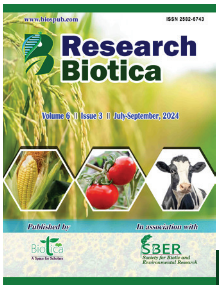

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Research Article

# Impact of Agroforestry on Soil Fertility in a Natural Farming System

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**Abstract**

This work examines the effects of sole turmeric and turmeric intercropped with tree along with mulching under the Natural Farming system on soils nutrients level and physical properties of the soils at depths of 0 to 15 cm and 15 to 30 cm. The experimental plot was laid out at hill terrace with RBD design. The research sbpecifically centers on the status of soil health in terms of nitrogen, phosphorus, potassium, organic carbon, bulk density and pH. It was established that intercropping significantly improved soil nitrogen, potassium and organic carbon levels at both within the soils layer as compared to sole turmeric cultivation. Nitrogen levels increased to 336.88 kg ha$^{-1}$ and 323.42 kg ha$^{-1}$ in the intercropped system at the depths of the soils 0-15 cm and 15-30 cm, respectively, while potassium levels and organic carbon were also noted to increase in the intercropped system which showed good potential soil fertility. However, there was no significant difference in the phosphorous content, bulk density and the pH between the two farming system. These findings suggested that intercropped turmeric with tree along with mulching improves soil fertility, promoting better soil health and potentially greater crop yield.

**Keywords:** Agroforestry, Intercropping, Natural farming, Soil fertility

## Introduction

Soil health is a fundamental determinant of the productivity and sustainability in agricultural systems. Natural farming is one such concept in practice which has gained popularity over the last few years, as a sustainable means of agriculture vis-à-vis to conventional method; it advocates minimal external inputs by deploying organic materials and methods that improve natural soil fertility. In this regard, the association of trees with crops and sometimes animals provided a possible way forward to rehabilitate degraded agricultural soils - agroforestry. The combination of these two technologies, natural farming and agroforestry can bring back life to the degraded land itself through revisiting soil ecology functions while also developing a food production that is robust even under climate uncertainty (Dinesha *et al.*, 2022). Natural farming in combination with agroforestry system leads to several environmental benefits. The deep roots of trees reduce soil erosion, increase infiltration rate and draw up nutrients from the subsoil for use by shallow rooted crops. Organic material comprising leaves fallen from trees and pruning infuses essential nutrients in soil thereby increasing microbial activities which eventually enhances the fertility of the soils (Sharma and Sahoo, 2021). Such natural enrichment of soil decreases dependency on chemical fertilizers, thus promoting natural farming which aimed at boosting up the health structure of soils through organic substances. The existing research usually points out broad benefits like improved nutrient cycling and better soil structure in agroforestry systems. However, the specific connections between agroforestry and natural farming, such as minimal soil disturbance and the enhancement of organic matter, haven't been fully explored across various agroecological environments. This indicates a real need for more in-depth studies that look into how these combined practices can support sustainable land management and climate resilience, particularly in areas where conventional natural farming has caused soil degradation. With this view the study was conducted to evaluate the impact of agroforestry under natural farming practice on soil health.

## Material and Methods

### *Study Site*

The study was conducted during 2023-2024 at Langol Farm of ICAR-Research Complex for NEH Region, Manipur centre

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located at Latitude 24°50'27.46" N, Longitude 93°55'25.03" E and an altitude of 839 m. The plot is situated on a terraced hill, with soil texture of sandy clay loam soil. The site has been under natural farming practices for trial purpose and integrates a variety of crops and tree species (*Parkia roxburghii*, *Mangifera indica* and *Aleurites fordii*). The site experienced average rainfall of 12.16 mm and average temperature range of 4.3 °C to 29.6 °C with sub-tropical humid climate.

*Experimental Design*

The experiment was set up using a randomized complete block design (RCBD). The study consists of two treatments:

1. Agroforestry with Natural Farming: Tree + Turmeric + Straw mulch

2. Natural Farming Monoculture: Turmeric

The size of the experimental plot is 4×3 $cm^2$. Mulching @ 5 t $ha^{-1}$ was applied to intercrop plots using rice straw. All the plots were manure with FYM @ 5 t $ha^{-1}$. All the crops were planted with recommended spacing.

*Soil Sampling*

Soil samples were collected from each plot at 0-15 cm and 15-30 cm layer. A composite sample was prepared by collecting subsamples from three random locations within each plot. The samples was air-dried, sieved (2 mm) and stored for further analysis.

*Soil Analysis*

The bulk density of soil (g $cm^{-3}$) is measured by using the specific gravity method, which involves determining the weight of a known volume of soil. The soil pH is measured using a 1:2.5 soil-to-water suspension (Jackson, 1973). In this method, a specific amount of soil is mixed with distilled water and the suspension is measured with a digital pH meter. The wet digestion method documented by Walkley and Black (1934) was used to measure soil organic carbon (%). The alkaline potassium permanganate method, developed by Subbiah and Asija (1956), was used to determine the available Nitrogen (N) (kg $ha^{-1}$) in the soil. For measuring available Phosphorus (P) (kg $ha^{-1}$) in the soil, the Olsen's method developed by Olsen *et al.* (1954) was used. The neutral 1 N ammonium acetate method, developed by Merwin and Peech (1951), was used to determine the potassium available (K) (kg $ha^{-1}$) in soil.

*Data Analysis*

Data collected was statistically analyzed using paired-t test to test for significant differences between treatments. The software SPSS (v 29.0) was used to analyze the data.

## Results and Discussion

The comparison of soil nutrient levels and physical properties between natural farming monoculture (turmeric) and agroforestry with natural farming (tree + turmeric systems + straw much) across two soil depths (0-15 cm and 15-30 cm) as depicted in table 1 and 2, reveals important insights into how intercropping can impact soil fertility and structure. At both depths intercropping has more nitrogen, potassium and organic carbon content than sole turmeric. Nitrogen a key nutrient for plant growth and development is higher in intercropping probably due to better nitrogen cycling and possibly nitrogen fixation if legumes are part of the intercrop mix (Li *et al.*, 2020). Potassium important for water regulation, enzyme activation and overall plant health is higher in intercropping at both depths; hence, intercropping might be increasing potassium retention or making it more available for uptake (Xu *et al.*, 2021). The higher organic carbon in intercropping indicates good amount of organic matter content which is essential for long term soil health, soil structure and microbial activity (Lal, 2015). Organic carbon is the key for nutrient retention and water holding capacity and makes cropping systems more resilient. These findings align with previous research highlighting the benefits of intercropping in enhancing soil organic matter and nutrient cycling, particularly in systems where diverse crops interact to create a more favorable soil environment (Brooker *et al.*, 2015).

Despite these improvements in nutrient availability, other soil parameters like phosphorus content, bulk density and pH do not show significant differences between the two cropping systems. The lack of significant variation in phosphorus may be attributed to the inherent limitations of phosphorus mobility in soils, which typically requires external inputs rather than changes in cropping practices alone (Lizcano-Toledo *et al.*, 2021). Bulk density, a measure of soil compaction, is lower in the intercropped system, indicating potentially better soil structure, but the difference is not statistically significant at either depth. This suggests that while intercropping may reduce soil compaction, its effects may not be immediate or substantial enough to show clear differences within the timeframe of the study. Similarly, the pH levels between the systems remain comparable, implying that both systems maintain similar soil acidity, which is important for nutrient availability and plant growth (Neina, 2019). Overall, the data suggests that intercropping turmeric with tree significantly boosts nitrogen, potassium and organic carbon, leading to a more nutrient-rich and potentially more productive system, particularly in the 0-30 cm soil layer where most root activity and nutrient uptake occurs. However, the limited impact on phosphorus, bulk density and pH indicates that while intercropping is beneficial for some aspects of soil health, other factors such as external phosphorus management and longer-term soil structure improvements may require additional interventions. Many experiments have illustrated that the combination of agroforestry with organic farming would significantly enhance soil health. This encompasses increased levels of organic matter, better structure and microbial activity as well as improved nutrient cycling. According to Jose (2009), agroforestry systems have enhanced the soil organic carbon as a result of the addition of organic matter from littering trees and root residues. Abreu *et al.* (2016) reported that organic farming methods have enhanced the availability of nitrogen, phosphorus and potassium within agroforestry systems thereby increasing their availability to be taken up by the plant. Agroforestry coupled with organic farming in practices like composting and mulching maximizes retention of soil water and obliterates a significant erosion of the soil, ensuring preservation of topsoil and sustaining productivity over periods of time (Jordan, 2004; Sharma *et al.*, 2022; Duanyuan *et al.*, 2023). These findings together suggest that agroforestry, when practised in combination with organic farming practices, will exert a synergistic effect of restoring and maintaining soil health, thus providing a sustainable approach to improve agricultural resilience and productivity. It thus represents a promising alternative to conventional farming systems in the face of soil degradation and nutrient depletion.

Table 1: Soil physico-chemical parameters under different cropping system at 0-15 cm layer

| Cropping system | Nitrogen (kg ha$^{-1}$) | Phosphorous (kg ha$^{-1}$) | Potassium (kg ha$^{-1}$) | Organic Carbon (%) | Bulk density (g cm$^{-3}$) | pH |
|---|---|---|---|---|---|---|
| Natural Farming Monoculture | 296.88 | 48.21 | 131.38 | 1.85 | 1.13 | 5.53 |
| Agroforestry with Natural Farming | 336.88 | 54.21 | 146.38 | 2.04 | 0.81 | 5.23 |
| P value (<0.5) | S | NS | S | S | NS | NS |

[S: Significant; NS: Non Significant]

Table 2: Soil physico-chemical parameters under different cropping system at 15-30 cm layer

| Cropping system | Nitrogen (kg ha$^{-1}$) | Phosphorous (kg ha$^{-1}$) | Potassium (kg ha$^{-1}$) | Organic Carbon (%) | Bulk density (g cm$^{-3}$) | pH |
|---|---|---|---|---|---|---|
| Natural Farming Monoculture | 286.42 | 45.01 | 122.45 | 1.65 | 1.24 | 5.83 |
| Agroforestry with Natural Farming | 323.42 | 52.01 | 135.45 | 1.93 | 0.89 | 5.47 |
| P value (<0.5) | S | NS | S | S | NS | NS |

[S: Significant; NS: Non-Significant]

## Conclusion

The study shows that integrating agroforestry in a natural farming system significantly improved soil health compared with monoculture natural farming system. Nitrogen, potassium and organic carbon were found to be higher level in the agroforestry plots, which would improve soil fertility, microbial activity and moisture retention. These improvements led to increased crop yields, while phosphorus content, bulk density and pH remained similar between systems. Agroforestry is, by all probability, causing better recycling of nutrients and enrichment in organic matter due to deep-rooted trees and, thus, corresponds to the principles of natural farming. This research does indicate potential in the area of restoring degraded soils with agroforestry while reducing external inputs to achieve a more resilient and sustainable farming system. Despite the growing interest in sustainable farming, not much research has been done on integrating agroforestry with natural farming systems, especially on soil health and crop productivity. Studies that combine both - how tree-crop interactions under natural farming principles affect soil nutrient dynamics, organic matter content and long term soil fertility - are still limited. Further research would be very helpful in optimizing tree-crop combinations, understanding nutrient interactions and developing best practices for farmers who seek to balance productivity with ecological sustainability. This knowledge would be instrumental in advocating for wider adoption of such integrated approaches, offering a pathway toward more resilient and environmentally friendly agricultural systems.

## References


Abreu, S.A.H., Arruda, E.M., Barros, L.R., de Almeida, R.F., MaranhÃ, D.D.C., da Silva, V.L., Flores, R.A., Calil, F.N., Collier, L.S., 2016. Chemical attributes of the soil in agroforestry systems subjected to organic fertilizations. *African Journal of Agricultural Research* 11(27), 2378-2388. DOI: https://doi.org/10.5897/AJAR2016.11182.

Brooker, R.W., Bennett, A.E., Cong, W.F., Daniell, T.J., George, T.S., Hallett, P.D., Hawes, C., Iannetta, P.P., Jones, H.G., Karley, A.J., Li, L., 2015. Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology. *New Phytologist* 206(1), 107-117. DOI: https://doi.org/10.1111/nph.13132.

Dinesha, S., Raj, A., Bhanusree, M.R., Balraju, W., Rakesh, S., Raj, W.G., Jha, R.K., Kumar, K., 2022. Agroforestry assisted natural farming in India: Challenges and implications for diversification and restoration of agroecosystem. *International Journal of Environment and Climate Change* 12(12), 1053-1069. DOI: https://doi.org/10.9734/ijecc/2022/v12i121544.

Duanyuan, H., Zhou, T., He, Z., Peng, Y., Lei, J., Dong, J., Wu, X., Wang, J., Yan, W., 2023. Effects of straw mulching on soil properties and enzyme activities of *Camellia oleifera*-Cassia intercropping agroforestry systems. *Plants* 12(17), 1-11. DOI: https://doi.org/10.3390/plants12173046.

Jackson, M.L., 1973. *Soil Chemical Analysis*. Prentice Hall India Pvt. Ltd. New Delhi. p. 498.

Jordan, C.F., 2004. Organic farming and agroforestry:

Alley cropping for mulch production for organic farms of southeastern United States. *Agroforestry Systems* 61, 79-90. DOI: https://doi.org/10.1023/B:AGFO.0000028991.86647.35.

Jose, S., 2009. Agroforestry for ecosystem services and environmental benefits: An overview. *Agroforestry Systems* 76(1), 1-10. DOI: https://doi.org/10.1007/s10457-009-9229-7.

Lal, R., 2015. Restoring soil quality to mitigate soil degradation. *Sustainability* 7(5), 5875-5895. DOI: https://doi.org/10.3390/su7055875.

Li, L., Li, S.M., Sun, J.H., Zhou, L.L., Bao, X.G., Zhang, H.G., Zhang, F.S., 2020. Diversity enhances agricultural productivity via rhizosphere phosphorus facilitation on phosphorus-deficient soils. *Proceedings of the National Academy of Sciences, USA* 104(27), 11192-11196. DOI: https://doi.org/10.1073/pnas.0704591104.

Lizcano-Toledo, R., Reyes-Martín, M.P., Celi, L., Fernández-Ondoño, E., 2021. Phosphorus dynamics in the soil-plant-environment relationship in cropping systems: A review. *Applied Sciences* 11(23), 1-17. DOI: https://doi.org/10.3390/app112311133.

Merwin, H.D., Peech, M., 1951. Exchangeability of soil potassium in the sand, silt and clay fractions as influenced by the nature of the complementary exchangeable cation. *Soil Science Society of America Journal* 15, 125-128. DOI: https://doi.org/10.2136/sssaj1951.036159950015000C0026x.

Neina, D., 2019. The role of soil pH in plant nutrition and soil remediation. *Applied and Environmental Soil Science* 1, 1-9. DOI: https://doi.org/10.1155/2019/5794869.

Olsen, S.R., Cole, C.V., Watanabe, F.S., Dean, L.A., 1954. Estimation of available phosphorus in soils by extraction with $NaHCO_3$. US Department of Agriculture Circular 19, 939.

Sharma, A., Sahoo, G., 2021. Agroforestry in organic farming. *Agricos e-Newsletter* 2(4), 131-134.

Sharma, U., Bhardwaj, D.R., Sharma, S., Sankhyan, N., Thakur, C.L., Rana, N., Sharma, S., 2022. Assessment of the efficacy of various mulch materials on improving the growth and yield of ginger (*Zingiber officinale*) under bamboo-based agroforestry system in NW-Himalaya. *Agroforestry Systems* 96(5), 925-940. DOI: https://doi.org/10.1007/s10457-022-00753-8.

Subbiah, B.V., Asija, G.L., 1956. A rapid procedure for the estimation of available nitrogen in soils. *Current Science* 25(8), 259-260. URL: https://www.jstor.org/stable/24057566.

Walkley, A., Black, I.A., 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromicacid titration method. *Soil Science* 37(1), 29-37.

Xu, Q., Fu, H., Zhu, B., Hussain, H.A., Zhang, K., Tian, X., Duan, M., Xie, X., Wang, L., 2021. Potassium improves drought stress tolerance in plants by affecting root morphology, root exudates and microbial diversity. *Metabolites* 11(3), 1-16. DOI: https://doi.org/10.3390/metabo11030131.