

# African wormwood production



agriculture,  
forestry & fisheries

Department:  
Agriculture, forestry & fisheries  
REPUBLIC OF SOUTH AFRICA

# African wormwood production



June 2009

---

DEPARTMENT OF AGRICULTURE  
Directorate: Plant Production

---

2009

Compiled by Directorate Plant Production in collaboration with  
members of SAEOPA and KARWIL Consultancy

Obtainable from

Resource Centre  
Directorate Agricultural Information Services  
Private Bag X144, Pretoria, 0001 South Africa

The web: [www.nda.agric.za/publications](http://www.nda.agric.za/publications)

Published by

Directorate Agricultural Information Services  
Department of Agriculture  
Private Bag X144, Pretoria, 0001 South Africa

Further information or contacts

Directorate Plant Production, Division Industrial Crops

Tel: 012 319 6079

Fax: 012 319 6372

E-mail: [DPP@nda.agric.za](mailto:DPP@nda.agric.za)

## CONTENTS

<b>Part I: General aspects</b> .....	1
1. Classification .....	1
2. Origin and distribution .....	2
3. Production levels .....	2
4. Major production areas in South Africa .....	2
5. Description of the plant .....	3
6. Cultivars .....	4
7. Climatic requirements .....	7
8. Soil requirements .....	7
<b>Part II: Cultivation practices</b> .....	8
1. Propagation .....	8
2. Soil preparation .....	8
3. Planting .....	9
4. Fertilisation .....	10
5. Irrigation .....	10
6. Pest control .....	10
7. Disease control .....	11
8. Weed control .....	12
9. Other cultivation practices .....	12
10. Mulching .....	13
11. Harvesting .....	13



<b>Part III: Post-harvest handling</b> .....	13
1. Sorting and distillation .....	13
2. Grading .....	14
3. Packaging and storage .....	14
4. Marketing .....	14
<b>Part IV: Production schedules</b> .....	15
<b>Part V: Utilisation</b> .....	17
1. Industrial .....	17
2. Pharmaceutical and therapeutic .....	17
3. Other .....	17
4. Safety data .....	18
<b>References</b> .....	18



(Photo: SANBI: [www.sanbi.co.za](http://www.sanbi.co.za))

---

## Part I: General aspects

---

### 1. CLASSIFICATION

**Scientific name:** *Artemisia afra*, A.

**Common names:** Wild wormwood, African wormwood (English); wildeals (Afrikaans); umhlonyane (isiXhosa); mhlonyane (isiZulu); lengana (Setswana); sengana (Southern Sotho)

**Family:** Asteraceae

The alternative family name Compositae is derived from the Latin word *compositus* which means 'made up of parts united in one common whole'. This refers to the collection of different florets arranged together in an inflorescence.

## 2. ORIGIN AND DISTRIBUTION

*Artemisia afra* is distributed worldwide; there are more than 400 species, mainly from the Northern hemisphere. Many of the other *Artemisia* species are aromatic perennials and are used for medicinal purposes.

*A. afra* is a common species in South Africa with a wide distribution in all provinces of South Africa, except the Northern Cape. It also grows in Lesotho, Swaziland and northwards into tropical Africa.

In the wild it grows in mountainous areas, at altitudes of up to 2 500 m on damp slopes, along stream edges and forest margins. *A. afra* is the only indigenous species in this genus.

## 3. PRODUCTION LEVELS

### South Africa

Some 10 to 20 tons of leaf material per hectare per year can be expected. The yields of oil vary considerably at different sites in South Africa. A range of between 0,3 to 3,2 % has been achieved by the South African Essential Oil Producers' Association (SAEOPA) growers.

### Internationally

There is international interest in the chemical properties of *A. afra* within the pharmaceutical and perfumery fields. Limited quantities of *A. afra* essential oil are being sold internationally. In certain quarters, the oil is traded on the world markets under the name 'Lanyana'. It has been reported that in 1993 the worldwide production was 750 kg, worth US \$510 000, and there are no current figures that are reported in the market.

## 4. MAJOR PRODUCTION AREAS IN SOUTH AFRICA

*A. afra* is a common species in South Africa with a wide natural distribution from the Cedarberg mountains in the Western Cape throughout the Eastern Cape, KwaZulu-Natal, Mpumalanga, Free State, Gauteng, North West and Limpopo provinces. It is currently cultivated on a limited scale in the KZN Midlands (Cedara),



**African wormwood**  
**(*Artemisia afra*)**  
**(Photo:**  
**SA HealthInfo)**



at Tongaat and Newcastle, Mpumalanga (Nelspruit), Gauteng (Pretoria). Cultivation also takes place in the Eastern Cape and Limpopo provinces.

## **5. DESCRIPTION OF THE PLANT**

### **Stem**

*A. afra* is a highly aromatic, an erect, multistemmed, perennial shrub of up to 2 m in height.

### **Leaves**

It has feathery leaves, finely divided, and silver greyish to green in colour. The leaves are up to 80 mm long × 40 mm wide.



### **Flowers**

Flowers are inconspicuous, yellow and borne at the ends of branches in globose capitula's ± 3 mm in diameter.

The cream coloured flower heads are produced at the end of summer.





*Artemisia afra* flower

(Photo: Wild flowers of Northern South Africa; Anita Fabian and Gerrit Germishuizen)

## Essential part

Stems, leaves and flowering tops are distilled. Processing or distillation is done when the leafy stems are still fresh (i.e. soon after harvesting).

## 6. CULTIVARS

Currently, there are no registered cultivars of *A. afra* in South Africa. Selections are being made at Cedara College of Agriculture, according to physical and chemical properties. Research on the germination and propagation was done at the University of Pretoria and Lowveld College of Agriculture during 2002 (SAEOPA, Database.)

Some of the *Artemisia* species that are grown in South Africa are:

### *Artemisia absinthium*

Common wormwood.

It is an expansive spreading shrub-like plant. It grows up to 1,2 m and has coarsely lobed, alternate leaves that are covered with a silky pubescence, giving the plant a grey appearance. The flower heads are spherical and borne with panicles. Propagation is by cuttings, root division and seeds. It has to be planted in soils which contain some clay. Stakes are sometimes used to hold the plants.



***Artemisia absinthium***



***Artemisia absinthium***  
**(Photo: Norman Hagen)**

Harvesting is done when the plants are in full bloom. The less woody stems and branches, with their flowering tops, should be cut off and dried in the shade, then stripped, pulverised and stored.

### ***Artemisia dracunculus*, commonly known as tarragon**

Tarragon is perennial and herbaceous, but is somewhat shrub-like in growth, tending to be woody in the base. The leaves are alternate, long and narrow with entire margins. The small, greenish-white flower heads are in loose panicles.

The plant reaches a height of about 0,6 m. The fresh leaves are used in pickles and salads and for flavouring vinegar. When dried, they can be added to chops, steaks, soups, stews, egg dishes, chicken mushrooms, tartar sauce, fish sauces and mayonnaise.



*Artemisia vulgaris*

***Artemisia vulgaris*, also called mugwort, felon herb, St John's plant, bulwand, sailor's tobacco and green ginger**

*Artemisia vulgaris* is naturalised in the Eastern Cape. Mugwort is native to Europe, Asia, and North America. It is widely distributed in the United States, where it has become a weed of pasture and fields. Mugwort grows to a height of 0,5 m or more. It has a spreading habit, the stems are often purplish. The mature leaves are dark green above, but the underside is white with a cottony pubescence. The flower heads are very small, numerous, light yellow, in paniculate spikes.

***Artemisia annua*, commonly know as Chinese wormwood or sweet wormwood)**

This plant is native to Asia and is cultivated for the chemical constituent artemisinin which is used as an antimalarial drug. There is considerable worldwide interest, and several new selections have been made that have high quantities of artemisinin.

## **7. CLIMATIC REQUIREMENTS**

### **Temperature**

*A. afra* is planted in temperate and subtropic regions. Actively growing in the summer months, it is able to withstand quite low temperatures during the winter months.

### **Rainfall**

*A. afra* can be cultivated successfully where rainfall is in excess of 650 mm per year. Its natural habitat is in the higher-rainfall areas of the coastal regions and central escarpment area.

## **8. SOIL REQUIREMENTS**

*A. afra* grows well in well-drained, sandy, sandy loam and loam soils with a pH of 5,0 to 7,5.



---

## Part II: Cultivation practices

---

### 1. PROPAGATION

#### Propagation methods

##### *Vegetative propagation*

*A. afra* can be propagated by root or stem cuttings that root easily in spring and summer. Take 10 cm cuttings, trim off excess leaves at the base of the stem. Plant cuttings half to two thirds of the length into a prepared tray or seedbed and keep moist until well established. Use of semihardwood rooting hormone will ensure formation of roots in 4 to 6 weeks. A nursery with a mist bed and heated floor will enhance rooting.

Root cuttings also work well, however, only a limited quantity can be made from a single mother plant. Plantlets need to be planted out from trays or beds to bigger plant bags. Once a plantlet has a strong root system it can be planted out into the land.

##### *Seed collecting*

Seed collecting from wild populations may produce plants that are diverse in physical and chemical appearance. If cultivars with specific properties are selected in future, it is recommended that vegetative propagation be done to keep these true to type. Fresh seed germinates readily, but plants take longer to mature than from cuttings.

### 2. SOIL PREPARATION

Herbal and essential oil crops grown on natural soils yield products that are of high quality and in demand globally. Producers are advised to have the soil

analysed at a laboratory to check for mineral deficiencies and excesses, organic status and carbon ratios. A soil analysis will be a guideline to the producer in correcting the nutritional status of the soil. Fertiliser use has to be planned according to whether the crop will be grown inorganically or organically.

Soil preparation has to be done according to good cultivation practices. Suitable soil preparation practices have to be followed according to the farming operation (rip, plough, disc, harrow, contour, etc.). If mechanical harvesting and weed control is envisaged, prepare row widths adapted to the machinery to be used.

Producers who follow the correct soil treatment will have the benefit of producing crops of high value with lower input costs in terms of weed, pest and disease control.

### **3. PLANTING**

#### **Planting density/spacing**

Direct seeding into the land is difficult because of the very small seed. Seed can be mixed with a neutral carrier such as superphosphate and finely ground lime on a 50:50 blend. Overseeding is needed to ensure a proper stand. The seeds can be sown in rows using the fertiliser bins of the planter or specialised planters. Plant spacing in the row should be 30 cm with a 60 cm row width. This will give 55 000 plants per hectare. The carrying capacity of the soil and available irrigation, as well as machinery to be used in cultivation and harvesting will also have an influence on plant density.

#### **Planting date**

Planting of rooted cuttings can be done as soon as the active growing season commences, and mostly during the time of the year when soil moisture is sufficient. Avoid planting during very hot times of the year and close to and during winter when plants are usually dormant. Planting can be done from the middle of October to the beginning of January.

## Planting depth

Seeding depth should be 5,0 mm below the soil. The use of a roller will enhance emergence. Plant stand is affected as plants have to be thinned to the correct spacing after emergence.

## 4. FERTILISATION

As there are very few trials being done on fertilisation in South Africa, recommendations are made from work done on the fertilisation of *A. annua* in Australia. The plants reacted well to nitrogen phosphate and potash applied at 60 kg N, 60 kg P and 50 kg K and predrilled in bands.

Organic compost supplied at 3 to 5 t/ha has good results.

Correct interpretation of soil analysis results according to soil type will provide guidance to shortages and excesses and the soil has to be adapted to the correct balance. The pH levels below 5,0 and above 7,5 could cause problems with growth.

## 5. IRRIGATION

Irrigate regularly after transplanting, for the first 3 months, to get the plants established. Irrigate then, when necessary, until the plants reach maturity.

If rainfall is sufficient, the crop can be farmed on dryland. Irrigation will increase production. Do not overirrigate. Flood, sprinkler and drip irrigation can be used.

It has been shown in trials that oil yields increase with stress factors such as moisture and heat. It is, therefore, a good practice to stop irrigation in time before harvesting to induce this kind of stress. Irrigation should be stopped well in advance of harvesting to put plants under stress to produce oil. Irrigation tends to increase herbage, but reduce oil content in leaves.

## 6. PEST CONTROL

No serious pests have been noticed on *A. afra*. Because the crop is not cultivated on a major scale commercially, the presence of pests may be recorded in future.



For prospective producers of herbal and essential oil crops, the following pest control guidelines are recommended.

### **Pest control guidelines**

- ◆ Natural pest control measures should be used as first choice.
- ◆ Follow a pest management programme.
- ◆ Regular scouting of the crop is needed.
- ◆ Early detection and management of pest problems can prevent major problems.
- ◆ The knowledge of certain herbs that repel or attract insects can be used in companion planting for pest control.
- ◆ If organic practices will be used, make sure that products are certified for use.

Extension officers from the Department of Agriculture and researchers from agricultural institutes should be contacted for further information on the identification of insects and for recommended controls,

Use the publication\* *A guide for the control of plant pests – 2002*, compiled by Annette Nel, Mareli Krause, Neervana Ramautar & Kathy van Zyl.

## **7. DISEASE CONTROL**

No known diseases have been recorded for *A. afra* in South Africa.

Because most of the production is still from wild harvesting, plant diseases have not been noticed.

### **Disease control guidelines**

- ◆ Follow a disease management programme.

---

\* Obtainable from the Resource Centre, Directorate Agricultural Information Services, Private Bag X144, Pretoria, 0001. Tel: 012 319 7141/7085. Fax: 012 319 7260

- ◆ Regular scouting of the crop is needed.
- ◆ Early detection and management of diseases can prevent major problems.
- ◆ Natural organic disease control measures should be used as first choice.
- ◆ Use clean seed and plant material from a reputable supplier.

## 8. WEED CONTROL

Hand-hoeing and mechanical weeding with a tractor-drawn cultivator is recommended for the control of weeds. Take care not to damage the roots. A good plant density and quick formation of a canopy will decrease weed population. Generally, 2 to 3 weeding sessions are necessary during the year.

A better option is to use the distillation waste in making organic compost with it and to apply the compost as mulch. Exclusion of sunlight is one of the best weeding practices. Cover crop practices with plants that inhibit weed growth is advised.

Very little information exists on herbicides that can be used. Until proper trials can be done, no recommendations can be given.

### Weed control guidelines

- ◆ Do not allow weeds to set seed in the land.
- ◆ Shade-out weeds by plant canopy, high plant density, closer row width, if moisture content of the soil and crop specification allow for it.
- ◆ Use manual or mechanical control.
- ◆ Organic control measures, such as flame weeding and ultraviolet (UV) radiation, can be used where applicable, and if the crop can tolerate the method.

## 9. OTHER CULTIVATION PRACTICES

Wild harvesting has been done in the past and is still applied on a small scale. Care should be taken to harvest wild populations on a sustainable basis and under supervision of the relevant departments.

## 10. MULCHING

Mulching reduces the weed incidence in the crop and increases soil moisture retention. Distillation waste of this crop, applied as organic mulch is found effective for controlling weeds in the crop. Mulching with compost or grass will inhibit weed growth.

## 11. HARVESTING

### Date and method of maturing

Two harvestings of the leaves could be made in the same season, the first in mid-summer, and the second in late summer or early autumn, before frost occurs.

When harvesting for essential oil production, cut off the upper green foliage and leave the lower woody parts of the stems. The plants respond well to mechanical harvesting if sharp cutters that do not splinter the woody stems are used.

The essential oil distilled from flowering tops has a higher oil yield as well as superior quality. Harvesting should be done from beginning to mid-flowering time when oil quality is the best.

---

## Part III: Post-harvest handling

---

### 1. SORTING AND DISTILLATION

Harvesting wet plants could cause poor oil recovery during distillation.

It is better to wait a few days after rain and harvesting after at least 3 days of hot sunshine to ensure good oil yield. Distillation of fresh plant cuttings has to be done. Trials have to be undertaken with wilting to establish if there is a positive action. The material should be packed firmly as this prevents the formation of steam channels. If the material is too long it can be cut into smaller pieces to ensure firm packaging.

The mixture of vapours of water and *Artemisia* oil passes into the condenser. As the distillation proceeds, the distillate collects in the separator. The oil, being insoluble and lighter than water, floats on the top in the separator and is continuously drawn off. The oil is then poured out and filtered manually or by using chemicals.

## 2. GRADING

*A. afra* essential oil is straw-coloured, with a fresh, herby, slightly camphoric top note. With time, a highly agreeable herbal-sweet and spicy fragrance develops.

Main components in oils obtained from wild populations of *A. afra*: 1.8 cineole (50,4 %),  $\alpha$ -thujone (74,91 to 75,28 %),  $\beta$ -thujone (21,49 to 22,44 %), and camphor (22,9 %). These components vary considerably in samples taken from wild populations all over South Africa. There is positive evidence that the chemical content of *A. afra* can change considerably, depending on the locality where it is grown. Further research is needed on plants from all over South Africa.

Another known fact is that plants with varying chemotypes have been found in different natural localities in the country. Research is currently done on these occurrences and different types have to be selected for specific desired chemical constituents in the trade (SAEOPA, Database).

## 3. PACKAGING AND STORAGE

Essential oils are stored in air-tight fluorinated plastic, treated aluminium, dark glass or ceramic containers (in a cool, dry place away from direct sunlight).

## 4. MARKETING

### Essential oil market

The major market in the world for essential oils is the United States, followed by Japan and Europe. However, production continues to be concentrated in Europe, with seven of the world's largest essential oil processing firms.

In the United States, the major users of essential oils are the soft drink companies. Japan accounts for 10 % of the world demand. The Canadian market is dominated by the United States perfume and flavouring industry. France is dominating the world perfumery market, and Switzerland is one of the leaders in the pharmaceutical field. Britain and India are known to feature strongly in the flavouring sector.

The essential oil industry is characterised by a number of difficulties, including lack of stable quality, inconsistent supplies, and variability of active ingredients owing to environmental effects. This has encouraged many of the end users to depend on synthetic oils in an effort to eliminate the above problems. The result is a weaker market for naturally produced essential oils.

With the increased interest in “natural” products and growing health consciousness among the public, plus the fact that a natural product is perceived to have a superior quality, there is an opportunity to effectively market natural grown essential oils should the above problems be addressed.

---

## **Part IV: Production schedules**

---

As farming enterprises are so diverse, a very basic schedule is proposed. Producers have to adapt the schedule to their own needs.

Production schedules may differ considerably according to climate, region, topography, slope, rainfall and availability of irrigation. Producers should take into consideration the fact that there are other soil preparation practices such as no till or minimum tilling. Weed, pest and disease control will also be influenced by climate, rainfall and region.

There is no “typical schedule” for any of these crops; it should be adapted depending on the region and existing agricultural conditions, practices, equipment and infrastructure.

General crop schedule – <i>Artemisia afra</i>												
Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Field preparation</b>												
Rip and plough												
Disking												
Prepare seedbed												
<b>Planting, cultivation and harvesting</b>												
Plant and transplant												
Weed control												
Pest control												
Disease control												
Irrigate												
Harvest												

---

## Part V: Utilisation

---

*A. afra* is one of the medicinal plants used most widely and effectively by people of all cultures in South Africa. It has a very bitter taste and is usually sweetened with sugar or honey when taken. "Wildeals" brandy is a very popular medicine which is currently made and sold.

### 1. INDUSTRIAL

The roots, stems and leaves are used in many different ways and taken as poultices, infusions, body washes, lotions, smoked, snuffed or taken as a tea for a wide range of ailments such as diabetes, measles, coughs, colds, fever, loss of appetite, colic, earache, enemas and headache.

### 2. PHARMACEUTICAL AND THERAPEUTIC

It is effective against all lung-related illnesses and to clear blocked nasal passages. It is used as an inhalation for the relief of headache and nasal congestion. In traditional practice, fresh leaves are inserted into the nostrils to relieve nasal congestion or placed in boiling water as a steam bath for menstrual pain or after childbirth. Warmed leaves may be applied externally as a poultice to relieve inflammation. Aqueous infusions are administered per rectum or applied as a lotion to treat haemorrhoids.

### 3. OTHER

*A. afra* has been reported to contain antihistamic and narcotic analgesic effects. The volatile oil obtained from the aboveground parts of the crop showed antimicrobial activity against various bacteria and fungi of public health or agricultural significance. The antioxidant activity of the oil in preventing the decolouration of  $\beta$ -carotene and linoleic acid was also demonstrated from the same study (Matsabisa, 1999).



*A. afra* is also known to have good insecticidal properties and can be used as a companion plant to reduce pest pressure on crops. It should be planted as a border plant surrounding other medicinal or vegetable plants.

It is used in formulations for animal shampoos and insect repellents.

#### 4. SAFETY DATA

Owing to high content of thujone, this oil must not be used internally, and should be used with caution during pregnancy and for epileptics. This is a herb that should not be taken longer than a 7 to 10 day period as it can cause headaches and shaking.

#### REFERENCES\*

- AFRICAN LABORATORY FOR NATURAL PRODUCTS (ALNAP) 2001. Medicinal and aromatic plants. Addis Ababa, Ethiopia: ICS-UNIDO.  
Online: <http://www.ics.trieste.it/essentialOils/alnap.aspx>. Accessed 16 August 2006.
- DU PREEZ, R. 2005. *Herbs for the garden*. Nelspruit, South Africa: ARC-Institute for Tropical and Subtropical Crops.
- ESTEBAN, M.D., COLLADO, I.G., MACIAS, F.A., MASSANET, G.M. & LUIS, F.R. 1986. *Flavonoids from Artemisia lanata* *Phytochemistry*, 25: 1502–1504.
- FABIAN, A. & GERMISHUIZEN, G. 1997. *Wild Flowers of Northern South Africa*. Cape Town, South Africa: Fernwood Press.
- FERREIRA, J.F.S., SIMON, J.E. & JANICK, J. 1997. *Artemisia annua*: botany, horticulture and pharmacology, in: *Horticultural Reviews*. Edited by J. Janick. John Willey & Sons, Inc. 19: 319–371.
- GRAVEN, E.H., WEBER, L., VENTER, M. & GARDNER, J.B. 1990. The development of *Artemisia afra* (Jacq.) as a new essential oil crop. *The Journal of Essential Oil Research*, 2: 215–220. (ALNAP Database Ref. ID: 2298).
- GUOSHI, T., CHEN, C., FANG, Q. & JIANG, H. 1988. In: *Pharmacopoeia of the People's Republic of China*. Edited by S. Cheng, M. Fang and J. Guo. English Ed. Beijing, China: The People's Medical Publishing House, 63.

---

\* Further information on references could be obtained from members of SAEOPA and KARWYL Consultancy.

- HARPER, D. 2004. Malaria. Online Etymology Dictionary.  
Online: <http://www.etymonline.com/index.php?search=malaria&searchmode=none>.  
Accessed 25 August 2006.
- MATSABISA, G.M. 1999. Traditional medicines: *Artemisia afra* herba. SA Healthinfo. Online:  
<http://www.sahealthinfo.org/traditionalmeds/monographs/artemisia.htm>. Accessed  
13 September 2006.
- THE CENTRE FOR NOVEL AGRICULTURAL PRODUCTS' (CNAP). *Artemisia* Research Project. *A sustainable supply of Artemisia from high yield Artemisia annua*. 2007. The University of York, Department of Biology.  
Online: <http://www.york.ac.uk/org/cnap/artemisiaproject/index.htm>. Accessed 13  
September 2006.
- HUTCHINGS, A., SCOTT, A.H., LEWIS, G. & CUNNINGHAM, A. 1996. *Zulu medicinal plants. An Inventory*. University of Natal Press, National Botanical Institute, University of Zululand. 362–327.
- MCNEIL, D.G. 2004. Herbal Drug is embraced in Treating Malaria. The New York Times.  
Online: <http://www.nytimes.com>. Accessed 23 August 2006.
- MUELLER, M.S., KARHAGOMBA, I.B., HIRT, H.M. & WEMAKOR, E. 2000. The potential of *Artemisia annua* L. as a locally produced remedy for malaria in the tropics: agricultural, chemical and clinical aspects. *Journal of Ethnopharmacology*. 73: 487–493.
- OLUMESE, P. 2004. Antimalarial combination therapy in Africa. *Africa Health*. Online:  
[http://mosquito.who.int/cmc\\_upload/0/000/015/270/ah\\_therapy\\_po.htm](http://mosquito.who.int/cmc_upload/0/000/015/270/ah_therapy_po.htm). Accessed  
23 August 2006.
- PURCELL, K. 2004. WHO Approves Artemisinin for Malaria in Africa *American Botanical Council HerbalGram*, 64:19–20. Online: <http://www.herbalgram.org>. Accessed  
06 September 2006.
- ROBERTS, M. 1990. *Indigenous healing plants*. Halfway House, South Africa: Southern Book Publishers.
- SIMON, J., PARK, C., QING-LI, WU. & JULIANI, R. 2005. *Artemisia annua*, the anti-malarial: From Botany and Biology, through Chemistry and Pharmacology to Production, Processing and Post-harvest handling *Use Agriculture and Natural Plant Products Program, Rutgers University*. Presentation at essential oil conference, Stellenbosch.
- SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE, THE SOUTH AFRICAN MEDICAL RESEARCH COUNCIL AND THE UNIVERSITY OF THE WESTERN CAPE MONOGRAPH 2008. South African National Biodiversity Institution. Online: <http://www.sanbi.com>. Accessed 23 August 2006.
- THE INTERNATIONAL FEDERATION OF PHARMACEUTICALS MANUFACTURES ASSOCIATIONS (IFPMA) 2004. Novartis Coartem.  
Online: [http://www.ifpma.org/Health/malaria/health\\_coartem\\_mal.aspx](http://www.ifpma.org/Health/malaria/health_coartem_mal.aspx). Accessed  
06 September 2006.

- THE WORLD HEALTH ORGANIZATION 2004. Roll Back Malaria Infosheet. *Facts on ACTs (Artemisinin-based Combination Therapies), An update on recent Progress in Policy and Access to Treatment*. Online: [http://www.rbm.who.int/cmc\\_upload/0/000/015/364/RBMInfosheet\\_9.htm](http://www.rbm.who.int/cmc_upload/0/000/015/364/RBMInfosheet_9.htm). Accessed 16 August 2006.
- TRIGG, P.I. & KONDRACHINE, A.V. 1998. Commentary: malaria control in the 1990s. *Bulletin of the World Health Organization*, 76:11–16.
- UNICEF. 2004. *Malaria*. Online: [http://www.unicef.org/health/index\\_malaria.html](http://www.unicef.org/health/index_malaria.html). Accessed 20 September 2006.
- VAN DER WALT, L. 2004. *Artemisia afra (Jacq.) ex Wild. Kirstenbosch, South African National Biodiversity Institute*.  
Online: <http://www.plantzafrica.com/plantab/artemisiaafra.htm>. Accessed 17 January 2006.
- VAN WYK, B.E., VAN OUDTSHOORN, B. & GERICKE, N. 1997. *Medicinal plants of South Africa*. Pretoria: Briza Publications. 142.
- WATT, J.M. & BREYER-BRANDWIJK, M.G. 1962. *Medicinal and poisonous plants of southern and eastern Africa*. 2<sup>nd</sup> Edition. London: E & S Livingstone. 197.
- World Health Organization. 2003. *African malaria report*.  
Online: [http://www.rbm.who.int/amd2003/amr2003/amr\\_toc.htm](http://www.rbm.who.int/amd2003/amr2003/amr_toc.htm). Accessed 07 September 2006.
- WORLD HEALTH ORGANIZATION 2004. Part II: 1.3 *Artemether-Lumefantrine. The Use of Antimalarial Drugs*.  
Online: [http://mosquito.who.int/cmc\\_upload/0/000/014/923/am2\\_1-13.htm](http://mosquito.who.int/cmc_upload/0/000/014/923/am2_1-13.htm). Accessed 07 September 2006.
- WORLD HEALTH ORGANIZATION 2004. Review of application for Inclusion of a drug in the WHO essential drug list. *Fixed combination of artemether and lumefantrine (Coartem®)*.  
Online: <http://www.who.int/medicines/organization/par/edl/coartem.doc>. Accessed 07 September 2006.
- WORLD HEALTH ORGANIZATION 2004. Roll back malaria infosheet. *What is Malaria?* Online: [http://www.rbm.who.int/cmc\\_upload/0/000/015/372/RBMInfosheet\\_1.htm](http://www.rbm.who.int/cmc_upload/0/000/015/372/RBMInfosheet_1.htm). Accessed 07 September 2006.
- WRIGHT, C.W. 2002. *Artemisia*. First edition. London, New York: Taylor & Francis. 344 pp.

