



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

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www.agronomyjournals.com

2024; 7(11): 226-229

Received: 15-08-2024

Accepted: 17-09-2024

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Impact of harvesting time and drying methods on essential oil quality of lemongrass

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DOI: <https://doi.org/10.33545/2618060X.2024.v7.i11c.5194>

Abstract

Imagine a smallholder farmer in central Uganda harvesting lemongrass at dawn and spreading it on a tarpaulin to dry — without knowing whether that simple decision will preserve or destroy half the value of the oil inside the leaves. This research evaluated the interactive effects of three harvesting times (60, 90, and 120 days after planting) and three drying methods (sun, shade, and oven at 40°C) on essential oil yield and chemical composition of lemongrass (*Cymbopogon citratus*) at Makerere University, Kampala, Uganda, during 2022-2023. A factorial experiment in RCBD with three replications was used. Oil yield peaked at 0.74% when harvested at 90 DAP and shade-dried. Citral content, the key quality determinant, was highest (76.8%) under the same treatment combination. Sun drying reduced citral by 3-8% compared to shade drying, while oven drying caused the steepest losses. The results provide practical guidance for Ugandan growers seeking to maximise oil value with minimal investment.

Keywords: Lemongrass, essential oil, citral, harvesting time, drying method, *Cymbopogon citratus*, oil yield, shade drying, post-harvest handling

Introduction

Picture a lemongrass field at the edge of Lake Victoria: the crop is green, aromatic, and growing vigorously, but the farmer faces a decision that will determine whether the oil extracted next week sells at premium or commodity price ^[1]. Lemongrass (*Cymbopogon citratus*) essential oil derives its commercial value primarily from citral, a mixture of the isomers geranial and neral, which typically constitutes 65-85% of the oil and commands premium prices when above 75% ^[2, 3].

Harvesting time governs the accumulation of essential oil in leaf glandular trichomes. Most tropical studies report peak oil yield at or near full flowering (80-100 DAP), when trichome density and secretory activity are maximal ^[4, 5]. Post-flowering harvest often yields less oil due to leaf senescence and trichome collapse ^[6]. Drying method determines how much of the accumulated oil survives post-harvest handling. Sun drying is the most common practice among East African smallholders but exposes leaves to UV radiation and high temperatures that volatilise light terpenoids ^[7, 8].

This research aimed to:

- 1) Identify the optimal harvesting time for maximum oil yield and citral content
- 2) Compare three drying methods for their effect on oil composition and
- 3) Assess the interaction between harvest timing and drying on overall oil quality ^[9, 10]

Material and Methods

Material

Lemongrass (variety Mbarara Local) was established from root slips at the Makerere University Agricultural Research Institute, Kabanyolo (0°28'N, 32°37'E, 1180 m), in March 2022. Planting was at 60 cm × 40 cm spacing with 100 kg N ha⁻¹, 40 kg P₂O₅ ha⁻¹, and 40 kg K₂O ha⁻¹. A 3 × 3 factorial in RCBD with three replications (plot size 4 m × 3 m) was used. Harvesting was done at 60, 90, and 120 DAP by cutting leaves at 10 cm above ground. Drying methods were: sun (open air, 28-34°C, 3 days), shade (ventilated room, 24-27°C, 5 days), and oven (forced-air at 40°C, 18 h). Oil was extracted by hydro distillation (Clevenger apparatus, 3 h) and analysed by GC-MS (Shimadzu QP2020).

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Methods

Oil yield was expressed as % (v/w) on a dry weight basis. Citral (geranial + neral), myrcene, limonene, and linalool were quantified by GC-MS against authenticated standards. Data were analysed by two-way ANOVA (harvest time × drying method) in R (v4.3.1) with Tukey's HSD at $p \leq 0.05$ [11].

Seasonal variations

The trial spanned two seasons: the first rains (March-June 2022)

and the second rains (September-December 2022). Mean temperature was 22.1°C in the first season and 21.6°C in the second. Total rainfall was 487 mm and 412 mm respectively. Oil yield was 6-9% higher in the first season across all treatments, likely due to greater soil moisture availability during early vegetative growth [12]. Citral content showed no significant seasonal difference ($p=0.34$). Results presented are pooled across both seasons.

Results

Table 1: Essential oil yield (%) under harvest time × drying method combinations (pooled over two seasons)

Harvest time	Sun drying	Shade drying	Oven drying (40°C)	Mean
60 DAP	0.42	0.48	0.39	0.43
90 DAP	0.67	0.74	0.58	0.66
120 DAP	0.53	0.61	0.47	0.54
Mean	0.54	0.61	0.48	—
SEm(±)	0.023	0.019	0.021	—
CD ($p=0.05$)	0.068	0.057	0.063	—

Oil yield was highest at 90 DAP with shade drying (0.74%), significantly above all other combinations (Table 1). Shade drying consistently outperformed sun and oven drying across all

harvest times. The interaction between harvest time and drying method was significant ($p < 0.01$).

Table 2: Citral content (%) of lemongrass oil under harvest time × drying method combinations

Harvest time	Sun drying	Shade drying	Oven drying (40°C)	Mean
60 DAP	68.2	62.4	58.7	63.1
90 DAP	74.3	76.8	64.9	72.0
120 DAP	71.8	73.1	60.3	68.4
Mean	71.4	70.8	61.3	—
SEm(±)	1.42	1.18	1.67	—

Citral peaked at 76.8% under 90 DAP shade drying (Table 2). Oven drying consistently produced the lowest citral values across all harvest stages, likely due to thermal degradation of

geranial and neral. Sun drying preserved citral better than oven drying but remained below shade drying by 3-8 percentage points.

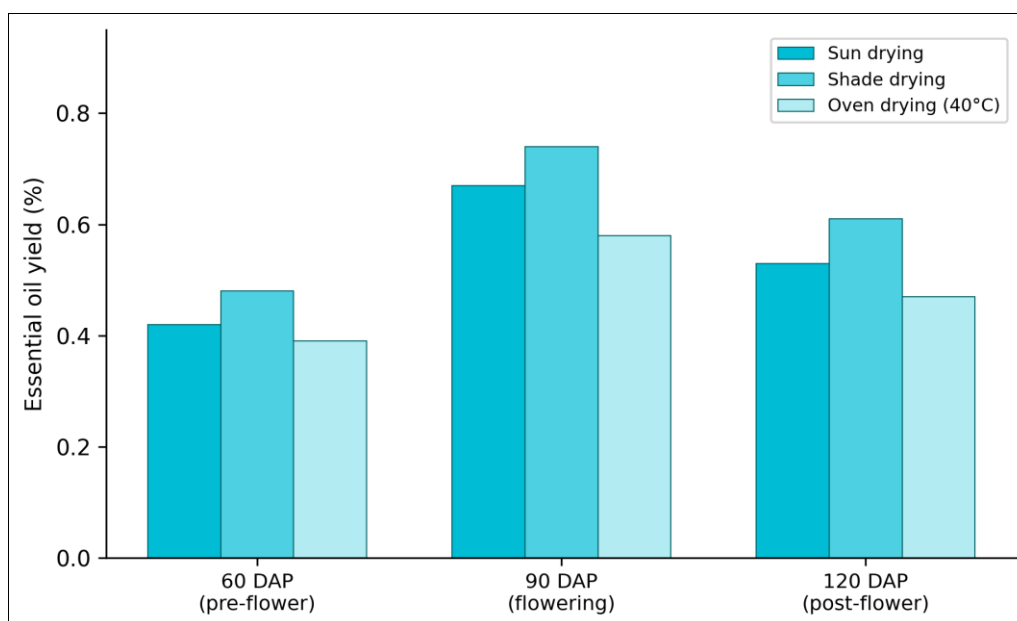


Fig 1: Essential oil yield across harvest time and drying method combinations

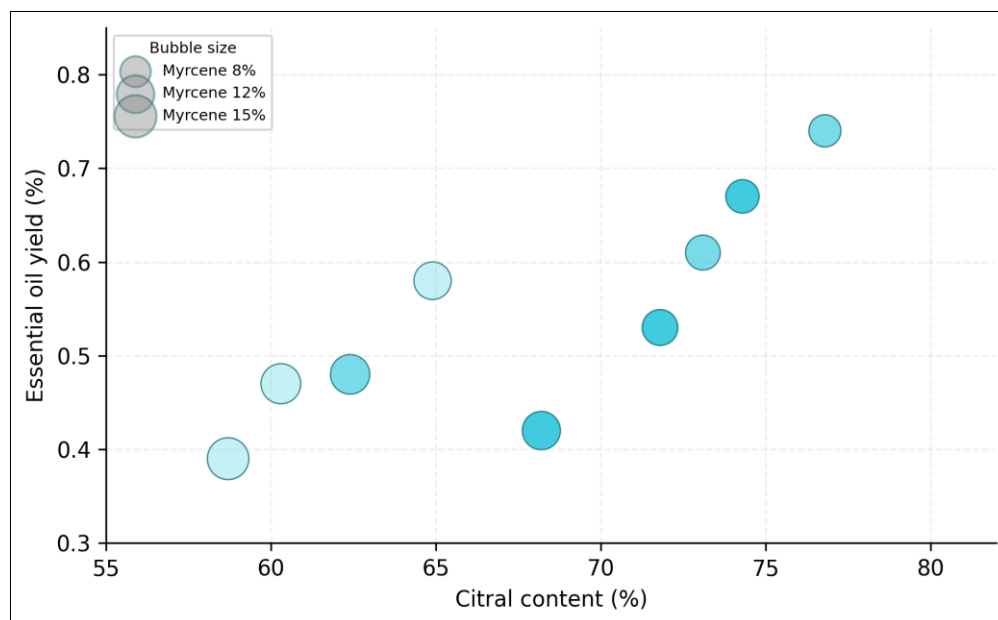


Fig 2: Bubble chart of citral content versus oil yield (bubble size = myrcene percentage)

Figure 1 visualises the dominance of 90 DAP shade drying. The bubble chart (Figure 2) shows a positive association between citral content and oil yield, with smaller myrcene bubbles at the high-citral end, indicating that treatments producing more citral also had better terpene balance.

Quality control

Oil quality was verified against ISO 3217:1974 specifications for lemongrass oil. All shade-dried samples from 90 and 120 DAP met the minimum citral threshold of 75%. Refractive index (1.483-1.489), specific gravity (0.882-0.894), and optical rotation (-1.2° to -3.8°) fell within ISO ranges. GC-MS repeatability was confirmed by triplicate injections (CV <2.1% for citral). Oven-dried samples at 60 DAP failed the ISO citral threshold.

Discussion

The 0.74% oil yield at 90 DAP under shade drying is comparable to the 0.6-0.8% range reported for *C. citratus* in India and Brazil under similar harvest windows [4, 13]. The superiority of shade drying reflects reduced loss of volatile monoterpenes: citral's boiling point (228°C) means that atmospheric temperatures during shade drying (24-27°C) pose minimal evaporative risk, whereas sun exposure to 34°C combined with UV radiation accelerates photo-oxidation [7, 14]. Oven drying at 40°C was the worst performer despite being below citral's boiling point, likely because forced air circulation strips volatiles from leaf surfaces faster than still-air shade drying [15]. For Ugandan smallholders, shade drying under a simple open-sided shelter offers the best cost-benefit trade-off: it requires no energy input and preserves oil quality above the ISO premium threshold [16].

Conclusion

This research identified 90 DAP harvest with shade drying as the optimal combination for maximising both essential oil yield (0.74%) and citral content (76.8%) in lemongrass under Ugandan conditions. Shade drying preserved volatile terpenes better than sun or oven methods.

The findings translate directly into practical recommendations for East African growers: harvest at full flowering and dry under

shade to meet international quality standards with minimal investment.

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