Journal of Essential Oil Research
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tjeo20

The Development of Artemisia afra (Jacq.) as a New Essential Oil Crop

E. H. Graven [a], L. Webber [a], M. Venter [a] & J. B. Gardner [a]

[a] Agricultural and Rural Development Research Institute University of Fort Hare, Alice, Ciskei, Republic of South Africa
Published online: 28 Nov 2011.

To cite this article: E. H. Graven, L. Webber, M. Venter & J. B. Gardner (1990) The Development of Artemisia afra (Jacq.) as a New Essential Oil Crop, Journal of Essential Oil Research, 2:5, 215-220, DOI: 10.1080/10412905.1990.9697870

To link to this article: http://dx.doi.org/10.1080/10412905.1990.9697870

The Development of *Artemisia afra* (Jacq.) as a New Essential Oil Crop

E. H. Graven*, L. Webber, M. Venter and J. B. Gardner
Agricultural and Rural Development Research Institute
University of Fort Hare
Alice, Ciskei, Republic of South Africa

Received: September 1989

ABSTRACT: It has been shown that statistically significant higher oil yields could be obtained from *Artemisia afra* when the plants were harvested during anthesis and early seed set. The chemical composition of four generations of the same clone was found to be very constant. On examination of the oil composition of wild populations of *A. afra*, the existence of chemotypes was revealed. Oils rich in 1,8-cineole (50.14%), α-thujone (74.91-75.28%), β-thujone (21.49-22.44%), and camphor (27.92%) were found.

KEY WORD INDEX: *Artemisia afra,* Compositae, South African wormwood, Infra-specific Chemical Difference, Essential Oil.

INTRODUCTION: *Artemisia afra* Jacq., which is known as African wormwood, Wilde als and Mhlonyana, is one of the oldest known and most widely used Southern African medicinal plants. Although it is used primarily for bronchial and respiratory complaints, it has also been used as a anthelmintic, and for treatment of a host of divergent ailments (1). This perennial and woody member of the Compositae family occurs throughout Southern Africa and is closely related to European wormwood *(A. absinthium).* In Ciskei, it is found in the well-watered areas and is fairly abundant in parts of the Amatola mountains. *A. afra* is not readily consumed by livestock. Also, exploitive veld management systems, which weaken the vegetal cover, favor the establishment and growth of seedlings and may result in the development of dense stands. Where *A. afra* is permitted to grow unchecked throughout a growing season, the resultant growth is tall and woody with only a few leaves on the terminal ends of the branches. Defoliation by cutting or fire results in the development of a profusion of leafy stems.

Following the establishment of an essential oil project at the University of Fort Hare (26°50′E, 32°47′L) in Ciskei (2), *A. afra* has been exploited as an attendant vehicle contributing towards rural development of the area. Initially, the freshly picked herb was purchased from tribesfolk who collected it in the wild. It soon became apparent, however, that the naturally occurring plants could not provide a sustained supply of

*Senior author

quality material, and that conventional arable production practices would have to be applied in order for meaningful commercial development of the crop to take place.

Field production practices have been evolved to suit local circumstances. These essentially consist of planting rooted cuttings or seedlings at 500 mm intervals in rows 750 mm apart in order to facilitate mechanical weed control. As *A. afra* is able to survive and multiply under the highly competitive conditions prevailing in its natural habitat; i.e., undisturbed veld, it is not surprising that it is capable of vigorous growth when treated as a conventional arable crop. It is, however, subject to severe parasitization by a local species of dodder (*Cuscuta* spp.), and is susceptible to an unidentified fungal root rot where the soil is poorly drained.

The development of harvesting schedules which will result in high yields of quality oil is an integral part of the domestication program for this crop. Field observations have indicated that growth vigor and longevity of *A. afra* may be severely reduced by too frequent cutting. Conversely, harvesting only once during the growing season, when the crop flowers at maturity in the autumn, results in excessive senescence of the lower leaves with a commensurate reduction in oil yield.

Graven et al. (3) have reported on a comprehensive field experiment in which oil yields of *A. afra* were increased from less than 50 kg ha^{-1} where the crop was harvested only once per season, to more than 150 kg ha^{-1} where judicious cutting schedules were applied. They concluded that for highest oil yields in Ciskei, *A. afra* should be cut back to 300 mm in the winter and the first cutting be taken in the full vegetative stage (November). It was observed that such treatment will stimulate the development of elongated leafy stems and permit the harvesting of a second crop during the reproductive stage in the autumn. In a subsequent study (unpublished), it was speculated that the exact stage of harvest during the reproductive phase may have a material influence on oil yields achieved for the season.

It is the purpose of this report to evaluate the effect of a) harvest date, on oil yield; b) vegetative propagation on the oil composition of an individual clone; and c) the variability in the oil composition of adjacent individual plants within an open pollinated *a. afra* population.

EXPERIMENTAL: (a) During the reproductive phase of plant growth, four plots within a well-established three-year-old stand of *A. afra* were randomly selected each day and harvested. (b) Four successive vegetatively propagated generations of a selected clone were grown, harvested, distilled, and the oil analyzed by GC to identify major constituents only. (c) Twenty wild collections of *A. afra* were harvested, distilled, and the major components characterized by GC according to previously published techniques (2).

Standard dry steam distillation procedures have been evolved for the extraction of the oil. Bulk handling equipment and methods for the local processing of the crops have also been developed. In the course of experimentation, various applied aspects have been studied. These include the effect of post-harvest and pre-distillation treatment of the herbage, the influence of steam pressure, and distillation rate on oil recovery, etc. These will be discussed elsewhere.

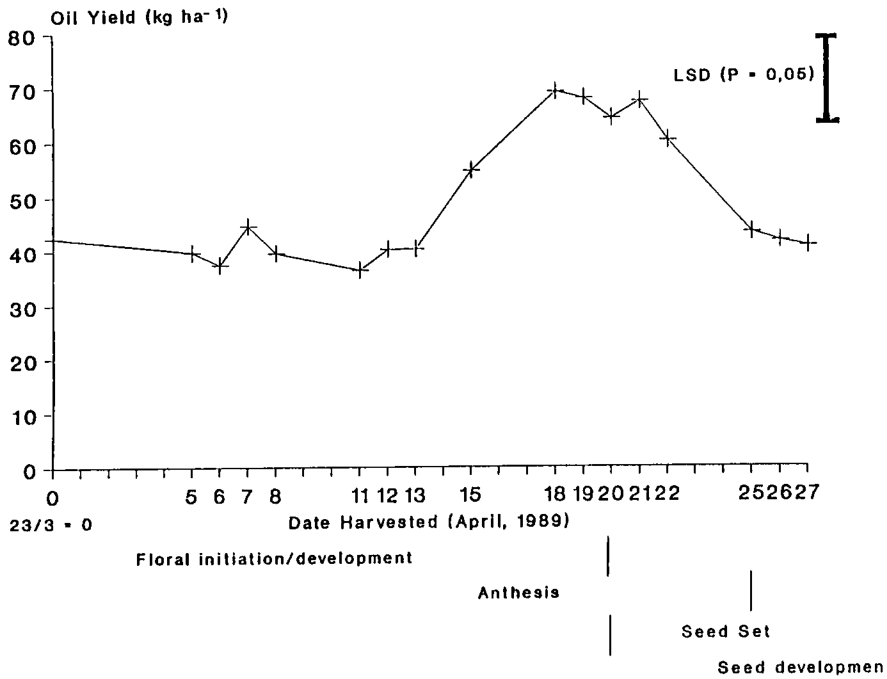

Figure 1. Effect of progressive harvesting during the reproductive stage on the oil yield of 3 year old *Artemisia afra*.

RESULTS AND DISCUSSION: (a) The results of the field experiment where four randomly selected plots of well-established three-year-old *A. afra* were harvested at daily intervals during the reproductive phase are presented in Figure 1. It is evident that significantly ($p = 0.01$) higher oil yields were obtained where the crop was harvested during anthesis and early seed set as opposed to earlier or later harvesting in the reproductive period. It has been established that *A. afra* herbage may be stored after harvesting and drying without material oil losses, provided elementary precautions are taken (4). In order to maximize oil yields, producers may consequently consider harvesting most of the crop at the late anthesis/early seed set stage provided storage facilities are available and the oil can be extracted within a reasonable time.

(b) Chemical analyses have indicated that neither the frequency nor the stage at which *A. afra* plants are cut has a material influence on the chemical composition of the oil. The overriding factor which determines the chemical composition of *A. afra* oil appears to be the genetic make-up of the individual plant(s). This is well illustrated by the data in Figure 2 which indicates the chemical composition of four successive, vegetatively propagated strains of *A. afra* clone. It is noteworthy that despite the fact that no particular care was taken to ensure that the successive generations were harvested at the same physiological stage or that they were grown under identical conditions, the oil composition has remained remarkably consistent.

(c) Wild growing, open pollinated *A. afra* comprises a wide range of divergent genotypes as reflected by their oil composition. In Table I, the four major chemical components in the oil of 20 selected *A. afra* genotypes are presented.

Table I. Percentage of four major chemical components in the essential oil of 20 randomly selected *Artemisia afra* plants from a production field at Fort Hare.

Plant Number Genotypes	1,8-cineole (11.82)	α-thujone (18.13)	β-thujone (18.49)	sum (α + β) thujone	Camphor (20.47)	Total % of four major components
1	8.05	75.60	14.71	(90.31)	—	98.36
2	5.61	66.15	13.32	(79.38)	7.93	93.01
3	6.84	64.25	17.33	(81.58)	4.06	92.48
4	7.38	59.73	13.10	(72.83)	13.76	93.97
5	31.48	41.78	15.02	(56.80)	3.12	91.40
6	8.96	75.28	11.74	(87.02)	0.23	96.21
7	4.16	54.97	22.44	(77.41)	12.49	94.06
8	9.74	63.91	12.92	(76.83)	10.63	97.20
9	22.12	47.68	14.95	(62.63)	8.24	92.99
10	22.00	45.47	15.19	(60.66)	9.76	92.42
11	8.02	74.91	12.66	(87.57)	0.24	95.83
12	8.57	63.18	12.26	(75.44)	8.84	92.87
13	50.14	4.72	1.16	(5.88)	5.65	61.37
14	6.32	57.13	10.24	(14.79)	19.04	92.73
15	14.74	50.25	14.79	(6.45)	15.73	95.51
16	8.91	21.73	65.04	(17.12)	27.92	65.01
17	26.85	42.04	17.12	(59.16)	3.88	89.44
18	21.35	51.54	11.20	(62.74)	9.71	93.80
19	19.87	55.27	21.49	(76.76)	—	96.63
20	10.09	47.13	10.58	(57.71)	15.83	83.63

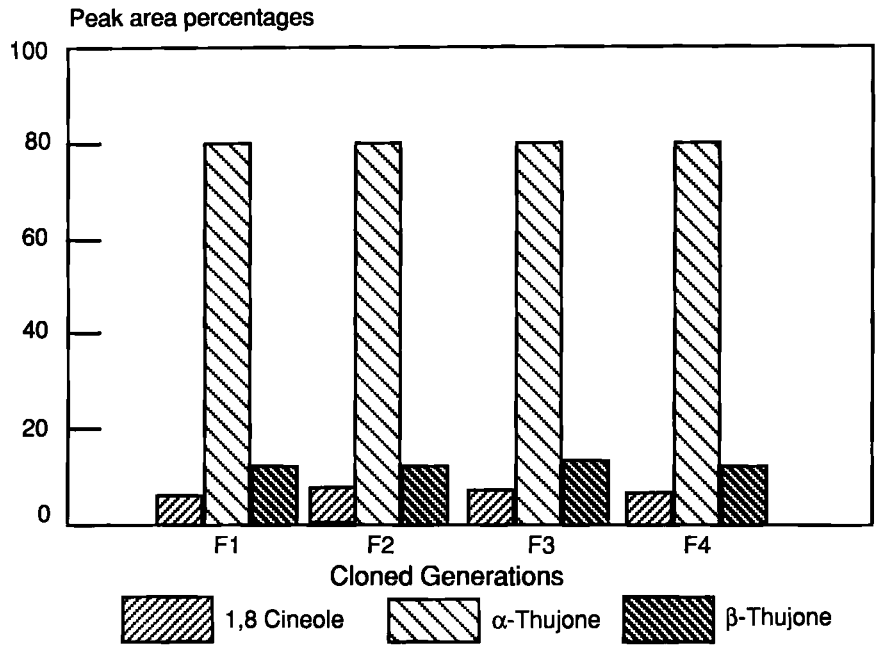

Figure 2. Effect of vegetative propagation on 3 major chemical components in the essential oil of successive generations of a selected *Artemisia afra* clone (clone 12).

The individual plants for this study were randomly selected from a production field at Fort Hare. From this table it is clear that the 1,8-cineole content of the various oils ranges from 4.16 to 50.14%, the α-thujone from 4.72 to 75.6%, the β-thujone from 1.16 to 22.44%, and the camphor from 0.24 to 27.92%. The wide divergence of chemotypes within a single local population invites speculation as to whether the wide differences reported by some workers in the composition of plant oils from various localities are in fact large because single plant samples were used for the analysis. This is a matter which deserves further attention.

In his review of research on wild forms of *Artemisia herba alba,* Lawrence (5) reported the occurrence of at least seven distinct chemotypes, and it would appear that *A. afra* shows similar divergent tendencies; e.g.:

- (i) High 1,8-cineole (Genotype 13)
- (ii) High α-thujone (Genotypes 6 & 11)
- (iii) High β-thujone (Genotypes 7 & 19)
- (iv) High camphor (Genotype 16)

Following the development of effective methods of vegetative propagation for the rapid multiplication of *A. afra* clonal material, considerable attention has been given to the identification of desirable chemotypes. This presents exciting opportunities for the accentuation of desirable chemical characteristics and the production of exclusive new oils.

REFERENCES

1. J. M. Watt and M. G. Beyer-Brandwijk, *The medicinal and poisonous plants of Southern and Eastern Africa,* pp 199-202, Livingstone, London (1976).
2. E. H. Graven, J. B. Gardner, and C. L. C. Tutt, *Native South African aromatic plants—a possible vehicle for rural development.* In: *Progress in Essential Oil Research.* Edit., E.-J. Brunke, pp 461-484, Walter de Gruyter & Co., New York (1986).
3. E. H. Graven, L. Webber, M. W. Venter, and J. B. Gardner, *Influence of cutting schedules on the yield and chemical composition of Artemisia afra oil.* Paper presented at 19th International Symposium on Essential Oils, Zurich, Switzerland, September (1988).
4. S. Piprek, E. H. Gravn, and P. F. Whitfield, *Some potentially important indigenous aromatic plants for the eastern seaboard areas of Southern Africa.* In: *Aromatic Plants: Basic and Applied Aspects.* Edits., N. Margaris, A. Koedam, and D. Vokou, pp 255-263, Martinus Nijhoff, The Hague (1982).
5. B. M. Lawrence, *Progress in essential oils.* Perfum. & Flav. **14** (3) 71-80 (1989).