Short Communication

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2026.64.010099

On-Farm Composting of Hop Waste Biomass: Operational Deviations and Compost Quality Outcomes Across Six Hop Farms

Barbara Čeh*

Slovenian Institute of Hop Research and Brewing, Slovenia

***Corresponding author:** Barbara Čeh, Slovenian Institute of Hop Research and Brewing, Slovenia

ARTICLE INFO

Received: February 10, 2026

Published: February 18, 2026

Citation: Barbara Čeh. On-Farm Composting of Hop Waste Biomass: Operational Deviations and Compost Quality Outcomes Across Six Hop Farms. Biomed J Sci & Tech Res 64(5)-2026. BJSTR. MS.ID.010099.

ABSTRACT

On-farm composting of hop waste biomass (leaves and stems remaining after cone harvesting) was assessed on six hop farms over two composting seasons. Piles were established immediately post-harvest (early September) in 2023 (four farms) and 2024 (six farms). Farmers aimed to follow established guidelines; however, operational constraints (turning frequency, pile mass, moisture management, and timing of pile covering) produced measurable variability in compost quality. Compost was sampled in April 2024 and April 2025 and evaluated using maturity indicators (odour, structure, temperature), chemical parameters (including pH, C, N, P, K), and a rapid bioassay (Chinese cabbage germination). All composts had an earthy smell and temperatures comparable to ambient at sampling, consistent with completion of active composting. The most severe quality deterioration occurred when turning was insufficient—particularly when a pile was turned only twice in autumn—resulting in failure to reach sanitization temperature (≥55 °C), incomplete biomass decomposition, moderate nutrient levels, an unfavourable C:N ratio, and germination below 80%, indicating possible phytotoxicity. Additional suboptimal outcomes were associated with small initial biomass (~7 t), overly dry biomass without rewetting, and delayed pile covering (mid-December), likely increasing nutrient losses. Turning during rainfall improved performance in overly dry piles. The highest-quality compost was produced when guidelines were consistently implemented (adequate mass ~15 t, regular turning guided by temperature monitoring, and timely covering after the thermophilic phase), achieving 94% germination test result.

Keywords: Hop Waste Biomass; Hop; Humulus Lupulus L; Compost; Organic Fertilizer

Highlights

- Hop waste biomass (stems + leaves) was composted on six farms over two seasons (2023/2024; 2024/2025).
- The most critical failure mode was insufficient turning (only two turns in thermophilic phase), preventing sanitization (≥55 °C).
- Suboptimal compost also occurred with small initial biomass (~7 t), too dry biomass without rewetting in autumn, and late covering.
- Turning during rainfall improved overly dry pile and improved compost quality.
- Best practice (≈15 t pile, temperature-guided turning, timely covering) achieved the best results, also 94% germination of Chinese cabbage seeds (excellent compost).

DOI: 10.26717/BJSTR.2026.64.010099

Introduction

Composting is a controlled aerobic biological process that stabilizes organic residues into a humus-like material (compost), enabling recycling of plant waste into a hygienized organic fertilizer (Plants database, [1,2]) When properly managed, composting reduces pathogen and weed-seed risks and contributes organic matter and nutrients to soil, supporting soil fertility and microbial functioning (Jahangir, et al. [3]). Hop production generates large quantities of post-harvest vegetative residues next to the harvest halls, making on-farm composting a practical waste-management and nutrient-recycling option (Čeh, et al. [4]). While guidelines exist for composting hop waste biomass (Čeh, et al. [5]), adoption on farms is often constrained by equipment availability, labour peaks during harvest, and variable weather. This short communication links real-world process deviations during on-farm hop biomass composting to compost quality outcomes.

Materials and Methods

Study Sites and Composting Setup

Composting was conducted on six hop farms (two regions) across two seasons: 2023/2024 (four farms) and 2024/2025 (six farms). Piles were built directly after hop harvest (late August to mid-September) using hop stems and leaves. Piles were trapezoidal, ~2 m high, typically formed from ~15 t fresh biomass (≈1 ha of hop yard), with two exceptions where ~7–7.5 t was available. Piles differed in particle size (harvester-dependent cutting) and whether leaves and stems were premixed during harvesting or mixed later (harvester differences).

Process Monitoring and Covering

Pile temperature was measured immediately after set up daily at 50 and 100 cm depths on multiple sides. Turning was recommended when core temperature exceeded ~60 °C; turning generally stopped once temperatures declined below ~45 °C (end of thermophilic phase; in November). Piles were then covered with a semi-permeable membrane for winter maturation; in some cases, covering was delayed or not maintained for the full maturation period.

Compost Sampling and Analyses

Compost was sampled in April 2024 and April 2025. Visual assessment included colour, odour, structure/homogeneity, presence of undecomposed fragments and impurities, and moisture estimation by squeeze test (Cornell Waste Management Institute [6]). Composite samples (multiple subsamples from the pile interior) were taken for chemical analysis (including pH, organic C, total N, mineral N forms, P, K, and selected micronutrients (SIST ISO 14255:1999; SIST ISO 14235:1999; SIST ISO 14255:1999; SIST ISO 11261:1996; SIST ISO 6491:1999; SIST EN ISO 6869:2001; Hodnik [7]). Compost suitability was also assessed using a 14-day Chinese cabbage germination bioassay (percent emergence) (Yuan, et al. [8]).

Results & Discussion

Across all farms, compost had an earthy odour and temperatures similar to ambient at spring sampling, indicating the end of active composting. However, compost quality varied substantially with operational execution. The most consequential deviation was insufficient turning, especially where turning occurred only twice in autumn: this pile did not reach ≥55 °C, retained many undecomposed stems, showed weaker maturity/nutrient indicators, and produced <80% germination, consistent with incomplete stabilization and potential phytotoxicity. Additional suboptimal outcomes were linked to small initial pile mass (~7 t) (reduced heat retention and process stability), dry biomass not rewetted in the thermophilic phase, and late covering (mid-December), which plausibly increased leaching and nutrient loss prior to protection. A practical corrective measure emerged for dry starting material: turning during rainfall effectively increased moisture and improved decomposition outcomes. Concluding paragraph (compact): Overall, the dataset indicates that on-farm hop biomass composting is robust in reaching "finished" temperature/odor endpoints but not necessarily sanitization and phytotoxicity safety unless the process is actively managed; turning frequency and timing (guided by temperature), sufficient pile mass, moisture correction, and prompt covering after the thermophilic phase jointly determine whether the final material functions as a high-quality compost or remains immature and potentially inhibitory.

Conclusion

On-farm composting of hop waste biomass can yield mature, agronomically valuable compost, but the process is sensitive to management. Insufficient turning (only twice) was the dominant risk factor, leading to failure of sanitization temperatures and to compost with possible phytotoxicity. Ensuring adequate pile mass (~15 t), implementing temperature-guided turning, correcting moisture deficits (for example turning during rainfall when needed), and applying timely semi-permeable covering after the thermophilic phase produced the best compost quality, including 94% germination in the bioassay.

Acknowledgement

The work was carried out within the After-LIFE programme of the EU LIFE project BioTHOP. The results were obtained within the EIP project EKOHMELJ, and the manuscript was prepared within the professional assignment "Technology of Hop Production and Processing". We thank the funders for their financial support and trust.

Conflict of Interest

The author declare no conflict of interest.

References

1. (1999) Plants Database, United States Department of Agriculture. Natural Resources Conservation Service.
2. Pan C, Zhao Y, Chen X, Zhang G, Xie L, et al. (2023) Improved carbon sequestration by utilization of ferrous ions during different organic wastes composting. J Environ Manage 347: 119188.
3. Jahangir MMR, Islam S, Nitu TT, Uddin S, Kabir AKMA, et al. (2021) Biocompost-based integrated soil fertility management improves postharvest soil structural and elemental quality in a two-year conservation agriculture practice. Agronomy 11: 11.
4. Čeh B, Polanšek J, Trošt Ž, Karničnik Klančnik A (2025) On-site composting of waste hop biomass: The impact of covering piles on leachate quantity and compost quality. Plant Soil Environ 71(2): 109-122.
5. Čeh B, Flis J, Luskar L, Polanšek J, Trošt Ž (2022) Smernice za ravnanje s hmeljevino in njeno predelavo v kompost na kmetijskem gospodarstvu, ki se ukvarja s hmeljarstvom, p. 1-24.
6. (1996) Compost Physics. Cornell Waste Management Institute.
7. Hodnik A (1988) Kemične analize talnih vzorcev, rastlinskih vzorcev in odcednih vod. Univerza v Ljubljani, Katedra za pedologijo, prehrano rastlin in ekologijo, Ljubljana.
8. Yuan L, Jie L, Guangming Z, Ming C, Dan M, et al. (2018) Seed germination test for toxicity evaluation of compost: Its roles, problems and prospects. Waste management 71: 109-114.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2026.64.010099

Barbara Čeh. Biomed J Sci & Tech Res