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Influence of agroforestry systems on soil micro-nutrients

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Abstract
A field-cum lab investigation on Influence of agroforestry systems on soil micro-nutrients was carried out. The main objective of the investigation was how agroforestry systems influence soil micro-nutrient status. The research was carried out on three agroforestry systems including Kadamb (*Anthocephalus cadamba* Miq.) based Agri silvicultural system, Simarouba (*Simarouba glauca* DC) based Agri silvicultural system, Litchi (*Litchi chinensis* Sonn.) based agri horticultural system, and one open system (without trees). DTPA extracting solution was used to analyse available Copper, Zinc, Iron and Manganese. According to the findings, all agroforestry systems have the ability to increase these micro-nutrient content in both surface (15 cm) as well as sub-surface (30 cm) soil. Simarauba had reported the highest micronutrient increasing capability compared to the other plantations and control plot.

Keywords: Agroforestry systems, Micro-nutrients, litchi, Kadamb, Bihar

Introduction
Even though they are required in small amounts, micro-nutrients are considered essential soil elements for the growth of crops. Micro-nutrients have huge impact on crop growth and development. Indian agriculture production has increased significantly over the last half-century due to the implementation of modern agricultural techniques. High-yielding crop varieties and fertilisers have made it possible to produce far more than previously. Previously, it was possible to achieve higher yields by applying only nitrogenous fertilisers, but within a few years, soil nutrient stocks were rapidly depleted, and it is no longer possible to achieve higher yields by applying only primary nutrients. As a result, secondary nutrients and micronutrients are now required to obtain a higher yield and meet our demand. Excess fertiliser application can harm our soil and render it incapable of acting as a sustainable supply system, which is now a major concern. Agroforestry can be an important option in this regard. Agroforestry improves soil management by improving nutrient uptake, nutrient release, plant litter deposition, improving soil physical properties, reducing erosion, buffering soil temperature and acidity, and providing many other important services [1]. Therefore, it is critical to understand which agroforestry system is best suited to a given environment.

Materials and Methods
The study, titled "Influence of agroforestry systems on soil micro-nutrients," included three agroforestry systems: 1. Kadamb (*Anthocephalus cadamba* Miq.) based agrisilvicultural system, 2. Simarouba (*Simarouba glauca* DC) based agrisilvicultural system, 3. Litchi (*Litchi chinensis* Sonn.) based agrihorti Thekadamb-based agrisilvicultural system was 13 years old, with tree spacing of 5 m x 4 m maintained. Among the two sites, one located at Pusa farm Rajendra Prasad Central Agricultural University, Pusa, Bihar and the other at Birauli Farm, Samastipur, Bihar (Fig 1). The climate here is subtropical, with three distinct seasons: rainy (June to September), winter (October to February), and summer (March to May). Table 1 shows initial soil properties of experimental sites. DTPA (Diethylenetriamine Penta acetic acid) extracting solution (0.005 M DTPA + 0.1M TEA +0.01 M CaCl2buffered at pH 7.3) in the soil to solution ratio of 1:2 shaken for two hours [2] was used to extract available Cu, Zn, Fe and Mn from the soil. The available micro-nutrients in the clear aliquot were determined using an Atomic Absorption Spectrophotometer (Perkin Elmer A Analyst 200). To begin, place 10g soil and 20ml DTPA solution in a polyethylene bottle and shake for 2 hours. Filter through Whatman No. 42 filter paper and measure the micronutrients using an atomic absorption spectrophotometer and the suitable cathode lamps.

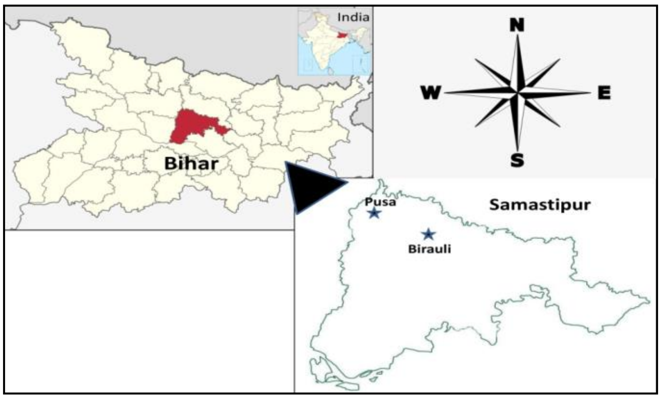

Fig 1: Location of Experimental sites.

Table 2: Initial soil properties of experimental sites

Soil properties	Value
Soil pH	8.3-9.1
Soil Organic Matter	0.95%-3.20%
Available Nitrogen	155.9 kg ha^{-1} (Low)
Available Phosphorus	20.7 kg ha^{-1} (Medium)
Available Potassium	141.5 kg ha^{-1} (Medium)
Available Sulphur	44.3 mg kg^{-1} (High)
Available Boron	0.6 mg kg^{-1} (Low)

Results

Zinc (Zn): Soil available Zn increased significantly in all three agroforestry systems compared to the control (Fig-2). When compared to the control plot, kadamb, simarouba, and litchi increased soil Zn at 15 and 30 cm depths. In 15 cm depth, there was an increase in soil Zn in the simarouba plot over kadamb and kadamb over litchi. Soil Zn decreased from the surface to the subsurface in kadamb, simarouba, and litchi. Soil Zn in simarouba plantations was significantly higher in value than in all other agroforestry systems, regardless of soil depth. Soil Zn levels ranged from 0.78 mg kg^{-1} in simarouba based AFS surface soil to 0.43 mg kg^{-1} in control treatment subsurface soil.

Copper (Cu): The soil available Cu status increased significantly in all three agroforestry systems when compared to the control plot (Fig-3). All agroforestry systems, including the control, show a decrease in soil Cu at depths lower than the surface soil. Soil Cu increased in both soil depths in kadamb, simarouba, and litchi plantations compared to controls. In 15 and 30cm depths, soil Cu in simarouba was higher than Litchi, whereas Litchi was higher than kadamb plantation. The reduction of soil Cu from the surface (15cm) to the subsurface (30cm) soil was discovered in kadamb, simarouba, and litchi. In 15 cm and 30 cm soil depths, simarouba plantations were found to have significantly higher soil Cu than all other treatments among the different agroforestry systems. Copper levels in the soil ranged from 0.9 mg kg^{-1} in the surface soil of the simarouba-based agroforestry system to 0.6 mg kg^{-1} in the subsurface soil of the control plot.

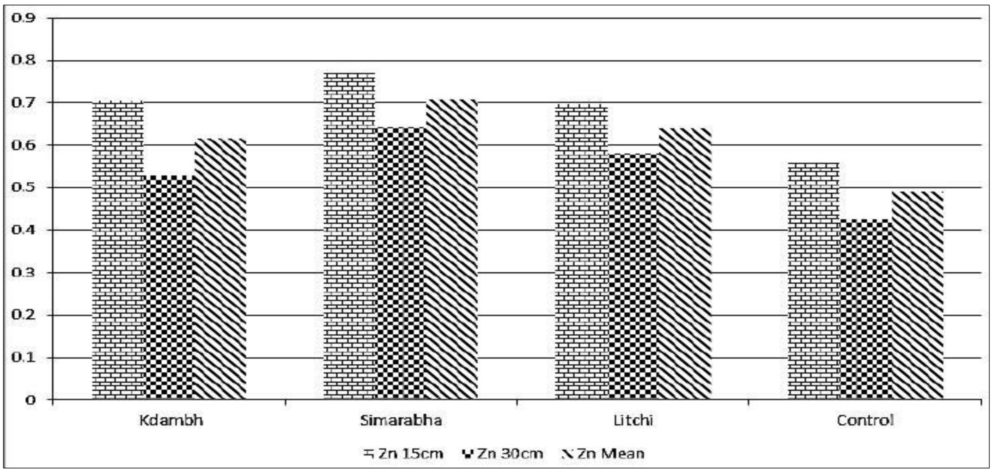

Fig 2: Effects of different AFS on soil available Zinc

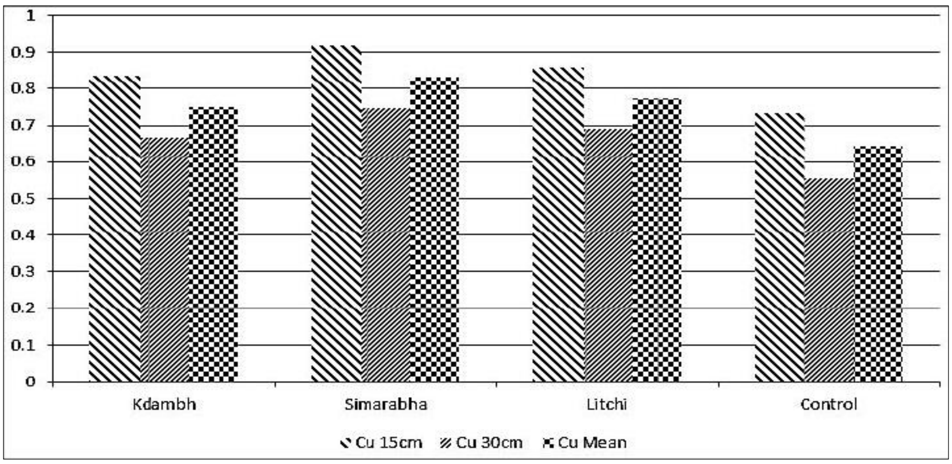

Fig 3: Effects of different AFS on soil available Copper

Manganese (Mn)

When compared to the control plot, all three agroforestry systems had a significant increase in soil available Mn status (Fig-4). All agroforestry systems, including the control, show a decrease in soil Mn below the surface soil. When kadamb, simarouba, and litchi plantations were compared to controls, soil Mn increased in both soil depths. Soil Mn in simarouba was higher than kadamb at 15 cm depth, whereas kadamb was higher than litchi plantation. In Kadamb, simarouba, and litchi, the reduction of soil Mn from the surface (15cm) to the subsurface (30cm) soil was measured. Simarouba plantations had significantly higher soil Mn than all other treatments across all soil depths and agroforestry systems. Mn levels in the soil ranged from 3.7 mg kg^{-1} in the upper soil of the simarouba plantation to 1.2 mg kg^{-1} in the lower soil of the control treatment.

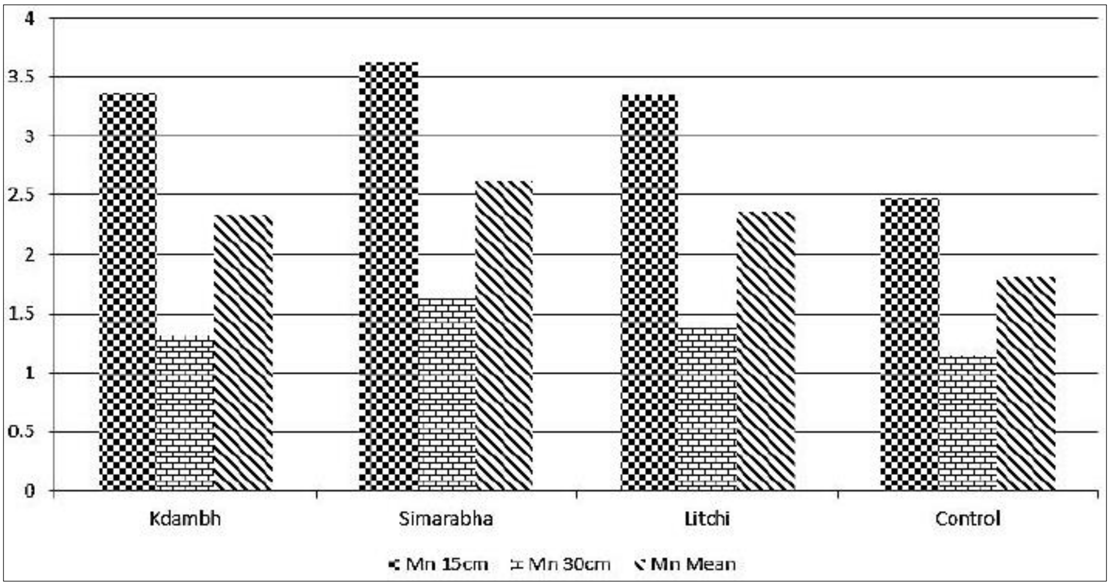

Fig 4: Effects of different AFS on soil available Copper

Iron (Fe): All AFS systems demonstrated a significant increase in soil Fe status when compared to the control plot (Fig-5). All agroforestry systems, including the control, show a decrease in soil Fe at depths lower than the surface soil. Soil Fe increased in kadamb, simarouba, and litchi plantations at 15 and 30 cm depths compared to controls. In 15 and 30cm depths, simarouba had higher soil Fe than litchi, while litchi had higher soil Fe than kadamb plantation. The reduction of soil Fe from the surface (15cm) to the subsurface (30cm) was confirmed in kadamb, simarouba, and litchi. In 15 cm and 30 cm soil depths, simarouba plantations were found to have significantly higher soil Fe than all other treatments among the different agroforestry systems.There is available soil. Fe levels ranged from 8.5 mg kg^{-1} in the surface soil of the simarouba-based agroforestry system to 3.9 mg kg^{-1} in the control plot's subsurface soil.

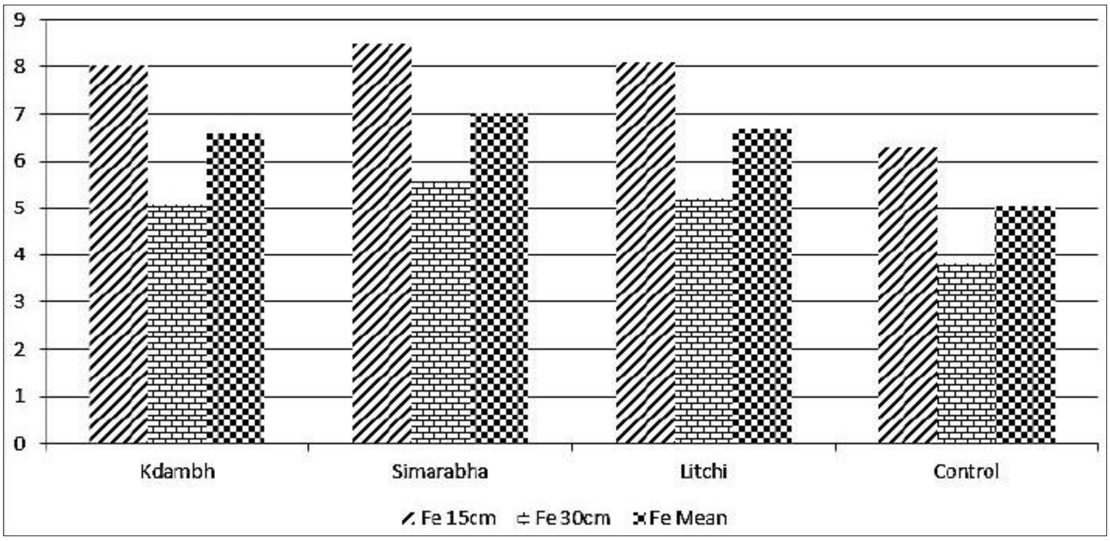

Fig 5: Effects of different AFS on soil available Copper

Discussion

As shown in Fig: 2-5, there was a significant increase in soil available zinc (Zn), manganese (Mn), copper (Cu), and iron (Fe) in kadamb, simarouba, and litchi-based agroforestry systems compared to controls. Singh *et al.* (2007) [3] and Yadav *et al.* (2008) [4] found that tree litter fall returns significant amounts of Zn, Fe, Mn, and Cu, and Costa *et al.* (2018) [5] found that agroforestry fields had higher soil Fe than non-agroforestry fields. Regardless of treatment, a decrease in soil Zn, Mn, Cu, and Fe from the surface to the subsurface soil was confirmed. Similar findings were discovered in the works of Aggarwal *et al*. (2005) [6] and Costa *et al.* (2018) [5]. Some plant micronutrients are more susceptible to leaching and can be recycled by trees with deep rooted system [7]. Soil Zn, Mn, Cu, and Fe levels varied between treatments by 0.77-0.42, 3.62-1.14, 0.92-0.56, and 8.46-3.81 mg kg-1, respectively. The amounts and quality of litter fall depositions varied between tree species, which may lead to variations in soil nutrient content in different agroforestry system soils.

Conclusion
It can be concluded that agroforestry development increased the availability of all four micronutrients at all soil depths. It was also discovered that soil micronutrient contents differed between plantations. Forest tree-based agroforestry systems (simarouba and kadamba) recycle more plant nutrients than fruit tree-based agroforestry systems (lichi). Surface soil contains more micronutrients in all treatments, including the control. Agroforestry recycles plant micronutrients more effectively than conventional agriculture due to its deep rhizosphere and large litter fall. Crop production could be taken over by agroforestry system development as a stable and revitalising option for soil sustainability.

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