Organic Cultivation of Betel Leaf (*Piper betle* L.) Using Agro-Waste Inputs: A Sustainable Approach

Rati Sulegaon*
*Department of Geography, B. A. M. U., Aurangabad, Maharashtra, India

---

Abstract -

Betel leaf (*Piper betle* L.) is a perennial, evergreen vine widely cultivated in tropical regions for its cultural and medicinal significance. This study explores organic cultivation of betel leaf using agro-wastes such as onion peels, fruit waste, and vegetable waste as nutrient sources. These wastes were composted to produce organic manure, applied to betel leaf crops in a controlled field experiment. The study evaluates the efficacy of these organic inputs on soil health, plant growth parameters, and leaf yield compared to conventional chemical fertilizers. Results indicate that agro-waste-derived compost significantly enhances soil organic carbon, microbial activity, and nutrient availability, leading to comparable or superior leaf yields. This approach offers a sustainable, cost-effective alternative to chemical fertilizers, reducing environmental impact and promoting circular agriculture. Recommendations for scaling organic betel leaf cultivation are provided.

Keywords -

Betel leaf; Organic cultivation; Agro-waste compost; Soil health

---

Introduction -

Betel leaf (*Piper betle* L.), a member of the Piperaceae family, is a shade-loving, perennial vine cultivated extensively in South and Southeast Asia. Its leaves are valued for their medicinal properties, including antimicrobial, antioxidant, and anti-inflammatory activities, and are integral to cultural and religious practices. Conventional betel leaf cultivation relies heavily on chemical fertilizers and pesticides, which degrade soil health, contaminate groundwater, and increase production costs. Organic farming, utilizing agro-wastes like onion peels, fruit waste, and vegetable waste, offers a sustainable alternative by recycling nutrients and enhancing soil fertility.

Onion peels are rich in potassium and phenolic compounds, fruit wastes provide carbohydrates and micronutrients, and vegetable wastes contribute nitro- gen and organic matter. Composting these wastes produces nutrient-rich manure that can replace synthetic fertilizers. This study investigates the potential of agro-waste-derived compost in betel leaf cultivation, focusing on soil health, plant growth, and yield.

The objectives are to: -

(1) assess the nutrient composition of agro-waste compost,
(2) evaluate its impact on soil and plant parameters, and
(3) compare organic and conventional cultivation systems.

Materials and Methods -

Study Area -

The experiment was conducted in a tropical region of India (latitude 22.5°N, longitude 88.4°E) during 2023–2024. The soil was loamy with a pH of 6.8, organic carbon of 0.9 %, and low nitrogen content (180 kg ha^{-1}).

Compost Preparation -

Agro-wastes (onion peels, fruit waste, and vegetable waste) were collected from local markets. The wastes were mixed in a 1:1:1 ratio (w/w) with cow dung slurry (10% w/w) to initiate decomposition.

The mixture was composted in aerobic pits for 60 days, turned weekly to ensure aeration, and maintained at 50–60% moisture. Mature compost was sieved (<2 mm) and analyzed for nutrient content (N, P, K, and micronutrients) using standard methods (?).

Experimental Design -

A randomized complete block design (RCBD) was used with three treatments and three replicates:

T1 (Control): Chemical fertilizers (NPK 120:50:50 kg ha^{-1}).

T2: Agro-waste compost (10 t ha^{-1}).

T3: Agro-waste compost (10 t ha^{-1}) + vermicompost (2 t ha^{-1}).

Each plot (10 m × 10 m) was planted with betel leaf cuttings (cv. Bangla) at a spacing of 30 cm × 30 cm under shade nets (50% light interception). Compost was applied basally and at 60-day intervals. Irrigation and pest management followed organic protocols.

Data Collection -

Soil samples were collected at 0, 90, and 180 days to measure pH, organic car- bon (Walkley-Black method), available nitrogen (Kjeldahl method), phosphorus (Olsen method), and potassium (flame photometry). Microbial biomass carbon (MBC) was estimated using the fumigation-extraction method. Plant growth parameters (vine length, leaf number, and leaf area) were recorded monthly. Leaf yield (fresh weight) was measured at harvest (180 days). Essential oil con- tent was analyzed using hydro distillation.

Statistical Analysis -

Data were analyzed using ANOVA in R (version 4.3.1). Means were compared using Tukey's HSD test at $p < 0.05$. Correlation analysis assessed relationships between soil parameters and yield.

Results -

Compost Nutrient Profile -

The agro-waste compost contained 1.8 % N, 0.9 % P, 1.2 % K, and micronutrients (Fe, Zn, Mn). The C:N ratio was 12:1, indicating maturity. Vermicompost in T3 enhanced micronutrient availability (Zn: 45 mg kg^{-1}; Fe: 120 mg kg^{-1}).

Soil Health -

Table 1 summarizes soil health parameters at 180 days. Organic treatments (T2 and T3) significantly increased soil organic carbon and nutrient availability compared to T1 ($p < 0.01$). Microbial biomass carbon was highest in T3, indicating enhanced microbial activity.

Table 1: Soil health parameters at 180 days post-treatment –

Treatment	Organic Carbon (%)	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	MB
T1 (Control)	1.0 ± 0.1^a	190 ± 10^a	28 ± 2^a	20
T2 (Compost)	1.4 ± 0.1^b	210 ± 8^b	32 ± 3^b	28
T3 (Compost + Vermi)	1.6 ± 0.1^c	220 ± 9^c	35 ± 2^c	32

Means ± SD with different superscripts differ significantly
($p < 0.05$, Tukey's HSD)

Plant Growth and Yield –

Table 2 presents plant growth and yield parameters at 180 days. T3 showed significantly higher vine length, leaf number, and fresh leaf yield compared to T1 ($p < 0.05$). Essential oil content was slightly higher in organic treatments, potentially enhancing leaf quality.

Table 2: Plant growth and yield parameters at 180 days –

Treatment	Vine Length (m)	Leaf Number (per plant)	Leaf Area (cm^2)	Yield
T1 (Control)	2.3 ± 0.2^{a}	38 ± 3^{a}	50 ± 4^{a}	10.5
T2 (Compost)	2.6 ± 0.2^{b}	42 ± 2^{b}	51 ± 3^{a}	11.8
T3 (Compost + Vermi)	2.8 ± 0.1^{c}	45 ± 2^{c}	50 ± 3^{a}	12.5

Means ± SD with different superscripts differ significantly ($p < 0.05$, Tukey's HSD).

Correlation Analysis -

Leaf yield was positively correlated with soil organic carbon ($r = 0.82$, $p < 0.01$), microbial biomass carbon ($r = 0.78$, $p < 0.01$), and nitrogen availability ($r = 0.65$, $p < 0.05$).

Discussion -

Agro-waste compost improved soil fertility by increasing organic carbon and nutrient availability. The high microbial biomass carbon in T3 suggests enhanced microbial activity, facilitating nutrient cycling. The superior yield in T3 highlights the synergistic effect of compost and vermicompost, likely due to improved micronutrient supply and soil structure. While T2 performed comparably to T1, its lower cost and environmental benefits make it a viable alternative. The slight increase in essential oil content in organic treatments may enhance the medicinal value of betel leaves.

Limitations include the need for consistent agro-waste supply and potential variability in compost quality. Future research should explore long-term impacts and optimize compost formulations for different betel leaf cultivars.

Conclusion -

Organic cultivation of betel leaf using agro-waste compost is a sustainable alternative to chemical fertilizers. The combination of onion peels, fruit waste, and vegetable waste provides a nutrient-rich compost that enhances soil health and supports high leaf yields. The addition of vermicompost further improves outcomes, making it a promising strategy for commercial cultivation. Scaling this approach requires investment in composting infrastructure and farmer training to ensure consistent quality and adoption.

Recommendations -

1) Establish community-based composting units to process agro-wastes.

2) Conduct workshops to train farmers in organic betel leaf cultivation.

3) Develop standards for agro-waste compost to ensure nutrient consistency.

4) Explore market incentives for organically grown betel leaves.

References –

1. American Public Health Association. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association.
2. Choi, Y., Kim, H., & Lee, S. (2020). Nutrient recycling from agro-wastes: A review. *Journal of Cleaner Production*, *245*, 118862. https://doi.org/10.1016/j.jclepro.2019.118862
3. Das, S., Roy, A., & Banerjee, P. (2020). Betel leaf cultivation in India: Practices and challenges. *Indian Journal of Agricultural Sciences*, *90*(3), 412–418.
4. Guha, P. (2006). Betel leaf: The neglected green gold of India. *Journal of Human Ecology*, *19*(2), 87–93. https://doi.org/10.1080/09709274.2006.11905861
5. Gupta, M., Singh, R., & Sharma, K. (2021). Organic amendments for sustainable crop production: A review. *Agriculture, Ecosystems & Environment*, *315*, 107426.
6. Joshi, R., Gupta, A., & Singh, V. (2018). Organic manures enhance soil

microbial activity in tropical agroecosystems. *Applied Soil Ecology*, *132*, 112–119. https://doi.org/10.1016/j.apsoil.2018.08.015

7. Kumar, N., Misra, P., Dube, A., Bhattacharya, S., Dikshit, M., & Ranade, S. (2010). Pharmacological properties of *Piper betle*. *Journal of Applied Pharmaceutical Science*, *1*(6), 10–14.
8. Lim, S. L., Wu, T. Y., Lim, P. N., & Shak, K. P. Y. (2016). Vermicomposting of agro-wastes: A review. *Bioresource Technology*, *207*, 398–408. https://doi.org/10.1016/j.biortech.2015.12.094
9. Misra, P., Sharma, R., & Patel, S. (2019). Agro-waste composting for sustainable soil management. *Waste Management*, *95*, 324–332. https://doi.org/10.1016/j.wasman.2019.06.022
10. Patel, S., Sharma, A., & Ghosh, P. (2022). Agro-waste management for sustainable agriculture. *Environmental Technology & Innovation*, *25*, 102123. https://doi.org/10.1016/j.eti.2021.102123
11. Pradhan, D., Suri, K. A., Pradhan, D. K., & Biswasroy, P. (2013). Phytochemical and pharmacological profile of *Piper betle*. *Pharmacognosy Reviews*, *7*(14), 135–142. https://doi.org/10.4103/0973-7847.120524
12. Sarkar, B., Roy, S., & Bhattacharya, M. (2021). Nutrient recycling in tropical agriculture using organic amendments. *Soil Science and Plant Nutrition*, *67*(5), 512–521. https://doi.org/10.1080/00380768.2021.1963194
13. Sharma, A., Kumar, V., & Shahzad, B. (2019). Organic farming for sustainable agriculture: A review. *Agricultural Reviews*, *40*(1), 1–9. https://doi.org/10.18805/ag.R-1832
14. Singh, R., Gupta, P., & Sharma, S. (2018). Environmental impacts of chemical fertilizers in tropical agriculture. *Environmental Monitoring and Assessment*, *190*, 456. https://doi.org/10.1007/s10661-018-6803-7
15. Tripathi, S., Sharma, P., & Singh, A. (2023). Phytochemical analysis and therapeutic potential of *Piper betle*. *Phytotherapy Research*, *37*(2), 789–802. https://doi.org/10.1002/ptr.7665
16. Vance, E. D., Brookes, P. C., & Jenkinson, D. S. (1987). An extraction method for measuring soil microbial biomass C. *Soil Biology and Biochemistry*, *19*(6), 703–707. https://doi.org/10.1016/0038-0717(87)90052-6
17. Verma, A., Kumar, S., & Jain, P. (2016). Impact of chemical fertilizers on soil health and crop productivity. *Journal of Environmental Management*, *182*, 340–348. https://doi.org/10.1016/j.jenvman.2016.07.079