INDIGENOUS KNOWLEDGE OF FEVER TEA (*LIPPIA JAVANICA*) AND EFFECT OF SHADE NETTING ON PLANT GROWTH, OIL YIELD AND COMPOUND COMPOSITION

by

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DECLARATION

I hereby declare that the work herein submitted as a dissertation for the M. Inst. Agrar (Agronomy) degree is the result of my own investigation. Work by other authors that served as sources of information have duly been acknowledged by references to the authors.

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Miss N.N. Mokoka Date

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DEDICATION

To God be the glory for being faithful, and for the strength and great things He has done in my life. This thesis is dedicated to my late father, Mr Tlou Mokoka, with love and appreciation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INDIGENOUS KNOWLEDGE OF FEVER TEA (*LIPPIA JAVANICA*) AND EFFECT OF SHADE NETTING ON PLANT GROWTH, OIL YIELD AND COMPOUND COMPOSITION

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Abstract

An experiment was conducted to determine the effects of shade netting on growth, oil yield and compound composition of fever tea (*Lippia javaica*). The treatments were nine shade nets of different light intensities (100% bird net, 40% green, 10, 12 and 18% white and 30, 40, 55 and 70% black). The layout used was a completely randomized design. The parameters measured were shoot width, fresh shoot mass, the number of plants flowered, plant height and photosynthetically active radiation.

Shade netting did not have any effect on the shoot width of *L. javanica*. Eighteen percent white net was best suited to produce fresh shoot mass, whereas 55% black net, 40% black net and 10% white net produced lower fresh shoot mass. More plants that flowered were obtained under 70% black net than those grown under 30% black net. The number of plants that flowered increased from 22 to 35 with an increase in shading density. The height of plants was not affected by shade netting at 49 DAT. However, at 59 and 67 DAT, the height of the plants was greater under low light intensities (40, 55, and 70% black nets) than that of high light intensity (30% black). Twelve percent white net had the greatest plant height at 102 DAT. Shade netting significantly affected the adsorption and utilization of photosynthetically active radiation (PAR) above, across and below the plants at 102 DAT. Hundred percent bird net had the greatest amount of light intercepted above, across and below the plants. The amount of light intercepted above, below and across the plants was lower for lower shading intensity (30% black) than that of higher shading intensities (40%, 55% and 70% black).

To determine shade-netting effect on oil yield and compound composition, fresh leaves (± 200g) of *L. javanica* were sampled from each shade net for essential oil extraction by hydrodistillation. The oil yield ranged from 0.29% to 0.41%. The oil had a clear to yellowish brown colour. No significant differences were detected for oil yield amongst the shade nets. The chemical compound analysis was carried out by GC/MS. The chemical compounds identified in the essential oil were α-pinene, sebinen, myrcene, 1.8 myrcene, ipsenone, ipsedienone, β-caryophyllen and germacrene-D. *L. javanica* plants grown under 10% white net, resulted in significantly higher myrcene content (15.7%) as compared to plants grown in other shade nets. Shade netting did not have any effect on the composition of α-pinene, sebinene, 1.8 myrcene, ipsenone, ipsedienone, β-caryophyllen and germacrene-D. For commercial usage of myrcene, white net (10%) would be best suited for *L. javanica* production.

To obtain information about indigenous knowledge of *L. javanica*, a survey was carried out among street traders, traditional healers, hawkers and farmers in Gauteng. The age group was between 20 and 73. The majority of respondents, who were self employed, were traditional healers followed by farmers. Most (98%) of the respondents indicated that they collected *L. javanica* from the veld by cutting the plant, whereas other respondents uprooted the whole plant when harvesting. Amongst the different uses of *L. javanica* mentioned, treatment of colds and coughs through steaming was stated by most (47%) of the respondents. Most (88%) of the respondents felt that it was important to conserve the plant for future generations and also to prevent the plant from becoming extinct. Traditional healers knew the uses and other important aspects of *L. javanica* than the farmers.

Keywords: Shade netting, oil yield, compound composition, plant growth, indigenous knowledge, *Lippia javanica*

GENERAL INTRODUCTION

Plants were once a primary source of all medicines and they continue to provide mankind with new remedies. Natural products and their derivatives represent more than 50% of all drugs in clinical use in the world (Kinghorn & Baladrin, 1993). It is reported that up to 80% of South Africans make use of traditional medicines and over 100 000 indigenous healers use indigenous plants as their *materia medica*. The trade in plants is believed to generate a large volume of economic activity with an estimated value of R500 million per annum (van Wyk, van Oudtshoorn & Gericke, 1997).

A large part of day-to-day medicine is still derived from plants and large volumes of plants or their extracts are sold in the formal and commercial economic sectors in South Africa. It has been estimated that approximately 3 000 species of plants in South Africa have medicinal properties, and of these, some 350 species are commonly used and traded as medicinal plants (van Wyk *et al*., 1997). However, high proportions (32%) of the most commonly used medicinal plants are trees (42 trees out of 132 medicinal plants listed by van Wyk *et al*., 1997). It is reported that in 83% of the trees, the bark is used.

In China, more than 80% of the material of the 700 000 tons of medicinal plants is used for direct decoction in traditional medicine and as ingredients in official medicine (Pei-gen, 1991; Shan-an & Zhong-ming, 1991). Cultivation of medicinal plants is becoming increasingly important in China, a country that uses 5 000 to 10 000 species medicinally (Pei-gen, 1991; Shan-an & Zhong-ming, 1991). Many of China's botanical gardens play an important role in introducing wild medicinal species into cultivation and for studying their growth requirements, propagation and ecophysiological requirements.

In West Africa, for example, a vast majority of drug plants grow only in the wild, rather than being cultivated (Cole, 1996). In India several botanical gardens, notably the Tropical Botanic Gardens and Research Institute at Trivandrum, have active programmes in medicinal plant conservation and research and in Sri-Lanka, botanic gardens play a major role in this area (Heywood, 1991).

The annual demand for medicinal plants is reported to exceed 700 000 tons and the economic value is also huge. In the United States a figure of 90% of the demand for medicinal plants has been reported. One has to distinguish, however, between the quantities that are wild-harvested in the country concerned and those that are imported from other countries. A recent report on the trade in plant material for medicinal and food purposes indicated that, of the 1 560 plant species that are traded in Germany for instance, 70-90% are primarily harvested from the wild in Europe, Africa, America, Asia and other areas (Lange & Schippmann, 1997).

For centuries, people have used plants as the primary therapeutic agent in medicine. The discovery of antibiotics, however, led to the development of a pharmaceutical industry in the second half of the last century that relied heavily on pure single active natural compounds and synthetic drugs (Eloff, 2000). Many medicinal and aromatic plants in Africa are collected from wild populations. Some species that are slow-growing and slow reproducing are especially vulnerable to excessive collection. Consequently, many species are threatened and in danger of extinction. Lange (1998) recommends that to identify and assess those species most threatened by wild-collection owing to their demand in trade, the following knowledge is necessary: plant part used, level of demand, trade volumes, trade routes, source countries, collection practices and harvesting techniques, as well as biological parameters, such as life form, population sizes, plant community considerations, habitat requirements, distribution, growth rates, and reproductive biology.

An increasing number of developing countries are already showing an interest in farming medicinal plant-trees, shrubs, lianas and herbs, annuals as well as perennials (Srivasta, 1996). Due to urbanization, a large informal trade business has been established with medicinal plants. Unfortunately, utilization of the plants has depleted the wild populations, resulting in many plant species being considered vulnerable, and being lost from their natural habitat. If raw materials of medicinal plants can be delivered in sustainable quantities (Mander, 1997a), indigenous plants will continue to form an important component of primary health care in southern Africa.

Observations of the markets in South Africa indicate that many medicinal and aromatic plants are harvested from wild populations without any regulation or control, and are currently not cultivated. The demand for medicinal and aromatic plants by pharmaceutical, perfume and cosmetic companies continues to grow and develop. It is, therefore, becoming increasingly important to replace wild harvesting with cultivation.

Indigenous knowledge and cultivation guidelines for *Lippia javanica* are lacking, rendering introduction of the crop to commercial markets difficult. There is confusion about efficiency of wild-harvested plants and the cultivated ones, and also, whether it is important to protect these plants or not. There is a great demand of medicinal plants, including *L. javanica* in Gauteng, due to the biggest muthi market at Faraday. *L. javanica* grows relatively fast, in an open veld, in the bush, as well as on forest margins and prefers sunny areas. Different crops require different production conditions for them to survive and to provide better yields. Shade nets are one option, which crops can best grow under to avoid crop damage from direct sunlight, birds, hail and wind. Therefore, this study had two distinctive objectives: a) to determine the effect of different shade netting on the growth, oil yield and compound composition of *L. javanica* and b) to conduct a survey of indigenous knowledge about *L. javanica* with Gauteng Farmers, Traditional Healers, Collectors and Traders of medicinal plants.

CHAPTER 1

LITERATURE REVIEW

1.1 Description of *Lippia javanica*

Lippia javanica is an erect, woody shrub that grows up to two meters in height. The hairy leaves have conspicuous veins and are highly aromatic, with a strong lemon smell. Small yellowish white flowers are produced in dense rounded heads. Various organic acids and alcohols occur in the plant. Volatile oils have decongestant and antiseptic effects, but the fever-reducing and possible pain-relieving activities need further study (van Wyk, van Oudshoorn & Gericke, 2000). *L. javanica* is rich in volatile oil and numerous monoterpenoids have been identified, including myrcene, caryophyllene, linalool, p-cymene and ipsdienone. Leaves yield stearic, palmitic, myristic, oleic, arachidic, behenic and lignoceric acids and triacontane alkanes (Neidlein & Staehle, 1973).

L. javanica belongs to the Verbenaceae family. There are 36 genera and approximately 1035 species in tropical and subtropical regions, with just a few representatives in temperate areas. There are six indigenous species of *Lippia* in South Africa. These plants are widespread throughout large parts of South Africa, with the exception of the Western Cape. It grows from the Eastern Cape northwards extending into tropical Africa, including Botswana, Swaziland, Mozambique, Malawi, Zambia, Tanzania and Kenya (Le Roux, 2004). It can be grow from seed, but also grows easily from cuttings. It grows relatively fast, in open veld, in the bush, as well as on forest margins and prefers sunny areas. This plant is known medicinally to many African tribes and to many avid herbalists and herb gardeners (Le Roux, 2004). Different parts (leaves, twigs and occasionally roots) of the plant are used for different reasons.

It is said to be effective against fever, especially in cases of malaria, influenza, measles, and as a prophylactic against lung infections. In these cases *L. javanica* is often mixed with another herb *Artemisia afra.*

Apart from its medicinal uses, it is also used ritually in cleansing ceremonies, when someone has been in contact with a corpse and apparently for protection against dogs, crocodiles and lightning (Pooley, 1998).

1.2 **Influence of shade netting on plant growth**

Shading materials are likely to influence the spectral distribution of radiation (i.e. diffuse/direct), in addition to decrease the quantity of radiation. Due to the greater penetration of diffuse radiation, the proportion of diffuse to direct radiation increases towards the bottom of the canopy (Ludlow, 1978). Shade-cloth materials are also used for protection of plants against possible wind and rain damage (Yates, 1989).

Natural shading within plant canopies reduces the photosynthetic activity of shaded leaves (Mika & Antoszwski, 1972). Plants grown in shade have lower maximum photosynthetic rates than those grown in full sun (Boardman, 1977; Grant & Ryugo, 1984; Kappel & Flore, 1983). Growth and yield of crops are related to the amount of solar radiation received during the growing period (Cockshull, Graves & Cave; 1992 and Challa & Baker, 1998). In summer conditions, climatic restrictions to plant growth have been attributed mainly to the effects of high temperatures on photosynthesis and respiration (Lapuerta & CTFIL, 1995).

Light availability and distribution within the canopy are known to affect tree cropping performance and fruit quality (Biasi, Costa, & Manson, 1995). Biasi *et al*., conducted an experiment in order to evaluate the effects of light on fruit quality in kiwi fruit vines (*Actinidia deliciosa*). Two shading levels (45% and 90%) were realized in a mature orchard by placing shade nets over trees. The highest shading intensity was applied at two different stages, i.e. before blooming and after fruit set. The results indicated that shaded vines showed higher fruit drop than unshaded ones, even at only 45% shade and with both early and late treatments, leading to reduced productivity. Fruits on shaded vines showed reduced growth, but the totally shaded fruits presented good size and shape. Fruit colour was only slightly affected by shading. Even 90% shade allowed fruits to develop their colour, with only a slight increase of peel paleness and a decrease of flesh colour.

Light intensity influences the leaf assimilation rate and can modulate the activity or synthesis of certain enymes involved in carbon metabolism in both source and sink tissues (Possingham, Coote, & Hawher, 1980; Sicher & Krember, 1985; Smart, 1988; Guan & Jones 1991). Antognozzi, Boco, Famiani, Palliotti, Tombesi (1995) applied shading from 8 weeks after full bloom to harvest with nets and aluminium foil. With one or two nets and aluminium foil, the light intensity intercepted by the fruits was reduced by about 66%, 84% and 100%, respectively, with respect to the uncovered outer fruits.

Shade plants have inherently low photosynthetic rates, and lack the ability to effectively increase light-saturated photosynthesis (Bjőrkman, 1981). Braman, Latimer, Oetting, McQueens, Eckberg, & Prinster (2000) found that 50% shading had little effect on azalea leaf area development when compared to azaleas in full sun. Yet, Salisbury & Ross (1985) indicated that shading increased the mean leaf area, which is the generalized leaf response to reduced light level. Munir, Jamil, Baloch & Khattak (2003) reported that high light transmission shade net (29%) allowed for more photosynthesis at a higher rate from an early stage, producing more branches and leaves and allowing plants to flower earlier than low light transmission nets (60%-80%).

Leaves exposed to high levels of irradiance and low temperature may exhibit sustained decreases in the efficiency, with which photosystem II converts the energy of absorbed photons into electron transfer (Adams, 1995). It has been reported that the ability of a plant to adapt to changes in light integral is a reflection of the adaptability of the plant species (Loach, 1972). Photosynthetically active radiation (PAR) is one of the main abiotic factors limiting plant establishment, growth and regeneration in the forest understorey (Chazdon & Fetcher 1984; Denslow 1987) and according to Lee, Baskaran, Mansoor, Mohamad & Yap (1996), and the most important one in tropical forests. Plant species that can tolerate varying degrees of shade undergo integrated morphological and physiological changes that allow the plant to efficiently use lower levels of light (Boardman, 1977 & Smith, 1982).

Shade tolerant species tend to have lower light compensation and saturation points when grown under reduced light (Boardman, 1977; Collard, Joiner, Conover & McConnel, 1977; Fails, Lewis & Barden, 1982a, 1982b; Logan, 1970). Increased horizontal branching (Fails *et al*., 1982a; Kappel & Flore, 1983) and a more open canopy (Fails *et al*., 1982a) are other means by which shade-grown plants improve light-harvesting capacity.

Plants adapt to different irradiance levels by anatomical, morphological, and/ or physiological changes that allow the maintenance of a positive carbon balance in a wide range of light environments (Kramer and Kozlowski, 1979; Bjorkman, 1981). Low irradiance generally leads to larger leaves with reduced thickness, stomatal density, and conductive tissue per unit leaf area index.

In an experiment of assessing long-term leaf gas exchange, leaf chlorophyll concentrations, growth characteristics of *photinia* x *fraseri* grown under four light regimes, Norcini, Andersen & Knox 1991, found that growth was best under 100% sun in terms of growth index (GI) increase in total leaf area, number of leaves and dry weight (total, stem, leaf, and root), although plants grown under 69%, 47% and 29% shade had the same GI increase at the end of the experiment. In addition, Moriyama, Nakamuna, Egami, & Shimizu (1999) reported that 60% and 80% shading decreased phenolic content of tea leaves compared to 0% shading.

1.3 **Oil yield and compound composition**

In the study conducted by Abegaz, Asfaw & Lwande (1993) on the constituents of the essential oils from wild and cultivated *Lippia adoensis,* it was found that the oil composition from the cultivated *L. adoensis* was dominated by linalool consisting 68-76% and 73-83% of the oils from the flowers and leaves, respectively and the second major component was germacrene D. The chromatograms of the oils obtained from the wild forms of *L. adoensis* showed relatively large amounts of limonene, perillaldehyde, piperitenone, neral, geranial and ipsdienone. The composition of the oils obtained from the wild form was found to be quite different from those of the cultivated form of *L. adoensis.*

The absence of linalool in the oil of the wild form (the major component in the oil of the cultivated form) together with the absence of limonene, perillaldehyde and piperitone in the latter clearly differentiates the two oils. The essential oil of *L. ukambensis* has been reported by Chogo & Crank (1982). The pale yellow oil from the plant (0.3% from the fresh leaves) contained camphor (36.5%), trans-sabiene hydrate (18.5%) and 1,8-cineole (11.3%) as the major components. Other components were b-cubenene (6.5%), camphene (4%), x-terpineol (2.3%), limonene (2.2%), b-pinene (2.1%) and x-pinene (0.3%).

Uribe-Hernández, Hurtado-Ramos, Olmedo-Arcega & Martinez-Sosa (1992) who studied the essential oil of oregano (*Lippia graveolens)*, produced from two countries, namely Mezquitic and Colotlan, found that the oil was characterised by a high content of thymol. Based on the oil yield as well as thymol content, the essential oil of oregano from both locations had the possibility of undergoing commercial exploitation, either as a source of thymol or as an additive for use by the food industry, besides being used as a raw material. The chemical composition of the essential oils of *Lippia* species, including *L. javanica* that has been previously reported by different authors (Table 1).

1.4 **Indigenous knowledge and conservation of medicinal plants**

South Africa is considered to be a “hotspot” for biodiversity and more than 22 000 plant species occur within its boundaries. This represents 10% of the world’s species, although the land surface of South Africa is less than 1% of the earth. The country is divided into seven biomes and into 68 vegetation types (Low & Rebelo, 1996). Most people in South Africa have low standards of living and the population is growing rapidly. There is evidence that resource destruction from over-exploitation is occurring on a scale where conservation efforts need to expand to protect resources. Poverty and under-development often force people to disregard resource management practices aimed at sustainability (Smuts & Hobbs, 1991). The challenge for resource management, however, is to make the right trade-offs between conservation and development needs (Stauth & Baskind, 1992).

According to Stauth *et al*. (1992), conservation efforts cannot succeed if the economy is not able to satisfy the basic desires and aspirations of the great majority of the population. Where there is a great need, there is usually a danger of over-exploitation, the three major causes of which are poverty, ignorance and "greed".

Table 1 Chemical composition of the essential oils of *Lippia* species

Species	**Characteristics of components**	**References**
L. aristata Schau.	Sabinene, cadinene, b-carophyllene, b-elemene, limonene, sabinene B-caryophellene	Craveiro, Alencar, Matos, Andrade & Machado (1981)
L. dauensis (Chiov.)	Myrcene, b-ocimene, 2-methyl-6-methylene-2, 7-octadien-4-ol, ipsenone, cis-tagetone, dihydrotagetone	Mwangi, Addae-Mensah, Munavu & Lwandi (1991)
L. graveolens HBK	P-cymene, 1,8-cineole, thymol, carvacrol	Compadre, Hussain, Leon & Enriquez (1987)
L. somalensis Vakte	&-3-carene, myrcene, p-cymene, limonene, 1,8-cineole, b-cubebene	Mwangi, Addae-Mensah, Munavu & Lwandi (1991)
L. javanica (Brum f.) Spreng.	Myrcenone, myrcene, (e)-and (Z)-tagetenone	Mwangi, Addae-Mensah, Munavu & Lwandi (1992)
L. turbinata	x-thujone, carvone, b-caryophyllene, germacrene-D , bicyclogermacrene , spathulenol, caryophyllene oxide	Velasco-Neguerela & Pe'rez-Alonso (1993)
L. polystachya	x-thujone, carvone	Velasco-Neguerela & Pe'rez-Alonso (1993)
L. junelliana	Myrcenone, myrcene, limonene camphor, (E)-tagetenone, transhydrocarvone , cis-dihydrocarvone	Velasco-Neguerela & Pe'rez-Alonso (1993)

While greed and ignorance can, to a limited extent, be handled through regulation and education, only economic development can alleviate poverty (Stauth *et al*., 1992). Lange (1998) suggests that a good way of conserving medicinal plants is to ensure that the commercial value of the resources provides an economic incentive to the harvesters (communities and individuals) by conserving the areas in which the plants grow. The challenge for southern Africa is developing incentives that encourage curatorship and management of plant resources concurrently with sustaining rural incomes and livelihoods that are not overly detrimental to the environment (Williams, 2002).

South Africa is also faced with the challenge of conserving its natural resources. One challenge facing protected area management in South Africa is to reconcile two opposing and mutually exclusive activities, i.e. conservation and natural resource utilization (Dzerefos & Witkowski, 1999). About 60% of people in South Africa consult traditional healers for cheap services. According to Williams (2002) there are approximately 107 muthi traders at Faraday Muthi Market and at least 298 ethno species are sold on this market. The declining supply of indigenous medicinal plants and associated products is likely to generate significant economic and welfare losses, considering the large number of people who either consume or trade indigenous medicinal plants (Mander, 1988).

Considerable amounts of medicinal and aromatic plant drugs, which are produced and commercialized, come from indigenous sources, even nowadays. However, there are many contradictory and confusing data about the real origin of the drugs (Lewington, 1993). The situation is even more complicated, as many species, which have been introduced into agrarian systems are still collected, yet, even in the same geographical region where the large scale cultivation is going on. The importance of wild growing medicinal plants is indicated by the estimates of Farnsworth & Soejarto (1991) and Schumacher (1991), who state that two thirds of the plant species used by one of the largest consumers (Germany) are collected from the wild.

A similar conclusion was reached by Franz (1993) and Palevich (1991) who reported that world-wide, only a small portion of medicinal plant drugs is produced solely by cultivation. Sustainable harvesting of indigenous plants is possible in theory, but is more complex than policy-makers think because it depends as much on understanding the biological component as the social and economic aspects of plant use (Martin, Barrow, Cunningham & Shanley, 2001). Conservation measures include *in-situ* preservation and *ex-situ* cultivation of resources at an approximately determined level and the scale depends on the species, resource users and growers.

Sustainable commercialization of most plant resources can only occur through cultivation/domestication. Rather than banning wild collection and commercial gatherers of medicinal plants, it appears sensible to encourage prudent, sustainable harvesting along with propagation and cultivation where possible (Lewington, 1993). Also, it is becoming increasingly evident that cultivation and conservation of key species is a matter of urgency, a huge challenge, generally not always cost-effective and certainly not a quick-fix solution. It can be argued that cultivation detracts from the incentive to informally conserve habitats, since it removes the impetus to protect individual species *in-situ* (Sheldon, Balick & Laird, 1997). This argument is becoming redundant as evidenced by the growth in the medicinal plant trade and the challenges that conservation officials have in trying to contain the activities of commercial gatherers around the country.

Promotion of cultivation should be done carefully, as cultivation may lead to loss of income to commercial gatherers and the degradation / destruction of habitats, where economic benefits are no longer derived from conserving the resource (Lange, 1998) and high risks for farmers investing in a new venture, where benefits are not guaranteed. It is, therefore, difficult to balance wild-collected and cultivation, and almost impossible without the commitment to regulation by government authorities and support from the private sector (Lange, 1998).

CHAPTER 2

SHADE NETTING EFFECTS ON THE GROWTH OF FEVER TEA

2.1 INTRODUCTION

Commercial shadecloth materials have been used in horticulture to protect plants from direct sunlight, wind, hail, and birds. Researchers have used these materials to simulate shading by plant canopies (e.g. Wong & Wilson, 1980; Samarakoon, Wilson & Shelton, 1990). Plant productivity is greatly dependent, amongst others, factors on the absorption and utilization of photosynthetically active radiation (Jackson, 1980). The extent of this utilisation depends on species (De Jong, 1983; Kriedemann & Smart, 1971) and light conditions within the canopy, which are influenced by tree size, spacing and training system.

Campbell, Knight, & Olszack, 1985 suggested that shading of carambola trees resulted in reduced fruit production and recommended planting trees in sites exposed to full sun. They also found that the canopies of trees in 100% sunlight were less than 70% of the width of canopies of trees growing in 24% sunlight, while canopy height was unaffected by developmental light level.

Biasi *et al.* (1995) found that the average weight of kiwi fruit at harvest did produce a reduction in propotion to shade intensity from 20-30% with early and late 90% shadings respectively. In many plant species, chlorophyll formation increases under high light intensity (Bjorkman, 1981; Mclaren & Smith, 1978). Shaded leaves have lower chlorophyll content than unshaded ones (Barreiro, Guiamet, Beltrano & Montaldi, 1992). However, increase in chlorophyll in leaves of shaded plants has been reported for shade-tolerant species, whereas shade-intolerant species exhibited a decrease, or no consistent change in chlorophyll with shade (Bjorkman & Holmgren, 1963; Thompson, Huang & Kriedemann, 1992). Reduced respiration is one of the key adaptations of shade-tolerant plants and is lacking in shade-intolerant species (Leopold & Kriedemann, 1975).

Grant & Ryugo, 1984 investigated the effects of shading on return bloom of kiwifruit, by training some canes on each vine underneath the main canopy of the vine. They found that, heavily shaded canes showed a reduction in the percentage of buds that produced flowers (56%, but not statistically significant), and in the number of flowering nodes per shoot (24%, $P < 0.05$).

As described in the general photo-thermal model in soya bean [*Glycine max* (L) Merrill], the major factors influencing flowering time were photoperiod and temperature (Hadley, Roberts, Summerfield, Minchin, 1984; Ellis, Hadley, Roberts & Summerfiled, 1990). White shademeshes were found to increase the diffuse component and thereby, increase total solar radiation transmission, compared with black and green shademeshes (Healey, K.D., & Rickert, K.G., 1998). The range of light intensity to which a plant can adapt is determined by an individual species' genetic adaptation to the light environment of its native habitat (Boardman, 1977; Pearcy, 1998). Plants native to high light environments are capable of higher photosynthetic rates at high light intensity than plants from low-light environments. Information about the effect of shade nets on *Lippia javanica* is limited. Therefore the study was carried out to determine the effect of shade nets on the growth of *L. javanica*

2.2 **MATERIALS AND METHODS**

2.2.1 **Location**

The study was conducted at University of Pretoria's Experimental Farm at the Plant Production Section, from March 2002 until February 2003.

2.2.2 **Treatments**

"Alnet" Shade Nets provided the shading materials used, placed as permanent structures.

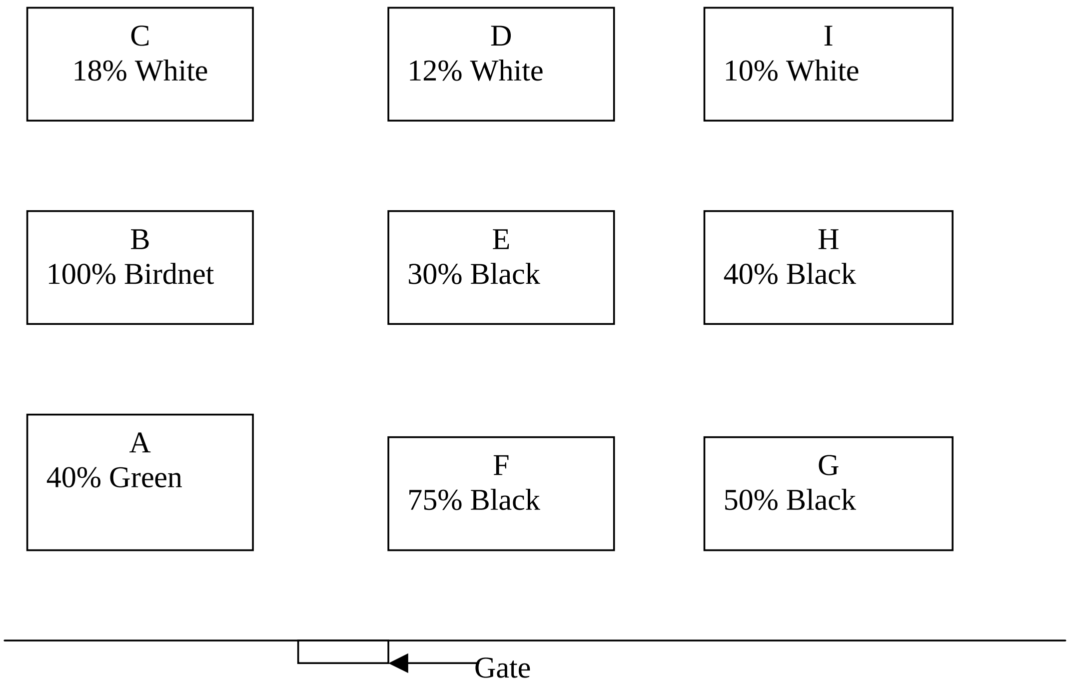

Fig. 2.1 A layout view of nine shade nets used for this experiment labelled A to I.

2.2.3 **Planting materials**

Lippia javanica plants were obtained from the Council for Scientific and Industrial Research (CSIR). Cuttings were made from the original plants for multiplication in order to obtain the required number of plants (144) for the experiment.

Multiplication was done on 08 March, 18 April and 15 June 2002. To stimulate the rapid and prolific rooting of cuttings, plants were cut 7cm long and the lower 10 - 15mm of the cutting was stirred in the hormone powder Seradix [(I.B.A(4(3-Indolyl)-butyric acid)]. Cuttings were planted in a mist - bed having 0.8mm silica sand (Fig. 2.2). The sprinklers were irrigating every 4 seconds, with the electronic mist propagation timer control running 24hours a day. The humidity in the mist - bed house was maintained between 60 and 100% relative humidity with a fogging system.

Fig. 2.2 Cuttings of *Lippia javanica* planted on the mist - bed

While plants were growing on the mist - bed, they were sprayed with *chloropyrifos* solution to control white flies. Irrigation was done three times a day, manually glasshouse until the plants were ready for transplanting. A month before transplanting, plants were taken into a glasshouse for hardening purposes (Fig.2.3). Prior to planting, the plants were dipped into a solution of *chloropyrifos* for the control of white flies. The experiment was planted on 10 October 2002 in 5L black polyethylene bags using pine bark as a growing medium (Fig. 2.4).

Fig. 2.3 Hardening process of *Lippia javanica* in the glasshouse

Fig. 2.4 Planting of the experiment

Fig. 2.5 *Lippia* plants growing in 10% white net

Fig. 2.6 *Lippia* plants growing in 30% black net

Fig. 2.7 *Lippia* plants growing in 40% green net

2.2.4 Trial design

A completely randomized design consisting of nine treatments was used. Sixteen bags planted with *L. javanica* were placed on the second row of each shade net from the left. Weeding inside the bag was done manually during the growing season.

2.2.5 **Irrigation and nutrient applications**

The plants were drip irrigated using a micro-jet drip system delivering 8L per hour three times a day. When the plants were still small, it took about 10 minutes to irrigate them, and it took about 20 minutes to irrigate when they were big.

The nutrient solutions for irrigation were mixed in a 5000L tank as follows:
Calcium Nitrate (Ca) = 3.2kg
Hydro-gro = 5kg
Water-Soluble Potassium Sulphate (S) = 750g
Spore kill = 100ml

2.2.6 **Parameters measured and statistical analyses**

Light interception was recorded for above, below and across the plants for each shade level at 34 days after transplanting (DAT), 49 DAT and at 102 DAT, using a Sunfleck Ceptometer (Decagon Devices, Inc.). In all the shade nets, plants were cut to a height of 30cm one month after planting to obtain uniform growth. Following that, the plant height was measured using a measuring tape and the number of plants that flowered in each shade net were recorded on the following days after transplanting: 49, 59, 67, 102 and 121.

The shoot widths as well as the fresh shoot mass were measured at harvest (121 DAT). The General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) was used to conduct the Analysis of Variance (ANOVA) among the treatments. During statistical analysis of PAR, time was considered as a block effect. In terms of analyzing the number of plants that flowered in each shade net, ranking was done because the data did not follow a normal distribution and time was considered as a block effect. Mean comparison was done using Tukey's Studentized Range and Scheffe's grouping.

2.3 **RESULTS AND DISCUSSION**

2.3.1 **Shoot width**

No significant differences were detected for shoot width of *Lippia javanica* plants grown under different shade nets (Table. 2.1). This result contrast a report by AVRDC-ARC (1998), which showed plant width at 30 days after transplanting of non-shaded hot pepper plants to be significantly less than that of plants grown under 30% shading.

2.3.2 **Fresh shoot mass**

Lippia javanica plants grown under 55% black net produced significantly lower fresh shoot mass, than plants grown under 18% white net, but their fresh shoot mass did not differ significantly from that of plants grown under 40% black net and 10% white net (Table 2.1). It is known that black shade nets absorb more light that other coloured shade nets. These results may argue that, since black nets absorb more light, plants grown under black nets might have received less light, resulting in stunted growth, which resulted in a significant reduction in fresh shoot mass. At an earlier stage of plant growth, plants, due to lower light intensity, expanded their leaves to receive more light for photosynthesis, yet the expansion of leaves did not contribute to the mass of the plant. These results were in agreement with the experiment conducted by Lin & Jolliffe (1996), whereby high light intensity resulted in larger cucumber fruit fresh weight compared to those under lower light intensities. Also in the study on the effect of different shading levels on tomato plants, Gizawy, Abdallah, Gomma & Mohamed (1992) found that the highest fruit weight was in tomato plants grown under lower shading density of 35% but higher densities (51% and 63%) decreased the fruit weight.

Table 2.1 Effect of shade netting on shoot width, fresh shoot mass and number of plants flowered at harvest (121 DAT)

Shade nets	Shoot width [z] (cm)	Fresh shoot mass [z] (g)	Number of plants flowered [z]
Bird net (100%)	1.49a	390b	24.80bc
Green net (40%)	1.47a	374b	19.20c
White net (10%)	1.49a	338bc	25.60bc
White net (12%)	1.47a	360b	23.0bcd
White net (18%)	1.39a	495a	16.40d
Black net (30%)	1.48a	390b	10.60e
Black net (40%)	1.43a	324bc	22.40bcd
Black net (55%)	1.47a	236c	29.80ab
Black net (70%)	1.48a	382b	35.20a
Means	1.46	366	23
LSD	0.13	103.3	7.61

[z] Means followed by the same letter within a column are not significantly different at 5% level of probability

2.3.3 **Number of plants flowered**

The number of plants which flowered at harvest, 121 days after transplanting (DAT) (Table 2.1), seventy percent black net had significantly more *L. javanica* plants that flowered than the ones grown under black net (30%), but not significantly more than plants grown under black net (55%). In this case the number of plants flowered increased from 22-35 with an increase in shading density. This result contradict with the findings of Jeon & Chung (1982), and Gizawy *et al*. (1992), where flowering on tomato plants was retarded with increasing shading density and also the plants without shading took minimum time to flower (95 days), while those receiving least of light (68% shade) throughout their development delayed flowering by 38 days. However, Munir *et al*. (2003) reported that the number of flowering buds decreased significantly with an increase in light intensity, i.e. 26 to 7 buds were counted at two extreme shade levels.

Similarly, Cremer, 1998, Flint, 1960 & Hedley, 1974 reported that the increasing light intensity significantly decreased the flowering time and leaf numbers in *Antirrhinum*. In the present study, the number of plants that flowered obtained from plants grown under 100% bird net, 10% white, 12% white, 18% white and 40% green net were similar (Table 2.1).

2.3.4 **Plant height**

Shade nets did not affect the height of plants at 49 days after transplanting (DAT) (Table 2.2). Lack of differences in plant height might be attributed to the fact that plants were still small and actively growing in all shade nets. However, at 59 DAT, the height of plants under 30% black net were significantly lower, as compared to the height of plants under 12% white net, but not significantly different from the height of the plants under the black net 40%, 10% white net and 40% green net.

Table 2.2 Plant height of *L. javanica* as affected by shade netting during 2002/03 seasons

	Plant height ^{z} (cm)			
Shade	49	59	67	102
Bird net (100%)	41.1a	61.9a	66.8a	75.7ab
Green net (40%)	45.8a	56.5ab	71.2a	78.9ab
White net (10%)	40.6a	57.4ab	70.3a	76.1ab
White net (12%)	43.2a	60.7a	71.9a	82.0a
White net (18%)	44.5a	61.4a	71.6a	78.5ab
Black net (30%)	38.8a	51.1b	57.2b	65.1c
Black net (40%)	42.8a	57.4ab	63.9ab	70.4c
Black net (55%)	45.0a	58.1a	65.1a	71.3c
Black net (70%)	45.6a	59.1a	66.8a	72.4c
Means	43.1	58.2	67.2	74.5
LSD	5.1	6.5	7.7	8.0

^{Z} Means followed by the same letter within a column are not significantly different at 5% level of probability

Similarly, at 67 DAT, 30% black net resulted in significantly shorter plant height as compared to the plant height under other shade nets, except for the height of the plants in 40% black net. At 102 DAT, the height of the plants under 30% black net were shorter compared to plants height under white net 12%, but not significantly different from the height of the plants under 40%, 55% and 70% black nets. The results do differ with those of Gizawy, Gomaa, Habbasha & Mohamed (1992), whereby shading rates were more favourable for plant height at the two tested growth stages (60 and 90 days after transplanting). These increases in plant height were significant in both seasons. Also Munir, Jamil, Baloch & Khattak (2003) found that plant height was significantly increased as light intensity decreased. Plant height also increased under high light intensities such as 100% bird net, 40% green net, 10% white net and 18% white net (Table 2.2). Even though 30% shading had plants with the lowest height at all the different days after transplanting, the results were not consistent, because at both 59 and 67 DAT, the plant height under 40%, 55% and 70% black nets were higher i.e. the height of the plants increased with a decrease in light intensity, which confirm, the study by AVRDC-ARC (1998), in which the decreased light intensity due to increased shading, therefore promoted greater cell elongation and enlargement resulting in taller plants.

2.3.5 **Photosynthetic active radiation (PAR)**

Shade levels significantly affected the adsorption and utilization of PAR above, across and below the plants at 102 days after transplanting (DAT) (Table.2.3). The interception of light above the plants was higher in 10% white nets, as compared to 30% black net, but not significantly different from 100% bird net and 40% green net. Light interception below the plants was higher for 100% bird net, compared to the interception of light under 30% black net, but not significantly different from 10% white net, 40% and 55% black nets. The results also indicated that the radiation of light across the plants was higher at 100% bird net compared to 30% black net, but not statistically different from 10% white, 40% and 55% black net.

Table 2.3 PAR measurements for above, below and across *L. javanica* plants under different shade netting at 102 days after transplanting (DAT).

Shade netting	Photosynthetically Active Radiation [z] (mol/m²/s)		
	Above	Across	Below
Birdnet (100%)	1256a	1082a	920a
Green Net (40%)	1295a	775b	775ab
White Net (10%)	1321a	1105a	872a
White Net (12%)	779bc	560bc	521bc
White Net (18%)	1027ab	1091a	750ab
Black Net (30%)	549c	372c	329c
Black Net (40%)	1120ab	731b	831a
Black Net (55%)	1181ab	997a	821a
Black Net (70%)	1173ab	912a	706ab
Means	1078	847	725
$LSD_{0.05}$	416.9	250.6	277.2

[z] Means followed by the same letter within a column are not significantly different at 5% level of probability

In the present study, the amount of light intercepted above, below and across the plants was lower for lower shading intensity (30% black) than that of higher shading intensities (40%, 55% and 70% black) (Table2.3), which confirms the results of the study conducted by Wright & Sandrang (1995) on the efficiency of light utilization in strawberry. Their study shows that there was a significant increase in the fraction of PAR absorbed by the plants grown under low light levels. This shows that *L. javanica* is highly adapted to varying levels of light intensity and tolerate shading.

2.4 **CONCLUSSIONS**

Shade nets did not have any effect on the shoot width of *Lippia javanica*. Fifty-five percent black net, 40% black net and 10% white net affected *L. javanica* plants negatively by lowering the fresh shoot mass. Eighteen percent white net can be regarded most suitable to produce fresh shoot mass. The number of plants that flowered increased with an increase in shading intensity under 70% black net. The number of plants that flowered under a lower shading intensity of 30% black net was low.

During the early stages of plant growth, plant height was not affected by shade netting. The height of the plants was lower under 30% black at 59,67 and 102 days after transplanting (DAT). The height of the plant was the best under 12% white net, which was not much different from full sun conditions.

At 59 and 67 DAT, the height of the plants was higher under low light intensities (40, 55 and 70% black nets) than high light intensity (30% black). Shade netting positively affected the adsorption and utilization of photosynthetically active radiation (PAR) across, below and above plants at 102 days after transplanting (DAT). Hundred percent bird net had the highest amount of light intercepted by the plants above, across and below the plants. Thirty percent shade net had the lowest amount of light intercepted by the plants above, across and below the plants.

2.5 **SUMMARY**

An experiment was conducted at University of Pretoria's Experimental Farm to determine the effects of shade netting on the growth of *Lippia javanica*. A completely randomized design with nine shade nets viz. 100% bird net, 40% green net, 10, 12 and 18% white nets, 30, 40, 55 and 70% black nets was used. *L. javanica* plants were obtained from the Council for Scientific and Industrial Research (CSIR). Multiplication of plants was done from March to June 2002. The experiment was planted on 10 October 2002 in 5L black polyethylene bags using pine bark as a growing medium.

The variables measured were shoot width, fresh shoot mass, the number of plants flowered, plant height and photosynthetically active radiation. General Linear Model (GLM) procedure in Statistical Analysis System (SAS) was used to conduct the Analysis of Variance (ANOVA). No significant differences were detected for shoot width of *Lippia javanica*, grown under different shade nets. Shade netting significantly affected fresh shoot mass at 121 DAT. This experiment demonstrated that 18% white net was best suited to produce substantial fresh shoot mass, whereas 55% black net produced a lower amount of fresh shoot mass. Plants grown under high shading density (70% black net) resulted in increased number of plants which flowered significantly better as compared to plants grown under low shading density (30% black net). Shade nets did not influence plant height at 49 days after transplanting (DAT). Black net 30% was not suitable to increase the height of plants at 102 DAT. Plant height increased under high light intensities such as 100% bird net, 40% green net, 10% white net and 18% white net. Shade netting affected the absorption and utilization of photosynthetically active radiation (PAR) positively across, below and above plants at 102 days after transplanting (DAT). The amount of light intercepted by the plants was lower for lower shading intensity (30% black) than that of higher shading intensities (40%, 55% and 70% black).

CHAPTER 3

SHADE NETTING EFFECTS ON YIELD AND COMPOSITION OF FEVER TEA (*LIPPIA JAVANICA)* OIL

3.1 INTRODUCTION

Essential oils are natural products formed from isoprene units that can be extracted by hydrodistillation (Guenther, 1974). *Lippia javanica* is rich in volatile oil and numerous monoterpenoids have been identified, including myrcene, caryophyllene, linalool, p-cymene and ipsdienone. Leaves yield stearic, palmitic, myristic, oleic, arachidic, behenic and lignoceric acids and triacontane alkanes (Neidlein & Staehle, 1974). Iridoid glycosides and highly toxic triterpernoids (icterogenins) have been detected in *L. javanica* and related family species (Watt & Breyer-Branderijk, 1962; Vahmeijer, 1981). Various organic acids and alcohols also occur in the plant (van Wyk, van Oudtshoorn & Gericke, 1997).

Grassroots Natural Products (2002) claims that the oil of *L. javanica* has been found to completely inhibit growth of the following microorganisms: *Staphylococcus aureus*, *Escherichia coli*, *Salmonella gallinarum*, *Klesiella pneumomiae*, *Candida albicans* and *Pseudomonas aeruginosa.* The essential oil is high in ipsdienone, which has been shown to repel European tree insect pests, ie, pine shoot beetle and ash bark beetle. The essential oil is now being tested in the cream industry and a simple cream containing fever tea leaves is being used in the Zululand region of South Africa to treat the skin conditions that arise in AIDS patients. The oil helps to clear away mental confusion and unwanted thoughts, soothes away heated emotions, through a calm, gentle perspective and also offers a relief from every day trouble and irritability. It also clears the negative and replaces it with the positive, gentle outlook. The oil has a healing, soothing effect on the skin, it has a strong antiseptic action and is helpful in the treatment of insect stings and bites.

Menut & Lamty (1995) published a report on the different African *Lippia* species which shows that the oil compositions can vary between different species and even within the same species.

For example, two *Lippia multiflora* chemotypes have been found in the Congo, whereby one was characterized by the abundance of aromatic monoterpens (p-cymene, thymol), while the other was characterized by the predominance of acyclic monoterpenes (myrcene, ispenone, tagetones). The chemical composition of the oil can vary significantly according to the geographic area, the ecological location and the developmental stage of the plant.

Work has been done on the chemical composition of *L. javanica* oil. There is a high need to maintain and increase the oil yield for meeting all the uses as outlined. It is well known that most commercial production of plants is performed using different production structures such as greenhouses and shade nets. However, little is known of the different shade netting effects on *L. javanica* oil. This study was carried out to determine the effect of different shade netting on the essential oil yield and the identified chemical compound composition of *L. javanica*.

3.2 **MATERIALS AND METHODS**

Fresh leaves of *Lippia javanica* were sampled for yield determination at harvest (121 days after transplanting) from the experiment in Chapter 2. From each shade net, four plants of approximately 200g were grouped together for oil yield determination. The essential oil content of *L. javanica* was determined through hydrodistillation for 3 hours using all-glass Clevenger-type apparatus at Wits University Pharmacology Laboratory.

The essential oil isolation of the chemical compounds was performed at the Council for Scientific and Industrial Research (CSIR). The analysis was carried out on a Hewlet Packard 5890 gas chromatograph (GC) series II fitted with HP-5 mass spectrometric (MS), Cross-linked 5%. [PH ME Siloxane (Agilent Technologies, Palo Alto, CA) column (30m x 0.25mm x 0.25 um film thickness)]. The column head pressure was 55 kPa. The chromatograph was coupled to a Hewlett Packard 2971 (Agilent Technonologies, Palo Alto, CA) series mass selective detector. The temperature programme was as follows: Split and splitless injection - 5 min solvent delay, initial temperature: 50 ^{o}C -- 50^{o}C → 240 ^{o}C @ 3 ^{o}C/min.

Helium was used as carrier gas at a flow rate of 35cm/s split flow 30-40:1. The software used was chemistation (Agilent Technologies, Palo Alto, CA). The data obtained from chemical compound composition and oil yield across the shade net was analysed using Genstat 5 Release 3.2, Lawes Agricultural Trust (1995) for windows to determine ANOVA. Means were separated using least significant difference on the data.

3.3 **RESULTS AND DISCUSSION**

3.3.1 **Oil yield**

Fresh leaves of *Lippia javanica* oil yield ranged from 0.29% to 0.41%. The oil had a clear to yellowish brown colour. Shade net did not significantly affect the oil yield of *L. javanica* plants (Table. 3.1). In contrast to these results, Clark & Menary (1980) and Duriyaprapan & Britten (1982) reported that a high light intensity resulted in high oil yield of peppermint (*Mentha piperita*) and a reduced oil production occurred under low radiation in Japanese mint (*Mentha arvensis*), respectively. From the results observed by Clark & Menary (1980) and by Duriyaprapan & Britten (1982), it is clear that either one or more parameters involved in oil synthesis are light sensitive or they respond positive to the increase in photosynthesis as governed by light intensity. In case of *L. javanica*, it is evident that the parameters involved in oil synthesis are light insensitive and may not entirely depend upon the processes of photosynthesis.

3.3.2 **Chemical Compound Composition**

The chemical compounds that were identified in the oil of *L. javanica* were α-pinene, sebinen, myrcene, 1.8 myrcene, ipsenone, ipsedienone, β-caryophyllen and germacrene-D (Table 3.1). Most of these chemical compounds were monoterpenoids, whereas Watt & Breyer-Branderijk (1962) and Vahmeijer (1981) reported Iridoid, glycosides, and triterpernoids in addition to monoterpenoids in *L. javanica*. Some of the chemical compounds identified were not similar to those reported by Neidlein & Staehle (1974), probably because chemical composition of the oil varies significantly according to the geographical area, the ecological location and most importantly, the developmental stages of the plant.

The percentage composition of chemical content remained significantly similar throughout all shade nets except myrcene under 10% white net, hence, any of the shade nets can be used to compute the percentage attribution of every chemical content identified within the essential oil (Table 3.1). Therefore, the chemical percentage composition under 10% white net was α-pinene (0.79%), sebinene (2.47%), myrcene (15.7%), 1.8 myrcene (13.4%), ipsenone (18.3%), ipsdienone (7.37%), β-caryophyllen (5.05%) and germacrene-D (1.94%) (Table 3.1).

L. javanica plants grown under 10% white net, resulted in significantly higher myrcene content (15.7%) as compared to plants grown in 100% bird net, which suggests that myrcene was influenced by shade nets (Table 3.1). Kuney (1994) reported that the greatest use of myrcene was as an intermediate in the commercial production of terpene alcohols: geraniol, nerol, and linalool, which served as intermediates for the production of large-volume aroma and flavor chemicals. It was also used in large quantities in the manufacture of specialty aroma compounds (myrcenol and its derivatives).

Table 3.1 Effect of shade nets on essential oil yield and chemical compound composition (%) of *L. javanica*

Shade nets	% Oil yield	Sebinene	Myrcene	1.8 Myrcene	Ipsenone	β-Caryophyllene	Ipsdienone	Germacrene -D	α-pinene
Bird net (100%)	0.30a	1.22a	8.40b	6.40a	25.3a	4.76a	10.3a	1.47a	0.12a
Green net (40%)	0.35a	4.05a	5.27b	10.0a	18.5a	4.56a	14.4a	1.85a	0.63a
White net (10%)	0.41a	2.47a	15.7a	13.4a	18.3a	5.05a	7.37a	1.94a	0.79a
White net (12%)	0.41a	2.72a	4.30b	13.1a	19.9a	8.01a	7.13a	4.29a	0.67a
White net (18%)	0.41a	1.43a	9.27b	6.9a	26.0a	6.00a	8.76a	4.55a	0.25a
Black net (30%)	0.36a	2.51a	8.33b	11.5a	22.0a	5.85a	7.70a	3.56a	0.66a
Black net (40%)	0.39a	3.41a	6.42b	10.4a	17.9a	4.40a	9.13a	1.46a	1.10a
Black net (55%)	0.37a	4.03a	3.78b	12.5a	29.9a	7.56a	6.98a	4.57a	0.87a
Black net (70%)	0.32a	1.70a	6.16b	10.3a	28.4a	6.82a	7.44a	3.87a	0.26
Means	0.37	2.62	7.52	10.5	22.9	5.89	8.80	3.06	0.60
LSD	0.13	2.58	6.42	9.4	14.6	4.76	8.64	3.72	0.83

[z] Means followed by the same letter within a column are not significantly different at 5% level of probability

Therefore the role of myrcene for commercialization under shade net 10% white may be considered and the decision should be based on the benefits of *L. javanica* as compared to other plant sources producing myrcene. According to Knudsen, Lang, Jansen, Seidenkrantz, Eriksson & Haflidason (1993), monoterpene compounds such as (E) -β- ocimene and myrcene contribute significantly to the floral ordours of numerous plant species. They further stated that it is possible that the coordination of the formation and emission of myrcene and (E) -β- ocimene is the result of the action of a single multiproduct monoterpene synthase. Dudareva, Martin, Kish, Kolosova, Gorenstein, Faldt, Miller & Bohlmann (2003) identified three new monoterpene synthase genes from snapdragon floral scent as myrcene (amale20 and ama0c15) and (E) -β- ocimene (ama0a23) synthesis. In the case of plants that emit monoterpenes, the emission depends mostly on temperature because these species have a monoterpene reservoir pool that releases these compounds by diffusion (Atkinson, 2003). The myrcene synthase with biochemical characterization of myrcene in *L. javanica* as influenced by temperature and light intensity, is not fully understood.

3.4 **CONCLUSSIONS**

Shade netting did not have an impact on the essential oil yield of *Lippia javanica* plants, which suggests that oil yield components might be light insensitive. Therefore, for essential oil production, the use of shade nets could be based on other parameters that are influenced by shade rather than oil yield, but without considering any other growth parameters, it is highly advisable to use 100% bird net to avoid the high construction costs that will be incurred by other shade nets since they produced similar oil yield. Shade nets did not influence the chemical compounds α- pinene, 1.8 myrcene, ipsenone, ipsedienone, caryophyllen, β-caryophyllen and germacrene-D, but had an effect on the compound myrcene. For commercial production of myrcene, white net (10%) would be best suited for *L. javanica* production. The potentiality of myrcene and other chemical components of *L. javanica* should be further exploited in the cosmetics, pesticides and pharmaceutical industries.

3.5 SUMMARY

Shade netting effect was determined on the oil yield and compound composition of *Lippia javanica*. Four plants of approximately 200g were grouped together from each shade net, for oil yield determination. Composition of *L. javanica* oil prepared from fresh leaves was determined by gas chromatography (GC) and mass spectrometric techniques (MS). The chemical compounds that were identified were, α-pinene, sebinen, myrcene, 1,8 myrcene, ipsenone, ipsedinone, β- caryophyllen and germacrene-D. The oil yield of *L. javanica* ranged from 0.29% to 0.41%. The oil had a clear to yellowish brown colour. Shade netting did not affect the oil yield of *L. javanica* plants at harvest (121 days after transplanting).

The percentage composition of chemical content remained significantly similar throughout all shade nets except myrcene under 10% white net. *Lippia javanica* plants that were grown under white net (10%) resulted in significantly higher myrcene production compared to plants grown under other shade nets. Therefore, for commercial usage of myrcene, white net (10%) would be best suited for *L. javanica* production.

CHAPTER 4

A SURVEY ON INDIGENOUS KNOWLEDGE OF FEVER TEA (*LIPPIA JAVANICA)*

4.1 **INTRODUCTION**

Indigenous medicinal plants are widely used in South Africa, with reports of up to 80% of blacks in South Africa making use of traditional medicines (Holdstock, 1978). The author estimated that between 80 and 85% of the black population in Soweto (a black township in Johannesburg) consumed indigenous medicine. Ellis (1986) found that 100% of a random sample of hospital patients in Estcourt area (a typical rural population) used indigenous medicine. More recently, a study in peri-urban Bushbuckridge (Mander, 1997a) estimated that 58% of the clinic patients used indigenous medicine. In KwaZulu-Natal the current population is estimated to be 8.7 million, with the black population comprising 83% of the total population or 7.2 million people (Central Statistical Services, 1996). Assuming that 84% of the black populations use indigenous medicine in KwaZulu-Natal, the number of potential users of indigenous medicine could therefore be 6 million people (Mander, 1998).

Many local medicinal and aromatic plants are still harvested freely and they are under severe threat of over-harvesting, hence they face commercial or local extinction, if not global extinction (Lange, 1998). As a result of the declining supply of medicinal plants and the localized extinctions that have occurred, Cunningham (1988) called for the cultivation of indigenous medicinal plants for marketing. The cultivation of medicinal plants has many advantageous features from production and utilization point of view and this has been justified by large amount of literature data (Bernáth, 1992; Németh, 1996). However, looking through the list of the plants collected from the natural systems it seems to be obvious that many of the species will remain on the list of the collected ones in the future too.

Most of the early herbal and muthi storeowners established their practices near the migrant force in the mines and mine hostels. Nevertheless, urbanization does not preclude the use of traditional medicines and the demand for herbs are met by herb-traders and traditional healers who are supplied with plants by a large network of commercial gatherers from both rural and urban areas. A growing population has increased the demand for herbal medicine and has put such pressure on these resources that they are in danger of over-exploitation and extinction (Cunningham, 1988).

Although it is widely recognized that medicinal and aromatic plants make important contributions to the global economy and to human welfare, one of the greatest difficulties in assessing the importance of medicinal and aromatic plants as resources, either locally or globally, is the shortage of reliable information. Information is lacking about what species are used, what their distribution is, how they are collected or harvested, which species are cultivated and where, what the quantities involved are, and what the trade statistics are (Heywood, 1991).

The Zulu communities use the hot leaf infusions of *L. javanica* as tea, mainly to treat coughs, colds, fever, bronchitis and most frequently as inhalants, but it is also taken orally. Leaves are sometimes smeared on the body as a protection against dogs and crocodiles and also to treat febrile rashes (Doke & Vilakazi, 1972). Cold leaf infusions are taken for gangrenous rectitis conditions (Bryant, 1966). The Xhosas also use the weak leaf and stem infusions for coughs, colds and bronchial ailments with the addition of *Artemisia afra* (Jacq. Ex Wild) (Smith, 1895; Watt & Breyer-Brandwijk, 1962). In West Africa, leaves and roots are used for fevers, headaches and skin diseases (Dalziel, 1937). In Zimbabwe the leaves are used for a variety of ailments including asthma, headaches, febrile and respiratory complaints, convulsions, weak joints, cataracts and sore eyes (Gelfand, Mavi, Drummond & Ndemera, 1985). Plants are also used to disinfect suspected anthrax-infested meat. Roots are used for headaches, scabies and backache, and infusions used to bathe marasmic infants. In Botswana the roots are used as antinodes for suspected food poisoning, and for bronchitis and sore eyes (Hedberg & Staugard, 1989). The Vhavenda use leaf infusions as anthelmintics for respiratory and febrile ailments and as a prophylactics against dystentery, diarrheoea and malaria (Mabogo, 1990).

Some patients and traditional healers prefer to use wild stock because they believe there is great efficacy in wild-harvested material (Ellenberger, 1998).

The current demand for numerous popular plant species used for traditional medicines exceeds supply, with traders reporting acute shortages and price increases. To date, several plant species, such as wild ginger (*Siphonochilus aethiopicus*) and the pepper-bark tree (*Warburgia salutaris*) have been exploited to such an extent that they are seldom found in unprotected areas (Cunningham, 1988). *Lippia javanica* is also one of the most commonly used plants in South Africa for its medicinal properties. Indigenous knowledge and cultivation of *L. javanica* is lacking and rendering introduction of the crop to commercial markets is difficult. Therefore the objectives of this study were to do a survey of indigenous knowledge about *L. javanica* with Gauteng farmers, traders, traditional healers and collectors.

4.2 **RESEARCH METHODOLOGY**

4.2.1 **Description of the study area**

Katlehong

Katlehong is a township situated in the East Rand about 128 kilometers from Johannesburg City. Respondents from this area were traditional healers who are serviced by the Department of Agriculture's Conservation Directorate. The Directorate has introduced a Muthi garden at the Katlehong Community whereby they are propagating medicinal plants and doing conservation awareness.

Zuurbekom

Zuurbekom is situated in the West Rand about 89 kilometers from Johannesburg. Respondents were farmers who are clients of the Department of Agriculture, farming with crops and livestock (Table 4.1).

Doornkop

Doornkop is situated in the West Rand about 83 kilometers from Johannesburg. Respondents were farmers who are clients of the Department of Agriculture, mostly farming with livestock and crops (Table 4.1).

Finetown

Finetown is an informal settlement situated in the South, 98 kilometers from Johannesburg next to Ennerdale (Table 4.1).

Johannesburg street traders

Street traders were selling muthi plants in the streets of Johannesburg (Table 4.1).

Table 4.1 Summary of the survey done

Date	Venue	Duration	Number of respondents
01/10/2002	Doornkop farmers	30 minutes	16
09/10/2002	Zuurbekom farmers	30 minutes	12
29-30/10/2002	Katlehong healers	1 hour	29
02/12/2002	Finetown	30 minutes	6
05/12/2002	JHB street traders	30 minutes	6

4.2.2 **Questionnaire design**

Preparation of the survey and questionnaire design started in March 2002 and was finalized in September 2002. The survey was divided into five sections: Respondent's profile; Plant Information; Harvesting (Preparation and Storage); and Marketing. Questions were made to be either open-ended or closed.

They were designed to capture both quantitative and qualitative data. Questionnaires were filled at study groups, workshops and through visits that were made to the respondents. Before questionnaires were filled, an explanation was done and the leaves of *Lippia javanica* were shown to the respondents in order for them to have an idea of the plant, while answering the questions.

4.2.3 **Sampling procedure**

It was difficult to include different parts of Gauteng areas during the study due to time constraints and people are often not willing to give information without any incentives, therefore the study was done through access of the Department of Agriculture, Conservation Environment and Land Affairs and personal contacts with other respondents.

4.2.4 **Data coding**

The information in the questionnaire was coded, especially for open-ended questions. All the variables for the answers were listed and given a number (code). The codes were placed in a spreadsheet for analysis.

4.2.5 **Data analysis**

Data was analysed using Statistical Analysis System's software. Frequency distributions and 2-way frequency distribution tables with chi-square test were made.

4.3 **RESULTS AND DISCUSSION**

The survey was done with Traditional Healers, Street Traders and Farmers serviced by the Gauteng Department of Agriculture. The combined number of respondents was 69. A questionnaire of the survey is presented in Appendix C.

4.3.1 **Respondent's profile**

Most of the respondents (56%) were unemployed, 32% were self-employed, 9% were pensioners and 3% were disabled. Among those who were self employed, the majority (54%) were traditional healers, 23% were farmers, 8% were hawkers, builders or traders. Williams (2002) did an investigation of the Faraday Street Traditional Medicine market in Johannesburg, whereby the traditional healers interviewed were mostly self-employed practitioners, but a few of them also had other full-time or part-time jobs. It was also clear that Soweto had an estimated 20 000 traditional healers, and Faraday was a source of plants for many of these healers, as well as healers from around the Witwatersrand who do not harvest their own medicinal plants. The age of the respondents ranged from 20-73 with the average being 48 years. Fifty-four percent of the respondents were female. In terms of ethnic grouping, most of the respondents (99%) were blacks and only 1% were coloured. In responding to what their highest qualification was, majority (36%) had studied up to standard six, 23% had standard 7-8, 17% had standard 9-matric, 22% had higher qualifications than matric.

4.3.2 **Plant information**

Majority of the respondents (60%) indicated that the local name of *Lippia javanica* was *umsuzwane*, 13% said *mtswane*, 11% said *mosunkwane*, 6% said *fever tea*, 3% said *umswazi* and another 3% said *tlalabadimo,* whereas 2% said the local name of *Lippia javanica* was *hlwenya* and the last 2% said *kgerere*. These names show that the respondents were Zulus, Tswanas or Northern Sotho speaking. Some of the names that were mentioned by respondents were indicators of perhaps what happened long time ago, or maybe that the plant healed people who were very sick or anything that symbolizes something to the community. As compared to the study by Williams (2002) the predominance of Zulu/Nguni consumers in the Faraday market was expected, given the nature of the work force in the Witwatersrand and patterns of indigenous plant use within the different ethnic groups. The numbers of Tswana, Sotho and Ndebele medicinal plant users in the region were smaller, and this is partly attributable to religious affiliations within these ethnic groups that often reproach the use of traditional medicines.

However, it was found that the number of Sesotho customers in the market was expected to increase on Fridays when mainly Sotho “Friday traders” sell locally harvested plants in the Sotho vernacular. The majority of respondents (47%) indicated that the most favourable habitat of *Lippia javanica* was the homesteads, 27% said the grassveld, 16% indicated the midlands forest, 9% said grassland, whereas only 1% said woodland.

According to the respondents the different uses of *L. javanica* were identified as follows: majority (47%) indicated that they used it for colds and coughs through steaming, 6% said it protected them from lightning and another 6% indicated that it protected them from Aids, 5% said asthma, another 5% said chest pains, as well as another 5% said it cured poisoning. In addition to the uses of *L. javanica* mentioned above, other were also mentioned (Table 4.2).

Table 4.2 Some uses of *L. javanica* as mentioned by the respondents

Percent respondents	**Uses**
3	Calm depression Relief sore bones and joints Bronchial diseases
2	Blood purification Tea Diseases of kids Sex diseases
1	Stomach pain Pregnant women Arthritis Malaria Nose bleeding Evil spirits Lucky herb

4.3.3 **Harvesting, Preparation and Storage**

Most of the respondents (82%) indicated that it was easy to obtain *Lippia javanica*, while 18% indicated that it was not. Those who found it easy was probably because the plant was not yet extinct in their areas, whereas those who found it difficult was because they had to travel long distances to obtain the plant.

The majority of respondents (98%) indicated that they collect *L. javanica* from the veld and only 2% purchased the plant. This shows how the growth of medicinal plants is in danger of becoming extinct as people who are using the plant on a daily basis are collecting from the veld and no efforts are being made to propagate medicinal plants. The percentage responses of *L. javanica* parts as used by respondents (Table 4.3), show that most respondents used leaves, roots and stem, while very few used the bark as well as flowers.

Table 4.3 Percentage responses of the plant parts used

Percentage responses	**Plant parts used**
38	Leaves
30	Roots
25	Stems
4	Bark
2	Flowers

Most of the respondents (56%) indicated that the stage of growth when the plant is harvested is after flowering, whereas 22% indicated that they harvest the plant before flowering. On the other hand, others (22%) indicated that *L. javanica* is harvested either before or after flowering. This is not surprising because different people use the plant differently, as indicated by its use for making tea, for curing fever and coughs.

When respondents were asked how the plant was harvested, most respondents (64%) indicated that they cut the plant, 19% said they uprooted the plant, while 16% said they harvest by both cutting and uprooting the plant.

The other important factor raised was how often the plant was harvested and 39 said the plant was harvested weekly, 21% indicated monthly, 19% harvested when a need to use the plant arose, whereas 11% indicated annually and only 11% harvested daily. The number of bags that were harvested per day ranged from 1 to 50 bags. Most of the respondents (37%) harvested 2 bags per day, 31% harvested one bag per day, 17% harvested 3 bags per day, 10% harvested 5 bags per day, whereas 2 % harvested 4 bags per day. Another 2% harvested 10 bags per day and the last 2% harvested 50 bags per day. Majority of the respondents (54%) indicated that there were no storage protocols, while 46% said there were storage protocols for *L. javanica*. For those who answered that there were storage protocols, 65% of them indicated that they dried the plant, and stored it in sealed plastic bags, boxes and tins, and 20% indicated that they stored the plant fresh, whereas the rest (15%) indicated that they used both storage protocols. Most of the respondents (73%) stated that there was pre-processing before selling the plant, while only 27% said there was no pre-processing before selling the plant. Other respondents also indicated that there was pre-processing before selling the plant (Table 4.4).

Table 4.4 Percentage respondents regarding utilization of the plant

Percentage respondents	**Utilization**
84	Dried for future use
7	Long shelf-life
3	Research purposes
3	Fresh use
3	Strong use

4.3.4 **Marketing**

Most of the respondents (89%) indicated that they do not sell the plant, whereas 11% said they did sell the plant. It was clear that the respondents were mostly traditional healers as they collected the plant and used it for healing purposes. The number of bags of the plant material that were sold ranged from 1 to 10 (Table 4.5).

Table 4.5 Percentage respondents regarding the number of bags sold per day

Percentage respondents	**Number of bags**
10	10
20	5
20	2
20	1

They also indicated the number of customers they have, which ranged from 4 to 20 per day (Table 4.6). Majority of the respondents (84%) indicated that the amount of money that best described their income per week from selling the plant was less than R100, while 8% said their income was between R101-R200 and another 8% indicated their income was between R201-R300. Respondents were also asked about other plants that they did sell besides *Lippia javanica*, where *Siphonochilus aethiopicus* obtained most responses (33%), followed by *Eucomis autumnalis* (*umathunga*) and *Warburgia salutaris* (*isibhaha*) with 23% responses each and *Boophane disticha* obtained 21% responses. In terms of the demand as indicated by the respondents, *Siphonochilus aethiopicus* was ranked the highest (1), followed by *L. javanica* which ranked number two, then *Boophane disticha* was ranked number three, followed by *Eucomis autumnalis* which ranked number four and *Warburgia salutaris* was ranked number five.

Table 4.6 Percentage respondents regarding the number of customers they have per day

Percentage respondents	**Number of customers**
36	8
27	4
18	20
9	5
9	11

4.3.5 **Domestication**

The majority of the respondents (54%) preferred the cultivated plants, 42% preferred wild-harvested plants, while 4% preferred both wild-harvested and cultivated plants. Most of the respondents (55%) said they did not experience any difference between the wild-harvested and the cultivated plants, whereas 45% indicated that they experienced a difference between the wild-harvested and the cultivated plants.

Majority of the respondents (88%) said it was important to conserve the plants, while the rest said it was not important to conserve the plant. There were also reasons given by those who said it was important to conserve the plant (Table 4.7).

Table 4.7 Reasons for conserving *L. javanica* as indicated by respondents

Percentage respondents	**Reasons for conserving the plants**
30	Future generations
24	Important to prevent extinction
13	Plants were very useful in their nation and they have the healing properties to cure sicknesses
11	Indigenous knowledge and for heritage purposes
8	To ensure natural sustainability
6	Muthi plants were scarce in Gauteng and they are highly demanded but not accessible
5	Medical aids were expensive
2	For trading purposes
2	To help the modern technology in medical research

4.4 **CONCLUSIONS**

From the study it was evident that majority of the respondents, who were self employed were traditional healers followed by farmers. Traditional healers knew more about the uses of *Lippia javanica* and other related issues than the farmers. The new entrants farmers into farming lack information about medicinal plants. Coordination between traditional healers and the farmers who are interested in medicinal plants would be necessary to capacitate the farmers so as to ensure sustainability of the natural resources.

Introduction of medicinal plants to the school curriculum will be necessary at the lower grades as majority of the new generation do not have knowledge of medicinal plants and their importance thereof. Co-ordination between the Education and Agriculture Departments is necessary to see how indigenous knowledge could be introduced to schools. More awareness could be generated during workshops and also through ABET schools for elderly people who needs to acquire knowledge on medicinal plants.

The majority of people live in Gauteng province, travel to the rural areas either to buy or to collect the medicinal plant*.* *L. javanica* like other medicinal plants such as *Siphonochilus aethiopicus* is in danger of being extinct because people who use this medicinal plant continue to collect from the veld and they normally uproot the plant.

Conservation and propagation of medicinal plants are essential in Gauteng because there is potential with the biggest muthi market in South Africa at Faraday and people travel long distances to get these plants and also for people who prefer to use the fresh leaves of *L. javanica*. This action will address the problem as identified by Williams (2002) that Gauteng is not close to the source of supply for at least 60-80% of the plants sold in the market, and there are inherent risks involved in transporting plants across provincial borders.

Routine roadblocks set up by the Traffic Department for motorists occasionally apprehend vehicles loaded with plants that are bound for Gauteng. Faraday traders have complained also that they are more of a law enforcement target than their counterparts in KwaZulu-Natal and Mpumalanga.

Cultivation of medicinal plants is commercially attractive to companies because they have greater control over quality and supply, which will in turn benefit communities. If nurseries of medicinal plants could be developed, they will help in awareness campaigns targeted at communities. The fact that income can be generated from medicinal plants will help to sustain the practice of cultivating them. Intercropping medicinal plants with cash crops could assist both the new and old farmers not only with indigenous knowledge, but also with controlling insects in their gardens. Traditional knowledge and practices pertaining to medicinal plants will be preserved as herbal medicines are increasingly used to complement other forms of community health care. Recognition of the value of these medicinal plants will foster sustainable methods of propagation and cultivation.

4.5 **SUMMARY**

The objective of the survey was to find indigenous knowledge about *Lippia javanica* among street traders, traditional healers, hawkers and Gauteng farmers. The number of respondents was 69 and both females (54%) and males (46%) participated. Most of the respondents were traditional healers (54%), followed by farmers (23%) whom it was easy to gain access because they were serviced by the Department of Agriculture. The age group was between 20-73. Most (60%) respondents stated that the local name of *L. javanica* was *umsuzwane*, followed by *mtswane* (13%) and *mosunkwane* (11%), which shows that the respondents were mainly the Zulu, Tswana and Northern Sotho speaking people. Amongst the different uses of *L. javanica* mentioned, colds and coughs treatment through steaming was stated by most (47%) of the respondents.

Most (98%) of the respondents indicated that they collected *L. javanica* from the veld by cutting the plant, whereas other respondents uprooted the whole plant when they harvested.

The stage of growth of harvesting the plant was indicated to be both before and after flowering. The number of bags that were harvested per day ranged from 1 to 50 bags. Majority of the respondents did not sell the plants because they were traditional healers. *L. javanica* ranked number two in terms of the demand amongst the five medicinal plants mentioned in this study.

Most of the respondents felt that it was important to conserve the plant for future generations and also to prevent the plant from becoming extinct. Traditional healers knew the uses and other important aspects of *L. javanica* than the farmers. Intercropping medicinal plants such as *L. javanica* with cash crops will play a major role in the farming sector by controlling the insect pests and creating awareness about the usefulness of medicinal plants. Conservation and propagation of medicinal plants is essential in Gauteng because of the big Muthi Market at Faraday.

GENERAL DISCUSSION AND CONCLUSIONS

A completely randomized design consisting of nine treatments namely: 100% bird net, 40% green net, 10% white net, 12% white net, 18% white net, 30%, 40%, 55% and 70% black net were tested on the growth of fever tea (*Lippia javanica)*. The variables measured were shoot width, fresh shoot mass, the number of plants flowered, plant height and photosynthetically active radiation. No significant differences were detected for shoot width of *Lippia javanica* plants grown under different shade nets. However, in other studies with different plants, shaded plants had thicker shoots than unshaded ones. *L. javanica* plants grown under 55% black net produced significantly lower fresh shoot mass than plants grown under 18% white net, but not more than those grown in 40% black net and 10% white net. At an earlier stage of plant growth, plants, due to the lower light intensity, expanded their leaves to receive more light for photosynthesis, but expansion of leaves did not contribute to the mass of the plant.

Seventy percent black net had significantly more *L. javanica* plants that flowered than the ones grown under 30% black net, but not more than plants grown under black net (55%). In this case the number of plants flowered increased from 22-35 with an increase in shading density. Plant height did not show any significant differences at 49 days after transplanting (DAT). Black net 30% was not best suited for the height of plants. Even though 30% shading had shorter plants at all the different days after transplanting, the results were not consistent, because at both 59 and 67 DAT, the plant height under 40%, 55% and 70% black nets were higher i.e. the height of the plants increased with an decrease in light intensity. Shade levels significantly affected the adsorption and utilization of PAR above, across and below the plants at 102 days after transplanting (DAT). The results indicated that the radiation of light across the plants was higher at 100% bird net, compared to 30% black net, but not statistically different from 10% white, 40% and 55% black net. The study also indicated that the amount of light intercepted by the plants was low for lower shading intensity (30% black) than that of plants under higher shading intensities (40%, 55% and 70% black)

The shade netting effect was determined for oil yield and compound composition of *L. javanica.* The chemical compounds that were identified were, α-pinene, sebinen, myrcene, 1,8 myrcene, ipsenone, ipsedinone, β- caryophyllen and germacrene-D.

Shade netting did not affect the oil yield of *L. javanica* plants at harvest (121 days after transplanting). Therefore, for essential oil production, the use of shade nets could be based on other parameters that are influenced by shade rather than oil yield since it was similar in all the shade nets, but without considering any other growth parameters, it is highly advisable to use bird net (100%) to avoid the high construction costs that will be incurred by other shade nets.

Shade netting affected myrcene whereas other chemical compounds were not affected. Therefore, for commercial usage of myrcene, white net (10%) would be suited for *L. javanica* production. The potentiality of myrcene and other chemical components of *L. javanica* should be further exploited in the cosmetics, pesticides and pharmaceutical industries.

In the survey study the objective was to explore indigenous knowledge about *Lippia javanica* among street traders, traditional healers, hawkers and farmers in Gauteng farmers. From the study it was evident that majority of the respondents who were self employed, were traditional healers followed by farmers. Traditional healers knew more on the uses and other related issues about *L. javanica* than the farmers. Coordination between traditional healers and the farmers who are interested in medicinal plants would be necessary to capacitate the farmers so as to ensure sustainability of the natural resources.

Majority of the people living in Gauteng travel to rural areas either to buy or to collect medicinal plants, which in turn causes the danger of *L. javanica* and other plants such as *Siphonochilus aethiopicus* to be extinct, since they normally harvest by uprooting the plant.

Intercropping medicinal plants such as *L. javanica* with cash crops will play a major role in the farming sector by controlling the insect pests and creating awareness about the usefulness of medicinal plants.

Introduction of medicinal plants to school's curriculum will be necessary at the lower grades as majority of the new generation do not have the knowledge of medicinal plants and their importance thereof. Most of the respondents felt that it was important to conserve the plant for future generations and also to prevent the plant from being extinct. Conservation and propagation of medicinal plants is essential in Gauteng, because there is a demand with the biggest muthi market in South Africa at Faraday.

GENERAL SUMMARY

There are six indigenous species of *Lippia* in South Africa. Indigenous knowledge and cultivation of fever tea (*Lippia javanica)* is lacking and rendering introduction of the crop to commercial markets is difficult. An experiment was conducted to determine the effects of shade netting on the growth, oil yield and compound composition of *Lippia javanica* and a survey was conducted to document indigenous knowledge about *L. javanica* among street traders, traditional healers, hawkers and farmers in Gauteng. A completely randomized design with nine shade nets viz. 100% bird net, 40% green net, 10, 12 and 18% white nets, 30, 40, 55 and 70% black nets was used. The parameters measured were shoot width, fresh shoot mass, the number of plants flowered, plant height and photosynthetically active radiation. General Linear Model (GLM) procedure in Statistical Analysis System (SAS) was used to conduct the Analysis of Variance (ANOVA). No significant differences were detected for shoot width of *L. javanica* grown under different shade nets. All the shade nets significantly affected fresh shoot mass at 121 DAT. It was demonstrated in this experiment that 18% white net was best suited to produce fresh shoot mass, whereas 55% black net produced the least fresh shoot mass. Plants grown under high shading density (70% black net) resulted in increased number of plants that flowered than plants grown under low shading density (30% black net). Thirty percent black net 30% was not best suited for the height of plants. Shade levels significantly affected fresh shoot mass at 121 DAT. Black net 30% was not ideal for the height of plants.

Composition of *L. javanica* oil prepared from fresh leaves was determined by gas chromatography (GC) and mass spectrometric (MS) techniques. The chemical compounds identified were, α-pinene, sebinen, myrcene, 1,8 myrcene, ipsenone, ipsedinone, β caryophyllen and germacrene-D. The oil yield of *L. javanica* ranged from 0.29% to 0.41%. The oil had a clear to yellowish brown colour. Shade netting did not affect the oil yield of *L. javanica* plants at harvest (121 days after transplanting).

L. javanica plants that were grown under white net (10%) resulted in significantly higher myrcene production compared to plants grown under other shade nets. White net (10%) would be best suited in producing *L. javanica* for commercial usage of myrcene.

The objective of the survey was to explore indigenous knowledge about *Lippia javanica* among street traders, traditional healers, hawkers and farmers in Gauteng. The number of respondents was 69 and both females (54%) and males (46%) participated. Most of the respondents were traditional healers (54%), followed by farmers (23%) whom it was easy to gain access to because they were serviced by the Department of Agriculture. The age group was between 20 and 73. Most (60%) respondents stated that the local name of *L. javanica* was *umsuzwane*, followed by *mtswane* (13%) and *mosunkwane* (11%), which shows that the respondents were mainly Zulu, Tswana and Northern Sotho speaking people. Amongst the different uses of *L. javanica* mentioned, colds and coughs treatment through steaming was stated by most (47%) of the respondents. Most (98%) of the respondents indicated that they collected *L. javanica* from the veld by cutting the plant, whereas other respondents uprooted the whole plant when they harvested. The number of bags that were harvested per day ranged from 1 to 50 bags. Most of the respondents felt that it was important to conserve the plant for future generations and also to prevent the plant from becoming extinct. Intercropping medicinal plants such as *L. javanica* with cash crops can play a major role in farming by controlling the insect pests and creating awareness about the usefulness of medicinal plants.

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APPENDICES

APPENDIX A

SUMMARISED ANALYSIS OF VARIANCES

Table A1 Analysis of variance for shoot width and fresh shoot mass as affected by shade netting at 121 days after transplanting (DAT)

Source of variation	DF	Mean squares [z]	
		Shoot width	Fresh shoot mass (g)
Shade nets	8	0.019 [ns]	75529.6**
Error	135	0.034	21810.2
Total	143		

[z] F values significant at 5% level of probability (*) or highly significant at 1% level of probability (**)
[ns] = not significant

Table A2 Analysis of variance for number of plants flowered as affected by shade nets

Source of variation	DF	Sum of squares	Mean square	F value	Pr > F
Shade nets	12	6474.22	539.52	15.47	0.0001**
Error	32	1115.78	34.86		
Total	44	7590			

F values significant at 5% level of probability (*) or highly significant at 1% level of probability (**)

Table A3 Analysis of variance for plant height at 49, 59, 67 and 102 Days after transplanting (DAT) as affected by shade nets

Source of variation	DF	Mean squares [z]			
		49	59	67	102
Shade nets	8	85.59 [ns]	168.57 [ns]	365.62 **	429.20**
Error	135	42.87	85.91	123.81	131.51
Total	143	6472	12946	19640	21188

[z] F values significant at 5% level of probability (*) or highly significant at 1% level of probability (**). [ns] = not significant.

Table A4 Analysis of variance for Photosynthetically Active Radiation (PAR) as affected by shade nets

Source of variation	DF	Mean squares [z]		
		PAR Above	PAR Across	PAR Below
Shade nets	10	174632.3*	180028.5**	111310.4**
Error	16	58004.3	20959.8	25648.1
Total	26			

[z] F values significant at 5% level of probability (*) or highly significant at 1% level of probability (**).

APPENDIX B

Table B1 Analysis of variance for oil yield and compound composition as affected shade nets at 121 days after transplanting (DAT)

Source of variation	DF	Mean squares [z]								
		Oil yield (%)	Sebinene	Myrcene	1.8 Myrcene	Ipsenone	Ipsdienone	β caryophellene	Germacrene - D	α-pinene
Shade nets	8	0.01[ns]	4.46[ns]	52.11*	24.81[ns]	85.0[ns]	22.36[ns]	7.05[ns]	7.36[ns]	0.42[ns]
Error	24	0.01	3.13	19.34	41.4	100.3	35.04	10.63	6.50	0.32
Total	35									

[Z] F values significant at 5% level of probability (*) or highly significant at 1% level of probability (**). [ns] = not significant.

APPENDIX C

QUESTIONNAIRE FOR A SURVEY

Please answer each question by drawing a circle around the appropriate number in a shaded box or write your answer in the shaded space provided

Respondent number V1 [|] 1-2

Section A: Respondents Profile

1. What is your current situation?

Employed	**1**	V2 [ ] 3
Unemployed	**2**	
Self employed	**3**	
Pensioner	**4**	
Disabled	**5**	
Other (specify):		

2. If employed, what is your occupation?

	V3 [|] 4-5

3. Please state your age?

	V4 [|] 6-7

4. What is your gender?

Male	**1**	V5 [ ] 8
Female	**2**	

5. What is your ethnic group?

Black	**1**	V6		9
White	**2**			
Coloured	**3**			
Indian	**4**			
Other (specify):				

6. What is your **highest** educational qualification?

Matric +	**1**	V7		10
Standard 9 – matric	**2**			
Standard 7 – 8	**3**			
Up to std 6	**4**			

Section B: Plant Information

7. What is the local name of *Lippia Javanica?*

	V8		11

8. What are the uses of the plant? List them.

	V9			12-13
	V10			14-15
	V11			16-17
	V12			18-19

9. What is the most favorable habitat for the plant?

Midlands forest	**1**	V13		20
Grassveld	**2**			
Homesteads	**3**			
Grassland	**4**			
Woodland	**5**			

Section C Harvesting: Preparation & Storage

10. Is it easy to get hold of the plant?

Yes	**1**	V14		21
No	**2**			

11. Please indicate in the table below, how do you get hold of *Lippia javanica.*

1 = Yes
2 = No

Buy		V15		22
Collect		V16		23

12. What plant parts are used?

1 =Yes
2 = No

1. Leaves		V17		24
2. Roots		V18		25
3. Stems		V19		26
4. Barks		V20		27
5. Flowers		V21		28
6. Bulbs		V22		29

13. At what stage of growth is the plant harvested?

Before flowering	**1**	V23		30
After flowering	**2**			
Other (specify):				

14. How is the plant harvested?

Cut	**1**	V24		31
Uprooted	**2**			
Other (specify):				

15. How often is the plant harvested?

Annually	**1**	V25 [ ]	32
Monthly	**2**		
Weekly	**3**		
Daily	**4**		
Other (specify):			

16. How much plant material is harvested per day?

Number of bags		V26 [ ]	33
Other (specify):			

17. (a) Are there any storage protocols?

Yes	**1**	V27 [ ]	34
No	**2**		

(b) If **yes**, explain

	V28 [ ][ ]	35-36

18. (a) Is there any pre-processing before selling the plant? e.g. drying

Yes	**1**	V29 [ ]	37
No	**2**		

(b) If **yes**, specify

	V30 [ ][ ]	38-39

Section D: Marketing

19. (a) Do you sell the plant?

Yes	**1**	V31		40
No	**2**			

(b) If yes, how many kilograms of plant material are sold per day by you?

	V32			41-42

20. Approximately how many customers do you have?

Per day		V33		43-44
Per week		V34		45-46

21. What amount of money best describes your income per week from selling the plant?

Less than R100 per week	**1**	V35		47
R101- R200	**2**			
R201- R300	**3**			
R301- R400	**4**			
More than R400	**5**			

22. What other plants do you sell besides *Lippia Javanica*?
1 = Yes
2 = No

1. *Boophane disticha* (Incwadi)		V36		48
2. *Eucomis autumnalis* (Umathunga)		V37		49
3. (*Siphonochilus aethiopicus* (Isiphephetho)		V38		50
4. *Warburgia salutaris* (Isibhaba)		V39		51

23. Rate the demand of each of the following plants.
1 = Highest
5 = Lowest

1. *Boophane disticha* (incwadi)		V40		52
2. *Eucomis autumnalis* (Umathunga)		V41		53
3. *Siphonochilus aethiopicus* (Isiphephetho)		V42		54
4. *Warburgia salutaris* (isibhaba)		V43		55
5. *Lippia javanica* (umsuzwane) (musukujane)		V44		56

Section E: Domestication

24. (a) Do you prefer the wild-harvested or the cultivated *Lippia javanica* plants?

Wild –harvested	**1**	V45		57
Cultivated	**2**			

(b) In terms of their usage do they differ?

Yes	**1**	V46		58
No	**2**			

25. Do you think it is important to protect the plants?

Yes	**1**	V47		59
No	**2**			

26. If **yes**, why?

	V48			60-61

THANK YOU FOR YOU ASSISTANCE