TROZ Centre for Agriculture in the Tropics and Subtropics

Universität Hohenheim

Artemisia annua ANAMED, a Medicinal Plant for Malaria Treatment: a Study on Growth Performance and Artemisinin Content under Tropical Highland Conditions of SW Ethiopia

Bekele Bayde, B.[1, 2], T. H. Hilger[1] and G. Cadisch[1]

[1] Hohenheim University, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Stuttgart, Germany.
[2] Ethiopian Kale Heywet Church, Southwest Zone Office, Arba Minch, Ethiopia

Introduction

Worldwide approximately 300 million people are affected by malaria. The problems of controlling malaria are aggravated by inadequate health structures and poor socioeconomic conditions. Over the last few years an increasing resistance to the drugs normally used to combat the parasite causing malaria was observed. As an alternative, *Artemisia annua* contains artemisinin in leaves and flowers, a sesquiterpene lactone effective against drug resistant malaria. The WHO recommends an artemisinin based combination therapy (ACT). A tea based therapy is also available suitable for low income population as it is cheap. A new strain - *Artemisia annua* ANAMED (A-3) – adapted to tropical conditions was introduced to south-western Ethiopia in 2001, an area highly affected by malaria.

Objectives

This study aimed at assessing the **growth performance of A-3** in SW Ethiopia and **changes of its artemisinin content** as affected by environmental conditions and growth stage

Photos clockwise: Habitus of *Artrmisia annua* ANAMED, a single plant, field sampling (time harvest six month after planting), sample separation and air-drying

Materials and Methods

Field trials were carried out at three locations in the Gamo Gofa Highlands of SW Ethiopia - Boreda, Chencha and Bonke.

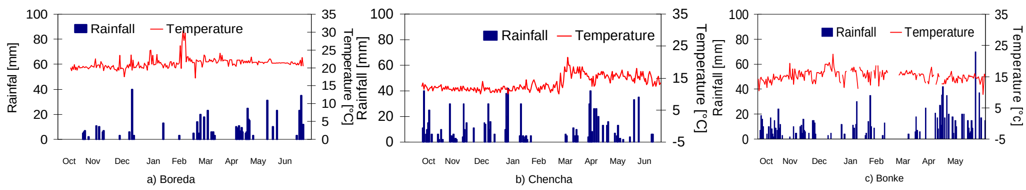
Trial description, data collection & analysis

- 3 fields with 100 m² each
- *Artemisia annua* ANAMED (A-3)
- Spacing: 1 m x 1 m
- Soil samples were taken before planting and analyzed by using standard methods
- Daily rainfall, minimum, maximum temperature
- At monthly intervals, six to ten plants were harvested to assess dry matter production of A-3 over time
- Before drying, samples were separated into leaves, twigs and branches and air-dried and carefully stored
- Leaf samples of time harvests and final harvest were analyzed for their artemisinin content
- Leaf artemisinin content was determined at Médiplant, Courthey, Switzerland by using liquid chromatography with high pressure (CLHP) method

Location of the test sites in the Gamo Gafo Highlands of SW Ethiopia

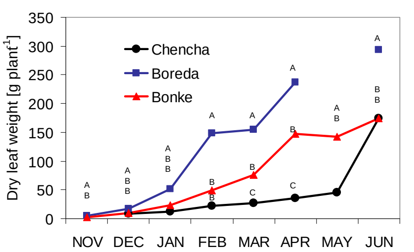
Description of the three test sites in the Gamo Gafo Highlands of SW Ethiopia.

	Altitude (m a.s.l.)	Soil type	Texture Sand	Silt	Clay	CEC (mmol$_c$ kg^{-1})	pH (CaCl$_2$)	N_t (%)	C_{org} (%)	P_{Bray} (mg kg^{-1})
			--- % ---							
Boreda	2250	gleyic Luvisol	14.9	33.2	51.9	247.4	5.5	0.29	2.89	0.9
Chencha	2618	mollic Nitisol	13.8	43.0	43.2	251.7	5.5	0.25	2.75	1.8
Bonke	2907	Luvisol	12.5	48.2	39.2	182.7	4.7	0.37	3.47	2.8

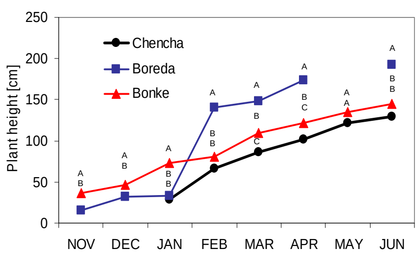


Rainfall and temperature pattern during the observation period: a) Boreda: Rainfall Σ Oct 2006 - Jun 2007 = 481 mm; mean average Temperature for Oct 2006 - Jun 2007: 21.2°C, b) Chencha: Rainfall Σ Oct 2006 - Jun 2007 = 837 mm; mean average Temperature for Oct 2006 - Jun 2007: 13.4°C and c) Bonke: Rainfall Σ Oct 2006 - Jun 2007 = 1068 mm; mean average Temperature for Oct 2006 – May 2007: 13.3°C

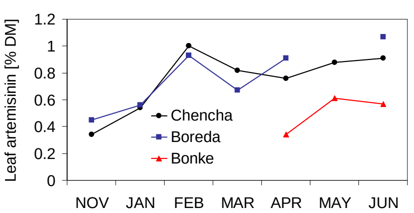
Results



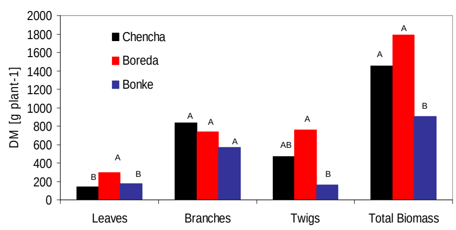
Leaf dry matter increase of A-3 during an 8 months monitoring period as affected by site. Planting dates followed by different letters differ significantly at P≤ 0.05.



Plant height development of A-3 during a 8 months monitoring period as affected by site. Planting dates followed by different letters differ significantly at P≤ 0.05.



Artemisinin content of dry leaves of A-3 during an 8 months monitoring period as affected by site. At Bonke, artemisinin content was below detection level in the first four months.



Leaf, branch and twig DM and total dry matter as affected by site. Bars followed by different letters differ significantly at P≤ 0.05.

Leaf dry matter yield (kg ha^{-1}) of A-3, leaf artemisinin content (%) and artemisinin yield (kg ha^{-1}) as affected by site.

Site	Leaf DM yield (kg/ha)	Leaf artemisinin (%)	Artemisinin yield (kg/ha)
Chencha	1,435	0.91	13.1
Boreda	2,932	1.07	31.4
Bonke	1,748	0.57	10.0

Conclusions

- An altitude of 2,200 m a.s.l. with a minimum and maximum temperature of 17.3 and 24.5°C led to a better growth performance of A-3 than higher elevations (2,600-2,900 m a.s.l.) and lower temperatures (8.4/18.3 and 10.4/16.3°C).
- A lower but well distributed rainfall (480 *vs.* 850-1,050 mm) as found at the lower elevation was also favourable for artemisia growth.
- These conclusions are supported by negative correlations between leaf yield of A-3 and altitude (R^2= -0.86), rainfall amount (R^2=-0.85) and positive correlations for temperature (T_{max}: R^2=0.99, T_{min}: R^2=0.91) and leaf yield .
- Similar relations were for leaf artemisinin content with altitude (R^2=-0.96) and rainfall (R^2=-0.92).
- Relationships between A-3 yield and artemisinin content were less clear and require further assessment.

Open research questions

- What is the effect of lower altitudes, e.g. 1,500 to 2,200 m a.s.l., on A-3 growth and artemisinin synthesis?
- What is the impact of fertilisation on yield and artemisinin content?
- Can we grow A-3 at higher densities and harvest earlier without loss of current yield level? The maximum of artemisinin content was already achieved 4 months after planting so that two crops can be grown per year.
- Can we intercrop A-3 and food crops?

Contact: Thomas H. Hilger
Institute of Plant Production and Agroecology in the Tropics and Subtropics
Hohenheim University (380a)
70593 Stuttgart, Germany
Email: t-hilger@uni-hohenheim.de
https://www.uni-hohenheim.de/www380

Acknowledgements:
The research stay of Belay Bekele in Ethiopia was supported by the Eiselen Foundation, Ulm, Germany.