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Review

Honeybush (*Cyclopia* spp.): From local cottage industry to global markets — The catalytic and supporting role of research

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Abstract

Honeybush tea (*Cyclopia* spp.), one of the traditional South African herbal teas with a long history of regional use, remained a cottage industry until the mid-1990s when researchers were instrumental in the development of a formal agricultural and agro-processing industry. It is one of the few indigenous South African plants that made the transition from the wild to a commercial product during the past 100 years. Research activities during the past 20 years included propagation, production, genetic improvement, processing, composition and the potential for value-adding. The present review provides an up-to-date and comprehensive record of the development of the South African honeybush industry, against the background of the historical highlights in the making of an industry. It provides a blueprint of the processes and actions involved in the development of a new agricultural and agro-processing industry from an herbal plant. Insight into challenges faced by the industry and future research needed to keep it competitive are provided.

Keywords: Botany; *Cyclopia* spp.; Herbal tea; Honeybush; Industry; Processing; Production

1. Introduction

Honeybush tea, produced from *Cyclopia* species, is one of the traditional South African herbal teas with a long history of regional use; yet, unlike rooibos (*Aspalathus linearis*), it remained a cottage industry until the mid-1990s. Initiatives by researchers played a vital role in the 're-discovery' of this product and development of the industry. In less than 10 years since the first research project was initiated, commercial cultivation and factory-based production became a reality. During this period there was no formal marketing campaign, but initiatives by dedicated individuals led to the development of global markets and significant trade. During the past 3 years honeybush was sold in 25 countries, with the Netherlands and Germany representing the major markets.

The first review on honeybush was written by Du Toit et al. (1998) and summarised, amongst other things, information collected on its traditional use and processing during field trips to the Langkloof area in 1994 and 1995. The review also highlighted future prospects of the honeybush industry, as well as the need for commercial cultivation, improvement of product quality and coordinated research to address various problems faced by the emerging industry. A recent comprehensive review

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of South African herbal teas, including honeybush, focused mainly on their phenolic composition and biological properties (Joubert et al., 2008a), essential factors in establishing honeybush as a health drink.

The purpose of this review is to provide an up-to-date and comprehensive record of the development of the South African honeybush industry. It will be placed in the context of the catalytic and supporting role that research, especially by the Agricultural Research Council (ARC) and such research partners as the National Botanical Institute (later renamed to the South African National Biodiversity Institute, SANBI), has played in this process. Long-term commitment characterises the involvement of a core group of researchers and is, without a doubt, one of the reasons honeybush made the transition from an obscure, regional drink to a product enjoyed world-wide.

The wealth of information on cultivation aspects collected as casual observations by researchers and farmers, some of which were captured in popular publications, is presented in the review to provide an inclusive written record accessible to scientists. The aim of bringing such information into the public domain is to stimulate new research that will ensure that honeybush production remains an economically viable option to South African farmers.

The review also aims at providing South African researchers with a roadmap of the processes involved and actions that could be taken to foster interest and participation in the development of an agricultural and agro-processing industry based on an indigenous plant.

2. Taxonomy and distribution

The genus *Cyclopia* Vent. belongs to the leguminous family Fabaceae and is a member of the tribe Podalrieae. The genus *Cyclopia* was taxonomically described for the first time by Ventenat in 1808 and by 1825 three species had been described (Schutte, 1997). According to Schutte (1997) earlier revisions of *Cyclopia* were conducted by Bentham in 1843 (12 species), Harvey in 1862 (nine species and eight varieties), Hofmeyer and Philip in 1922 (12 species and four varieties) and Kies in 1951 (20 species with 12 varieties). The revision done by Schutte (1995, 1997) recognised 23 species in the genus *Cyclopia*. A summary of taxonomical and distribution information for these species is given in Table 1.

The name 'cyclopia' is derived from the Greek word 'cyclops' meaning 'round-eyed', which refers to the circle-shaped depression or sunken area in the base of the calyx where the pedicel is attached to the yellow flower (Fig. 1). This feature, together with trifoliate leaves (Fig. 2), distinguishes all *Cyclopia* spp. from related genera (Kies, 1951; Schutte, 1997).

Cyclopia spp. are endemic to the fynbos biome and occurs on the coastal plains and mountainous regions of the Western and Eastern Cape Provinces of South Africa. Some of the species are widespread, while others only occur within small areas in limited numbers (Fig. 3A; Table 1). *Cyclopia* spp. are long-lived perennials and depending on area and climate, they may reach heights of up to 3 m in the wild. They are adapted to the climate and soils in these areas. The soils are well drained, sandy to sandy loam with a low pH, phosphorus content and nematode count. In the mountainous areas the populations are found on the cooler, wetter southern slopes (Kies, 1951; Schutte, 1997).

The plants have woody stems, with a low leaf to stem ratio. *Cyclopia* spp. have adapted to the frequent fires in their natural habitat by developing one or other of two survival strategies, classifying them as sprouters or non-sprouters (i.e. re-seeders) (Schutte et al., 1995). Sprouters are recognised by the woody rootstock which produces new coppice shoots after fire whereas non-sprouters lack a lignotuber (Schutte et al., 1995). The seeds have a hardened seed coat that needs scarification before it will germinate and in nature fire fulfils this role. The form of the trifoliate leaves differs among species, from needle-like to small leaves (Schutte, 1997). Most of the species flower in spring (September–October), although some species, e.g. *C. sessiflora*, flower in winter (May–June).

In recent years, with the development of molecular cladistics, the combination of molecular and morphological systematics has led to reclassification of several species, genera and families in the Plant Kingdom. A few such studies included a number of *Cyclopia* spp. (Boatwright et al., 2008; Du Toit, 2005; Van der Bank et al., 2002) and focussed on the position of *Cyclopia* within the family Fabaceae or the tribe Podalrieae, and not on the phylogenetic relationships between the species. However, valuable phylogenetic relationships between species were determined and the classification of the *Cyclopia* spp. in this family and tribe was confirmed. According to Schutte (1997) there still exists some uncertainty with the intra-generic classification of some species and thus molecular studies which include more species and more populations per species should help to resolve the genus *Cyclopia*.

3. Traditional use and historical highlights — the making of an industry

The earliest reference to honeybush is found in a European taxonomic script of 1705 (Kies, 1951). C. Thunberg, a Swedish botanist, recorded the use of the name 'honigtee' (Dutch) during his travels in the Cape in the 1770s. The general names, 'honigtee', honeybush and 'heuningtee' or 'heuningbostee' (Afrikaans), for the *Cyclopia* spp. derived from the sweet, honey-like scent of the plant when in full bloom. C. Latrobe, travelling in the Langkloof area in 1815, was served 'tea-water', prepared by the inhabitants from a local plant, believed to be honeybush (Latrobe, 1818). Traditionally the leafy shoots and flowers were fermented and dried to prepare tea. The first mention of a specific species in terms of its use as a tea was by Greenish (1881) in a report on an anatomical and chemical study of *C. genistoides* (Cape tea, 'honig-thee'). A decoction of the plant was used as a restorative and as an expectorant in chronic catarrh and pulmonary tuberculosis (Bowie, 1830). Other species with a history of use as a tea were *C. vogelii*, later renamed *C. subternata* (Watt and Breyer-Brandwijk, 1962), *C. latifolia* and *C. longifolia* (Marloth, 1913, 1925). Regional use of a particular species for tea, probably an indication of their prevalence in those localities, was noted by Marloth (1925), i.e. *C. genistoides* was used on

Table 1
Taxonomic and other information of the 23 species of *Cyclopia* (compiled from Schutte, 1997).

Name	Section	Survival strategy	Rare	Distribution	Altitude (m)	Soil types
C. alopecuroidis	Praegnans	Sometimes sprouter		Upper slopes of the Kammanassie (non-sprouter) and Great Swartberg mountains (sprouter) in the southern region	1500–2000	Shale bands
C. alpina	Cyclopia	Sprouter	Rare	Summits and upper slopes of the Hottentots Holland, Hex River and Wemmershoek mountains in the western region and Kammanassie mountains in the southern regions	1170–2070	Rocky, sandy soil
C. aurescens Kies	Praegnans	Sprouter		Crest and upper slopes of the Klein Swartberg mountains north of Ladismith	Above 1800	Rocky, sandy soils
C. bolusii Hofmeyr & E. Phillips	Praegnans	Sprouter	Rare/localised	Great Swartberg mountains in southern regions	1900–2270	Moist, humic sandy soils in cracks in rocks
C. bowieana Harv.	Praegnans	Sometimes sprouter		Upper slopes of Langeberg (non-sprouter) and Outeniqua mountains (sprouter) in the southern regions	1220–1840	Rocky, sandy Table Mountain Sandstone
C. burtonii Hofmeyr & E. Phillips	Aequalis	Unknown	Rare	Great Swartberg mountains		
C. buxifolia (Burm. f.) Kies (includes *C. dregeana* Kies)	Aequalis	Unknown		Skurweberg, Great Winterhoek, Hex River, Du Toitskloof, Franschhoek, Hottentots Holland, Riviersonderend, Langeberg and Outeniqua mountains	830–1670	Rocky humic, sandy soils
C. falcata (Harv.) Kies	Cyclopia	Sprouter		Winterberg, Winterhoek, Franschhoek and Caledon mountains	550–1600	Clayey Table Mountain Sandstone
C. filiformis Kies	Truncatae	Non-sprouter		Van Stadens River near Port Elizabeth	100	
C. galioides (Bergius) DC.	Cyclopia	Sprouter		Cape Peninsula	160–700	Rocky, sandy Table Mountain Sandstone
C. genistoides (L.) Vent.	Cyclopia	Sprouter		Malmesbury–Darling area, the hills and mountains on the Cape Peninsula and Cape Flats, Grabouw, Kogelberg, Betty's Bay, Hermanus, Bredasdorp, De Hoop, Swellendam and eastwards to Albertina in the southern region	60–1170	Sandy soils
C. glabra	Praegnans	Sprouter		Crest and upper slopes of the Hex River mountains in the Western Cape	1670–2250	Amongst rocks in well drained Table Mountain Sandstone
C. intermedia E. Mey.	Cyclopia	Sprouter		Witteberg, Anysberg, Swartberg, Touwsberg, Rooiberg, Kammanassie, Kouga, Baviaanskloof, Langeberg, Outeniqua, Tsitsikamma and Van Stadens mountains; most widespread	500–1700	Rocky, loamy, sandy soils
C. latifolia DC.	Marsupium	Non-sprouter	Rare/localised	Constantiaberg and Tafelberg mountains in Cape Peninsula	900–1000	Marshy, rocky areas
C. laxiflora	Aequalis	Unknown	Rare	Knysna–Plettenberg area		
C. longifolia	Truncatae	Non-sprouter	Rare/localised	Van Stadens River mountains near Port Elizabeth	300–360	Moist, sandy soils along the banks of the river
C. maculata (Andrews) Kies (includes *C. tenuifolia* Lehm.)	Truncatae	Non-sprouter		Along riverbanks and streams in the south-western and southern region	150–830	Wet, peaty soils
C. meyeriana Walp.	Praegnans	Non sprouter		Cedarberg, Koue Bokkeveld, Winterhoek, Du Toitskloof, Hottentots Holland and Riviersonderend mountains in the Western Cape	150–830	Alongside streams
C. plicata Kies	Truncatae	Non-sprouter	Rare	Kamanassie and Kouga mountains in the southern region	1000–1700	Shale bands in loamy, rocky soils
C. pubescens Eckl. & Zeyh.	Truncatae	Non-sprouter	One population	Foot of the Van Stadens River mountains, west of Port Elizabeth	300	Marshy areas
C. sessiliflora Eckl. & Zeyh.	Marsupium	Sprouter		Langeberg and Warmwaterberg mountains in the southern region	300–1500	Well-drained loamy, sandy soils
C. squamosa Schutte	Marsupium	Unknown	Rare	Wemmershoek mountains in the south-western region		
C. subternata Vogel	Aequalis	Non-sprouter		Widely distributed along the coastal mountain ranges (Tsitsikama, Outeniqua and Langeberg) where it occurs on the southern slopes	160–1000	Well-drained, stony, loamy soils

Fig. 1. *Cyclopia* flower showing the circle-shaped depression or sunken area in the base of the calyx, a distinctive characteristic of the genus.

the Cape Peninsula, while *C. subternata* was used in the Caledon (Overberg) and George areas.

Honeybush remained largely unknown outside its natural habitat areas and the limited commercial activity of the twentieth century was centred in the Langkloof area. G. Nortje, during the 1930s, sold processed *C. intermedia,* harvested in the Kouga mountains, for less than 2 c/kg (S. Nortje, Nooitgedacht, Kouga, personal communication). A sporadic increase in demand during World War II raised the price to almost 5 c/kg. Fifty years later, advertisements in the classified columns of a farmers' magazine, Landbouweekblad, listed prices of R1.00/kg and R5.50/4.5 kg (Bond, 1980).

The first branded product, 'Caspa Cyclopia Tea', appeared on the South African market in the 1960s through the involvement of B. Ginsberg, the pioneer of rooibos marketing (Fig. 4). Other companies that followed were International Foods in Johannesburg and Goldberger Trading in East London. One farmer even investigated export, but the production was too low for the estimated demand. In spite of these early marketing efforts, honeybush remained in obscurity until 're-discovered' by researchers of SANBI and the ARC.

Table 2 summarises the main highlights in the process to establish a formal industry during the period 1992–2010. This period was ushered in by research on propagation of honeybush, approached from the perspective of nature conservation and sustainability as all material was sourced from the wild. Such dependence on natural stands, prone to fire devastation, could limit development of local and global markets and future expansion of these markets, thus creating the impetus for on-going production research. The participation of commercial and small-scale community-based farmers for honeybush cultivation was actively sought from the start of the research. Farmers were introduced to honeybush through farm visits and information days. A series of information and technical days held in the Langkloof, George and Overberg areas in 1998 reached approximately 200 different farmers and other interested parties. Initial trials were carried out in 64 locations throughout the fynbos biome, mostly on privately owned land, to gain knowledge about the soil and climatic requirements of 12 species. The need for production guidelines and high yielding plant material led to research on soil preparation, plant nutrition, harvesting practices and plant improvement with respect to commercial characteristics (growth, yield and chemical properties).

The primitive on-farm processing, which entailed fermentation heaps or baking ovens and sun-drying, delivered a product lacking uniformity that, in many instances, was of poor sensory and microbial quality (Du Toit et al., 1998). It was quickly realised that efforts to develop a formal industry would remain futile if product quality was not improved. Tea of good and consistent quality was required to build consumer confidence and expand the market. Processing and product quality were thus addressed as early as 1994. Technology transfer took place through information days and on-site visits to processors. Rotary fermentation and drying, tested for rooibos processing (Joubert and Müller, 1997), was eventually adopted by the honeybush processors. Today these are the processes of choice, delivering a product of consistent and high quality (Erasmus, 2002).

The interest in honeybush as a crop coincided with the demand of consumers world-wide for health-promoting foods and ingredients, especially antioxidants. In a survey carried out in 1992, three out of four American consumers wanted the same research effort applied to ageing as to putting a man on the moon (Sloan and Stiedemann, 1997). In the same survey 74% of the consumers indicated that they were aware of the diet/disease connection. With the link between oxidative stress and ageing fuelling global interest in natural antioxidants such as polyphenols, investigation of the phenolic composition of honeybush was needed to focus research on its potential health-promoting

Fig. 2. Trifoliate leaves of *C. genistoides* (A), *C. intermedia* (B), *C. maculata* (C) and *C. subternata* (D).

properties and to identify opportunities for value-adding. In-depth studies on the phenolic composition were carried out by the University of the Free State on fermented *C. intermedia* (Ferreira et al., 1998; Kamara et al., 2003) and unfermented *C. subternata* (Kamara et al., 2004), which laid the foundation for investigating the effect of processing conditions on composition and health-promoting properties, the development of quality parameters, value-adding, etc. The research on potential health benefits of honeybush to date mainly concentrated on antioxidant, anti-mutagenic, anti-cancer and phytoestrogen properties, with the Medical Research Council of South Africa playing a pivotal role in collaboration with the ARC (Joubert et al., 2008a).

The detrimental effect of high temperature 'fermentation' on the levels of polyphenols and in particular on the xanthone, mangiferin, well-known for its pharmacological effects (Wauthoz et al., 2007), prompted the inclusion of unfermented (green) honeybush in studies investigating the health-promoting potential of honeybush (Joubert et al., 2008a). In 2000 the industry took notice of green honeybush as an alternative tea product and as a source of mangiferin for production of extracts for the food, nutraceutical and cosmetic markets. This led to a patented process for vacuum drying to produce green honeybush tea (De Beer and Joubert, 2002).

4. Industry

The foundation for a formal honeybush industry was laid when research on propagation was initiated. The impetus for rapid development in the honeybush industry was a research project of J.H. de Lange, titled '*Cyclopia* species: Initiation of commercial plantings and studying of its conservation', launched by SANBI (Kirstenbosch) on 23 February 1992. Financial support for the project was obtained from the ARC. The project was subsequently followed by additional honeybush projects by various researchers of the ARC and several universities. Interest and participation of farmers, processors and marketers ensured that an industry emerged (Table 2). Currently approximately 200 ha of mostly *C. genistoides* and *C. subternata* are under cultivation (Fig. 3B), but to cater for demand, wild-harvesting, especially of *C. intermedia*, still contributes the major part of the annual production. The increase in demand has placed natural populations of sprouters, which are not well-protected, in jeopardy through unsustainable harvesting practices. Sustainable utilisation of the veld as a natural resource base is one of the main objectives of the South African Honeybush Tea Association (SAHTA). Economic activity is spread over the fynbos area from the Overberg to the Langkloof and Tsitsikamma (Fig. 3B and C). Four nurseries supply the demand for seedlings. Of the 15 producers, three are community projects and one is a Black Economic Empowerment project. Some of the producers harvest exclusively from the wild.

At the early stages of production in the 1990s it was decided that it would be in the interest of the industry to apply organic production principles as the cost for registration of chemicals to control pests, diseases or weeds in plantations would be prohibitive for such a small industry. Organic production principles are widely practised; however, the percentage of the farmers registered for organic production is small, mainly due to the high cost of certification.

Processing facilities are mostly situated in the Eastern Cape with only two processors in the Western Cape (Fig. 3C). It is only as recently as 2009 that a processing facility was established in the Overberg. The nearest other processing plant is the well-equipped factory and teabag packaging facility at Mossel Bay. Of the six processing facilities, four are located on farms. Most of the tea produced by the industry (95%) is still sold in bulk form to overseas clients. The industry, however, recognises that it is in its interest to shift from bulk supply to packaged products ready for the retail market. The presence of honeybush on supermarket shelves has become more regular in recent years following the involvement of major rooibos tea marketing companies. Local consumers have a choice of branded fermented honeybush products that are a mixture of different honeybush species. Some smaller brands contain only one species, but their distribution is limited to speciality shops and up-market farm stalls. At this stage the limited supply of tea restricts expansion of product differentiation on the basis of species. Mixtures of honeybush and rooibos, with honeybush usually comprising only a small percentage of the mixture, are another product available in the supermarkets. A small quantity of green honeybush is also sold through a supermarket chain.

The export market of honeybush has grown substantially over the past 10 years from 50 to 200 tonnes (Fig. 5). Severe drought and veld fires in the production areas have limited the availability of plant material during the past 2 years. Currently, supply cannot meet the demand. The export market can be categorised into three groups according to market share (Table 3). The market composition changes from year to year, but the Netherlands, Germany, United Kingdom (UK) and United States of America (USA) are the major importers since 2008. The Netherlands and Germany bought the bulk of tea exported in 2010 (74%), with the UK, USA, Poland and Sri Lanka accounting for between 1 and 9%, totalling 22%. The remaining 4% of tea was exported to 12 countries, including traditional tea-drinking countries such as India, Japan and China.

Community participation in the industry has been lagging behind main-stream production, processing and marketing. Efforts by the ARC and the non-governmental organisation, ASNAPP (Agri-Business in Sustainable Natural African Plant Products Programme), to expand their involvement have met with limited success. Major contributing factors are the per hectare cost of establishing a honeybush plantation and the time between establishment and the first harvest. The Haarlem and Ericaville communities have been involved in the cultivation of honeybush for several years. One of the commercial nurseries is situated in Haarlem. Interest in honeybush production by Genadendal farmers has been revived as a result of an ARC project (Anon., 2010a; Botha, 2011). A pilot plantation of *C. maculata* and *C. subternata* and a nursery have been established. A small-scale farmer of neighbouring Bereaville has taken the initiative to establish another pilot plantation with the same species.

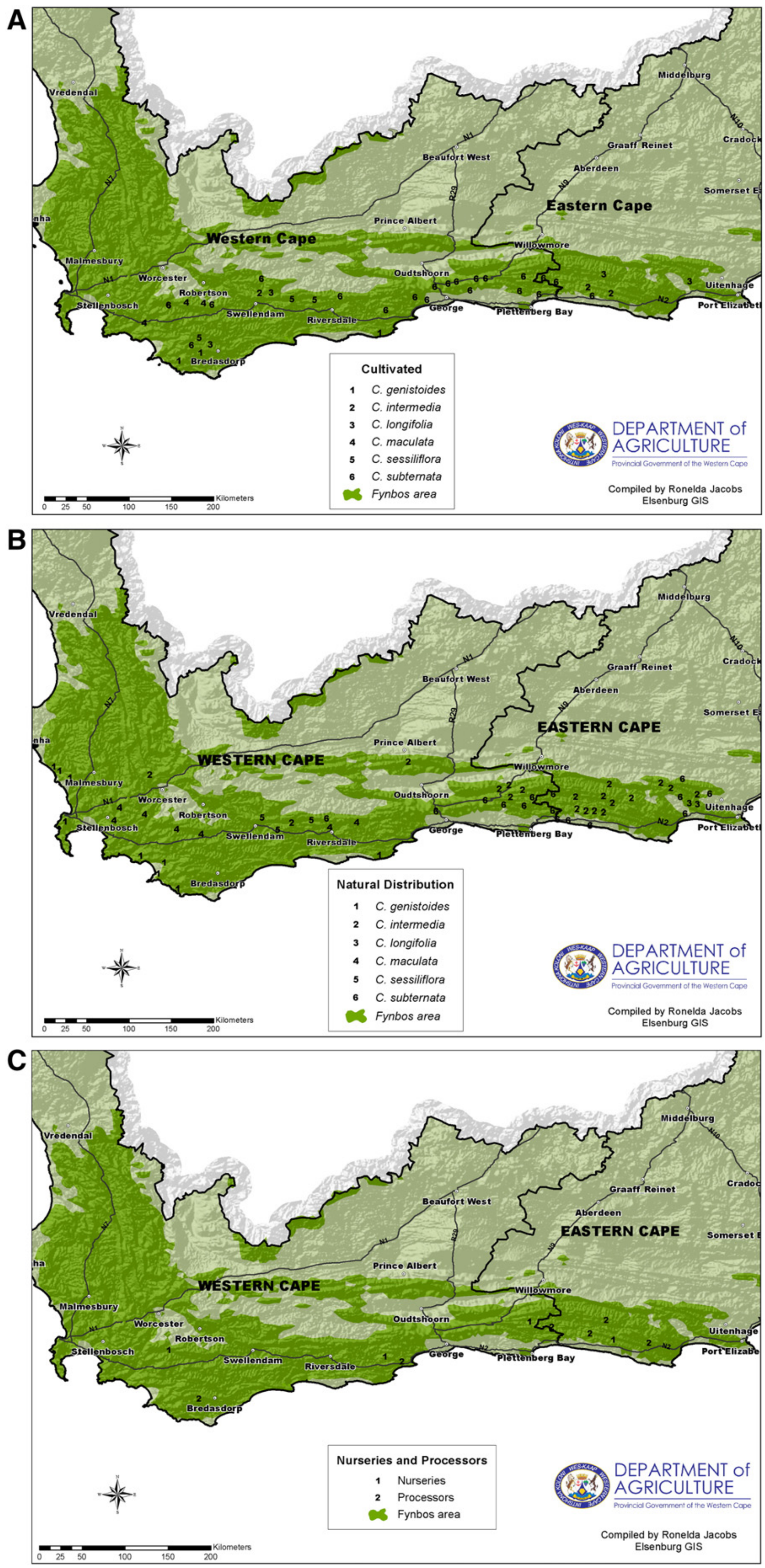

A
Vredendal
Malmesbury
Worcester
Stellenbosch
Robertson
Swellendam
Riversdale
Bredasdorp
Western Cape
Beaufort West
Prince Albert
Oudtshoorn
George
Plettenberg Bay
Willowmore
Aberdeen
Graaff Reinet
Middelburg
Cradock
Somerset E
Uitenhage
Port Elizabeth
Eastern Cape
N1
N2
N7
N9
N10
R29
Cultivated
1 C. genistoides
2 C. intermedia
3 C. longifolia
4 C. maculata
5 C. sessiliflora
6 C. subternata
Fynbos area
DEPARTMENT of AGRICULTURE
Provincial Government of the Western Cape
Compiled by Ronelda Jacobs
Elsenburg GIS
0 25 50 100 150 200 Kilometers
B
WESTERN CAPE
EASTERN CAPE
Natural Distribution
1 C. genistoides
2 C. intermedia
3 C. longifolia
4 C. maculata
5 C. sessiliflora
6 C. subternata
Fynbos area
DEPARTMENT of AGRICULTURE
Provincial Government of the Western Cape
Compiled by Ronelda Jacobs
Elsenburg GIS
0 25 50 100 150 200 Kilometers
C
WESTERN CAPE
EASTERN CAPE
Nurseries and Processors
1 Nurseries
2 Processors
Fynbos area
DEPARTMENT of AGRICULTURE
Provincial Government of the Western Cape
Compiled by Ronelda Jacobs
Elsenburg GIS
0 25 50 100 150 200 Kilometers

Fig. 4. 'Caspa Cyclopia Tea', the first branded honeybush tea, packed in the 1960s.

The increase in the demand for honeybush on international markets, possible delocalisation of its production outside South Africa and the opportunistic trademarking of the term 'rooibos' in the USA in 1994, raised the concerns of the honeybush industry that it may face a similar threat in future. It was only after a long and expensive legal battle that ownership of the term 'rooibos' was reclaimed by South Africa in 2005. To pre-empt this the ARC took the initiative in 2006 by trademarking the names 'Cape Herbal Tea', 'Cape Tea', 'Cape Honeybush Tea' and 'Cape Fynbos Tea'. Protection can also be offered through a Geographical Indicator (GI) as the uniqueness of honeybush makes it distinct from other products (Trotski and Erasmus, 2006). The feasibility of a GI for honeybush was investigated under the Biodivalloc programme of the Department of Agricultural Economics of the University of Pretoria and French partners (Blanchard Ortiz, 2006). The Western Cape Department of Agriculture was also involved. Blanchard et al. (2006) concluded that the honeybush tea industry is currently not large enough to use a GI, but that it will be useful in future.

The honeybush industry has the potential to emulate the success of the rooibos industry. For this reason and the role that it could play in the economic development of rural areas in the Western and Eastern Cape Provinces, several reports by provincial and national government departments and agencies have been published over the years. The most recent, published in 2010, is the 'Rooibos and Honeybush Market Development Programme Framework' of the Western Cape Department of Economic Development and Tourism. The latter department was instrumental in the conversion of SAHTA from an association to an Article 21 company. The department also provides tangible support for the development of a strategic business plan, the development and maintenance of the SAHTA web site and activities relating to promotion of the industry.

5. Production

The initial trials held at different locations with a number of species (Table 2) demonstrated that the success of propagation and cultivation would depend mostly on choosing the correct species for a specific growing area. A recent study by Jacobs (2007, 2008) in collaboration with the ARC, identified areas within the fynbos biome suitable for honeybush cultivation (Fig. 3B). Natural occurrence was an important factor in this process to map suitable production areas. Soil type, followed by rainfall, was identified as the most important factor in determining the suitability of cultivation areas for honeybush (Jacobs, 2008). The effects of factors such as temperature, day length, heat and cold units, and slope on the area suitability still need to be investigated.

Three main species, viz. *C. genistoides, C. intermedia* and *C. subternata*, are currently utilised commercially. Of these, *C. intermedia* is harvested almost exclusively from the wild. The potential to cultivate *C. longifolia, C. maculata* and *C. sessiliflora* is under investigation.

5.1. Species of importance

Fig. 3B depicts the localities of pilot and commercial plantations of the *Cyclopia* spp. of importance. Mostly these localities coincide with their natural habitats (Fig. 3A; Table 1). Information pertinent to production such as type of growth and flowering period, etc. is summarised in Table 4. Of these species, *C. genistoides, C. intermedia* and *C. sessilifora* are sprouters, while *C. maculata* and *C. subternata* are non-sprouters. Interest in *C. longifolia* developed only very recently and it is still unknown whether it is a sprouter or non-sprouter. Early indications are that some of the plants are sprouters.

Cyclopia intermedia has a lignotuber from which, after fire or cutting back, a large number of shoots sprout to form dense bushes up to 2 m tall. Similarly, *C. sessiliflora* re-sprouts after fire, growing to 0.5 to 2 m tall. *Cycopia genistoides* is also a sprouter, but without the prominent lignotuber of *C. intermedia.* New shoots re-sprout from thickened roots and from the base of the main stem after fire or harvest. *Cyclopia genistoides* plants from different areas vary considerably in size and growth habits. On the West Coast bushes in natural populations grow up to 2 m tall and during drought the plant will drop the lower leaves. Plants in the mountainous areas in the South-Western Cape and coastal area of the Southern Cape are up to 1 m tall. These plants are usually denser and the proximal leaves on the shoots are more persistent than in the case of the West Coast plants.

Fig. 3. A. Natural distribution of *Cyclopia* spp. in the Western and Eastern Cape Provinces. B. Locations of *Cyclopia* spp. plantations in the Western and Eastern Cape Provinces. C. Locations of honeybush nurseries and honeybush tea processors in the Western and Eastern Cape Provinces.

Table 2
Timeline of the major activities since 1992, including technology transfer and research, supporting the use of *Cyclopia* spp. and development of a honeybush industry.

Year	Activity
1992–1997	J.H. de Lange of the National Botanical Institute (renamed South African National Biodiversity Institute, SANBI), Kirstenbosch, initiated the studies on cultivation and nursery practices from a viewpoint of conservation and sustainability. In the course of the project a protocol for the propagation of seedlings was established. Research by M.A. Sutcliffe and C.S. Whithead shed considerable light on the germination requirements of *Cyclopia* seeds. More than 200 000 seedlings of 12 *Cyclopia* spp. were propagated and planted by J.H. de Lange at 64 locations on the West Coast and in the Boland, Overberg, Southern Cape, Little Karoo, Langkloof and Eastern Cape.
1993	J. Bloem and S. Staphorst of ARC Plant Protection Research Institute and J.H. de Lange of SANBI collected root nodules of many different *Cyclopia* spp. throughout the distribution range of the genus in the Western and Eastern Cape Provinces. The former two researchers developed an effective *Rhizobium* inoculant for seedlings and rooted cuttings to aid development of nitrogen fixing root nodules. B. Bouwman of the same ARC institute researched the use of a micorrhizal inoculant on seedlings for enhanced nutrient uptake and enhanced plant health.
	J.H. de Lange undertook the first promotion of honeybush tea at the 'Flora 93' exhibition in Cape Town. Generally, positive feedback was received from consumers who tasted honeybush tea for the first time. This was followed up in subsequent years with exhibitions and other promotion activities such as radio talks by E. Joubert, J.H. de Lange, M.E. Joubert and other role players to create consumer awareness for the product and interest from farmers in production.
	The first export of honeybush (500 kg) took place on 17 October. The plant material was exported to Japan by J. Beyers of Eenzaamheid Farm of Noll in the Upper Langkloof area. Soon to follow were S. Nortje and Q. Nortje of Nooitgedacht Farm in the Lower Kouga region.
	The first honeybush information day was held by J.H. de Lange on 29 October at Joubertina in the Langkloof to stimulate interest in honeybush production from farmers in the Kouga–Langkloof area.
	J. Beyers started fermenting *C. subternata* on a 'commercial scale' in baking ovens as an alternative to the traditional fermentation heaps used in the Langkloof at that stage. The remnants of baking ovens, originating from the 1890s, found in the Garcia Pass near Riversdale, indicate the traditional use of baking ovens by locals to prepare 'blommetjiestee'. The warm drawer of coal stoves was also used to ferment the plant material for household use.
1994–1996	Investigation of controlled processing and establishment of guidelines for processing were undertaken by E. Joubert of ARC Infruitec-Nietvoorbij and J. du Toit of Stellenbosch University. As controlled high temperature fermentation was shown to be essential for a good quality product, several processors tried a variety of static heating vessels, characterised by poor heat transfer and distribution. As the concept of rotary drum fermentation was previously successfully applied to rooibos by E. Joubert, processors were subsequently advised to use this technique for honeybush to achieve uniform and controlled high temperature fermentation. The first prototype rotary fermentation drum was built by TFD Designs, Stellenbosch, and exhibited during a honeybush farmers' day in the Langkloof on 14 May 1998. Rotary fermentation eventually became the industry norm.
1995	The first export of honeybush (4 tonnes) to Germany took place on 8 May and was undertaken by J. Beyers.
	Tobacco cutters were introduced as alternative to fodder cutters to achieve better control of cut size and improve the appearance of the processed tea.
	Local marketing of 'Kirstenbosch-selected' honeybush tea, first in loose format, but later also in teabag format was initiated by J.H. de Lange to promote the use of honeybush and to obtain funds for research. More than 5.5 tonnes were marketed in this manner until early 1997 when private entrepreneurs started marketing honeybush under the brands 'Trophy', 'Berg' and 'Landhuis Farm'.
	The first honeybush plantings were made in the communities, Haarlem and Genadendal. Other communities that became involved at a later stage were Friemersheim and Ericaville.
1996–current	E. Joubert initiated projects on phenolic composition and health promoting properties, which were mostly carried out as collaborative projects of ARC Infruitec-Nietvoorbij and partners, including the Medical Research Council of South Africa, University of Free State and Stellenbosch University. Outputs from these projects are described in Joubert et al. (2008a).
1997	A honeybush farmers' day was held on 23 July at Grootvadersbos Conservancy, Heidelberg, to stimulate interest of farmers in the Overberg area in honeybush production.
	The Sustainable Rural Livelihoods Programme of ARC Infruitec-Nietvoorbij became involved in the various production aspects of honeybush, including nursery practices, plantation management, pest and disease control, and soil preparation, with specific focus on the rural communities, Genadendal, Haarlem and Friemersheim. The programme also provided training of small-scale farmers in nursery and cultivation practices.
	Rooibos tea marketing companies, i.e. Cape Natural Tea Products, Khoisan Teas and Coetzee & Coetzee Distributors, became involved in marketing of honeybush tea. Value-adding occurred for the first time, with liquid honeybush extract for use in beverages, toiletries (soap, shampoo and bubble bath) containing honeybush and a honeybush liqueur appearing on the market.
	A. Spriggs of the Botany Department of the University of Cape Town started a study of the role of *Rhizobium* bacteria in the roots of *Cyclopia*.
1998	Green honeybush was produced for the first time on an experimental basis by E. Joubert.
	The first harvest of honeybush (*C. subternata*) from a commercial plantation took place on 17 September. The plantation was established by T. van Rooyen at the Waboomskraal area near George.
	The first registered organic honeybush tea (wild harvested) was produced by S. Nortje and Q. Nortje under the 'Melmont' brand.
1999	Establishment of the South African Honeybush Producers Association (SAPHA) took place on 24 February in George. The name was changed in 2002 to the South African Honeybush Tea Association (SAHTA) to be more inclusive of all stakeholders.
	The ARC Honeybush Breeding and Selection Programme, initiated by J.H. de Lange and P. Botma, kicked off with the major aim to improve bio-mass yield of *C. genistoides* and *C. subternata*. Inter-specific hybridisation also received attention.
	Insect and nematode surveys were carried out, respectively, by R. Burgess and H. Hugo of ARC Infruitec-Nietvoorbij.
	A study was undertaken by S. du Toit and E. Campbell of the University of Port Elizabeth to investigate the influence of fire on *C. longifolia* and *C. pubescens*, two rare Eastern Cape species.
2000	Regulations regarding control of the export of honeybush and green honeybush [a] were compiled by the National Department of Agriculture, in consultation with SAHPA.
	The first edition of the SAPHA Newsletter appeared in March.
	N. Malan of Reins Farm in the Albertinia area established vegetative propagation of *C. genistoides* as a viable commercial practice.
	The first major funding from the private sector (National Brands Ltd) was obtained for production and product research at ARC Infruitec-Nietvoorbij enabling research into (1) the nutrient uptake of *C. genistoides* and *C. subternata* by M.E. Joubert, (2) harvesting practices for *C. intermedia*, *C. subternata* and *C. sessiliflora* by P Botma, and (3) further studies on the antioxidant properties, as well as the antimutagenicity of honeybush. The latter studies were undertaken by E. Joubert, in collaboration with W.C.A. Gelderblom of the Medical Research Council.

Table 2 (*continued*)

Year	Activity
2001	A patent (SA Patent No. 2001/9559), with inventors S. de Beer, N.D. McCabe and E. Joubert, was granted for a process to produce instant honeybush tea. The first harvest of honeybush (*C. subternata*), cultivated in a community, took place in October by A. Gelderbloem, an emerging farmer of Friemersheim located near Groot Brakrivier. Production and harvesting took place under the guidance of the Sustainable Rural Livelihoods Programme of ARC Infruitec-Nietvoorbij.
2002	The official inauguration of the sophisticated tea processing factory of Cape Honeybush Tea Company at Mossel Bay took place on 19 February, exactly 10 years after the first honeybush research project by J.H. de Lange started. P. Taljaard of Kanetberg Farm in the Riversdale area was the driving force behind the new facility. A patent (SA Patent No. 2002/2802), with inventors S. de Beer and E. Joubert, was granted for a process to produce green honeybush tea using vacuum-drying.
2006	Preliminary guidelines for the cultivation and harvesting of honeybush tea were released by ARC Infruitec-Nietvoorbij.
2007	ARC established web pages for its Honeybush Tea Research programme to aid dissemination of information to industry and other stakeholders (http://www.arc.agric.za/home.asp?pid=4045).
2008	A strategic planning workshop, convened by M.E. Joubert of ARC Infruitec-Nietvoorbij and G. Dingaan of the Western Cape Department of Economic Development and Tourism, was held in George for industry stakeholders.
2009	C. Bester took over leadership of the ARC Honeybush Breeding and Selection Programme. SAHTA was changed to a Section 21 company to serve the needs of the industry better.
2010	At an industry seminar on 8 March at George, the Western Cape Provincial Government committed itself to increase its support to the industry, recognising honeybush as one of the unique indigenous products from South Africa that has the potential to reach niche markets around the world. At the same event SAHTA launched its new strategic plan to improve tea quality, cultivation and breeding material. Aroma impact compounds of honeybush were identified by J.C. Cronje of Stellenbosch University.

[a] The regulations were published under Government Notice R1177 in the Government Gazette 21759 of 24 Nov 2000 with Amendment Notice1132 of 2005.

The non-sprouters, *C. maculata* and *C. subternata,* are killed by fire and their survival strategy is based on efficient seedling regeneration from seeds in the soil seed bank. *Cyclopia subternata* plants usually have only one to three long branches. Some of the plants can grow up to 2 m tall. *Cyclopia maculata,* a vigorous grower, can reach a height of 2 m in 1 year and forms a tall shrub in nature (Fig. 6).

5.2. Propagation

5.2.1. Seed and vegetative propagation

Honeybush can be successfully propagated by seed or vegetatively (Fig. 7). The latter process is slower, requires more sophisticated nursery infrastructure and is thus more expensive (De Lange, 2006). Higher yields, a more uniform product and better quality, however, can be obtained if only selected honeybush plants are used for commercial production, which justifies the extra time and costs for vegetative propagation (Erasmus, 2002; Gleason, 2004).

Honeybush seeds have a very hard casing which should be scarified to enable germination. De Lange (2000) showed that mechanical scarification was effective for seeds from the various species, although it was less effective for *C. genistoides.* Alternatively, seeds can be scarified by treatment with sulphuric acid. The time required for mechanical scarification depends on the age and condition of the seed, while for

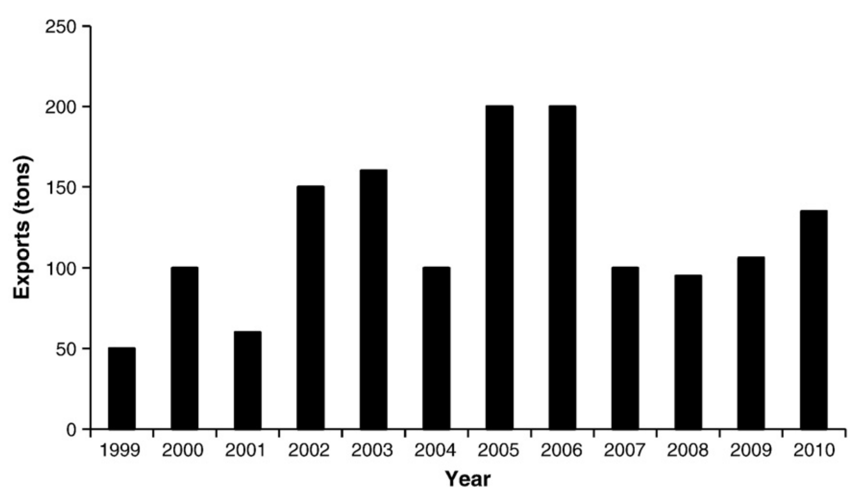


Fig. 5. Total exports of honeybush tea from 1999 to 2010.
Data from Perishable Products Export Control Board supplied by the South African Rooibos Council.

Table 3
Countries to which honeybush was exported from 2008 to 2010 with percentage of exports to each country (data from the Perishable Products Export Control Board supplied by the South African Rooibos Council).

Country	2008	2009	2010
Netherlands	21.73	44.52	43.75
Germany	12.69	25.36	30.41
United Kingdom	31.12	7.72	8.45
United States of America	19.54	9.27	6.53
Poland	–	7.59	5.94
Sri Lanka	1.44	0.19	1.13
Austria	0.85	0.14	0.89
Australia	0.97	–	0.67
Russia	1.22	–	0.67
Canada	–	0.14	0.62
Italy	–	–	0.24
India	–	–	0.22
Norway	0.55	0.34	0.13
Lithuania	–	–	0.12
Japan	5.29	3.90	<0.10
New Zealand	0.22	–	<0.10
China	0.37	<0.10	<0.10
Hong Kong	0.11	–	<0.10
South Korea	–	0.51	–
Malaysia	–	0.19	–
Portugal	–	<0.10	–
Czech Republic	2.12	–	–
Bulgaria	1.04	–	–
Chile	0.72	–	–
Switzerland	<0.10	–	–

sulphuric acid treatment only the species has an influence (De Lange, 2000).

Mbangcolo (2008) compared treatment of seeds of different species (*C. genistoides* and *C. intermedia*) with sulphuric acid (95%), hot water (100 °C) or a paper disc impregnated with smoke-saturated water, using demineralised water as control. Sulphuric acid proved to be the best scarification method of the four treatments. Apart from scarification, the seeds of some species, such as *C. intermedia,* also require a cold or chemical treatment for germination (De Lange, 2000). The imbibed seed can be stored in a refrigerator for 3 weeks or treated with a smoke extract, gibberellic acid or ethylene (De Lange, 2000).

The advantage of vegetative propagation is that plantations with higher production ability can be obtained by using selected sources for propagation material and is the preferred propagation method for some producers (Erasmus, 2002; Gleason, 2004; Malan, 2000). A protocol developed by De Lange (2000, 2006) makes it possible to produce plants successfully from vegetative material for commercial production. Research indicated that cuttings can be rooted successfully using conventional methods. Mbangcolo (2008) has evaluated the effect of species and the position of the cutting on rooting using different rooting hormones on *C. genistoides* and *C. intermedia*. De Lange (unpublished data) found that a hormonal treatment of 4-(indol-3-yl)butyric acid at 3 g/kg gave the best results and similar results were found by Mbangcolo (2008). The effect of setting the cuttings at different times of the year was also investigated with the best results obtained during summer time (Mbangcolo, 2008). Although both De Lange and Mbangcolo have done valuable research on vegetative propagation, and rooted cuttings are today produced successfully, many questions still remain with much more research needed in this field.

Research on the in vitro propagation methods of tissue culture and somatic embryogenesis is limited. Kokotkiewicz et al. (2009) had some success with the establishment of in vitro shoot and callus cultures for three *Cyclopia* spp., but micropropagation has yet to be applied successfully to *Cyclopia.*

5.2.2. Inoculation with Rhizobium bacteria

Cyclopia, which, as already mentioned, belongs to the legume family, forms a symbiosis with *Rhizobium* bacteria for the fixation of nitrogen (N_2) by developing root nodules and binding atmospheric nitrogen (Bloem, 2001; De Lange, 2000). This symbiosis allows honeybush to grow in nitrogen poor soils, common in the Western and Eastern Cape Provinces, without the application of nitrogen fertiliser (Spriggs, 2002). *Rhizobium* bacteria are specific as to with which plants they will form a symbiosis (Spriggs, 2002, 2005) and are not always present in the soils where new honeybush plantations are established. Therefore, it is important that honeybush seedlings and cuttings are inoculated with a suitable *Rhizobium* strain for the development of root nodules and binding of atmospheric nitrogen. Subsequently, several studies have been conducted in the understanding, development and identification of suitable *Rhizobium* bacteria strains (both α- and β-rhizobia) for the commercial production of honeybush as some of the strains are predominant in certain areas (Elliott et al., 2007; Kock, 2004; Spriggs, 2002, 2005; Spriggs and Dakora, 2007, 2009a,b,c;

Table 4
General information on the six *Cyclopia* spp. with commercial value and potential commercial value.

Species	Popular name	Flowering time	Pod ripening time	Comments
C. genistoides	Kustee/Coastal tea	August/September	November/December	Excellent growth form, harvest close to ground; good quality tea
C. intermedia	Bergtee/Mountain tea	September	November/December	Slow growing, harvest close to the ground; possibly drought resistant; very good quality tea
C. longifolia		September/October	December	Harvest close to the ground; tea quality under investigation
C. maculata		August/September	November/December	Vigorous growth, thick shoots, harvest knee-high; tea quality under investigation
C. sessiliflora	Heidelberg tea	May/June	November	Favourable growth form, slow growing, harvest close to the ground; susceptible to shoot tip disorder; good quality tea
C. subternata	Vleitee	September	December	Vigorous grower, producing relatively thick shoots, harvest knee-high; very good quality tea

Fig. 6. A mature *C. maculata* bush, growing tall (2 m) in marshy land near Riversonderend in the Overberg area.

Spriggs et al., 2003). Earlier research at the ARC by J. Bloem led to the selection of an effective *Rhizobium* strain viz. PPRICI3 (Spriggs, 2005). Honeybush seedlings can be inoculated with the *Rhizobium* bacteria when the seeds are sown, while cuttings are inoculated at the time when the roots start to develop, usually 4 weeks after cuttings were set (De Lange, 2000, 2005, 2006).

Fig. 7. Rooted cuttings of *C. genistoides* (A) and *C. subternata* (B) used for propagation.

5.3. Cultivation

Cyclopia subternata, growing mainly on sandy loam soil and requiring more water than *C. genistoides,* is cultivated in the Langkloof, the Riversdale area and in-land areas of the Overberg. *Cyclopia genistoides* grows naturally in the coastal, sandy areas from the West Coast to Mossel Bay. Plantations have thus been established in the Overberg and Mossel Bay/Albertinia areas (Figs. 3B and 8).

Cultivation trials have also been carried out with *C. intermedia* and *C. sessiliflora,* while trials with *C. longifolia* and *C. maculata* are in progress. Only these latter two species showed promise as relatively fast growers. *Cyclopia intermedia*, the species that currently makes up most of the production of honeybush, is not favoured for cultivation. It can only be harvested every second or third year, which makes it uneconomical to cultivate. Too frequent harvesting prevents plants from building up sufficient energy reserves in the rootstock, resulting in dieback. About 30 ha of *C. intermedia* have been planted to date in the Langkloof and Southern Cape areas. Natural populations in the Langkloof and Kouga mountains remain the major source of tea from this species.

5.3.1. Nutrition

Most fynbos soils are leached, acidic and easily depleted in mineral nutrients. A preliminary investigation of the effects that liming and mineral nutrition have on the growth of *C. subternata* was conducted (Joubert et al., 2007b). A short-duration pot trial showed that dry mass production could be enhanced by increasing the soil pH from 4.4 to 5.2. *Cyclopia subternata* also seemed to benefit from the addition of phosphorus (P), especially when lime was applied. Other mineral nutrients, i.e. potassium (K), magnesium (Mg), and nitrogen (N), either had no effect in the soil used or the effect was inconsistent. Treatment of seeds with the trace element, molybdenum, which facilitates rhizobial N fixation, promoted higher top growth, root and total plant dry mass. A follow-up field trial confirmed that P supplementation to a maximum level of 20 mg/kg in the soil benefited the non-

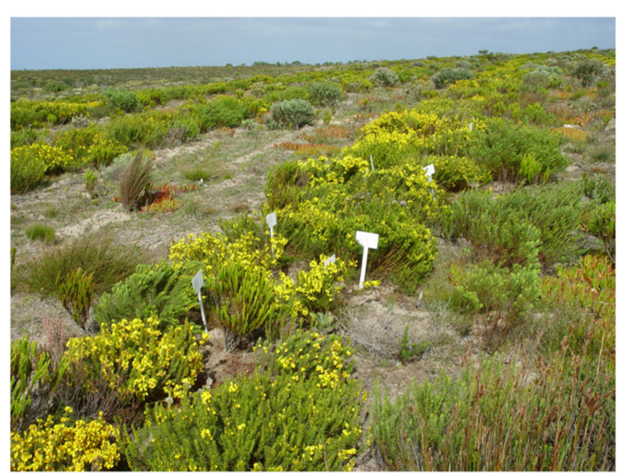


Fig. 8. A 3-year old commercial plantation of *C. genistoides* (Overberg type) in flower (15 September 2003) on Koksrivier Farm near the sea in the Overberg area.

sprouter *C. subternata* (Joubert et al., 2007a). It produced considerably more shoot growth than the sprouters, *C. genistoides*, *C. intermedia* and *C. sessiliflora*.

A five-year field survey of *C. genistoides* and *C. subternata* was carried out to determine the rate at which minerals should be replaced to counter losses through crop removal (Joubert et al., 2010b,c). In the case of *C. genistoides* 48% to 61% of the total mass of each mineral, i.e. N, P, K, Ca and Mg, was removed with harvesting, while quantities for *C. subternata* varied from 28% to 45%. In both these surveys the plants derived from seedlings and cuttings, as well as plants in nature. Harvestable top growth made up 38% of total plant dry mass in *C. genistoides,* irrespective of whether it derived from seedlings, cuttings or natural veld. In the case of *C. subternata*, a higher percentage of plant material was removed from cuttings than from seedlings, i.e. harvestable new top growth in *C. subternata* made up 15% for seedlings and 21% for cuttings of total plant dry mass. Correct soil preparation was found to be essential for good root development and thus successful establishment of plantations. Joubert (unpublished results) recommended that the soil should be worked to a minimum depth of 50 cm while attempting to avoid bringing any clay to the surface. A soil depth of 70 to 100 cm is required for optimum root penetration and development (Gleason, 2004).

5.3.2. Water requirements

The common practice is to plant 8000 to 10 000 seedlings or rooted cuttings per hectare (Viljoen, 2001) after the first good winter rains when the soil is moist. Planting should not take place later than the end of August to allow enough time for root development before the onset of dry and hot summer conditions. In most cases, watering during the hot summer months of the first year is required while the root system is not yet well developed. Research on the irrigation requirements of different *Cyclopia* spp. is, however, needed. The use of an organic mulch is recommended to help retain moisture in the soil. A preliminary study by Joubert et al. (2007a) demonstrated that plastic mulch exacerbated mortality in *C. genistoides*, reduced mortality in *C. sessiliflora*, and had no effect on mortality in *C. intermedia* and *C. subternata*. Root nematode infestation was identified as a probable factor in mortality.

5.3.3. Pest management and disease control

A survey to collect and identify insects in plantations and in the wild, conducted in 2000 (Knipe and Rosenberg, 2008), identified 46 insects associated with honeybush. These insects belonged to the following insect orders, namely *Lepidoptera* (moths and butterflies), *Hemiptera* (bugs, stinkbugs, aphids, scale insects), *Isoptera* (ants), *Hymenoptera* (wasps, bees), *Thysanoptera* (thrips) and *Coleoptera* (beetles, weevils). A pest mite and three predatory mites were also identified. Results showed that both damaging and beneficial insects co-existed. Insects like the Australian bug, pear leafroller and scale insects, known pests of various other crops, were frequently encountered. Numerous ladybirds, a well-known predatory insect of more troublesome pest insects like thrips, mites and aphids, were readily collected. The survey also showed the presence of various parasites that emerged from larvae.

Some of the insects collected severely affected the plant. A minute larva feeding inside the growth point of plants resulted in the plant sprouting numerous side branches thereby changing its growth habit. Burrowing larvae attacked plants by feeding inside the stem and branches resulting in severe dieback. Infested plants could be recognised by the heaps of frass found around the base of the plant. The larva of a large moth caused substantial damage to plants; due to the size of this larva and at times the number occurring on a plant, their feeding action completely stripped branches of their leaves.

Information on diseases associated with *Cyclopia* spp. is limited to the work of Halleen et al. (2010). Complaints from producers of poor growth and dieback led to the collection of several *C. subternata* plants showing severe symptoms of dieback from several locations in the Western Cape Province. The isolations consistently revealed the presence of Botryosphaeriaceae and *Phomopsis* species. Morphological and molecular identification revealed the presence of two Botryosphaeriaceae species, one of which was identified as *Neofusicoccum australe* (Halleen et al., 2010), as well as three unknown *Phomopsis* spp. Pathogenicity studies conducted with *N. australe* on shoots of field grown *C. subternata* plants resulted in the formation of lesions from which the newly identified pathogen could be re-isolated. Preliminary pathogenicity studies conducted with the *Phomopsis* spp. indicated that they might also be involved with dieback diseases (F. Halleen, ARC Infruitec-Nietvoorbij, Stellenbosch, South Africa; pers. comm.).

5.3.4. Harvesting

Sprouters, such as *C. genistoides*, *C. intermedia* and *C. sessiliflora*, can be harvested about 2 to 3 years after planting, depending on soil and climate (Viljoen, 2001). The plants are cut back to soil level to stimulate the formation of new shoots from the rootstock. Under ideal conditions *C. genistoides* can be harvested as early as 18 months after planting. Following the first harvest, *C. genistoides* is normally harvested annually between November and March, giving between 3 and 10 tonnes/ha. Yield will depend amongst others on the type of *C. genistoides*. Three types, viz. Overberg, West Coast and Kirstenbosch, are currently cultivated. The Overberg type forms a low growing bush with an abundance of stems and fine needle-like leaves. The Kirstenbosch type with dark green needle-like leaves also forms a compact bush with many side sprouts. Under the same environmental conditions the West Coast type grows taller, but less dense, and in dry conditions will drop its needle-like leaves. North et al. (2008) found September and January harvests of *C. genistoides* to give the best re-growth, but harvest date had no effect on bio-mass yield.

Cyclopia intermedia and *C. sessiliflora,* on the other hand, can only be harvested every second or third year as the plants need enough time to recover. The first harvest after establishment of the plantation will be after 24–36 months, depending on soil and climate. There is limited information on cultivation practices as these species are still largely harvested in the wild.

The non-sprouter, *C. subternata,* is a relatively fast grower and the plants can be harvested within a year of planting under ideal conditions. This was found to be the case for the first commercial plantation of *C. subternata*, located in the Waboomskraal area near George. Similar to *C. genistoides* it is harvested annually, but normally in April to June. North et al. (2008) found that the highest bio-mass yield for *C. subternata* is obtained when harvesting takes place during April (autumn) and July (winter). Its fastest re-growth occurs during the cooler, wetter months of July to September. *Cyclopia subternata* is harvested by cutting the shoots back to between 30 and 50 cm above the ground. Approximately one third of active growth should remain on the plant as too severe pruning places the plant under stress, leading to dieback. The lifespan of the non-sprouters is 7 to 8 years while that of sprouters are estimated to be at least 10 years, based on the productive age of the oldest *C. genistoides* plantation.

5.4. Input cost and break-even point

A report done for the Hessequa municipality captured the financial projections for investment and operational cost in relation to income expectations for honeybush (Anon., 2010b). The cost of establishing 1 ha of honeybush is estimated at approximately R 33 500, the biggest expense being that of the seedlings. The current price for a tonne of fresh honeybush is approximately R 4500. The estimated break-even point for *C. subternata* in an optimum plantation will be 3 years. After about 7 years this plantation should be re-established. The projected break-even point of *C. genistoides* is 4 years and that of *C. intermedia* and *C. sessiliflora* 7 years. Using cuttings instead of seedlings to establish plantations would be more expensive, but some pioneer farmers of the industry changed to cuttings from selected mother plants as higher production (Gleason, 2004) and improved quality (Erasmus, 2002) could be achieved.

6. Plant improvement

The initial studies on *Cyclopia* spp. and nursery practices done at SANBI (Kirstenbosch) by J.H. de Lange formed the basis of a genetic improvement programme for *Cyclopia* (De Lange, 2005; Table 2). During the initial phase, 12 different honeybush species (Table 5) were evaluated in more than 60 different locations across the Western and Eastern Cape Provinces (De Lange, 2005; De Lange and Von Mollendorf, 2006). These trials included the five species traditionally used, viz. *C. genistoides*, *C. intermedia*, *C. maculata*, *C. sessiliflora* and *C. subternata.* Apart from these latter species only *C. longifolia*, of which only a limited number of plants are left in nature, performed well in the preliminary trials. Although this species has not yet been extensively evaluated, recent short-term studies indicated good establishment and strong re-growth after harvest.

In 1999, the ARC initiated a formal programme to develop improved genetic material for the sustainable production of honeybush (Table 2). Promising individual plants in commercial plantations of *C. genistoides* and *C. subternata* were selected on different farms (De Lange and Von Mollendorf, 2006). These selections are currently being tested in trials at different sites. Selection criteria include vigour, growth habit, degree of branching, leaf-shoot ratio, compactness of growth and absence of disease symptoms. Important selection criteria on advanced selections include tea quality and phytochemical content, as well as suitability for processing (Bester and De Lange, 2010).

The genetic improvement programme further aims to improve the commercial characteristics (growth and yield) of the different species through intra- and inter-species crossing followed by selection of promising individuals from the crosses and evaluation of the selections in different climatic regions for adaptability. The goal is to release improved seed in the short term and in future clones to the industry (Bester and De Lange, 2010).

The cross-pollination technique (chemical and chirurgical manipulation of pollen and pistils) developed by De Lange led to several crosses between species (De Lange and Von Mollendorf, 2006). However, the success rate was very low with less than 2% of cross-pollinations being successful (De Lange and Von Mollendorf, 2006). Several different combinations of inter-species crosses between accessions of *C. buxifolia*, *C. genistoides*, *C. intermedia*, *C. maculata*, *C. sessiliflora* and *C. subternata* were achieved with the aim of broadening the genetic base and combining some of the favourable characteristics of particular species (Bester and De Lange, 2010; De Lange and Von

Table 5
Cyclopia spp. and the different populations of each included in the initial species evaluation phase.

Species	Population sites	Province
C. bowieana	Bonnievale Farm (±20 km west from Robinson Pass, near Mossel Bay)	Western Cape
C. burtonii	Swartberg mountains	Western Cape
C. buxifolia	Helderberg, Jonkershoek	Western Cape
C. dregeana (re-classified as *C. buxifolia)*	La Motte near Franschhoek	Western Cape
C. genistoides (Kirstenbosch selection)	Kirstenbosch (originally from Kalk Bay), Darling (West Coast), Koksriver Farm (Overberg)	Western Cape
C. intermedia	Different localities in Langkloof, Swartberg and Kouga mountains	Western and Eastern Cape
C. latifolia	Tafelberg	Western Cape
C. longifolia	Longmore Forestry station, Thornhill	Eastern Cape
C. maculata	Genadendal (non-sprouter), Overberg	Western Cape
	Paarl (sprouter) — now classified with *C. buxifolia*	Western Cape
C. meyeriana	Kunje, Koue Bokkeveld	
C. plicata	Near Haarlem, Langkloof	Western Cape
C. pubescens	Near Port Elizabeth	Eastern Cape
C. sessiflora	The farms, Plattekloof and Wadrift, in the Riversdale area	Western Cape
C. subternata	Different localities in Langkloof, Tsitsikamma and Waboomskraal near George	Western and Eastern Cape
An unidentified species	In mountains near Uniondale	Western Cape

Mollendorf, 2006). Although several promising individuals were identified, no immediate commercialisation of these inter-species hybrids is foreseen.

The next phase of the programme will be to focus on the improvement of commercial characteristics of the main commercial species through poly- and controlled intra-species crosses, to broaden the genetic base and to select promising individuals from the intra-species progenies. Studies on the genus will also be initiated to get a better understanding of its genetic composition e.g. relatedness, chromosome numbers and ploidy levels. Continuous improvement of the principal species and a better understanding of heritability and genetics of the traits will ensure that new and improved material becomes available on a regular basis (Bester and De Lange, 2010).

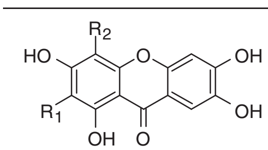
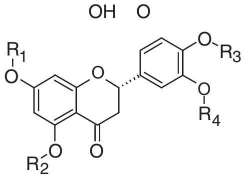
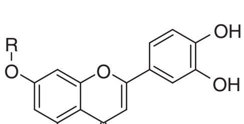
7. Chemical composition

Honeybush is well-known as a caffeine-free (Greenish, 1881), low tannin (Marloth, 1925; Terblanche, 1982), aromatic herbal tea with a wealth of polyphenolic compounds associated with its health-promoting properties (Joubert et al., 2009). Honeybush infusions were reported to contain 0.59 mg/ml fluoride (Touyz and Smit, 1982), although no information was given on the *Cyclopia* spp. analysed. The content of aluminium (Al), as well as mineral nutrients, was shown to be much less than that of *Camellia sinensis* teas, except for Ca which was higher (Malik et al., 2008).

In terms of polyphenol composition, only *C. intermedia* (fermented) and *C. subternata* (unfermented) have been comprehensively studied (Ferreira et al., 1998; Kamara et al., 2003, 2004). The presence of a number of polyphenols, previously identified in these two species, has been confirmed in *C. genistoides* and *C. sessiliflora* by liquid chromatography–mass spectrometry (De Beer and Joubert, 2010; Joubert et al., 2008c). The major compounds, present in all species analysed to date, are the xanthones, mangiferin and isomangiferin, and the flavanone, hesperidin. Other compounds identified in *Cyclopia* spp. include flavanones (hesperetin, eriodictyol, naringenin, eriocitrin, narirutin, naringenin-5-*O*-β-D-glucopyranoside, eriodictyol-5-*O*-β-D-glucopyranoside and eriodictyol-7-*O*-β-D-glucopyranoside), flavones (luteolin, 5-deoxyluteolin, scolymoside and diosmetin), isoflavones (formononetin, a formononetin-diglucoside, afrormosin, calycosin, wistin, orobol, pseudobaptigenin, fujikinetin and isosakuranetin), flavonols (several kaempferol glucosides), coumestans (medicagol, flemmichapparin and sophoracoumestan) and others (epigallocatechin gallate, *p*-coumaric acid, tyrosol and several tyrosol derivatives) (De Nysschen et al., 1996; Ferreira et al., 1998; Kamara et al., 2003, 2004). Tannins in *Cyclopia* spp. are of the proanthocyanidin type (Marnewick et al., 2005) and have been estimated at ca 4.34% of the hot water soluble solids of fermented honeybush (Du Toit and Joubert, 1998a).

Comparative content values for the major polyphenols in hot water extracts from unfermented *C. genistoides*, *C. intermedia*, *C. sessiliflora* and *C. subternata,* adapted from data in De Beer and Joubert (2010), are shown in Table 6 along with changes in content for extracts from fermented plant material. *Cyclopia genistoides* extracts were highest in mangiferin (9.55%) with *C. intermedia* (4.35%) and *C. sessiliflora* (4.67%) extracts having a similar content, while *C. subternata* had the lowest content (2.73%). These results are similar to those obtained by Joubert et al. (2008c), although in that study lower mangiferin contents were observed for *C. sessiliflora* and *C. subternata*. The trend for isomangiferin was similar to that of mangiferin in both studies. The hesperidin content of the hot water extracts did not differ greatly, but *C. genistoides* (0.71%) and *C. sessiliflora* (0.74%) hot water extracts were highest closely followed by those of *C. intermedia* (0.62%) and *C. subternata* (0.62%) (De Beer and

Table 6
Content (g/100 g extract) of major phenolic compounds in unfermented honeybush aqueous extracts from four different *Cyclopia* spp. and effect of fermentation. Adapted from De Beer and Joubert (2010).

Structure	Name	*C. genistoides*	*C. intermedia*	*C. sessiliflora*	*C. subternata*
	*Xanthones*				
	Mangiferin	9.55	4.35	4.67	2.73 [a]
	(R_1 = glc; R_2 = H)	(−83%)	(−97%)	(−87%)	(−98%) [b]
	Isomangiferin	2.72	1.40	1.69	0.86
	(R_2 = glc; R_1 = H)	(−59%)	(−81%)	(−54%)	(−83%)
	*Flavanones*				
	Hesperidin	0.71	0.62	0.74	0.62
	(R_1 = rut; R_3 = CH_3; R_2, R_4 = H)	(−56%)	(−47%)	(−49%)	(−61%)
	Eriocitrin	Traces	0.13	0.32	0.32
	(R_1 = rut; R_2, R_3, R_4 = H)	(−100%)	(−77%)	(−38%)	(−63%)
	Eriodictyol glucoside	nd	0.07	nd	0.35
	(1 of R_1, R_2, R_3, R_4 = glc; rest = H)		(−100%)		(−100%)
	*Flavone*				
	Scolymoside	Traces	0.04	0.06	0.68
	(R = rut)	(−100%)	(−100%)	(−100%)	(−71%)

glc, glucosyl; nd, not detected; rut, rutinosyl.
[a] Average content in aqueous extract from unfermented tea.
[b] Percentage decrease in content of extract with fermentation of plant material.

Joubert, 2010). Hesperidin content values obtained by Joubert et al. (2008c) were higher for *C. genistoides* (1.12%) and *C. intermedia* (0.92%), but lower for *C. sessiliflora* (0.50%) and *C. subternata* (0.42%). In another study, methanol extracts of *C. genistoides* Overberg type was shown to contain more mangiferin and less hesperidin than those of the West Coast type, while no difference in isomangiferin content was observed (Joubert et al., 2003). The mangiferin content of the plant material in this study also depended on harvest date. Eriocitrin was detected in all extracts from unfermented plant material, although only in trace amount for *C. genistoides* extracts (De Beer and Joubert, 2010). Scolymoside was present at 0.68% in extracts from unfermented *C. subternata*, but only detected in small amounts in other extracts. Other qualitative differences include an eriodictyol glucoside that was detected only in unfermented *C. intermedia* and *C. subternata* extracts.

The volatile fraction of unfermented and fermented *C. genistoides*, especially the odour-active volatile compounds, has been studied in detail by headspace gas chromatography with mass spectrometry (GC–MS) and olfactory (GC–O) detection (Cronje, 2010; Le Roux et al., 2008). The same volatile compounds were present in both unfermented and fermented *C. genistoides*, but major quantitative differences were observed (Fig. 9; adapted from Le Roux et al., 2008). In the unfermented plant material, saturated and unsaturated alcohols, aldehydes and methyl ketones are present in high concentrations, while terpenoids comprise the major aroma compounds of the fermented plant material. A total number of 255 volatile compounds were identified, including 46 odour-active compounds (Cronje, 2010). The major constituent in unfermented plant material, 6-methyl-5-hepten-2-one (54% of the total ion chromatogram), is associated with the following aroma description: 'oily-green, pungent-herbaceous, grassy with fresh green fruity notes'. Linalool, described as 'refreshing, floral-woody', is the major aroma constituent (36%) in fermented *C. genistoides*. The most intense odour-active compounds in the fermented plant material associated with a sweet aroma were (*E*)-β-damascenone, geraniol and 10-*epi*-γ-eudesmol. The flowers of *C. genistoides*, on the other hand, contained a large number of saturated and unsaturated C_5–C_{18} aldehydes, which may have a detrimental effect on the taste of the tea (Le Roux et al., 2006).

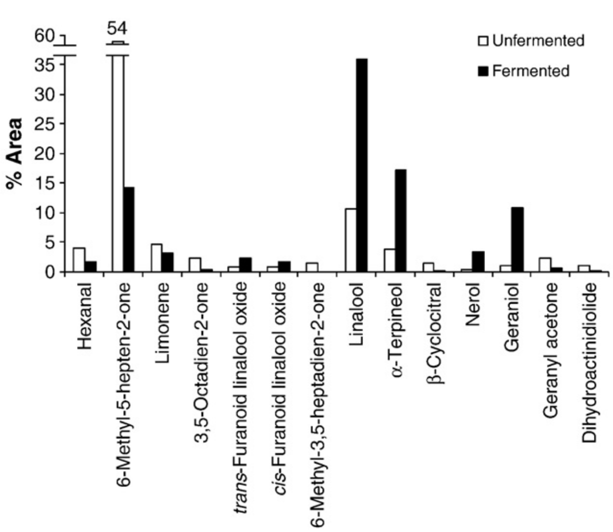


Fig. 9. Quantitative differences in the main volatile components identified by headspace GC–MS between dry, unfermented and dry, fermented *C. genistoides* plant material.
Adapted from Le Roux et al. (2008).

8. Agro-processing

8.1. Fermented honeybush

Processing of honeybush tea is important for development of its characteristic sweet aroma and flavour and the dark reddish brown colour of the leaves and infusion. Research by Cronje on the characterisation of the aroma constituents of honeybush (Cronje, 2010; Le Roux et al., 2008) provides insight into the changes taking place in the volatile fraction of honeybush (discussed in Section 6). The traditional processing methods entailed heap (Marloth, 1909, 1925) and oven fermentation (Hofmeyer and Phillips, 1922), followed by sun drying. As the fermentation heap required no energy input, this technique was favoured by the few on-farm processors in the Langkloof area that supplied the very limited demand for honeybush during the twentieth century (Du Toit et al., 1998). The various approaches followed in the past to bring about the desired sensory changes resulted in large variation in product quality. The use of a fermentation heap, long fermentation periods (3–5 days), temperatures of 50 °C and less that normally prevail towards the outer layer of the fermentation heap and tea moisture contents of 50–60%, resulted in extensive mould and bacterial growth (Du Toit et al., 1998). The thermotolerant mould, *Rhizomucor pusillus*, was found to be the predominant microbial contaminant (Du Toit et al., 1999). In addition to the poor microbial quality of the tea, drying out of the outer layer and inadequate aeration of the heap resulted in under- and unfermented tea, with a grassy flavour and poorly developed leaf colour. Microbial screening of tea sampled at a factory using rotation drums for fermentation and drying showed that the modern process delivers a product with very low total bacterial counts ($<$1000/g) and no moulds, *Salmonella* or *Escherichia coli* present.

The need to ferment at elevated temperatures ($>$60 °C) to eliminate microbial contaminants, and to supply the demand for a consistently high quality product could be achieved only if the environment during honeybush tea processing is controlled, which also allows optimisation of quality. The species, *C. intermedia* and *C. maculata*, both harvested from the wild, were used for optimisation of fermentation parameters. The *C. maculata* (ex Du Toitskloof) that was used for these experiments was later reclassified as *C. buxifolia* (Schutte, 1997) and differs from *C. maculata* growing in the Genadendal/Riversonderend area. One of the complaints of the modern consumers was that the tea released its colour too slowly. By subjecting the plant material to pre-wetting before fermentation colour development was enhanced during fermentation, reducing the occurrence of white pieces of stem in the final product and improving the extraction rate of soluble matter responsible for colour and flavour (Du Toit and Joubert, 1998a).

Sensory evaluation of *C. intermedia* and *C. maculata* (*C. buxifolia*) showed that the time needed for optimum development of the charateristic sweet flavour depended on the fermentation temperature, with increasing temperature requiring a shorter fermentation period (Du Toit and Joubert, 1999). Fig. 10 shows the relationship between the fermentation temperature and time, with the optimum combinations depicted as circles. In some cases the optimum time period could extend several hours past these optima, for example, at 80 °C the optimum period was between 48 and 72 h. Since fermentation is an energy intensive process and prolonging of the fermentation period would not significantly improve quality, the minimum time required for development of flavour would be the choice in practice. Teas fermented at 60, 70 and 80 °C were found to be still under-fermented after 24–36 h and thus unacceptable due to a grassy flavour. On the other hand, fermentation for longer than 36 h at 90 °C resulted in a 'burnt' flavour (Du Toit and Joubert, 1999). Conditions currently in use by industry range from 70 °C/60 h for *C. intermedia* to 80–85 °C/18–24 h for a number of species such as *C. genistoides*, *C. maculata* and *C. subternata*. Investigation of the optimum fermentation temperature–time combinations for these species is currently in progress at the ARC.

Drying of the tea is preferably done under artificial conditions, not only to prevent recontamination and ensure production of a clean, hygienic product (Erasmus, 2002), but also to allow processing of tea during unfavourable weather conditions. Slow drying was found to be undesirable as mould growth can occur before the moisture content is sufficiently reduced. Artificial drying also allows processors to extend the period of processing, which is important in reducing capital requirements. Du Toit and Joubert (1998b) demonstrated that artificial drying does not impair the flavour of the tea, but results in a darker leaf colour with less red. Drying of *C. genistoides* and *C. intermedia* at 40 to 70 °C did not affect their taste, nor the leaf colour of *C. intermedia*, but loss of red colour at high temperature drying was indicated for *C. genistoides.* Optimum aroma for these species was obtained with drying at 50 °C (Du Toit and Joubert, 1998b).

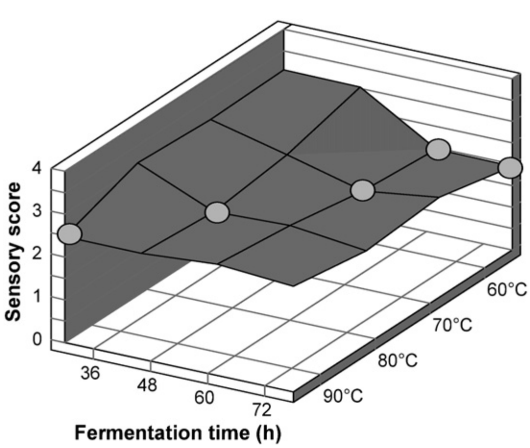


Fig. 10. Effect of fermentation temperature and time on overall quality of honeybush tea (average sensory score for *C. intermedia* and *C. maculata* (re-classified as *C. buxifolia*) with lowest score indicating best quality).
Data from Du Toit and Joubert (1999) combined with unpublished data.

Traditionally plants were harvested when in bloom as this enabled easier identification of the honeybush plants among other fynbos plants. This practice was discontinued as it would limit the harvesting period, placing greater demands on infrastructure and seriously limiting processing output. Furthermore, flowers provide bulk during transport, but disintegrate during rotary fermentation, and are lost as a fine dust when the dried product is sieved before packaging. Du Toit and Joubert (1998b) thus investigated whether flowers are essential for the sweet aroma and flavour of honeybush. Using *C. intermedia* they demonstrated that the presence of flowers improved the aroma and flavour, but was not essential for these characteristic sensory properties, contrary to early popular belief. A follow-up study on *C. maculata*, *C. sessiliflora* and *C. subternata* confirmed that the presence of flowers enhanced both the sweet aroma and flavour of these species, except in the case of *C. sessiliflora*, in which it had no effect on flavour (Table 7; unpublished results). Even with flowers present, the aroma of *C. maculata* was not as sweet as that of *C. sessiliflora* and *C. subternata*. The fermentation of plant material leads to a substantial increase in volatile compounds, especially terpenoids, associated amongst others with sweet-woody, floral-woody, sweet and floral aroma descriptors (Le Roux et al., 2008).

Using *C. subternata*, preliminary experiments were carried out to determine whether the plant age and age of the re-growth (after harvest) affect aroma, flavour and astringency of the infusion (Table 8; unpublished results), as well as its soluble solids content and colour. The only effect observed was for aroma, with infusions of the older plants (3 years versus 2 years) and the older re-growth (12 months versus 3 months) receiving higher scores. Flavour and astringency were not affected by plant age or age of re-growth. In both cases the younger plant material gave infusions with slightly higher soluble solids content than their older counterparts. The colour of the infusion, as determined with objective colour measurement, was not affected by the age of the plant material.

8.2. Unfermented (green) honeybush

Unfermented honeybush is produced by preventing oxidation and browning of the plant material so that a green product is

Table 7
Mean scores [a] and level of significance (P) for the effect of flowers on the aroma and flavour of infusions [b] prepared from three *Cyclopia* spp.

Species	Aroma [a]	Flavour [a]
C. maculata	5.92 (P<0.001)	3.77 (P=0.004)
C. sessiliflora	6.57 (P<0.001)	−2.82 (P=0.049)
C. subternata	8.68 (P<0.001)	3.19 (P<0.001)

[a] Positive values indicate sweeter aroma and flavour obtained when flowers were present for a specific species.

[b] Tea infusion prepared by adding 30 g tea (<2 mm particle size) to 750 ml boiling water and steeping for 5 min. Processing according to standardised method of Du Toit and Joubert (1998b).

Table 8
Mean scores [a] and level of significance (P) for the effect of age of the plant and re-growth on aroma, flavour and astringency of *C. subternata* infusions [b].

Sensory property	Plant age [a,c]	Re-growth [a,d]
Aroma	4.52 (P=0.023)	6.75 (P<0.001)
Flavour	1.07 (P>0.05)	1.65 (P>0.05)
Astringency	−1.07 (P>0.05)	0.17 (P>0.05)

[a] Positive values indicate sweeter aroma and flavour and less astringency for older plants (3 years versus 2 years) and older re-growth (12 months versus 3 months).
[b] Tea infusion prepared by adding 30 g tea (<2 mm) to 750 ml boiling water and steeping for 5 min. Processing according to standardised method of Du Toit and Joubert (1998a).
[c] Harvested on farm in Waboomskraal area.
[d] Harvested on farm in Du Toitskloof area.

obtained. Its aroma has a distinctive grassy note, most probably as a result of the high relative percentage of 6-methyl-5-hepten-2-one, originating from the leaf carotenoids. Other compounds that would contribute to the grassy, green aroma are hexanal, hexenal and hexenol (Le Roux et al., 2008), compounds that normally form with the disruption of the cell membranes of plant material as would be the case during shredding of the leaves. Steaming of the shredded plant material followed by vacuum-drying produces a dried product with excellent retention of the green leaf colour, but due to the high cost of the process, large-scale implementation is not feasible. Steaming has found application in industry, as well as drying without any pretreatment of the plant material before or after shredding. Species differ in the extent to which the green leaf colour is retained. Of the current commercialised species, the best colour retention has been observed in *C. genistoides*. Joubert et al. (2010a), using *C. subternata*, demonstrated that the best colour retention is obtained when the leaves are dried intact, but in terms of industrial feasibility, steaming directly after shredding, followed by immediate drying gave better colour retention than when no steam treatment was used. In the latter case, extractable soluble solids and total polyphenol content of the leaves decreased significantly. The xanthone content of the leaves was decreased by more than 13%. Significant decreases in content were also observed for other phenolic compounds.

8.3. Extracts

Powdered hot water extracts from fermented honeybush are produced for the food and cosmetic industries. At this stage, species are combined for preparation of the extract as not enough plant material is available for the production of species-specific extracts (R. van Breda, Afriplex, Paarl, South Africa; pers. comm.). Yields would depend on the species used. *Cyclopia genistoides* gave the highest yield of hot water soluble solids under laboratory-scale conditions (Fig. 11A). Fermentation of the plant material decreases the yield as much as 41% in the case of *C. subternata* (Fig. 11A). Fermentation also leads to quantitative changes in the phenolic composition of the soluble solids, with the total polyphenol content reduced from 32.4 to 17.5% (Fig. 11B).

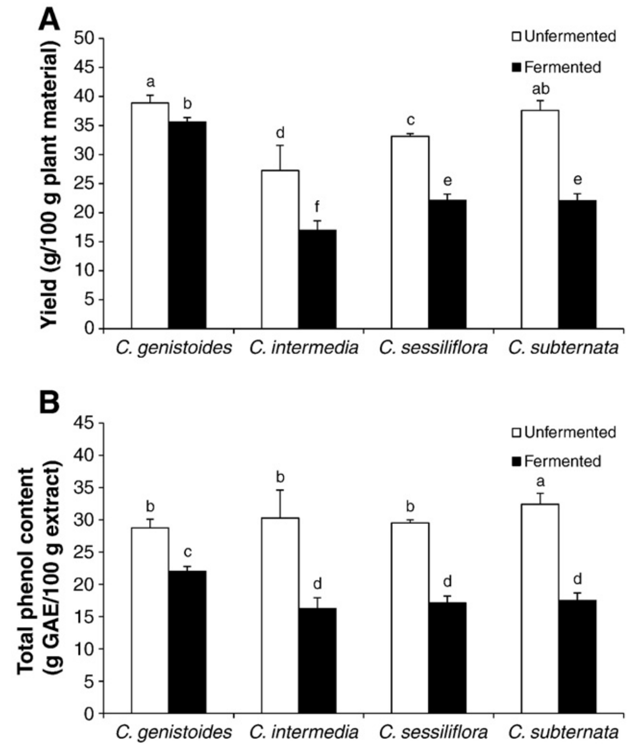


Fig. 11. Effect of *Cyclopia* spp. and fermentation on (A) the yield of soluble solids recovered from the plant material and (B) the total polyphenol content of the soluble solids. Error bars indicate standard deviation. Different letters indicate significant ($P<0.05$) differences between means.
Adapted from Joubert et al. (2008c).

A hot-water honeybush extract with standardised mangiferin content is produced for the food industry. Due to the large variation in mangiferin content of the two cultivated species, *C. genistoides* and *C. subternata*, and the substantial loss in mangiferin with fermentation (Joubert et al., 2008c), a relatively low level of mangiferin is specified. Unfermented *Cyclopia* as source material for the manufacture of mangiferin-enriched extracts, using an organic food grade solvent, has also received attention, but commercialisation has not yet materialised. Experiments have been carried out with *C. genistoides* and *C. sessiliflora* (Grüner et al., 2003). At this stage, the species of choice would be *C. genistoides*, which may contain as much as 7.2% mangiferin (Joubert et al., 2006). Experiments carried out with *C. subternata* showed that 50% aq. ethanol gives the best recovery of soluble solids, total polyphenols, mangiferin and hesperidin from the plant material (Fig. 12; adapted from Maicu, 2008).

9. Quality parameters and regulatory control

Fermented and unfermented (green) honeybush that are exported are subject to the regulatory standards of the Department of Agriculture which are administered by the Perishable Products Export Control Board. Quality and food safety standards as described by the Agricultural Product Standards Act 119 of 1990 (Government Notice No. R 1177 of 24 Nov 2000 and amended according to Notice No. R 1132 of 15 July 2005) deal with classification according to cut size,

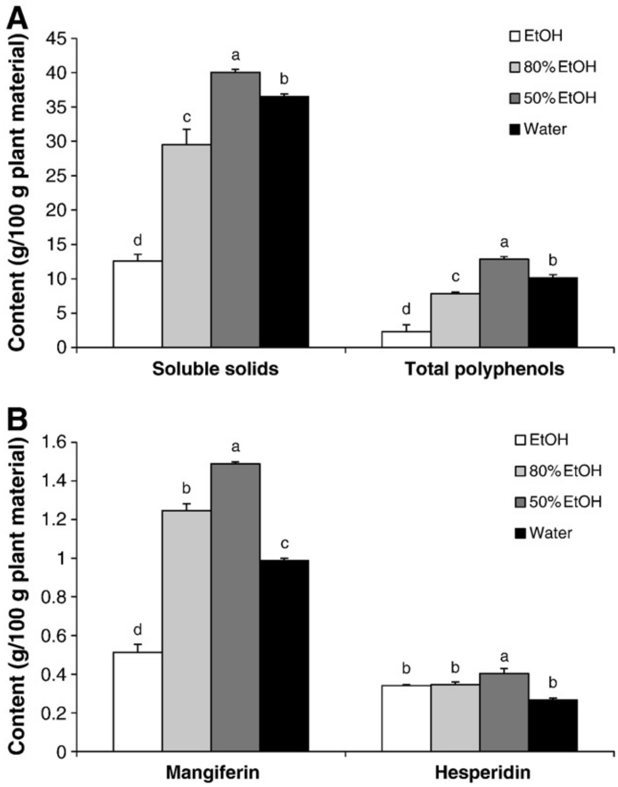


Fig. 12. Extraction efficacy of different solvents for soluble solids (A), total polyphenols (A), mangiferin (B) and hesperidin (B) from unfermented *C. subternata*. Error bars indicate standard deviation. Different letters indicate significant ($P<0.05$) differences between means.
Adapted from Maicu (2008).

moisture content, the presence of foreign matter, insects and frayed tufts, microbial content and pesticide levels. The plant material must be free from *Salmonella*, while limits exist for total bacterial, coliform bacterial, mould and yeast counts. For unfermented honeybush a higher total bacterial count is allowed and *Escherichia coli* (20 cfu/g) may be present. The limits of these standards are stricter than those of the World Health Organization (WHO) guidelines for herbal teas and infusions prepared with boiling water (WHO, 2007). In terms of sensory characteristics, it is specified that the tea must be 'free from any foreign flavours and odours which detrimentally affect the characteristic of the product'. The standard for taste and aroma is non-specific with both fermented and unfermented honeybush having exactly the same description, i.e. 'taste and aroma shall have the clean, characteristic taste and aroma and clear, distinctive colour of honeybush'. This vague description has no meaning in a quality control environment. With this in mind the ARC, in collaboration with the Sensory Laboratory of Stellenbosch University, is currently developing a general sensory wheel and lexicon with both positive and negative aroma, flavour and taste descriptors for fermented honeybush. Several *Cyclopia* spp., i.e. *C. genistoides*, *C. intermedia*, *C. maculata*, *C. sessiliflora* and *C. subternata*, were included in quantitative descriptive analysis carried out by a trained sensory panel.

In the case of industrial extract production, the focus falls on the total polyphenol (TP) content and total antioxidant activity (TAA) of the extracts. Minimum levels specified for these parameters depend on the extract manufacturer and the type of product. Joubert et al. (2008b) and Maicu (2008) determined the relationship between the TP content and TAA for unfermented honeybush extracts, demonstrating, respectively, a poor ($r=0.27$) and moderate correlation ($r=0.85$) for *C. genistoides* and *C. subternata*. The correlation between the mangiferin content of water extracts and their TAA also varied from moderate ($r=0.75$) for *C. genistoides* (Joubert et al., 2008b) to poor ($r=0.53$) for *C. subternata* (Maicu, 2008).

Investigation of near-infrared spectroscopy (NIRS) as a rapid method for quality control at the raw material stage of extract manufacture showed that the level of accuracy of the technique would make it suitable for screening the mangiferin and hesperidin contents of unfermented *C. genistoides* (Joubert et al., 2006). In the case of *C. subternata,* prediction of its mangiferin content would be less accurate than for *C. genistoides*, but still suitable for screening purposes (Maicu, 2008). Principal component analysis of the NIRS data of the milled plant material showed two clusters with slight overlap between samples (Fig. 13; data from Joubert et al., 2006 and Maicu, 2008), indicating that the technique could be used to distinguish between the species when the plant material is in a milled state.

10. Value-addition

The value-adding potential of *Cyclopia* remains underdeveloped as demand for honeybush as a tea still exceeds supply. A small quantity of extract is produced for use in food products, cosmetics and toiletries. A major international food ingredients company offers honeybush extract standardised to a

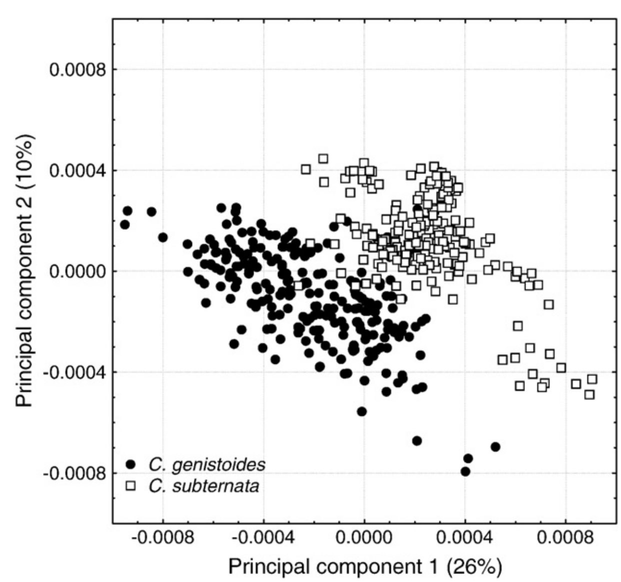


Fig. 13. Principal component analysis score plot (PC1 versus PC2) of near-infrared spectroscopy data illustrating the classification between *C. genistoides* and *C. subternata* plant material samples.
Compiled from data of Joubert et al. (2006) and Maicu (2008).

minimum level of 1.5% mangiferin as a dietary supplement for drinks, dairy products and food bars. Research, and in particular the investigation of the phenolic composition of honeybush (Ferreira et al., 1998; Kamara et al., 2003, 2004) played a vital role in identifying potential value-adding opportunities from this fynbos species. Foremost is the potential of *Cyclopia* spp., especially *C. genistoides*, for the production of an antioxidant product high in mangiferin content. The latter and its sustainability make *C. genistoides* an attractive source of mangiferin. Other potential applications are for the prevention of skin cancer, alleviation of menopausal symptoms and lowering of blood glucose levels. *Cyclopia intermedia*, used in a skin cancer study, showed promise for inhibition of tumour development (Marnewick et al., 2005). Extracts of unfermented and fermented plant material of a number of species was initially screened for phytoestrogenic activity (Verhoog et al., 2007a). Follow-up investigation of the phytoestrogen potential concentrated on unfermented *C. genistoides* (Verhoog et al., 2007b) and *C. subternata* (Mfenyana et al., 2008). Benchmarking of the *C. subternata* extracts against four commercial phytoestrogenic preparations demonstrated potency and efficacy in cell models comparable to the commercial products, including a soy extract, suggesting its potential as a phytoestrogen product for the nutraceutical market. The anti-diabetic potential of *Cyclopia* extract, shown by a consortium of ARC and MRC researchers in 2003, received patent protection in 2007 (Mose Larsen et al., 2008).

11. Future research and challenges

The past 20 years saw many inputs in terms of research, which catalysed the development and underpinned the growth of the honeybush industry. For sustained growth, research should be intensified to ensure that this agricultural and agro-processing industry remains competitive. Aspects that need urgent attention include: sustainable harvesting of *C. intermedia*; improvement of genetic material; effective organic control of weeds, diseases and pests; fertilisation and irrigation requirements of different species; complete mapping of suitable production areas for different species; and sustainable production practices for *C. intermedia, C. longifolia*, *C. macalata* and *C. sessiliflora*. Furthermore, groundwork for implementation of a biodiversity programme for honeybush cultivation and registration of a honeybush GI is needed.

The main challenge faced by the honeybush industry is to provide an adequate supply for the growing demand of the local and international markets. To achieve this, higher production per hectare, as well as an increase in the area under cultivation, is essential. Sustainable harvesting in the wild can also contribute to increased production, yet harvesting guidelines are needed to ensure survival of natural stands and to provide access to sensitive areas. A greater demand for the product in the very competitive herbal tea market must be created through promotional activities in order to facilitate sustainable growth of the industry. Current labelling regulations limit health claims that can be made. In vivo substantiation of health promoting properties will increase consumer awareness and demand for the product. Consumer awareness, even locally, is still low and a concerted effort of different role players is required to remedy the situation. Furthermore, South African legislation on biodiversity and environmental issues restricts research activities and commercialisation.

Honeybush tea represents a prime example of the transition made by a fynbos plant ‘from the wild to commercialised’ in South Africa. Continued success of this agricultural and agro-processing industry will depend on cooperation of all stakeholders to meet the challenges.

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