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Impact of *Tephrosia candida* alley cropping on soil fertility in Ranchi district of Jharkhand

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Abstract
A field trial was conducted at the Agroforestry Research Field, Faculty of Forestry, BAU, Ranchi, under a subtropical humid climate in Northeast India during 2023-2024 to assess the physico-chemical properties of soil in alley cropping and sole cropping systems at two depths (0-15 cm and 15-30 cm). The study involved four-year-old hedgerows of *Tephrosia candida* (Hoary Pea) intercropped with arable crops (during both Kharif and Rabi seasons) in a Randomized Block Design with four replications and ten treatments, *viz*., T_1 (*T. candida* + Soybean/Linseed), T_2 (*T. candida* + Finger millet/Field pea), T_3 (*T. candida* + Peanut/Lentil), T_4 (*T. candida* + Black gram/Mustard), T_5 (*T. candida* + Sesame/Chickpea), and sole cropping without hedgerows: T_6 (Soybean/Linseed), T_7 (Finger millet/Field pea), T_8 (Peanut/Lentil), T_9 (Black gram/Mustard), and T_{10} (Sesame/Chickpea).The results revealed that soil under *T. candida*-based alley cropping exhibited a considerable increase in pH across all treatments at both depths. Electrical conductivity also showed an improving trend under intercropping. Soil Organic Carbon (OC,%) significantly improved in alley cropping compared to sole cropping at both depths. A marked increase in the availability of nitrogen, phosphorus, and potassium was recorded in the soil across all treatments under alley cropping, particularly within the 0-15 cm soil depth. However, a consistent decline in the availability of essential nutrients (N, P, K, and OC) was observed in the subsoil layer (15-30 cm) under both alley and sole cropping systems. In contrast, soil pH exhibited a progressive increase with depth, indicating depth-dependent variation in soil chemical properties. The study clearly indicates that *T. candida*-based alley cropping serves as an effective and sustainable agroecological strategy for maintaining and improving soil health over extended periods.

Keywords: Alley cropping, hedgerow, soil properties, *Tephrosia*, sustainable

Introduction
A major challenge for agriculture in tropical regions is the development of effective farming systems for rainfed upland areas that can sustain and enhance crop yields while minimizing the degradation of non-renewable soil resources. Alley cropping, an agroforestry practice, involves growing arable crops between rows of trees or perennial shrubs. In tropical systems, the perennial species, usually leguminous trees or shrubs, are planted and maintained as hedgerows less than 10 m apart, with crops cultivated in the interspaces or alleys between them (Nair *et al*., 2021) [5]. This tree-based system improves soil quality through efficient nutrient recycling and erosion control, thereby creating soil conditions similar to those found during the fallow stage of shifting cultivation. The choice of tree species is a critical determinant of the effectiveness and sustainability of alley cropping systems. Leguminous trees are particularly favored because of their ability to fix atmospheric nitrogen, thereby enriching the soil with bioavailable nutrients that support companion crops. During the cropping phase, the hedgerows are regularly pruned, and the nutrient-rich biomass is incorporated into the soil as green manure, further improving soil fertility and productivity.

The benefits of alley cropping are multifaceted. Agronomically, it reduces soil erosion by acting as a physical barrier to surface runoff, enhances nutrient cycling through organic matter incorporation, and improves soil structure by promoting deep root penetration and aeration. Ecologically, the system enhances biodiversity, provides habitat corridors, and contributes to climate change mitigation through carbon sequestration in both biomass and soil. The hedgerows also play a crucial role in water management. Their physical presence reduces runoff velocity, encouraging water infiltration into the soil. Leaf litter and organic matter inputs increase soil water-holding capacity, thereby reducing susceptibility to drought stress. This is especially advantageous in water-limited environments, such as India's rainfed agricultural zones. For instance, Guto *et al.* (2012) [3] reported that soil water content was 56-77% higher near the base of *Leucaena* trees compared to adjacent open plots. Additionally, alley cropping helps moderate soil temperature extremes. Partial canopy cover provided by hedgerows shades the soil surface, reducing evaporation and creating a more favorable microclimate for soil biota. In Jharkhand, where agriculture is predominantly rainfed—accounting for over 80% of the cultivated area and largely practiced by smallholder and marginal farmers—such advantages are highly significant. The reliance on monsoon rains, coupled with inherently low soil fertility and high erosion rates, makes agricultural production highly vulnerable to climatic variability. Within this challenging agroecological backdrop, alley cropping emerges as a viable strategy to enhance ecological resilience, sustain crop productivity, and improve rural livelihoods.

Materials and Methods

Experimental Site

The study was conducted at the Agroforestry Research Field, Faculty of Forestry, Birsa Agricultural University (BAU), Ranchi, located between 23º30´-23º40´ N latitude and 85º30´-85º40´ E longitude at an altitude of 651 m above mean sea level (MSL). The site falls under a subtropical humid climate of Northeast India and the experiment was carried out during 2023-2024. The area experiences warm and humid weather, with an average annual rainfall of approximately 1400 mm, most of which is received during the monsoon season (June-September). The temperature ranges from 6.8 °C in winter to 37.9 °C in summer. The soil of the experimental site is classified as sandy loam in texture with a bulk density of 1.3 g cm^{-3}.

Field Experiment

The field trial was conducted in a four-year-old plantation of *Tephrosia candida* (Hoary Pea) maintained as hedgerows and intercropped with arable crops during both the Kharif and Rabi seasons. The experiment was laid out in a Randomized Block Design (RBD) with four replications and ten treatments, *viz*.: T_1 (*Tephrosia candida* + Soybean/ Linseed), T_2 (*T. candida* + Finger millet/ Field Pea), T_3 (*T. candida* + Peanut/ Lentil), T_4 (*T. candida* + Black gram/ Mustard), T_5 (*T. candida* + Sesame/ Chick Pea) and in sole without hedge T_6 (Soybean/ Linseed), T_7 (Finger millet/ Field Pea), T_8 (Peanut/ Lentil), T_9 (Black gram/ Mustard), T_{10} (Sesame/ Chick Pea).

Species description

Woody component

Hoary Pea [*Tephrosia candida* (Roxb.) D.C.] belongs to the family Fabaceae and is commonly known as white hoary pea, hoang pea, or white tephrosia. It is native to a broad geographical range covering the Indian subcontinent, parts of Southeast Asia, and several Indian Ocean islands. The species thrives at altitudes up to 1600 m and adapts well to climates with mean annual temperatures between 18 °C and 28 °C and rainfall ranging from 700 to 2500 mm.

Table 1: *Kharif* intercrops

Species	Family	Leguminous/Non leguminous	Use	Distribution	Rainfall (mm)	Temperature (°C)
Soybean	Fabaceae	Leguminous	Culinary	Native to East Asia	400-500	20 to 30 °C
Finger millet	Poaceae	Non leguminous	Culinary	Native to Ethopia & Uganda highlands	500	27 °C
Black gram	Fabaceae	Leguminous	Culinary	Native to Central Asia and India	600-1000	25-35 °C
Peanut	Fabaceae	Leguminous	Culinary and oil	Native to Brazil	500-900	26-36 °C
Sesame	Pedaliaceae	Non leguminous	Culinary and oil	Native to East Asia	600-1000	25-23 °C

Table 2: *Rabi* intercrops

Species	Family	Leguminous/Non leguminous	Use	Distribution	Rainfall (mm)	Temperature (°C)
Linseed	Linaceae	Non leguminous	Culinary and oil	Eastern Mediterranean and parts of India	150-200	23 to 26 °C
Field	Fabaceae	Leguminous	Culinary	Eastern Mediterranean	800-1000	13-18 °C
Lentil	Fabaceae	Leguminous	Culinary	Eastern Mediterranean	150-550	13 to 18 °C
Mustard	Brassicaceae	Non leguminous	Culinary and oil	Southern Mediterranean	625-1000	15-25 °C
Chick	Fabaceae	Leguminous	Culinary	Turkey	625-1000	21-26 °C

Methods

After the completion of the 2023-24 cropping cycle (*Kharif* and *Rabi* seasons), soil samples were collected randomly from two locations within each plot at two depths: 0-15 cm and 15-30 cm. The samples were air-dried under shade, gently ground, and passed through a 2-mm sieve. The sieved soil was thoroughly mixed, and composite samples were prepared for the assessment of physico-chemical properties, including soil pH, electrical conductivity (EC), organic carbon (OC%), and available nitrogen (N), phosphorus (P), and potassium (K). Soil pH was determined using a digital pH meter in a 1:2.5 soil-to-distilled water suspension (Jackson, 1973) [4], while EC (dS m^{-1}) was measured using an electrical conductivity meter (Jackson, 1973) [4]. Soil organic carbon was estimated by the chromic acid wet oxidation method (Walkley and Black, 1934) [11]. Available nitrogen was determined by the alkaline potassium permanganate method (Subbiah & Asija, 1956) [8]. Available phosphorus was analyzed by the ascorbic acid-reduced molybdophosphoric blue colour method (Watanabe & Olsen, 1965) [12], whereas available potassium was estimated using a flame photometer after extraction with neutral normal ammonium acetate (Tandon, 1993) [10].

Statistical analysis

Data on soil physico-chemical properties were subjected to analysis of variance (ANOVA) following the procedures outlined by Gomez and Gomez (1984) [2], and treatment means were compared at 5% significance levels using standard statistical software

Results and Discussion

Table 3: Changes in soil properties under Hoary Pea based alley cropping system during 2023 to 2024.

Treatments	Soil pH		Electrical conductivity (dSm^{-1})		Organic Carbon (%)		Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})	
	2023-24		2023-24		2023-24		2023-24		2023-24		2023-24	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1 (*T. candida + G. max/ L. usitatissimum*)	5.81	5.84	0.36	0.35	0.389	0.382	220.30	203.16	22.61	21.25	229.17	200.50
T_2 (*T. candida + E. coracana / P. sativum*)	5.65	5.68	0.34	0.35	0.312	0.302	208.13	198.76	21.33	20.25	245.40	217.13
T_3 (*T. candida + A. hypogaea / L. esculenta*)	5.82	5.86	0.37	0.36	0.440	0.431	240.76	234.17	21.45	20.30	259.35	230.25
T_4 (*T. candida + V. mungo / B. nigra*)	5.70	5.74	0.35	0.35	0.327	0.320	215.94	200.85	19.11	18.06	266.77	232.16
T_5 (*T. candida + S. indicum / C. arietinum*)	5.78	5.80	0.36	0.36	0.360	0.354	218.33	203.35	21.65	20.40	262.39	225.28
T_6 (Sole *G. max/ L. usitatissimum*)	5.74	5.79	0.32	0.31	0.385	0.378	217.48	200.13	21.33	20.09	220.34	190.05
T_7 (Sole *E. coracana/ P. sativum*)	5.60	5.65	0.30	0.29	0.310	0.302	205.17	195.25	19.50	18.22	235.50	204.49
T_8 (Sole *A. hypogaea/ L. esculenta*)	5.77	5.80	0.32	0.30	0.438	0.430	227.51	210.22	20.09	18.95	248.45	210.08
T_9 (Sole *V. mungo/ B. nigra*)	5.65	5.69	0.31	0.30	0.324	0.317	210.58	200.29	17.50	16.55	252.40	222.55
T_{10} (Sole *S. indicum/ C. arietinum*)	5.74	5.72	0.31	0.29	0.355	0.350	209.05	198.47	19.80	18.35	249.39	214.67
S. Em±	*0.19*	*0.18*	*0.01*	*0.01*	*0.013*	*0.015*	*5.94*	*5.87*	*0.56*	*0.52*	*5.94*	*5.76*
CD (p=0.05)	*NS**	*NS**	*NS**	*NS**	*0.039*	*0.044*	*17.64*	*17.43*	*1.67*	*1.54*	*17.64*	*17.11*
CV%	*6.23*	*6.31*	*5.84*	*7.21*	*5.61*	*5.43*	*5.18*	*5.79*	*5.38*	*5.18*	*5.29*	*5.73*
Initial Value	5.59	5.62	0.30	0.28	0.300	0.290	203.39	192.00	15.45	15.25	210.76	190.00

*NS- Non significant at p =0.05
Figure within a column followed by similar latter (s) do not significantly (p= 0.05) as per DMRT.

The soil under *T. candida* based alley cropping showed a general trend of increased pH across all treatments compared to sole crops at both soil depths (0-15 cm and 15-30 cm) during 2023-24. However, the variation in soil pH among treatments was non-significant at $p = 0.05$. The maximum soil pH was recorded under T_3 (*T. candida* + *Arachis hypogaea* / *Lens esculenta*) with values of 5.82 and 5.86 at 0-15 cm and 15-30 cm depths, representing increments of 0.05 and 0.06 units, respectively. In both alley and sole cropping systems, pH exhibited a depth-dependent increase, with higher values recorded in deeper soil layers.

Soil electrical conductivity (EC) was highest under T_8 (sole *A. hypogaea* / *L. esculenta*, 0.37 dS m^{-1}) at 0-15 cm and under T_3 (*T. candida* + *A. hypogaea* / *L. esculenta*, 0.35 dS m^{-1}) at 15-30 cm. The lowest EC values were observed in T_7 (sole *Eleusine coracana* / *Pisum sativum*, 0.30 dS m^{-1}) and T_{10} (sole *Sesamum indicum* / *Cicer arietinum*, 0.29 dS m^{-1}) at 0-15 cm and 15-30 cm, respectively. Nevertheless, treatment differences in EC were statistically non-significant ($p = 0.05$), with mixed effects observed between alley and sole cropping across soil depths.

Soil organic carbon (OC%) showed a significant increase under alley cropping compared to sole cropping at both depths. The maximum values were recorded under T_3 (*T. candida* + *A. hypogaea* / *L. esculenta*, 0.440% and 0.431%), which were statistically at par with T_8 (sole *A. hypogaea* / *L. esculenta*, 0.438% and 0.430%) at 0-15 cm and 15-30 cm, respectively. The lowest value was noted in T_7 (sole *E. coracana* / *P. sativum*, 0.310%) at 0-15 cm. A consistent decline in OC% was observed with increasing soil depth in both systems. Similar findings were reported by Quinkenstein *et al*. (2017) [7], who observed that tree-based systems on agricultural lands enhance soil organic carbon (SOC) stocks, a key indicator of humus content and soil fertility.

Available nitrogen was highest under T_3 (*T. candida* + *A. hypogaea* / *L. esculenta*, 240.76 and 234.17 kg ha^{-1}), followed by T_8 (sole *A. hypogaea* / *L. esculenta*, 227.51 and 210.22 kg ha^{-1}), while the lowest was recorded in T_7 (sole *E. coracana* / *P. sativum*, 205.17 and 195.25 kg ha^{-1}) at 0-15 cm and 15-30 cm depths, respectively. In general, nitrogen availability decreased with increasing soil depth across both systems.

Available phosphorus was consistently higher in alley cropping compared to sole cropping at both depths. The highest values were observed in T_1 (*T. candida* + *Glycine max* / *Linum usitatissimum*, 22.61 and 21.25 kg ha^{-1}), followed by T_5 (*T. candida* + *S. indicum* / *C. arietinum*, 21.65 and 20.40 kg ha^{-1}). The lowest values were recorded in T_9 (sole *Vigna mungo* / *Brassica nigra*, 17.50 and 16.55 kg ha^{-1}) at 0-15 cm and 15-30 cm, respectively. Phosphorus availability showed a declining trend with soil depth in both systems.

Available potassium also increased under alley cropping relative to sole cropping at both depths. The maximum value was found in T_4 (*T. candida* + *V. mungo* / *B. nigra*, 266.77 kg ha^{-1}) at 0-15 cm, while at 15-30 cm it was highest in T_3 (*T. candida* + *A. hypogaea* / *L. esculenta*, 232.16 kg ha^{-1}). These were followed by T_5 (*T. candida* + *S. indicum* / *C. arietinum*, 262.39 kg ha^{-1} at 0-15 cm) and T_3 (230.25 kg ha^{-1} at 15-30 cm). The minimum potassium availability was recorded under T_6 (sole *G. max* / *L. usitatissimum*, 220.30 and 190.05 kg ha^{-1}) at 0-15 cm and 15-30 cm, respectively. A general decline in the availability of soil nutrients (N, P, K, and OC) with increasing depth was evident in both alley and sole cropping systems.

Discussion

Soil properties such as pH, electrical conductivity (EC), organic carbon, and the availability of nitrogen, phosphorus, and potassium are critical indicators of soil fertility that directly influence crop growth, yield, and overall agricultural productivity. The present study demonstrated a positive influence of Hoary pea (*Tephrosia candida*) based alley cropping systems on the physico-chemical properties of soil when compared to sole cropping. Results indicated that soils under alley cropping systems exhibited elevated pH levels, thereby mitigating soil acidity and contributing to improved soil health. Similar findings were reported by Suhag *et al*. (2025) [9], who observed higher soil pH under *Leucaena leucocephala* based alley cropping compared to control, highlighting the potential of such systems in promoting sustainable land management.

The results of the present study also corroborate the findings of Das *et al*. (2021) [1], who reported improvements in soil physical and chemical properties as well as enhanced soil moisture regimes with the integration of *T. candida* into cropping systems. This emphasizes the role of leguminous hedgerow species in enhancing soil fertility and sustainability through organic matter addition and nutrient cycling.
Furthermore, the present findings are consistent with those of Prasad *et al*. (2022) [6], who observed that organic carbon and available N, P, and K were relatively higher in the surface soil layer (0-15 cm), while soil pH and EC values tended to be higher in the sub-surface soil profile (15-30 cm). This pattern suggests that alley cropping systems not only enhance nutrient availability but also promote stratification of soil properties, which can be advantageous for long-term soil fertility management.

Conclusion

The present study demonstrates that *Tephrosia candida*-based alley cropping systems significantly enhance key physico-chemical properties of soil. The incorporation of these leguminous woody perennials led to a notable increase in soil pH, reducing acidity and improving nutrient availability. Soil organic carbon levels were substantially enriched, indicating enhanced soil organic matter and potential carbon sequestration benefits. Moreover, the integration of *T. candida* with annual crops improved the availability of essential macronutrients, including nitrogen, phosphorus, and potassium, thereby strengthening soil fertility and productivity. Beyond soil health, alley cropping offers broader agroecological advantages: it contributes to sustainable land management, mitigates soil degradation, supports climate resilience by improving water retention and carbon storage, and promotes biodiversity within farming landscapes. Collectively, these findings highlight the efficacy of alley cropping as a long-term, sustainable strategy for enhancing soil fertility, sustaining crop productivity, and advancing resilient agricultural systems in subtropical regions.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to the research, authorship, or publication of this article.

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References

1. Das B, Sarkar PK, Dhakar MK, *et al*. Basin enrichment of Bael plants (*Aegle marmelos* Correa) through alley cropping of biomass producing plants: Effects on plant growth and soil properties. Fruits. 2021;76(2):61-71.
2. Gomez AA, Gomez KA. Multiple Cropping in the Humid Tropics of Asia. IDRC; 1984.
3. Guto SN, De Ridder N, Giller KE, Pypers P, Vanlauwe B. Minimum tillage and vegetative barrier effects on crop yields in relation to soil water content in the Central Kenya highlands. Field Crops Research. 2012;132:129-138.
4. Jackson ML. Soil chemical analysis. Prentice Hall; 1973.
5. Nair PKR, Kumar BM, Nair VD. Tropical Alley Cropping and Improved Fallows. In: An Introduction to Agroforestry. Springer; 2021. doi:10.1007/978-3-030-75358-0_6.
6. Prasad SK. Study of physico-chemical and nutrient stoichiometry of soil under Agri-horti system [Doctoral dissertation]. BANARAS HINDU UNIVERSITY VARANASI; 2022.
7. Quinkenstein A, Tsonkova P, Freese D. Alley Cropping with Short Rotation Coppices in the Temperate Region: A Land-use Strategy for Optimizing Microclimate, Soil Organic Carbon and Ecosystem Service Provision of Agricultural Landscapes. In: Dagar J, Tewari V, eds. Agroforestry. Springer; 2017. doi:10.1007/978-981-10-7650-3_10.
8. Subbiah BV, Asija GL. A rapid procedure for assessment of available nitrogen in soils. Current Science. 1956;25:259-260.
9. Suhag M, Ahamed T, Das AK, *et al*. Leucaena-Based Alley Cropping System: An Approach for Reclaiming Degraded Land, Reducing the Use of Inorganic Nitrogen Fertilizer, and Improving Crop Productivity. Nitrogen. 2025;6(2):25. doi:10.3390/nitrogen6020025.
10. Tandon HLS. Methods Analysis of Soils, Plants, Waters and Fertilizers Fertilizer Development and Consultation Organization. Fertilizer Development and Consultation Organization; 1993.
11. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37(1):29-38.
12. Watanabe FS, Olsen SR. Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extracts from soil. Soil Science Society of America Proceedings. 1965;29(6):677-678.