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Various leaves compost impacts on soil physiochemical properties pre- and post-cultivation *Triticum aestivum* L

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ABSTRACT

Decreasing soil fertility resulted in reduced yield and the imbalance application of synthetic fertilizer disturbed crop productivity. To study long-term soil conservation practices, a pot experiment was conducted in the 2022 cropping season. *Triticum aestivum* L. was sown under the application of partially and fully decomposed leaves compost (PFLC) of *Albizia lebbeck, Conocarpus erectus, Moringa oleifera*, and *Vigna radiata*. An average yield of *Triticum aestivum* L. showed significant positive results under each PFLC. Soil physiochemical properties showed positive impacts. Soil pH, electric conductivity, organic matter, potassium, and phosphorus levels were significantly enhanced. Moreover, partially decomposed leaves compost (PDLC) and fully decomposed leaves compost (FDLC) of *Vigna radiata* showed a biological yield of 7.17 and 7.63 g per plant respectively, and grain yield of 1.11 and 1.44 g per plant respectively among all other PFLC. Harvesting index percentage was recorded as maximum in PDLC of *Albizia lebbeck* (23%), *Moringa oleifera* (22%), and *Conocarpus erectus* (21%) to other PFLC treatments. Therefore, PFLC is recommendable for enhancing soil health and yield rate.

KEYWORDS

Soil health; Physiochemical properties; Leaves compost; Soil conservation

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Introduction

Wheat (*Triticum aestivum* L) is one of the most important cereal crops around the world; therefore, maximizing its productivity is an imperative task [1]. Recent decades have seen a rise in soil pollution, risking the health of humans as well as the environment [2,3]. Agricultural practices are crucial for maintaining food production and protecting the soil's long-term fertility. Contaminants like organic and inorganic chemicals build up as a result of human activity [4]. Over time, excessive use of synthetic fertilizers and pesticides (SFP) has caused the soil's quality to decline, posing serious problems for crop productivity and the sustainability of the environment. Due to a lack of clearly defined variables and indicators, monitoring soil quality is difficult [5]. Soil pollution is a hot topic due to population pressures and the growing population. Agrochemicals, mining, waste disposal, industry, and atmospheric deposition are some of the causes [6]. In addition to assisting as an important foundation for plant growth and supporting several ecological processes, the soil is a complex and dynamic ecosystem [7]. Soil fertility, nutrient cycling, and ecosystem function are all significantly influenced by soil physicochemical factors, such as soil pH, Organic matter contents (OM), Electrical conductivity (EC), and nutrient availability [8]. Effective soil management and sustainable agricultural practices depend critically on our ability to comprehend these variables and how they interact [6].

The availability of nutrients and microbial activity are influenced by soil pH, a measurement of soil acidity or alkalinity [9]. To maximize nutrient availability and crop productivity, soil pH must be balanced through amendments. Soil structure, water retention, and nutrient-holding capacity of soil are all improved by its OM content, which is made up of decomposed plant and animal residues [10]. Long-term soil productivity and resistance to environmental stresses depend on maintaining adequate levels of OM. EC, which has a negative effect on plant growth, is related to soil salinity [11]. To reduce the detrimental effects of salinity on agricultural productivity and maintain soil quality, EC levels must be monitored and managed [12]. Composts and other organic amendments have drawn a lot of attention as efficient soil management techniques to address these problems [13]. In numerous ecosystems, leaves are one of many compostable materials that are abundant and readily available. In addition to increasing soil fertility and nutrient use efficiency, composting leaves have also been shown to increase water-holding capacity and microbial activity. These organic amendments offer crucial nutrients and improve the soil's overall physical and chemical characteristics, which are important for crop development and growth [14]. It is essential to comprehend the ways various leaves compost (LC) i.e., fully decomposed leaves compost (FDLC) and partially decomposed leaves compost (PDLC) types affect the physicochemical characteristics of the soil to maximize its use in agricultural systems [15].

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Under controlled conditions, organic material breaks down into nutrient-rich humus as part of a natural process called composting. Compost made from specific plant materials offers special advantages due to its unique chemical composition [16]. *Albizia lebbeck* is known for its nitrogen-fixing abilities and high biomass output [17]. *Conocarpus erectus* is a salt-tolerant evergreen tree used for its ability to restore soil in saline environments, also rich in OM [18]. The leaves of the *Moringa oleifera* have received a lot of attention due to their high nutrient content and potential as a long-lasting organic fertilizer [19]. *Vigna radiata* (Mung beans) are a type of legume that fix atmospheric nitrogen and improve soil fertility [20]. Various LC treatments from *Albizia lebbeck*, *Conocarpus erectus*, Moringa oleifera, and *Vigna radiata* were applied to the soil before the crops were planted as part of field trials conducted during specific planting seasons. To monitor changes in the physical and chemical characteristics of soil, such as pH, OM content, nutrient levels other significant soil characteristics, soil samples are periodically collected. The objectives of the study were to assess how these LC treatments affect the soil's physiochemical properties. With a focus on increasing crop productivity and sustainability, the study aimed to evaluate the effects of these LC treatments on soil fertility, nutrient availability, microbial activity, and soil structure. In order to improve long-term agricultural productivity and soil quality, the research also aimed to determine the most efficient LC treatment(s) and offer recommendations for sustainable soil management practices using organic amendments, particularly LC.

Materials and Methods

A pot experiment was conducted during 2022-23 at the research area of College of Agriculture BZU Bahadur Sub-Campus Layyah (30.849°N, 71.094°E). The soil used in the pot experiment was sandy loam in texture. *Triticum aestivum* L seeds were collected from Punjab seed certification and sown in the last week of November. The soil was collected from the soil science research area on campus. The following plants' leaves for composting were collected from the field area near the Bahadur Sub-Campus Layyah. The material used consisted of leaves of various plants i.e., *Albizia lebbeck*, *Conocarpus erectus*, Moringa oleifera, and *Vigna radiata*.

These residues were collected from the field near the BZU Bahadur Sub-Campus Layyah, leaves cutting was done into a particle size of 2 mm and were exposed to aerobic digestion in a polyethylene bag of approximately 2×1×0.5 m³ volume. The material was turned at intervals, the temperature was controlled to 40°C (±10), and the moisture (was not lower than 445%), by adding water if necessary and turning the mixture. This temperature was measured by introducing a thermometer into the center of the pile in a polyethylene bag. A temperature of 40°C ±10 was not surpassed, to avoid alterations that might take place in the various plant's leaves. The composting process for FDLC was carried on for 120 days when the C:N ratio and the temperature had become constant. PDLC carried the same process up to 80 days characteristics such as the color and the scent were adjusted according to that described in the bibliography (Table 1 and table 2) [21].

Table 1. Five treatments were designed with three replications of each treatment to evaluate the effects of LC on soil physiochemical properties.

Treatments:	LC	Treatments:	LC
T1	Control	T6	PDLC *Albizia lebbeck*
T2	FDLC *Albizia lebbeck*	T7	PDLC *Conocarpus erectus*
T3	FDLC *Conocarpus erectus*	T8	PDLC *Moringa oleifera*
T4	FDLC *Moringa oleifera*	T9	PDLC *Vigna radiata*
T5	FDLC *Vigna radiata*		

T: treatment; LC: leaves compost; FDLC: fully decomposed leaves compost; PDLC: partially decomposed leaves compost

Table 2. Soil's physiochemical analytical results before sowing.

Sampling Parameters:	Analytical Results:
Soil pH	8.2
Soil Electrical Conductivity	1.9 dSm^{-1}
Soil OM %	0.7 %
Extractable Soil Phosphorus	25 $mgkg^{-1}$
Extractable Soil Potassium	66 $mgkg^{-1}$

dSm^{-1}: desi semen per meter inverse; $mgkg^{-1}$: milligrams per kilogram; %: percentage

The soil was filled (700g) in each pot. Compost was added 2% (14g) using decomposed leaves compost. Tap water was used for irrigation purposes, and pots were maintained at field capacity. During the experimentation, the crop was sown on well-prepared pots on November 29, 2021. Ten seeds were sown in each pot. Before the tillering stage, plants were thinned to four plants in each pot. Crop was grown till full maturity and plant growth and yield parameters were recorded at harvesting. Weeds were controlled manually. All other agronomic practices were kept normal and uniform.

Results and Discussions

Harvesting index percentage provides a relationship between grains and plant biomass. Figure 1 shows statistical harvesting index showed all types of compost were found to increase with FDLC significantly. Maximum harvesting index was recorded in compost PDLC of *Albizia lebbeck*. Then followed by *Conocarpus erectus* and Moringa oleifera. In the case of biological yield highest biomass was recorded in FDLC *Conocarpus erectus*. Similarly, grain yield was found maximum in FDLC *Vigna radiata* (1.44 g $plant^{-1}$). Overall rest of the treatments improve grains yield significantly in respect to control (without composts). The study evaluated the effects of different compost treatments on harvesting index percentage, revealing a significant increase in harvesting index when FDLC was applied. The highest harvesting index was recorded in the PDLC treatment with *Albizia lebbeck*, indicating the most efficient conversion of plant biomass into grains [22]. The highest biological yield was observed in the FDLC treatment with *Conocarpus erectus*, indicating that *Conocarpus erectus* compost promotes overall plant growth and biomass accumulation. The highest grain yield was recorded in the FDLC treatment with

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Vigna radiata, with a yield of 1.44 g per plant. All compost treatments showed significant improvements in grain yield compared to the control without OM (Table 3) [23,24].

PDLC: Partially decomposed leaves compost; FDLC: fully decomposed leaves compost;
BY: biological yield; GY: grain yield; HI: harvesting index

Table 3. LC impacts on harvesting index, grain yield and biological yield of *Triticum aestivum* L production.

Compost	Treatment	BY (g plant^{-1})	GY (g plant^{-1})	HI %
PDLC	Control	5.0421 $^{c-d}$	0.86 ^{d}	17 $^{c-d}$
	Albizia lebbeck	4.2068 ^{d}	0.95 $^{b-d}$	23 ^{a}
	Conocarpus erectus	4.66 ^{cd}	0.97 $^{b-d}$	21 $^{a-c}$
	Moringa oleifera	4.9909 ^{cd}	1.09 ^{bc}	22 ^{ab}
	Vigna radiata	7.1564 ^{a}	1.11 ^{b}	15 ^{d}
FDLC	Control	5.2854 ^{bc}	0.81 ^{d}	16 $^{c-d}$
	Albizia lebbeck	5.3364 ^{bc}	0.92 $^{b-d}$	17 $^{b-d}$
	Conocarpus erectus	6.0840 ^{b}	0.90 ^{cd}	14 ^{d}
	Moringa oleifera	5.6474 ^{bc}	1.07 ^{bc}	19 $^{a-d}$
	Vigna radiata	7.6275 ^{a}	1.44 ^{a}	18 ^{d}

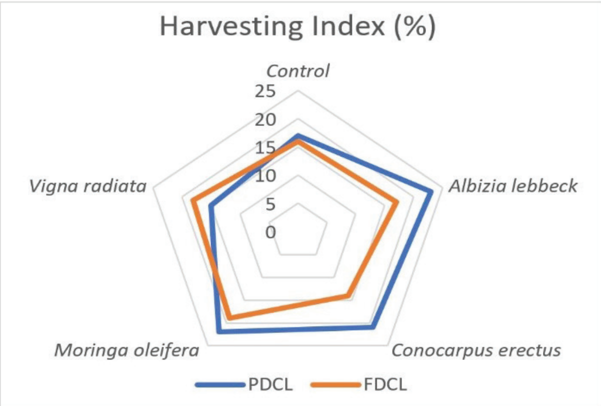

Figure 1. Comparative chart of harvesting index (%) between partially decomposed leaves compost and fully decomposed leaves compost treatments.

A significant change in soil pH was observed by PDLC and FDLC as showed in figure 2. *Moringa oleifera* showed a significant decrease in pH up to 7.8 in both PDLC and FDLC. Impacts of *Conocarpus erectus*, *Vigna radiata* and *Albizia lebbeck* showed a reduction in pH respectively in both PDLC and FDLC with respect to control [25-27]. The significant changes in soil pH when PDLC and FDLC were applied to Moringa oleifera, soil experienced a substantial decrease in pH, indicating the potential for creating a favorable soil environment for its cultivation [28].

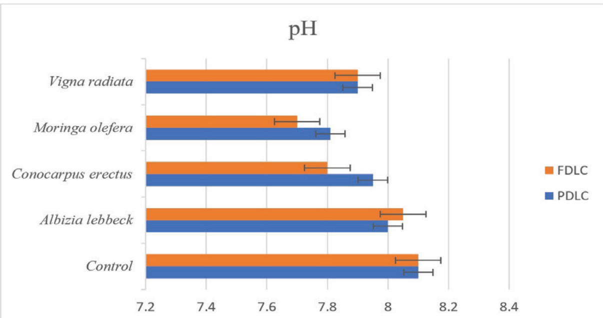

Figure 2. Comparative chart of change in soil pH between partially decomposed leaves compost and fully decomposed leaves compost treatments.

Table 4. Impacts of PDLC and FDLC *Albizia lebbeck*, *Conocarpus erectus*, *Moringa oleifera* and *Vigna radiata* on soil pH.

Treatments	PDLC	FDLC
Control	8.10 ^{a}	8.10 ^{a}
Albizia lebbeck	8.00 ^{ab}	8.05 ^{ab}
Conocarpus erectus	7.95 $^{a-c}$	7.80 ^{cd}
Moringa olefera	7.81 ^{cd}	7.70 ^{d}
Vigna radiata	7.90 ^{bc}	7.90 ^{bc}

In figure 3, a change in soil EC was observed by PDLC and FDLC. *Moringa oleifera* showed increase in EC up to 2.5 dSm^{-1}. Impacts of *Conocarpus erectus*, *Vigna radiata* and *Albizia lebbeck* showed narrow range EC change in both PDLC and FDLC with respect to control. Organic fertilizer by *Moringa oleifera* LC proved to be optimizing soil EC [28,29].

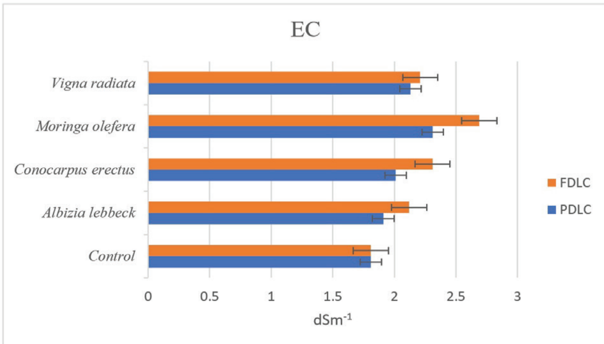

Figure 3. Comparative chart of change in soil EC between partially decomposed leaves compost and fully decomposed leaves compost treatments.

Table 5. Impacts of PDLC and FDLC *Albizia lebbeck*, *Conocarpus erectus*, *Moringa oleifera* and *Vigna radiata* on soil EC.

Treatments	PDLC (dSm^{-1})	FDLC (dSm^{-1})
Control	1.81	1.81
Albizia lebbeck	1.91	2.12
Conocarpus erectus	2.01	2.31
Moringa olefera	2.31	2.69
Vigna radiata	2.13	2.21

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Figure 4 showed significant change in P was observed by application of PDLC and FDLC [30]. Impacts of *Albizia lebbeck*, *Vigna radiata*, *Moringa oleifera* and *Conocarpus erectus* showed improved soil P in PDLC respectively and impacts of *Conocarpus erectus*, *Vigna radiata*, *Moringa oleifera* and *Albizia lebbeck* showed improved soil P in FDLC respectively with respect to control.

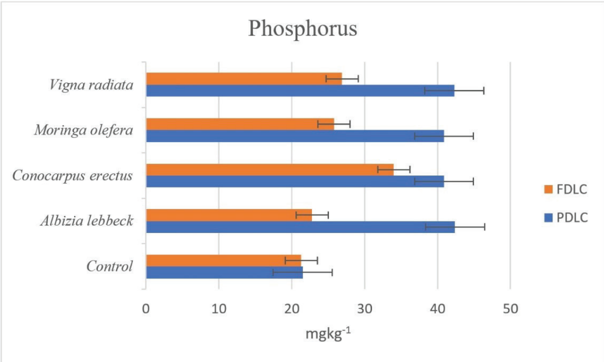

Figure 4. Comparative chart of change in soil phosphorus between partially decomposed leaves compost and fully decomposed leaves compost treatments.

Table 6. IImpacts of PDLC and FDLC *Albizia lebbeck*, *Conocarpus erectus*, *Moringa oleifera* and *Vigna radiata* on soil P availability.

Treatments	**PDLC (mgkg^{-1})**	**FDLC (mgkg^{-1})**
Control	21.5 ^{c}	21.3 ^{c}
Albizia lebbeck	42.4 ^{a}	22.8 ^{bc}
Conocarpus erectus	40.9 ^{a}	34 ^{ab}
Moringa olefera	40.9 ^{a}	25.8 ^{bc}
Vigna radiata	42.3 ^{a}	26.9 ^{bc}

A significant change in soil K was observed by PDLC and FDLC as demonstrated in figure 5. *Moringa oleifera* showed significant increase in K up to 105 mgkg^{-1}. Impacts of *Vigna radiata*, *Conocarpus erectus* and *Albizia lebbeck* showed increase in K level respectively in PDLC. *Vigna radiata*, *Albizia lebbeck* and *Conocarpus erectus* showed increase in level K by application of FDLC with respect to control. Moringa oleifera, *Conocarpus erectus* and other LC shows enhancement in soil K level [31,32].

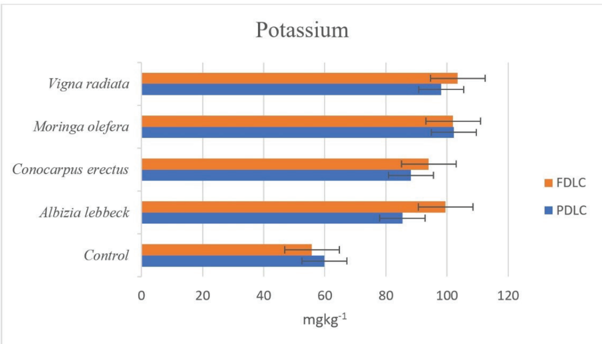

Figure 5. Comparative chart of change in soil potassium between partially decomposed leaves compost and fully decomposed leaves compost treatments.

Table 7. Impacts of PDLC and FDLC *Albizia lebbeck*, *Conocarpus erectus*, *Moringa oleifera* and *Vigna radiata* on soil K availability.

Treatments	**PDLC (mgkg^{-1})**	**FDLC (mgkg^{-1})**
Control	59.9 ^{d}	55.8 ^{d}
Albizia lebbeck	85.4 ^{c}	99.5 ^{ab}
Conocarpus erectus	88.2 ^{bc}	94 $^{a-c}$
Moringa olefera	102.2 ^{a}	102 ^{a}
Vigna radiata	98.1 $^{a-c}$	103.5 ^{a}

A significant increase in soil OM was observed by application of PDLC and FDLC (figure 6). Soil OM by application of PDLC, was observed between 1.1 to 1.3 % and Soil OM by application of FDLC, was observed between 1.1 to 1.2 % with respect to control. However, LC directly enhance the soil OM [33].

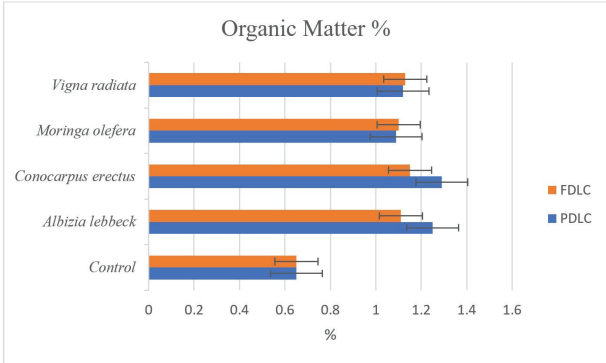

Figure 6. Comparative chart of change in an organic matter between partially decomposed leaves compost and fully decomposed leaves compost treatments.

Table 8. Impacts of PDLC and FDLC *Albizia lebbeck*, *Conocarpus erectus*, *Moringa oleifera* and *Vigna radiata* on soil OM.

Treatments	**PDLC (%)**	**FDLC (%)**
Control	0.65 ^{b}	0.65 ^{b}
Albizia lebbeck	1.25 ^{a}	1.11 ^{a}
Conocarpus erectus	1.29 ^{a}	1.15 ^{a}
Moringa olefera	1.09 ^{a}	1.1 ^{a}
Vigna radiata	1.12 ^{a}	1.13 ^{a}

Conclusions

The application of PDLC and FDLC led to significant changes in soil pH, EC, phosphorus (P), K, and OM levels. LC showed a significant decrease in pH in both PDLC and FDLC, similarly LC showed enhancement in soil K levels. Organic fertilizer LC was found to optimize soil EC. P was improved in PDLC and FDLC. LC directly enhanced soil OM. These findings suggest that PDLC and FDLC can create favorable soil environments for cultivation. Moreover, PDLC and FDLC of *Vigna radiata* showed biological yield of 7.17 and 7.63 g per plant respectively and grain yield of 1.11 and 1.44 g per plant respectively among all other LC. Harvesting index percentage was recorded maximum in PDLC of *Albizia lebbeck* (23%), *Moringa oleifera*

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(22%) and *Conocarpus erectus* (21%) with respect to other LC treatments. Overall, LC showed significant positive response in increasing crop's yield rate.

The development of cost-effective and scalable production methods for PDLC and FDLC is critical for their widespread adoption by farmers. Studying the dynamics and biochemical mechanisms behind the improvements observed with PDLC and FDLC applications can enhance our understanding of soil health management. Combining these findings with advanced technologies such as precision agriculture and artificial intelligence can lead to more efficient and sustainable agricultural practices, ultimately contributing to global food security and environmental sustainability.

Disclosure Statement

No potential conflict of interest was reported by the authors.

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