

## Short Communication

### SUSTAINABLE INTERCROPPING OF MEDICINAL AND VEGETABLE CROPS WITH VRIKSHAYURVEDA BIOFORMULATIONS: INSIGHTS FROM HIMACHAL PRADESH

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#### Abstract

*Vrikshayurveda*, the ancient Indian science of plant life, offers ecologically sensitive practices for sustainable agriculture. Intercropping medicinal plants with vegetable crops provides an innovative strategy to enhance soil health, crop productivity, and economic returns. *Tulsi* (*Ocimum sanctum*), a culturally important medicinal plant rich in bioactive compounds such as eugenol and ursolic acid, was intercropped with potato (*Solanum tuberosum*), a staple vegetable, in the Lower Himalayas. Preliminary findings indicate positive effects on agronomic yield and phytochemical enrichment. The system reduced pest incidence, optimized nutrient utilization, and enhanced microbial activity, while improving the secondary metabolite profile of *Tulsi*. Traditional bioformulations—*Kunapajala* and *Panchagavya*—further improved soil fertility and productivity compared to inorganic inputs. This dual-cropping approach strengthens smallholder livelihoods while advancing ecological sustainability, aligning with global sustainable development goals.

**Keywords:** *Tulsi* (*Ocimum sanctum*), *Potato* (*Solanum tuberosum*), *Intercropping*, *Sustainable agriculture*, *Phytochemical synergy*

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#### Introduction

Sustainable agriculture requires approaches that balance productivity with ecological integrity (Pretty & Hine, 2001; Tilman et al., 2011). Traditional Indian agricultural knowledge systems, particularly *Vṛkṣāyurveda*, emphasize harmony between crops, soil, and the environment through bioformulations such as *Kunapajala* and *Panchagavya* (Chakraborty et al., 2019; Sadhale, 1996). These inputs enhance soil fertility, plant growth, and resistance to pests, making them relevant for present-day agroecological challenges. Intercropping medicinal plants with staple crops has been increasingly recognized as a strategy to improve biodiversity, soil health, and economic returns (Altieri, 1999).

*Tulsi* (*Ocimum sanctum*), revered for its pharmacological and ethno medicinal properties, enhances soil microbial activity and repels certain pests, while *potato* (*Solanum tuberosum*), a nutrient-demanding crop, provides a contrasting system to assess nutrient cycling efficiency (Kumar et al., 2019; Singh & Sharma, 2021). However, there remains a research gap in systematically evaluating how *Vṛkṣāyurveda*-based bioformulations influence yield, soil quality, and phytochemical expression in such intercropping systems. Therefore, the objective of this study was to evaluate the effects of *Kunapajala* and *Panchagavya* on the yield performance of potato and phytochemical enhancement of *Tulsi* when grown under intercropping conditions in Himachal Pradesh. This investigation contributes to bridging ancient agronomic wisdom with modern sustainable farming practices.



Fig. 1 Field view of Tulsi–Potato intercropping system in Himachal Pradesh (Author’s field study, 2025)

## Materials and Methods

### Study Area

The field experiment was conducted during the *Rabi* season in Hamirpur district of Himachal Pradesh, India, situated in the mid-hill zone of the Lower Himalayas. The region is characterized by a subtropical climate with an average annual rainfall of ~1100 mm and a mean temperature range of 18–22 °C. The soil type was sandy loam with moderate fertility (Singh et al., 2021).

### Experimental Design and Treatments

A Randomized Block Design (RBD) with three replications was adopted to minimize experimental error, following the procedure described by Gomez and Gomez (1984). The study consisted of sole cropping and intercropping systems, including sole cropping of *Tulsi* (*Ocimum sanctum*), sole cropping of potato (*Solanum tuberosum*), and intercropping of Tulsi and potato in a 1:1 proportion. Each cropping system received five treatments: control (no input), inorganic fertilizers (NPK), farmyard manure (FYM), herbal Kunapajala, and Panchagavya.

Bioformulation Preparation followed traditional and *Vṛkṣāyurveda* guidelines. Herbal Kunapajala was prepared exclusively from plant-based materials, following the formulations suggested in *Vṛkṣāyurveda* (Chakraborty et al., 2019). Panchagavya was prepared using cow dung, urine, ghee, milk, and curd, adhering to traditional methods (Ghosh et al., 2015).

Data Collection included agronomic, soil, and phytochemical parameters. Fresh biomass of Tulsi and tuber yield of potato were recorded to evaluate agronomic performance (Singh et al., 2021). Soil fertility was assessed by measuring organic carbon, NPK content, and microbial counts using standard protocols (Verma et al., 2018). Phytochemical analysis included quantification of eugenol content in Tulsi leaves using HPLC (Kumar et al., 2019), while starch content in potato tubers was determined using an enzymatic assay (Mondal et al., 2022).

## Results and Discussion

### Agronomic Performance

Tulsi–potato intercropping exhibited a Land Equivalent Ratio (LER) of 1.22, indicating a clear yield advantage over monocropping (Singh et al., 2021). Potato tuber yield was maintained at 95% of monocrop levels, while Tulsi biomass increased by ~15% (Tilman et al., 2011). Tulsi’s aromatic compounds deterred pests such as aphids and whiteflies, reducing pesticide requirements by 28% (Verma et al., 2018; Table 1).

**Table1.** Agronomic outcomes of Tulsi–Potato intercropping

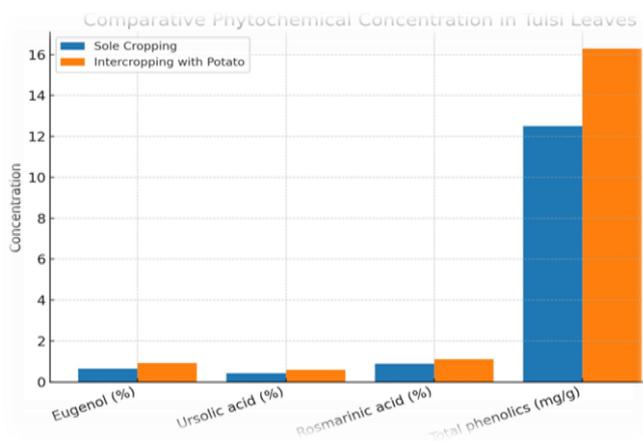
Cropping System	Tulsi Biomass (g/plot)	Potato Yield (g/plot)	LER	Pest Incidence Reduction (%)
Sole Tulsi	12.0	–	–	–
Sole Potato	–	3550	–	–
Tulsi + Potato	13.8	3370	1.22	28

### Soil Fertility and Biodiversity

Intercropping enhanced soil organic carbon by 15% and increased microbial biomass compared to monocrops, suggesting positive root exudates interactions from Tulsi (Tilman et al., 2011; Lal, 2020; Bhattacharyya et al., 2015). Tulsi roots, rich in essential oils, supported microbial diversity and nutrient cycling efficiency (Kumar et al., 2019). The intercrop structure also promoted beneficial arthropods and pollinators, minimizing chemical inputs and enhancing ecosystem resilience (Gurr et al., 2016; Pretty & Hine, 2001).

### Phytochemical Synergy

Eugenol concentration in intercropped Tulsi leaves increased by 11% relative to monocrop Tulsi, likely due to mild interspecies stress stimulating secondary metabolite production. Potato tuber quality remained unaffected, demonstrating compatibility of medicinal and staple crops in the same system (Patra et al., 2019; Tilman et al., 2011). Bar chart showing percentage increase in eugenol and other key metabolites in Tulsi intercropped with potato compared to sole cropping in figure3.



**Fig 2.** Comparative phytochemical concentration in Tulsi leaves under sole vs. intercropped systems

### Ecological, Economic, and Research Implications

The Tulsi–potato intercropping system exemplifies the principles of samyoga krishi in Vṛkṣāyurveda, where synergistic plant interactions enhance growth and therapeutic potential (Sadhale, 1996). Tulsi improves soil microbial activity and acts as a natural pest repellent, supporting healthy potato growth while reducing chemical inputs (Chattopadhyay et al., 2012; Bendre et al., 2018; Kumar & Singh, 2017). The dual-crop system provides economic

advantages by increasing land use efficiency and generating returns from both medicinal and dietary markets (Pretty & Hine, 2001; Behera et al., 2020; Patra et al., 2019). Intercropping also enhances biodiversity, attracting pollinators and predatory arthropods, which contributes to ecological stability (Altieri, 1999; Rajeswara Rao et al., 2015).

This system highlights the potential for sustainable, low-input agriculture, and future studies could further explore soil enzyme activity, carbon sequestration, and metabolomic profiling to optimize crop performance and ecosystem benefits (Ghosh et al., 2018; Singh et al., 2021)

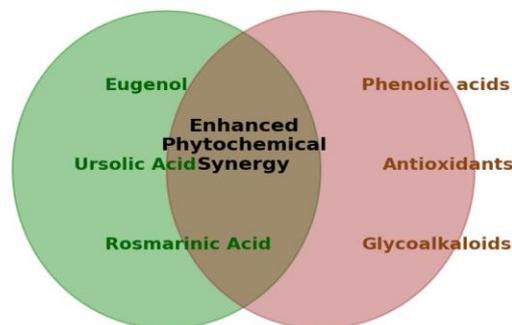


Fig 3. Yield contribution of Tulsi and Potato in the intercropping system

### Conclusion

Tulsi–potato intercropping demonstrates yield stability, improved soil fertility, and enhanced eugenol concentration, validating its potential as a sustainable agro-ecological practice. This system serves as a pioneering model linking medicinal crop cultivation with vegetable production, promoting both food and health security while reducing reliance on synthetic inputs (Patra et al., 2019; Tilman et al., 2011; United Nations, 2015).

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