Enhancing *Lippia alba* essential oil production and yield using full factorial design and Response Surface Methodology

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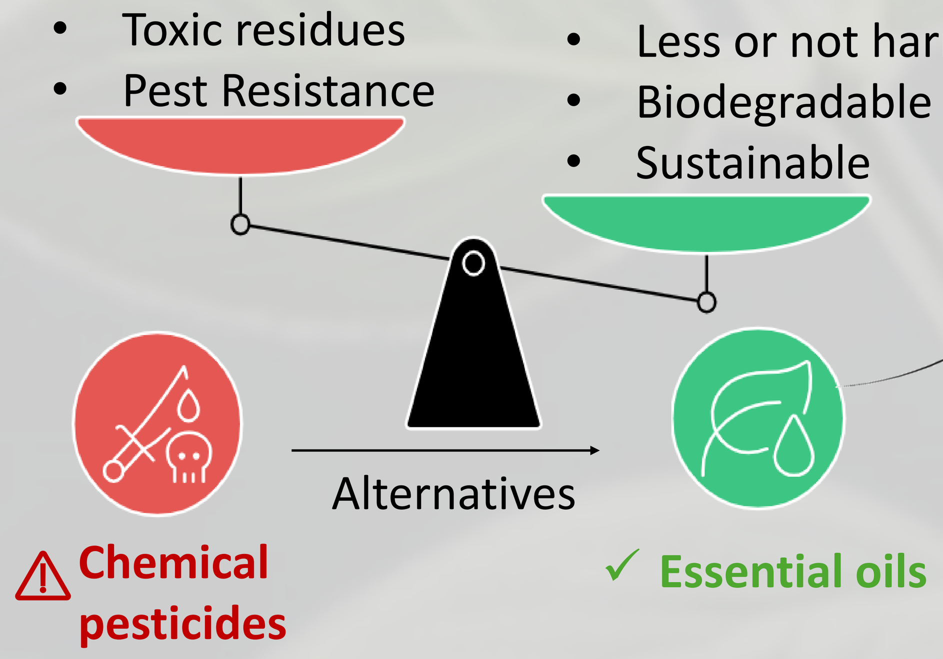
Context and objectives

In Sub-Saharan Africa, post-harvest cereal losses can reach 20%, mainly due to insect infestation and fungal contamination [1].

Pest control method for stored commodities

Efficient but :
- Health risk
- Toxic residues
- Pest Resistance

Efficient and:
- Less or not harmful
- Biodegradable
- Sustainable



Lippia alba's EO

- High essential oil yield
- Antifungal and Insecticidal properties
- Agroecological adaptation to Senegal
- Water use efficiency of the plant

Study aim:
- Production of *Lippia alba*
- Essential oil (EO) yield optimization using RSM
- Chemical characterization

Materials and methods

1. Plant cultivation

Propagation by cuttings — Field transplanting in three different plots

2. Design of experiment

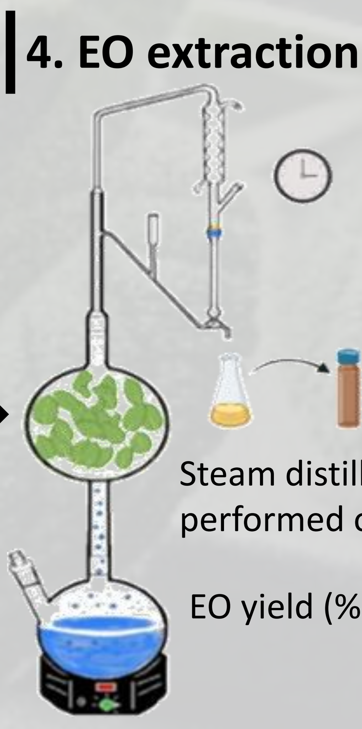
Table 1: Full Factorial Design (FFD) for essential oil yield

Parameters	Levels (coded)		
	Minimum (+1)	Medium (0)	Maximum (+1)
Phenological stage	Vegetative	Flowering	Fructification
Drying time (days)	0	3	6
Distillation time (hours)	1	2	3

3. Sample preparation

- Leaf harvest at three stages (vegetative, flowering and fructification)
- Leaf drying (shade)
- Sample preparation

4. EO extraction



Steam distillation was performed on 20 g of leaf

$$\text{EO yield (\%)} = \frac{\text{Mass EO obtained}}{\text{Plant dry mass}} * 100$$

5. GC-MS analysis

6. Data analysis

Data were analyzed using Response Surface Methodology (RSM) with Minitab 21. GC-MS data were analyzed using Masshunter and NIST database.

Key findings

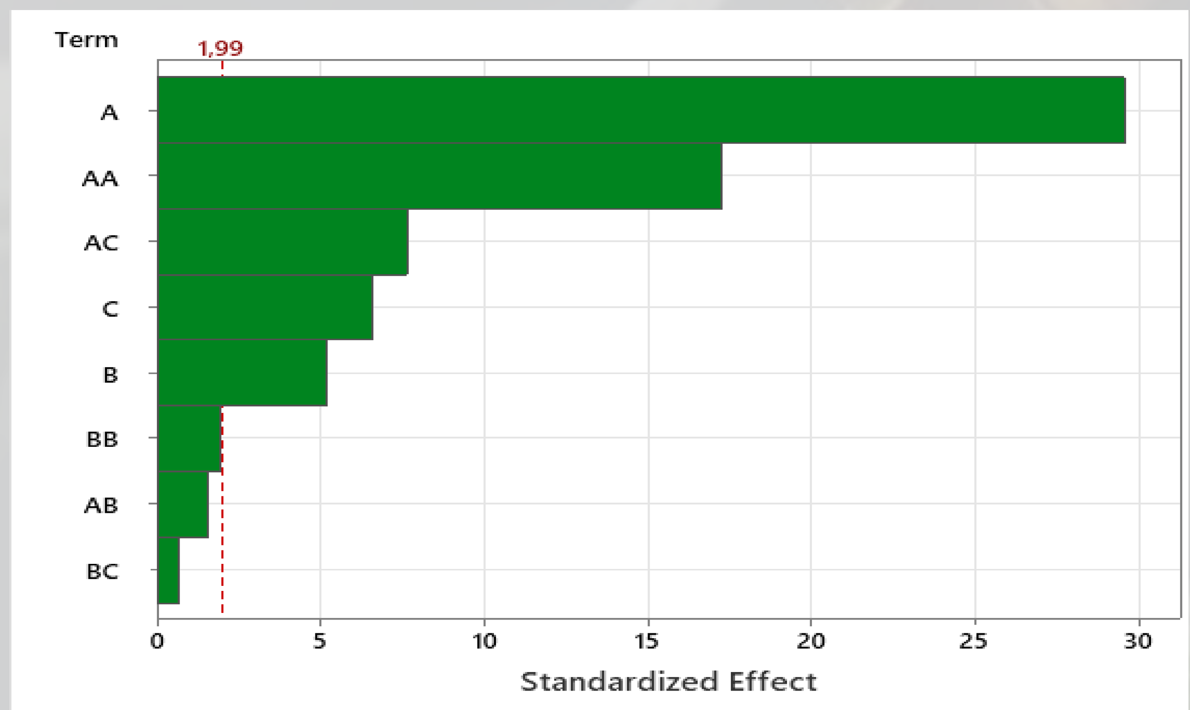


Fig. 1: Pareto chart of the standardized effects (response is essential oil yield; α= 0,05); Factor Name: A. Drying, B. Distillation, C. Phenology)

According to the Pareto chart:
- Drying time (A) and its quadratic effect (AA) were the most significant factors affecting oil yield (p < 0.05), followed by the interaction between drying and phenology (AC).
- While Distillation time (B) and phenological stage (C) have less pronounced effects (**Fig. 1**)

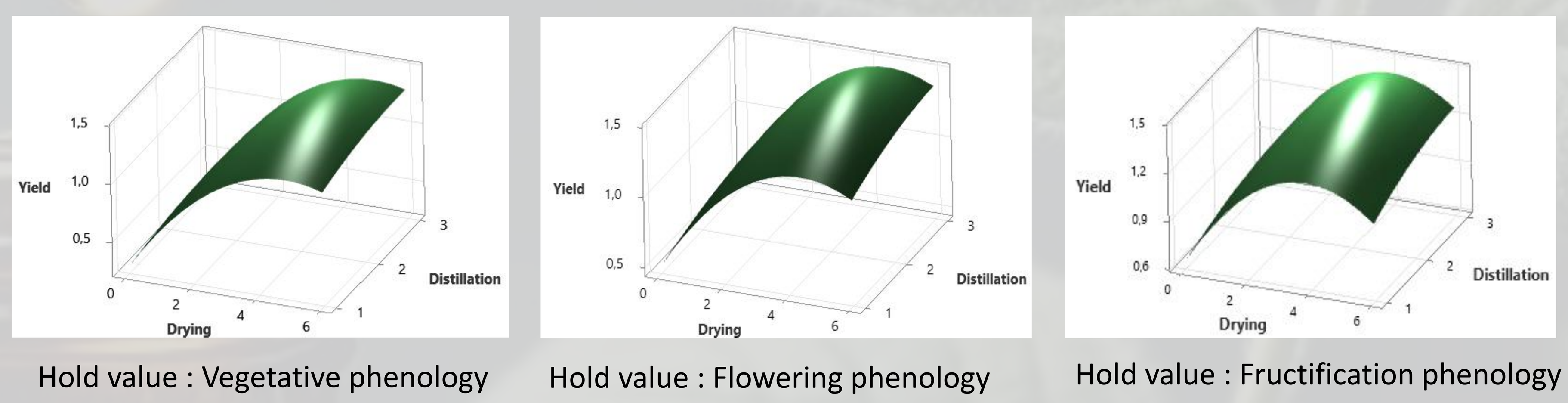


Fig. 2: Surface plots of EO yield vs. distillation and drying at each phenological stage

EO yield increased with drying time across all phenological stages, with a quadratic trend and limited effect of distillation.
The highest essential oil yield (>1.3%) was achieved under the following optimized conditions: flowering stage, 3 days of drying, and 3 hours of distillation (**Fig. 2**).

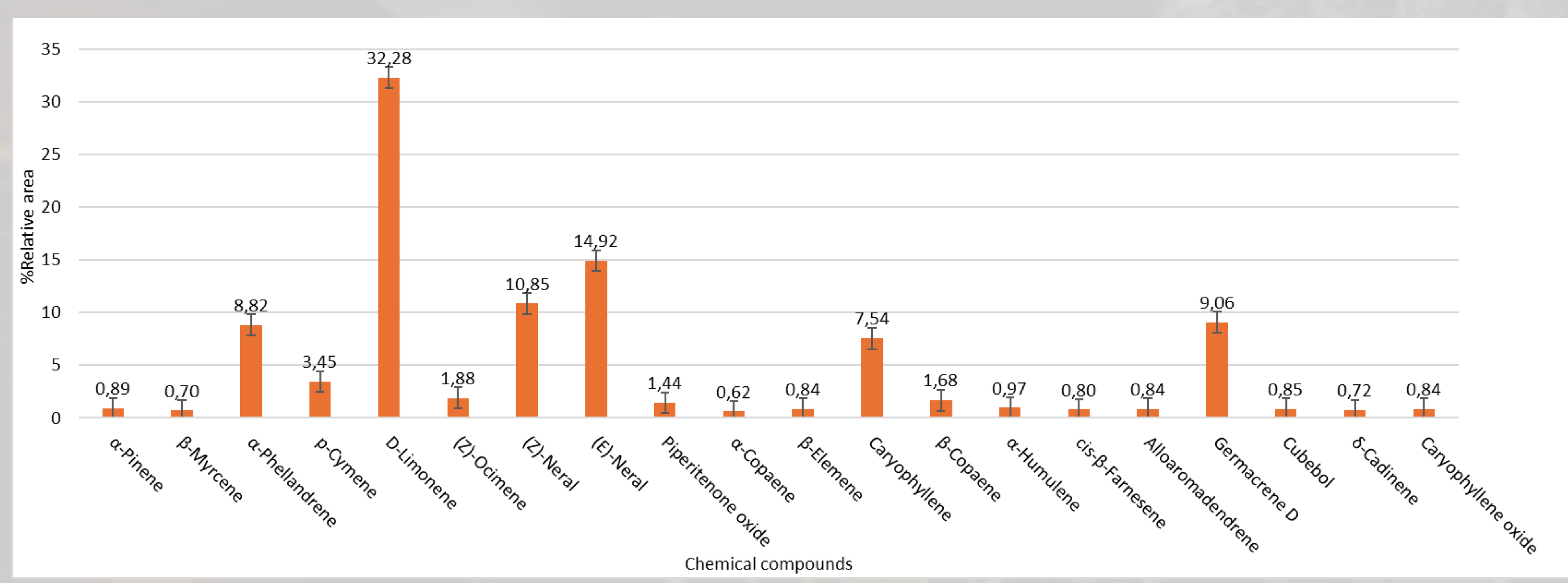


Fig. 3: Major compounds identified in *Lippia alba essential oil* at optimized conditions

The major constituents D-limonene, (E)-neral, and (Z)-neral (**Fig. 3**) are well-documented for their antifungal activities [2-3]→ Potential of *L. alba* oil as a natural protectant for stored products in Senegal

Conclusion and perspectives

- Drying time had the most significant effect on *Lippia alba* essential oil yield.
- GC-MS analysis revealed major constituents known for their antifungal properties.
- Upcoming work will be focused on the *in vitro* antifungal activity of *L. alba* essential oil and in *vivo* activity on seeds under the storage conditions to control *in situ* mycotoxin production.
- *Lippia alba* essential oil is targeted for use to improve the protection of stored cereals in West Africa.

References

1.FAO, 2022. **Réduction des pertes post-récolte, IGAD report**
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