

German chamomile production



agriculture,
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REPUBLIC OF SOUTH AFRICA

German chamomile production



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CONTENTS

Part I: General aspects	1
1. Classification	1
2. Origin and distribution	2
3. Production levels	2
4. Major production areas in South Africa	3
5. Description of the plants	3
6. Cultivars	4
7. Climatic requirements	4
8. Soil requirements	5
Part II: Cultivation practices	5
1. Propagation	5
2. Soil preparation	6
3. Planting	6
4. Fertilisation	7
5. Irrigation	7
6. Weed control	7
7. Pest control	8
8. Disease control	9
9. Harvesting	9



Part III: Post-harvest handling	10
1. Sorting and distillation	10
2. Grading	10
3. Packaging	10
4. Storage	11
5. Marketing	11
Part IV: Production schedules	12
Part V: Utilisation	15
1. Medicinal and therapeutic	15
2. Industrial	15
3. Other uses	15
4. Safety data	16
References	16



Part I: General aspects

1. CLASSIFICATION

Scientific names: *Matricaria recutita* (German chamomile)
Chamaemelum nobile (Roman chamomile)

Common names: German chamomile: Chamomile, Hungarian chamomile, Matricaris, Blue chamomile, Sweet false chamomile.
Roman chamomile: English chamomile, True chamomile, Sweet chamomile.

Family: Asteraceae

2. ORIGIN AND DISTRIBUTION

German chamomile is an annual plant that is native to Southern and Western Europe, and North and West Asia. It has been cultivated in North America and Australia where it is naturalised. Roman chamomile, a perennial species, has similar uses.

Dried chamomile flower is an age-old medicinal drug that was well known in ancient Egypt, Greece and Rome. In Egypt, chamomile had a religious use as the plant was consecrated to the god of the sun. Chamomile's popularity grew throughout the Middle Ages, when people used it as a remedy for numerous medical complaints. The word chamomile is derived from the Greek roots – *chamos* (ground) and *melos* (apple), referring to the fact that the plant grows low to the ground, and the fresh blooms have a pleasing apple scent.

There is also Roman chamomile, *Chamaemelum nobile*, and the indigenous Cape chamomile, *Eriocephalus spp.*, but these two are mostly not commercially planted as compared to German chamomile cultivars.

3. PRODUCTION LEVELS

South Africa

Essential oil yield of 1 to 4 kg/ha can be expected. Dried flower yield can vary, depending on time of planting, soil, climate, rainfall and irrigation. Between 2 and 6 tons of dry flowers can be harvested per hectare.

Internationally

Chamomiles are grown commercially in Europe and the former USSR (Belarus, Ukraine, Moldova,) North Caucasus to South Siberia, North Africa (Egypt, Ethiopia), Asia (Turkey, Afghanistan, Pakistan, North India, and Japan), North and South America (East Coast of the USA, Cuba, Argentina, and Brazil) and New Zealand.

Worldwide production figures are difficult to isolate owing to the small scale of the farming operation and the fact that statistics generally do not quote the figures of essential oil crops or herbs separately. In 1995, the world production was estimated to be approximately 500 tons of dried flowers per annum, from large-scale farming. In 1998, the world production of chamomile blue essential oil was estimated to be 1 000 tons of dried flower per annum from large-scale farming.

4. MAJOR PRODUCTION AREAS IN SOUTH AFRICA

German chamomile is mostly cultivated in the Free State, Eastern Cape, Gauteng, KwaZulu-Natal, North West and Mpumalanga provinces. The crop is cultivated in Lesotho.

5. DESCRIPTION OF THE PLANTS

Stem

German chamomile is an annual herb with erect, light-green, smooth and multi-branched stems. The entire plant is downy and greyish green in colour.

Roman chamomile is a creeping, herbaceous perennial reaching a height of about 30 cm. The aromatic plant is characterised by downy stems with a yellow disc.

Leaves

Roman chamomile has finely divided feathery leaves. German Chamomile has long and narrow leaves structure.

Flowers

Both species have white, daisy-like flowers, but the flower receptacle of German chamomile is hollow while that of Roman chamomile is solid. The hill of the lower receptacle gets progressively conical as the flower matures.



German chamomile plant



Roman chamomile plant



Chamomile flowers
(Photo: W.G. Alberts)



A mature plant of German chamomile
(Photo: W.G. Alberts)

Essential part

The flowers are harvested for distillation of essential oil and dried flowers are used as health tea, for medicinal extracts and for potpourri.

6. CULTIVARS

In South Africa, there are no registered cultivars, but Bona, New Bona and Bodegold are the German chamomile cultivars mostly planted commercially.

The indigenous Cape chamomile, *Eriocephalus* spp. should not be confused with the other chamomiles although they also have potential as essential oil plants. The oil components are also very different.

7. CLIMATIC REQUIREMENTS

Temperature

German chamomile requires cool, temperate conditions to grow well, and temperatures of 7 to 26 °C are required. German chamomile can survive cold winter nights as low as -12 °C. To be able to grow well vegetatively and produce an

abundance of flowers, chamomile needs long summer days, full sun and high heat units to produce optimum oil yields.

Rainfall

Although chamomile is drought tolerant, it needs enough water to germinate and for the developing of the young plants. German chamomile requires no extra water once properly established. An annual precipitation of 400 to 1 400 mm per season is enough to produce a good crop.

8. SOIL REQUIREMENTS

German chamomile can be grown on a wide range of soil types, but prefers a well-drained, sandy or sandy-loam soil with a pH of 4,8 to 8,3, and grows in any other soils that have good drainage.

Roman chamomile, the single variety, being the wild type, grows well in dry, sandy soil, the conditions of its natural habitat, but the double-flowered chamomile needs a richer soil and gives the best yield of blooms in moist, loam soils with higher clay percentage and a soil pH of 6,5 to 8,0.

Part II: Cultivation practices

1. PROPAGATION

German chamomile is mostly cultivated by direct seeding. Roman chamomile can be propagated by seed or by means of dividing the old plants or taking out root runners. Each plant normally produces from 12 to 14 sets of runners. Make sure plants with superior qualities are used for vegetative propagation. The short, 2-month growing season of German chamomile allows it to be interplanted with other biennial herbs or planted as an early or late crop.

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. Soil analysis will guide the producer in correcting the nutritional status of the soil.

Soil fertility levels have to be within acceptable ranges before a soil-building programme is started. Correct the soil pH according to analysis and soil type. 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. Apply suitable soil preparation practices 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 treat their soil correctly will have the benefit of producing crops of high value with less input in terms of weed, pest and disease control.

3. PLANTING

Planting density/spacing

German chamomile is planted annually at a seeding rate of 500 to 1 000 g/ha. The seeds can be mixed at a ratio of 5 g seed per 4 ℓ with very fine sand.

For Roman chamomile, spacing has to be done so that a full groundcover forms as quickly as possible, and weeds are eliminated. Spacing of plants should be 30 x 30 cm.

Planting date

There is a close correlation to early vegetal growth and flower production, therefore, sowing should be done in autumn, if conditions allow it, or as early as possible after winter. The later the sowing takes place, the lower the germination

rate. Late-sown plants do not develop enough flower stalks and vegetative growth, and therefore the flower yield will be less.

For Roman chamomile, which is a perennial, the old plants are divided into their sets in early spring and transplanted in the land.

Planting depth

The seeds are extremely small and should be sowed very shallow.

4. FERTILISATION

German chamomile does not require large quantities of fertilisers, but depending on soil tests, small quantities of nitrogen, phosphorus, and potassium should be applied before planting. It has a high sodium uptake, therefore regenerating the soil.

5. IRRIGATION

Sprinkler irrigation should be used. The soil has to be moist, especially during seedling establishment, but not flooded.

6. WEED CONTROL

Constant weeding is necessary until the chamomile 'mat' takes over. Keep the plants clean during the summer by hand-weeding, as hoeing could destroy small plants.

Weed control guidelines

- ◆ Do not allow weeds to seed in the land.
- ◆ No-till practices result in fewer weeds.
- ◆ Shade out weeds by plant canopy, high plant density, closer row width, if moisture content of soil and crop specification allow for it.
- ◆ Use manual or mechanical control.

- ◆ Organic control measures such as flame weeding and UV radiation can be used where applicable, and if the crop can tolerate the method.
- ◆ Some seeds germinate when exposed to sunlight. Use night ploughing as option for fewer weeds.

7. PEST CONTROL

Whiteflies, aphids, spider mites, and thrips are the major insect pests affecting chamomile. Many beneficial insects such as bees and ladybugs visit chamomile, therefore, any treatment to control pests should be done with extreme caution. Cutworms and snails sometimes pose a problem.

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.
- ◆ Correct identification of pests and natural beneficial predators is important
- ◆ The knowledge of certain herbs that repel or attract insects can be used in companion planting for pest control.
- ◆ Shipments.

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.

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

8. DISEASE CONTROL

No serious diseases have been reported on this crop. The same disease control guidelines provided in the document on the general production of essential oils should be used.

9. HARVESTING

Maturity time and methods

Flower heads are harvested in the summer while in full bloom. Readiness is estimated according to the whiteness of the land as a result of the number of open flowers. Flowers can be used fresh, frozen or dried. Volatile oils are lost rapidly upon drying. Harvesting is best during temperatures of 22 to 25 °C.

Harvesting is done by hand, hand-raking flowers, clipping or special machinery designed for chamomile. Hand-harvesting for the highest quality flower head for the tea market involves raking the flower heads from the plants, at intervals. Harvesting by hand-raking or by clipping is a very labour intensive and costly way of harvesting.

German chamomile was shown to have a continuous flowering habit and should produce higher yields from multiple harvests rather than a single harvest. The first harvest should be used to remove the first open flowers and follow-up harvests repeated at intervals, in order to remove later flowers as these also open.

It was also discovered from the research by Franzé Holzl (1978), that the flowers with discs starting to open to fully open, produced more oil than flowers of either less or greater maturity. This indicates that harvest time for optimum oil yield may be predicted from observation of the crop to maximise the proportion of flowers. This can be approximately judged by the whiteness of the crop. The white ligulate florets are fully open and not reflexed, and the crop appears at its whitest.

As plants produce more flowers, they accumulate more oil, however, the concentration of oil in each flower decreases. Dried flowers should be processed for tea production as quickly as possible because quality will be lost following storage for 6 months.

Part III: Post-harvest handling

1. SORTING AND DISTILLATION

The specific gravity of the oil is very similar to that for water, and the separation can be difficult with heavy emulsions formed. Some distillers add solvent to the receivers and later remove the solvent under vacuum. Steam-distillation for the production of chamomile essential oil may be carried out on fresh, frozen or dried flowers, without affecting oil yield or quality. Distillation for 12 hours is recommended for the highest yield of quality oil. Further distillation will obtain further oil but the composition of that oil will change.

The steam-distilled chamomile blue essential oil and high-grade floral water can also be produced on the farm with basic homemade equipment. Distillation of the flowers in modern steam stills takes between 5 to 6 hours at 7 bar pressure. Yields of oil per hectare will be strongly affected by the distillation technique.

Steam-distilled German chamomile flowers produce a very popular essential oil with a deep blue colour because of the chamazulene present. The flowers can be solvent-extracted with less complex and expensive equipment, to produce chamomile essential oil. The oil yields are higher but chamazulene is not formed as steam is needed, and owing to that, the oil will not be blue, and the price can be lower.

Dried flowers are sorted to be free of foreign material, for the tea market.

2. GRADING

The principal component of the oil is chamazulene. The active principles are a volatile oil, of a pale blue colour, a little anthemic acid (the bitter principle), tannic acid and a glucoside.

3. PACKAGING

The oil is normally packed in 1, 5 and 10 kg aluminum flasks. Larger pack sizes are also available.

Flowers for tea are sold in bulk to factories where it is processed in tea sachets, and blended with other products. Bulk flowers for extraction are processed further in factories as extracts for pharmaceutical and cosmetic purposes.

4. STORAGE

Store at the oil at 5 °C, in full, closed glass or aluminum containers.

5. MARKETING

Chamomile can be marketed wholesale in three main forms, namely: dried flower, steam-distilled essential oil, and solvent-produced extracts.

Essential oils market

The market for essential oils in SA is divided into local buyers and international buyers. The local buyers include marketing agents and companies from chemical and pharmaceutical, as well as food and flavouring industries. The international buyers are divided into flavour and fragrance houses, cosmetics and personal health care, aromatherapy and food manufacturers who buy in large quantities.

The major market for essential oils in the world 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 oils 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.

The world market is growing rapidly, especially in the natural products demand. The dried flowers are bought by tea companies, natural medicine manufacturers, makers of herbal extracts and health food shops. The floral water, also known as hydrolat, and the oil are bought by agents to supply cosmetic and aromatherapy companies.

There is occasional demand for the fresh flowers, both cut and potted, for use in herbal displays and flower arrangements.

The sale price

Prices are largely regulated by the world supply and demand. Chamomile is presently being produced in countries with low labour costs. This can make it difficult for a South African farmer to compete, unless there is a fair degree of value adding applied.

Part IV: Production schedules

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



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

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Irrigate												
Harvest												

Part V: Utilisation

German chamomile is mostly cultivated for essential oil and dried flowers. The essential oils are used as agents in alcoholic beverages, confections, desserts, perfumes, aromatherapy and cosmetics.

1. MEDICINAL AND THERAPEUTIC

The flowers of the German chamomile, though aromatic, have a very bitter taste. They contain a volatile oil, a bitter extractive and some tannic acid. As medicinal plants, the chamomiles have been traditionally considered to be antispasmodics, carminatives, diaphoretics, emmenagogues, sedatives and stomachic. The plants have been used as bitters, tonics, insect repellents, and as a folk remedies against asthma, colic, fevers, inflammations and cancer. German chamomile has been used to induce sleep and as an anthelmintic.

Roman chamomile is a pharmaceutical aromatic bitter, and chamazulene, obtained from German chamomile, is a pharmaceutical anti-inflammatory and antipyretic agent. Extracts of Roman chamomile have shown antitumour activity and extracts of German chamomile are reported to have antiseptic, antibacterial and antifungal properties.

2. INDUSTRIAL

Dried flowers from Roman and German chamomile are used for herbal teas and blends with other teas. Flowers of Roman chamomile have been used in the manufacture of herb beers. The dried flowers of Roman chamomile are used for blond dyeing.

3. OTHER USES

Roman chamomile is often grown as a groundcover or as an ornamental in flower gardens. Fresh cut flowers are used in flower arrangements and potted plants are sold for display.

4. SAFETY DATA

Roman and German chamomile are generally recognised as very safe for human consumption. It is nontoxic, nonirritant, but can cause dermatitis in some individuals. Chamomile in tea may cause allergic reactions in individuals sensitive to plant allergens.

Essential oils can be harmful if swallowed and should be kept out of children's reach. Essential oils remain potent for 6 months to 2 years with proper care.

REFERENCES*

- AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE (ADAS); ARTHUR RICKWOOD (RUNHAM S.). 1980. *Culinary and medicinal herbs*. Kidlington, Oxford: HMSO.
- ANTHONY, K.R.M., MEADLEY, J. & RÖBBELEN, G. 1993. *New crops for temperate regions*. London: Chapman and Hall.
- BAUER, K. & GARBE, D. 1985. "Common flavour and fragrance materials: preparation, properties and uses". Germany: VCH Publishers.
- BETRAY, G. & VOMEL, A. 1992. Influence of temperature on yield and active principles of chamomile under controlled conditions. *Acta Horticulturae*, 306: 83–87.
- CARRUTHERS, S.P., MILLER, F.A. & VAUGHAN, C.M.A. 1994. *Crops for industry and energy*. Centre of Agricultural Strategy, University of Reading.
- CLAPHAM, A.R., TUTIN, T.G. & MOORE, D.M. 1987. *Flora of the British Isles*. 3rd edition. Cambridge: Cambridge University Press.
- EMONGGOR, V.E. & CHWEYA, J.A. 1989. Effect on age on chamomile flower yield, essential oil content and composition. *Discovery and Innovation*. 1(4): 63–66.
- ENSMINGER, A.H., ENSMINGER, M.E., KONLANDE, J.E. & ROBSON, J.R.K. 1994. *Foods and Nutrition Encyclopaedia*. 2nd Edition. Boca Raton: CRC Press.

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

- FALZARI, L.M. & MENARY, R.C. 2003. *Chamomile for oil and dried flowers*. Rural Industries Research and Development Corporation. *Publication No. 02/156. Project No. UT-28A* ISBN 0642 58555 5 and ISSN 1440-6845
- Foster, S. 1993. *Herbal Renaissance*. Salt Lake City, UT: Gibbs-Smith Publishers.
- FRANZ, C.H., MULLER, E., PELZMAN, H., HARDL, K., HALVA, S. & CEYLAN, A. 1986. Influence of ecological factors on yield and essential oil of chamomile. *Acta Horticulturae*, 188: 157-162.
- FRANZ, C.H. & HÖLZL, J. 1978. "Variation in the essential oil of *Matricaria chamomilla* L. depending on plant age and stage of development." *Acta Horticulturae*, 73: 229-238.
- FRANZ, C.H. 1993: "Genetics" in Hay, R.K. M. & Waterman, P.G. "*Volatile oil crops: their biology, biochemistry and production*." Essex, England: Longman Scientific and Technical.
- GALAMBOSI, B. & HOLM, Y. 1991. The effect of spring sowing times and spacing on the yield and essential oil of chamomile grown in Finland. *Herba Hungarica*, 2: 47-53.
- GUENTHER, E. 1952. *The essential oils*. Vol. 4. Florida, USA: Robert E. Krieger Publishing Company Inc.
- HADI, M.H.S. 1990. *Effects of planting time and plant density on flower yield and active substance of Chamomile (Matricaria chamomilla L.) in Iran*.
- Huxley, A., Griffiths, M. & Levy, M. 1993. *The new royal Horticultural Society Dictionary of gardening*. London: Macmillan Press Limited.
- JOHRI, A.K., SRIVASTAVA, L.J., SINGH, J.M. & RANA, R.C. 1992. "Effect of planting time and level of nitrogen on flower and oil yields of German chamomile (*Matricaria recutita*)." *Indian Journal of Agronomy*, 37(2): 302-304.
- KACURIK, S. 1979. Variation of essential oil and chamazulene content in chamomile. *Ponohospodarstvo*, 25(1): 67-75.
- LAWRENCE, B.H. 1985. A review of the world production of essential oils (1984). *Perfumer and Flavourist*. 10(5): 1-16
- LAWRENCE, B.H. 1987. *Progress in essential oils*. Illinois, USA: Allured Publishing Corporation.
- LAWRENCE, B.H. 1993. *Essential oil, 1981-1987*. Illinois, USA: Allured Publishing Corporation.

- LETCHAMO, W. 1992. A comparative study of chamomile yield, essential oil and flavonoids content under two sowing season and nitrogen levels. *Acta Horticulturae*, 306: 375–384.
- LETCHAMO, W. 1996. Developmental and seasonal variation in flavonoids of diploid and tetraploid chamomile ligulate florets. *Plant Physiology*, 148: 645-651.
- LETCHAMO, W. 1993. *Nitrogen application affects yield and content of the active substances in chamomile genotypes*, p. 636–639, in: *New crops*: Edited by J. Janick and J.E. Simon. New York: John Wiley & Sons.
- LETO, C., CARRUBBA, A. & CIBELLA, R. 1997. Results of a four year trial period of chamomile cultivation in a semi arid Sicilian environment. *Horticultural Abstracts*, 5325.
- NICHOLSON, B.E., HARRISON, S.G., MASEFIELD, G.B. & WALLIS, M. 1982. *The Oxford book of food plants*. Oxford: Oxford University Press.
- OSMAN, A.E. & SALLAM, Z.M. 1974. Study of the oil and chamazulene contents in different organs of *Matricaria chamomilla* L, in: *6th International Essential Oil Congress*, San Francisco.
- SALAMON, I. 1992. The effect of different densities on the yield and stand structure of chamomile. *Spornik-Uvits-Zahradnictvi*, 19(2): 87–94.
- SALAMON, I. 1994. Growing conditions and essential oil of chamomile. *Journal of Herbs, Spices and Medicinal Plants*, 1(2): 37–45.
- SCHILCHER, H. 1972. Neuere Erkenntnisse bei der Qualitätsbeurteilung von Kamillenbluten bzw. Kamillenöl. Deut. *Apoth. Ztg.*, 112:1497–1500
- SCHRÖDER, F.J. 1978. Vegetative propagation and variability of *Matricaria chamomilla* L. *Acta Horticulturae*, 73: 73–80.
- SIMON, J.E., CHADWICK, A.F. & CRAKER, L.E. 1984. *Herbs: An Indexed Bibliography. 1971–1980. The Scientific Literature on Selected Herbs, and Aromatic and Medicinal Plants of the Temperate Zone*. Hamden, CT: Archon Books. 770 pp.
- SINGH, A. 1982. Cultivation of *Matricaria chamomilla*, in: *Cultivation and utilization of aromatic plants*. Edited by C. K. Atal, and B. M. Kapur, Jammu-Tawi: Regional Research Laboratory.
- VAN NOSTRAND, R. 1988. *Van Nostrand's Scientific Encyclopaedia*, 7th edition New York.

WHITTEN, G. 2000. German chamomile. *Tasmanian Herbal*, 1: 44–48.

ZALECKI, R. 1972. The cultivation and manuring of tetraploid chamomile. Part III: Row width and sowing density. *Herba Polonica*, 18(1): 70–78.

