarming rate due to destruction of its natural habitats owing to rapid agricultural development, urbanization, indiscriminate deforestation and uncontrolled collection of plant materials (Bapat *et al*., 2008).

Other major factors which affect medicinal plant growth are fire, wattle expansion or eradication program and grazing. Fire can destroy the parts of above ground vegetation including medicinal plants. Particularly, it may harm the bud of herb medicinal plants (Liu *et al*., 2007). Climate change is causing noticeable effects on the life cycles and distributions of the world's vegetation, including wild medicinal and aromatic plants (MAPs). Some MAPs are endemic to geographic regions or ecosystems particularly vulnerable to climate change, which could put them at risk (Cavaliere, 2009). There is also limited knowledge about the cultivation of indigenous medicinal plants (Diederichs, 2006:8).

Hyacinthaceae Family

The Hyacinthaceae, formerly included in the Liliaceae, is a family of around 70 genera and 1000 species of perennial herbs growing from bulbs, usually with a membranous tunic and several bulb scales (Hodkisss, 2014). The Hyacinthaceae can be divided into three main subfamilies, the Hyacinthoideae, the Urgineoideae and the Ornithogaloideae, with a small fourth subfamily the Oziroëoideae, restricted to South America (Mulholland *et al*., 2013). The near-cosmopolitan family Hyacinthaceae Batsch ex Borckh is well represented in southern Africa by one of two main centres of diversity, harbouring approximately half of the world's representatives (Koorbanally *et al*., 2006).

The family is well represented in South Africa (Cheesman, 2009), in which there are approximately thirteen species belonging to this genus (Koorbanally, 2000). The Hyacinthaceae are widely distributed through the temperate, subtropical and tropical parts of the world. They are well represented in Southern Africa where half of the known species may be found (Hodgkiss, 2014). It is best represented in southern Africa, particularly in the winter rainfall parts, with a second centre of diversity in the Mediterranean basin. Almost 200 species alone are known from the Cape Floral Region. The richest areas for species in southern Africa are the succulent Karoo and fynbos of the Northern and Western Cape, with most species of *Ledebouria* and *Eucomis* found in the montane grasslands of eastern South Africa, Swaziland and Lesotho (Hodgkiss, 2014).

The Hyacinthaceae ranks as one of the most important families in ethnomedicine along the eastern seaboard of southern Africa (Mander, 1998; Von Ahlefeldt *et al.*, 2003). The family Hyacinthaceae consists of bulbous plants with thick and sometimes contractile

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roots. They are highly valued for their medicinal properties (Afolayan and Adebola, 2004). The indigenous bulbous plants that are of importance to traditional healers mainly belong to the Amaryllidaceae and Hyacinthaceae family (Louw *et al*., 2002).

The plants included in this family have long been used in traditional medicine for a wide range of medicinal applications (Mulholland *et al*., 2013). The Hyacinthaceae comprises several genera, which are widely exploited for their medicinal, pharmaceutical and ornamental potential. In South Africa, several members of the Hyacinthaceae are harvested from wild populations without permits, processed and then sold as traditional medicine. This is reducing the density, distribution and genetic diversity of wild populations (McCartan, 1999). According to Pohl *et al*. (2000) Hyacinthaceae are broadly employed for purposes ranging from the treatment of hangovers, rheumatic fever, sprains, syphilis and cancer, to the bewitchment of neighbours and securing of good fortune.

McCartan (1999) specified that Hyacinthaceae comprises several genera including *Bowiea, Eucomis, Ledebouria, Scilla* and *Urginea*. These genera are characterised by bulbs, thick and sometimes contractile roots, basal leaves and simple or more rarely branched racemes. A recent survey revealed that of the most important species marketed by Durban street traders, seven hyacinthacs occurred within the top seventy, with three of these *(Merwilla plumbea* (Lindl.) Speta [syn. *Scilla natalensis* Planch], *Eucomis autumnalis* (Mill.) Chitt and *Bowiea volubilis* Harv. ex Hook.f.) ranking in the top ten (Mander, 1998 cited by Koorbanally *et al*., 2006).

Species of *Drimia* and *Bowiea* are highly toxic but are used in small doses in traditional medicine to treat various illnesses (Manning, 2004). The generic names *Hyacinthus, Ornithogalum* and *Scilla* have already been in use since ancient Greek times and represent the core genera of Hyacinthaceae. Hyacinthaceae are only occasionally used for human consumption, In Africa, Bushmen eat the bulbs of *Ledebouria apertiflora* (Bak.) Jessop and *Ledebouria revolute* (L.f.) Jessop (Pfosser and Speta, 2001).

The bulbs of several *Scilla* species are also widely used medicinally by the indigenous people in southern Africa. Many of the local tribes employ these *Scilla* species to treat ailments in both humans as well as in animals. Traditional healers have used decoctions from these plants to treat rheumatism, venereal diseases, mental illness, infertility in women and a variety of other ailments (Amschler *et al*., 1998; Kinghorn and Balandrin, 1994 cited by Koorbanally, 2000). In South Africa, large quantities of *S. natalensis* are harvested from wild populations and sold as traditional medicine, which is reducing the density, distribution and genetic diversity of wild populations (McCartan, 1999). The South African species are found to occur mostly along the eastern belt of the country from the Eastern Cape to Mpumalanga (Koorbanally, 2000).

According to Mander (1998), popular species such as *Alepidea amatymbica* Eckl. & Zeyh., *E. autumnalis* and *W. salutaris* were becoming increasingly difficult to obtain in South Africa and as a result are imported from neighbouring countries such as Lesotho, Mozambique and Swaziland (Moeng, 2010).

Eucomis species are deciduous bulbous geophytes also belonging to the family Hyacinthaceae. The bulbs are greatly valued in traditional herbal medicine for the treatment of a variety of ailments, and are thus, heavily harvested for trade in South Africa (Afolayan and Adebola, 2004). The genus *Eucomis* is widespread throughout eastern and southern Africa. It is used by traditional healers to treat a wide range of complaints, including rheumatism, as an anti-inflammatory and as a treatment for mental disease (Mulholland *et al*., 2013).

Drimia robusta Baker is another member of the family. It is a bulbous species of tremendous medicinal importance in South Africa. Hot water infusion from pulverized bulbs or leaves of this plant is used by the Zulus as an enema for feverish colds. The bulbs are also used in protective charm mixes, while the leaves are said to be diuretic and are used to clean the bladder and to treat diseases of the uterus (Pujol, 1990). Decoctions of this plant are used in traditional herbal medicine for the relief of symptoms of pain and fever. It was formerly used in the Cape for the treatment of common colds as an expectorant and emetic. *Sangomas* or spiritual healers also believe that *D. robusta* can be worn as a protective charm to ward off evil spirits and danger (Koorbanally, 2000). *Drimia sanguinea* (Schinz) Jessop is also one of the preferred medicinal plants; it is widely used to treat various ailments such as lack of libido and bad luck (Moeng, 2010).

Table 1.1: Hyacinthaceae plant species used for medicinal purposes by local communities

Species	Distribution (Province)	Traditional uses	Conservation status	Plant material used	Propagation	Bioactivities	Reference
Bowiea volubilis	EC, LP, KZN, NW, GP, MP	Skin diseases, sore eyes, bladder problems, barrenness, facilitate delivery and procure abortions	Vulnerable	Bulb	Daughter bulb formation and Tissue culture	Cardiac glycosides, mild anti- inflammatory	Hanneweg *et al.* (1996), Parbhoo (2011), Watt and Breyer-Brandwijk, (1962), Luyt *et al*. (1996)
Drimia robusta	KZN, EC, MP	Expectorant, emetic, diuretic, heart tonic, feverish colds	Vulnerable	Leaf Bulb	Tissue culture	Anti-bacterial, anti-inflammatory, anti- hypertensive and anti- cancer activities	Baskaran *et al*. (2013), Ngugi *et al* (1998)

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Drimia maritima	WC	Neurological pains, skin problems, deep wounds, eye afflictions, asthma, heart disorders, bronchitis, diabetes, constipation and cancer	Endangered	Bulb	Tissue culture, dividing rhizomes, tubers, corms or bulbs.	Cardiac glycosides, bufadienolides sclerosis, and Triterpenoids.	Anonymous (2014), Hammouda *et al*. (1873)
Eucomis autumnalis	EC,NP Transvaal, KZN, FS, MP, GP, NP, NW, WC	Low backache, post-operative recovery, urinary diseases, stomach aches, fevers, colic, hangovers, syphilis, facilitate child birth and blood disorders.	Vulnerable	Bulb	Tissue culture, offsets, seeds and leaf cuttings	Anti-inflammatory and antispasmodic action, steroidal Triterpenoids, saponins	SANBI-Notten (2002)
Scilla natalensis	EC, Lesotho, KZN, FS, MP and Swaziland	Sprain, fractures, boils, sores, enhance male potency and libido, laxative, internal tumor's, facilitate delivery, chest pains and kidney problems.	Vulnerable	Bulb	Tissue culture, seed and offsets	Analgesic and antimicrobial activity, anti-inflammatory and anti- mutagenic properties	SANBI- Notten, 2002 McCartan and van Staden, 1998; Jager *et al*. (1996); Sparg *et al*. (2002)
Ledebouria ovatifolia	WC, EC, KZN	Backaches, influenza, gastroenteritis, ethno veterinary purposes, diarrhea	Common	Bulb Leaves	Tissue culture, division, leaf cuttings, bulb regeneration techniques	Anti-bacterial, anti-inflammatory, anathematic, anti-schistosomic , anti- cancer activity	Hutchings *et al*. (1996); SANBI-Hankey (2011); Matchett.

EC- Eastern Cape, LP-Limpopo, KZN- KwaZulu Natal, NW- North West, GP- Gauteng province, MP- Mpumalanga WC- Western Cape, NP- Northern province , FS- Free State.

Mander (1998) found about 14% of the medicinal plant materials traded in South Africa and majority of the micropropagation works reported in South Africa are on the members of the family (van Staden, 1998; McCartan and van Staden, 1999).

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Table 1.2: Prices of Hyacinthaceae most traded/used species in different market channels

Scientific name	Price/kg	Adapted from:
Bowiea volubilis	R11.74−R27.80	Mander (1998)
Scilla natalensis	R1.89−R7.66	Mander (1998)
Drimia elata	R27.30	Dold and Cocks (2002)
Ledebouria spp.	R23.30	Dold and Cocks (2002)
Albuca setosa	R32.40	Dold and Cocks (2002)
Drimia sanguinea	R19.76	Moeng and Potgieter (2011)
Merwilla natalensis	R6.50	Street and Prinsloo (2013)

Table 2: Prices of five other South African most frequently traded/used medicinal plants

Scientific name	Price/kg
Warburgia salutaris	R8.52−R31.16
Siphonochilus aethiopicus	R140.45−R450
Eucomis autumnalis	R6.20−R10.66
Alepidea amatymbica	R11.68−R17.84
Curtisia dentata	R3.28−R23.85

Adapted from Mander (1998)

From the prices recorded above we observed that *S. natalensis* is the cheapest while *S. aethiopicus* is the most expensive plant product per kilogram.

Conservation of the Hyacinthaceae and Other Medicinal Plants

In response to the overexploitation of natural populations of medicinal plants in South Africa, several efforts have recently been attempted to protect the diversity of medicinal plants (Williams *et al*., 2013). Many people contribute towards plant conservation in South Africa. Involvement ranges from national government departments, such as the Department of Environmental Affairs and Tourism (DEAT), Department of Water Affairs and Forestry (DWAF), Department of Science and Technology (DST), the National Department of Agriculture (NDA), through to provincial and local government departments. In addition, various parastatal organisations and non-governmental and community-based organisations also contribute significantly to the conservation of South Africa’s plants and associated habitats (SANBI, 2006).

Institutions such as South African National Biodiversity Institute (SANBI), the Leslie Hill Institute of Plant Conservation, various universities, national government departments and provincial conservation agencies have all played key roles in documenting and understanding interactions and determinants in specific South African ecosystems (SANBI, 2006). Botanic gardens play a vital role in conservation of medicinal plants since they increase the level of awareness about medicinal plants and their values on top of conducting *ex situ* cultivation programmes and maintaining collections of these plant species (Mujuni, 2014) e.g. Kirstenbosch National Botanical gardens. Various universities, municipal botanical gardens, various programmes such as national Arbor Week, South African scientists involved in ongoing research and South African publishers have played and continue to show significant roles in promoting the conservation of South Africa’s threatened plant species, including the development of protocols for the cultivation and propagation of threatened indigenous plants.

The family Aizoaceae is the top priority for taxonomic research with 55% of taxa in need of revision, followed by Hyacinthaceae with 34% of taxa not yet revised (Staden *et al*., 2013). In South Africa, several members of the Hyacinthaceae are harvested from the wild populations without permits, processed and then sold as traditional medicine. This is reducing the density, distribution and genetic diversity of wild populations (McCartan, 1999).

Micro-Propagation

According to Afolayan and Adebola (2004) the Hyacinthaceae is one of the most horticultural important families of monocotyledons as the family includes a number of plants that are medicinally and ornamentally important. It is for these reasons that tissue culture has been carried out on various members of the Hyacinthaceae. Many members of Hyacinthaceae have been micropropagated. Members of the Hyacinthaceae family that have been successfully propagated *in vitro* include *Bowiea volubilis*, *Charybdis numidica* (Jord. & Fourr.) Speta, *Drimia robusta*, *Eucomis* spp., *Galtonia* spp., *Hyacinthus orientalis* L., *Lachenalia*, *Merwilla* spp., *Ornithogalum* spp., *Schizobasis intricata* Baker, *Thuranthos basuticum* (E.phillips) Oberm., *Urginea* spp. and *Veltheimia bracteata* Harv. ex Baker. With regard to the Hyacinthaceae family, the most successful cultures have been established *in vitro* from bulb sections or bulb scales. Some members of the family have been micropropagated successfully from floral explants (Cheesman, 2009).

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Many endangered plants have been saved through this method of propagation. For the protection of rare and endangered taxon, reproducing and conservation of plants with the use of *in vitro* cultures is one of the feasible methods (Maryam *et al*., 2014). Tissue culture techniques and applications have been found to be practical in the conservation of a great number of rare (Holobiuc *et al*., 2009) and threatened (Pence, 2005) species. Many laboratories have been used *in vitro* method of seed germination to conserve numerous rare plants including cacti, lilies, insectivorous, succulents and some orchid species (Boulay, 1995; Clayton *et al*., 1990). There has been significant progress in the use of tissue culture and genetic transformation to alter pathways for the biosynthesis of target metabolites (Giurgiu *et al*., 2014).

Conventional Propagation of the Hyacinthaceae

Offsets are used to propagate many members of the Hyacinthaceae but they are generally too slow for commercial propagation. Several artificial techniques therefore are used to increase the rate of natural multiplication. These techniques include scaling, basal cottage and bulb cuttings. It has been suggested that *ex situ* conservation through cultivation may alleviate pressures on natural resources, whilst meeting the demand for these plants (McCartan, 1999).

Several members of the Hyacinthaceae are cultivated as ornamentals, although the total area allotted to the production of these bulbs is relatively small. Breeding programs, which have been established for certain genera, may increase the popularity of the plants (McCartan, 1999). The family have been utilized in breeding programs at the Agricultural Research Council for many years with the aim to develop new products for the international floriculture market. Through conventional breeding, several *Lachenalia* and *Ornithogalum* cultivars were released. Besides conventional breeding, a project on the use of mutation technology has also resulted in the availability of new lines (Kleynhans, 2011).

Cultivation of Medicinal Plants in South Africa

Cultivation of medicinal plants to provide additional or alternative stocks of plants is very limited. Consequently certain popularly traded species have become over exploited and are now rare or extinct in the wild (e.g. *S. aethiopicus* and *W. salutaris*) (Geldenhuys and Mitchell, 2006 cited by Diederichs, 2006). Liu *et al.* (2007) stated that cultivation can be an effective way to decrease the pressure on utilization of wild medicinal plants for commercial trade or household consumption. The reasons for this are that the plants are easily accessible if cultivated. Cultivation can reduce the threat to wild populations by making propagated plants more readily available. An example of this is the successful cultivation of some South African Aloes as well as other medicinal plants such as *S. aethiopicus* (Donaldson, 2006).

Crouch and Edwards (2004) reported that the first systematic effort to stimulate cultivation of medicinal plants was initiated by the Durban Parks Department in 1983 by establishing a medicinal plant nursery at the Silverglen Nature Reserve. Since then, several initiatives have been undertaken to stimulate medicinal plant cultivation through establishment of medicinal plant nurseries (Moeng, 2010; Wiersum *et al*., 2006).

Hydroponic Production of Medicinal Plants

Travelling in South Africa one immediately notices that hydroponic farming is becoming a favourite method to produce crops, plants and flowers all year round. Because our country has enormous areas of arid land ranging from semi-desert to desert as well as places with only limited ground water, farmers have no alternative but to resort to high density crops where the minimum amount of water is used (van Zyl, 2012).

Medicinal herbs cultivation is widespread and the interest for this kind of cultures is growing on a fast pace. Harvesting the raw material from the wild can be very difficult due to the little control one can have dealing with problems like: misidentification, genetically and phonotypical variability, active substances variability and toxic compounds. Cultivating the medicinal plants in a more controlled environment can overcome these difficulties. Hydroponic culture is getting very popular because of the results it showed in recent practices (Giurgiu *et al*., 2014).

Production of medicinal herb and root crops in controlled environments provides opportunities for improving the quality, purity, consistency, bioactivity, and biomass production of the raw material (Hayden, 2006). Producers of medicinal plants are also attracted to hydroponic systems for cultivation because recent studies proved that growing in soilless cultures in protected environments results in higher concentrations of active principles found in plants comparing with traditional soil cultivation because of the total control the grower can have (Giurgiu *et al*., 2014).

Due to challenges that are encountered in conventional soil-based agriculture the rapidly progressing technology may develop a trend to depend on this hydroponic technique for efficient utilization of natural resources including medicinal plants in the future (Mugundhan *et al*., 2011).

Preliminary Report on Hydroponic Cultivation of *Siphonochilus Aethiopicus*

Siphonochilus aethiopicus is one of the most popular medicinal plants in South Africa (Williams, 1996). The generic name *Siphonochilus* is derived from the Greek *siphono* meaning tube, *chilus* meaning lip in reference to the shape of the flower, and the specific name *aethiopicus* means from southern Africa (Hankey & Reynolds, 2002). *S. aethiopicus*, commonly known as wild ginger or Natal ginger, belongs to the monocotyledonous family Zingiberaceae (Light, 2002). Wild ginger is native to southern tropical Africa (South of Malawi to the eastern part of South Africa) with a restricted distribution in South Africa where it is only found in Mpumalanga and Limpopo and has been extinct in KwaZulu-Natal (Department of Agriculture, 2009). The plants are characterised by a small cone-

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shaped rhizomes, which have a distinctive pungent smell (Viljoen *et al*., 2002). The rhizomes and roots are chewed fresh to treat asthma, hysteria, colds, coughs and flu, malaria, vaginal thrush, headache and it is chewed by women during menstruation (Hankey & Reynolds, 2002; Department of Agriculture, 2009; Nichols, 2005). Coopoosamy *et al*. (2010) observed that both the rhizomes and leaves of *S. aethiopicus* exhibit antibacterial and antifungal activities. According to Nichols (1989), plants can be propagated from seed, which can take up to a year to germinate. This plant is currently listed as critically endangered on the South African Red Data list of plants (Hankey & Reynolds, 2002; Raimondo, 2011). It is often quoted as being locally extinct and the most highly sought-after medicinal plant on South African *muthi* markets (van Wyk, 2008; Lotter *et al*., 2006). Even though the plant is now so scarce, demand continues unabated and the plants price continues to soar (Diederichs, 2006). Therefore, the objective of this study was to determine the effect of hydroponics on growth and antifungal activities of *S. aethiopicus*.

Materials and Methods

The experiment was conducted in a tunnel within the nursery of the Department of Horticultural Sciences, Cape Peninsula University of Technology (Bellville campus); Cape Town, South Africa, 33° 55’ 48.8” S, 18° 38’ 32.7’’ E. *S. aethiopicus* rhizomes were obtained from a commercial nursery Afro Indigenous at Centurion Gauteng. The rhizomes were imbedded into pots containing a medium mix of (2 parts pine bark, 1 part perlite and 1 part vermiculite) and were placed in a controlled tunnel and irrigated until crop emergence. Six weeks old healthy and vigorous seedlings with one to three leaves were each transplanted into separate pots (12.5 cm) inside the protected tunnel placed into a recirculating hydroponics system. Steel table (2.5 × 1 m) was used as a flat surface; the steel table had three plastic gutters (1.36 m long) which were held in place by cable ties (plastic gutters and cable ties were supplied by Builders Warehouse, Cape Town). Each gutter had 8 plastic pots containing a substrate mixture of coconut fibre and pine bark in the ratio of 1:1. Beneath the steel table there were 3 fish tanks (60 L) each containing one submersible water pump which recirculates water through a 20 ml black plastic pipe. Nutrient solution was supplied to the plants by spaghetti tubing with drippers at a rate of 2 L/h set to irrigate twice every three days for 15 minutes. The plants were fed by Nutrifeed fertilizer supplied by Starke Ayres, Cape Town. The nutrient solutions had a pH of 6.4 and Electrical Conductivity (EC) of 1.8. The solutions were refreshed every 2 weeks. The experiment was arranged in a randomized block design. The tunnel had the following experimental conditions; average temperature; morning (18–33 °C), day (26–49 °C) and evening (19–34 °C), relative humidity; morning (67–92%), day (80–94%) and evening (81–92%) and average light intensity; morning (3917 Klux), day (19270 Klux) and evening (2685 Klux). Plant growth parameters (Stem length, number of leaves and new shoots) were collected once every week and the experiment lasted for 9 weeks. Fresh rhizomes were harvested and dried at 30 °C. Dried plant material were cut into smaller pieces and ground into fine powder. Powdered material (3 g) was extracted with 60 ml of acetone to determine the minimum inhibitory concentration (MIC), yield and total activity (TA) of *S. aethiopicus* against *Fusarium oxysporum.* Growth parameters, MIC and total activity were analyzed using one-way analysis of variance (ANOVA). These analyses were performed using STATISTICA software (StatSoft, 2013).

Results

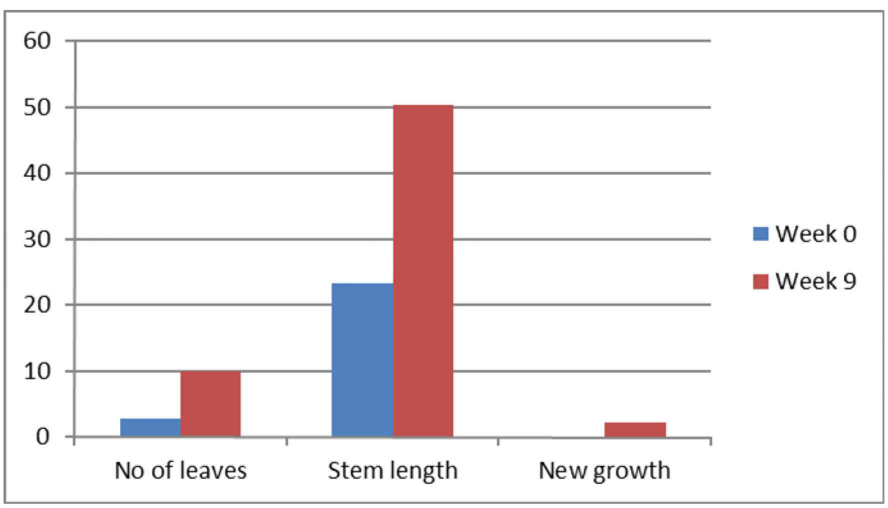

Figure 1.1 Effect of hydroponics on plant (*S. aethiopicus*) stem length, number of leaves and new shoots at week 0 and 9 (Average).

Growth: At nine weeks after planting tallest stem length (51 cm), highest number of leaves (8) and total new shoots (4) were obtained. Stem length was 27.1 times longer in average at week 9; number of leaves 7.3 times more and new shoots 2.2 times more. These results were obtained under a period of 3 months and plants grew in the Western Cape outside their restricted areas where they normally grow.

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Table 4: Results on yield, minimum inhibitory concentration (MIC) and total activities of acetone extracts obtained from rhizomes of field grown and hydroponically cultivated *S. aethiopicus***.**

Treatment	MIC ± SE (mg/ml)	Total activity (ml/g)	Yield (mg)
(12 h)	Acetone extract		
Field	0.078 ± 0.015 a	346.09 ± 86.5	122
Hydroponics	0.156 ± 0.03 a	296 ± 59	133
(18 h)	Acetone extract		
Field	0.3125 ± 0.0625 a	86.76 ± 21.69	122
Hydroponics	0.1875 ± 0 a	263 ± 59	133

Means followed by the same uppercase or lowercase letters in the same column indicate no significant difference (*P* > 0.05).

Hydroponically cultivated *S. aethiopicus* had similar antifungal activities when compared to the plants grown under field conditions. The MIC value of acetone extracts exposed to plants grown under hydroponics was not statistically different (*P* > 0.05) to plants grown under field conditions. According to a study implemented by Manzini (2005), the majority of the traditional healers said there was no difference in medicinal plants value between cultivated and the plants growing in the wild.

Economics

According to Mander (1998) cultivation of wild ginger should be a financially viable operation in South Africa since there is always a demand and the income generated justifies the efforts. In the markets *S. aethiopicus* unit price is R5.00 and price per kilogram ranging between R140.45/kg and R450.00/kg. Based on the current results, hydroponics plants produced relatively higher yield of bioactive fraction and total activity at 24 h than wild harvested plants. There are many reports of hydroponics cultivation producing more shoots than soil cultivation, hence strengthening the argument that the former could favor increased income generation through increase in production of medicinal plant materials.

Conclusion

In conclusion, investigation into the production of *S. aethiopicus* under hydroponics cultivation has produced two important findings that are worth highlighting; hydroponics can influence growth and medicinal properties in medicinal plants suggesting that this method of cultivation has a future in the horticultural world. Furthermore, the results of this study indicated that hydroponics cultivation can improve income earning opportunities and maximize profit.

Research Opportunities

Successful micro-propagation protocols for some species of the Hyacinthaceae family have already been developed and hopefully in the near future, protocols for many other species will be developed (Cheesman, 2009). *In vitro* plant regeneration could be a potential solution to conserve medicinal plants. Significant research and development opportunities exist to discover novel and useful biological activities for South African medicinal plants (Gericke, 2011). Research institutions will contribute to *in situ* conservation in response to national biodiversity assessment activities. Medicinal plant indicates exceptional opportunity for interdisciplinary research and we sturdily believe that extensive research through partnership and collaboration will be of help towards promotion and development of the traditional medicine for the future. An increasing use of medicinal plants will result to innovative research to develop drug products and income generating activities through trade in medicinal plants.

Recommendations (moving forward)

In order to meet the growing demand for medicinal plants, it becomes important to conserve these plant species by cultivation or other conservation measures (*in-situ* and *ex-situ* conservation) to ensure the supply of raw material to the industry and for their sustainable utilization. Research on the cultivation methods of indigenous threatened medicinal plants for human health care is of importance. Cultivation may be the best solution to replace the declining species.

Growing selected species in commercial nurseries could support market supply. Nurseries and farm grown materials are necessary to replace species harvested in the wild and encourage local farming of medicinal plants on suitable land to which plant gatherers would have free access. It is also necessary to bring plant gatherers together and emphasis the need to harvest sustainably. Traditional healers and plant gatherers should be encouraged to use other plant parts such as leaves instead of roots and rhizomes. Research should also be initiated to discover if supplementary parts (leaves) have the same or similar compounds as the routinely parts used.

In addition, development of permits, management tools/guidelines aiming to alleviate overharvesting on pressured plant species is fundamental. There is a need for implementation of management plans.

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Traditional health practitioners should be encouraged to develop their own medicinal plant gardens and replant the plants that they use the most; local people should also be encouraged to cultivate medicinal plants for use in their communities to reduce unsustainable harvesting of plants from the wild. There is a need to develop education programmes and raise awareness about the value of medicinal plants and threats that lead to over-collection. It is also essential to encourage medicinal plant sellers to share their successful methods of propagation. In addition, identify plant species that are frequently used by local people in medicine and draw a target list of plants to be cultivated.

Conclusion

Demand for medicinal plants is increasing at an alarming rate with growth in human needs and commercial trade but even though the demand increases continuously many species are not cultivated. Sustainable harvest and cultivation methods are the most important conservation strategies for acquiring most wild harvested species. These conservation strategies can reduce the extent to which wild plants are harvested and meet the growing demand for these plants. Mathibela (2013) stated that in order to meet the growing demand it becomes important to conserve these plant species either by way of domestication and cultivation or by other *ex situ* and *in situ* conservation measures for their sustainable use.

Emphasis on cultivation of wild medicinal plants rather than accumulating from the wild would ensure steadiness in supply, economic feasibility and relieve harvest pressure on wild population. In conclusion, evidences endorse that there is a potential for growth in the medicinal plant industry if optimum cultivation technologies such as tissue culture and hydroponics are implemented. Hydroponics has the potential to increase plant growth and overcome cultivation difficulties. Growing medicinal plants in protected environments also result in higher concentration of active compounds found in plants.
There is still time to prevent the situation from getting much worse, but we have to act now.

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