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Evaluation the efficiency of leaf compost on soil microbes and wheat growth

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Abstract

Since the beginning of the twenty-first century, Iraq has witnessed the introduction of many new plants, especially trees and shrubs, for multiple purposes, the most important of which is landscaping, as well as economic and environmental goals. Among these plants that have recently spread in the Iraqi environment are Moringa, Conocarpus, and Leucaena. This study aims to discover the possibility of using the leaves of these trees, in addition to the Eucalyptus tree and the Sesbania shrub, in making compost, improving soil properties, supporting the community of the microbes in the rhizosphere, and the effect of this on plant growth. Leaf compost was prepared separately for each species and the efficiency of this fertilizer in improving the growth and yield of wheat plants was tested. The treatment of compost of Leucaena LC and Sesbania leaves SC gave a positive and stimulating effect on the microbes life in the soil, addition of Moringa compost MC led to a reduction in the microbial community. Regarding the growth of wheat plants, the SC and MC treatments had the highest effect in improving growth rates and production. This study concluded the environmental importance of Leucaena, Moringa and Sesbania trees to improve the properties of Iraqi soils that suffer from salinity and high alkalinity, as well as the possibility of using these trees and shrubs in intercropping with economic crops as one of the sustainable agricultural methods.

Keywords: Sustainable Agriculture, Soil Microbiology, Soil Fertility, Organic Fertilizers, Wheat Production

Introduction

Fertilizers are defined as a mixture of materials remaining in the soil, plant and animal remains, fermented fertilizers, green manure, and other microorganisms that result from decomposition processes (ALnaass, *et al.*, 2021) ^[4].

Organic substance in the soil is the result of the accumulation of partially or completely decomposed plant and animal parts in addition to the microorganisms contained in the soil. Therefore, organic matter, regardless of its sources, works as organic fertilizers to increase plant production, in addition to its role as a reformer of poor soil, as it plays a crucial role in enhancing the physical properties of the soil (Paul, 2016) ^[24].

Soil improvement by adding compost is an important agricultural activity and a basic strategy in waste management. Adding organic fertilizer helps improve soil structure by binding soil particles together, which leads to the aggregation of soil particles. Organic fertilization also upgrade the soil's water and air system, boost the soil's ability to form large aggregates, increases the stability of the structure, and thus reduces the soil's exposure to erosion. (Tahat, *et al.*, 2020) ^[33].

The rhizosphere is considered one of the environmental media that are very suitable for the reproduction and metabolism of many types of microbes, as it has been shown that there is a relationship between microorganisms and plant roots. It has been found that microbes often do not show any harmful effects on, but rather cause beneficial effects on plant roots in this region. Therefore, the relationships between microorganisms and higher plants clearly affect soil fertility and agricultural production (Vetterlein, *et al.*, 2020 & Ling, *et al.*, 2022) ^[36, 17]. In addition to the fact that adding mature compost to the soil enhances plant growth and improves soil properties, it also produces an inhibitory effect on many pathogens. Adding fertilizers and organic materials, especially compost fertilizer, can inhibit plant pathogens generated in the soil.

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This inhibitory effect comes from converting the action of the microbial community in the soil after adding organic matter from harmful activity to beneficial activity for growing plants (On, *et al.*, 2015, Milinkovic, *et al.*, 2018, Corato, 2020, Neher *et al.*, 2022) ^[21, 18, 8, 19]. Therefore, adding compost to the soil maintains and enhances soil fertility and productivity and is therefore key to sustainable agriculture (Pergola, *et al.*, 2017, Ho, *et al.*, 2022) ^[25, 14].

Fallen tree leaves and tree pruning residues, whether ornamental trees in cities or fruit trees in orchards and gardens, are among the most important sources of raw materials for compost production. They are the main source of carbon in the compost mixture, in addition to containing plant compounds and nutrients (Parzych, 2022, Singh, *et al.*, 2023) ^[23, 32]. Among the trees whose leaves can be used in composting is *Leucaena* and the most common species, *Leucaena leucocephala*, which originates in Mexico and Central America. The *Leucaena* tree is grown for many purposes, including timber, grazing, organic fertilizer, combating desertification, improving soil properties, combating soil erosion, and other agricultural uses (Zayed, 2016, De Angelis, 2021 and Aleman-Ramirez 2022) ^[39, 9, 2]. *Eucalyptus camaldoleis* is a medicinal, ornamental and shade tree that is characterized by its rapid growth and prevents mosquitoes and fleas from approaching due to its repulsive smell. Man has exploited this property and expanded its cultivation to keep mosquitoes away from residential areas and as windbreaks. All species of this plant belong to the myrtle family (Hirsch, *et al.* 2019, Butt, *et al.*, 2022) ^[13, 6]. *Conocarpus lancifolius* is a medicinal plant from the Comperataceae family. The alcoholic extract of the dry aerial parts of *Conocarpus lancifolius* showed a high ability to reduce some bacterial species, yeast *Saccharomyces scerevecia* and some fungi such as: *Aspergillus flavus*, *Aspergillus niger*, *Candida albicans*, *Fusarium oxysporum* (Touqeer *et al.* 2014, Ali Elshair and Mohamed, 2019) ^[34, 3].

Moringa oleifera, sometimes called the miracle tree, a member of the Moringaceae family, is an alternative to chemical and inorganic fertilizers. Its potential impact on crop growth and productivity has been studied, as well as the possibility of encouraging farmers to use it instead of inorganic fertilizers. Also, one of the characteristics of *Moringa* seeds is that the ground seeds or the pressed seeds (after oil extraction) contain polypeptides, which are suitable as natural coagulants with an antibacterial and antifungal effect (Zaffer, *et al.* 2015, Abd El-Hack, *et al.* 2018, Granella, 2021, Pareek, *et al.* 2023) ^[38, 1, 12, 22]. *Sesbania aculeate* is a fast-growing shrub that adapts well to different types of soils and can be used in mixed cropping systems and as green manure (Bunma and Balslev, 2019, Rani, *et al.* 2020, Ghaffarian, *et al.* 2020) ^[5, 27, 11]. This research compared three plants introduced in last few decades to the Iraqi environment (Iraqi flora), namely the *Conocarpus* tree, the *Leucaena* tree and the *Moringa* tree, with two types of endemic plants, namely the *Eucalyptus* tree and the *Sesbania* shrub. The comparison was made in terms of the effect of organic fertilizer made from the leaves of these plants on the microbes life of soil (Fungi and bacteria) in the rhizosphere and plant growth. The effect of the prepared fertilizer on the growth and productivity of wheat was tested as it is one of the key crops grown in Iraq.

Materials and Methods

Compost Preparation

Green leaves were collected from *Eucalyptus*, *Conocarpus*,

Moringa, *Leucaena* and *Sesbania* shrubs in the gardens of the Faculty of Agriculture / University of Misan (N 31.813292, E 47.142399 Coordinates) in August 2019. The leaves were left to dry at room temperature and then ground into small pieces by hand. The dried leaves were placed in perforated plastic containers mixed with chicken manure and garden soil at a ratio of 8:1:1 (1600 g tree leaves, 200 g soil and 200 g poultry manure). The dried plant leaves were mixed with soil and poultry manure to increase the microbial content and accelerate the formation of compost. The mixture was placed in the containers and the moisture of the mixture was maintained to suit the aerobic fermentation process by adding tap water left for more than 24 hours to get rid of chlorine so as not to affect the decomposing organisms.

Soil Amendment with Compost

The pot experiment was conducted in the Greenhouse of the College of Agriculture /University of Misan according to the completely randomized design (RCD) with six treatments and four replicates. Soil segments were taken from the garden of the College of Agriculture and mixed with sandy soil (Mixture) at a ratio of (1:1) (V: V) and distributed into 24 pots with a capacity of 4 kg. The soil texture was examined for some soil's chemical and physical properties (Table 1). Four (4) pots were left untreated as a control treatment and the remaining were treated with a different type of compost at a rate of (250 g) per pot and mixed well with the soil and watered thoroughly, six treatment were as following: LC: *Leucaena* Compost, SC: *Sesbania* Compost, CC: *Conocarpus* Compost, EC: *Eucalyptus* Compost, MC: *Moringa* Compost and the Control (Con.) The seeds of the wheat variety Al-Jamiza (Egyptian) were planted, which was grown in Babylon Governorate - Iraq for the 2018 season, 10 seeds were planted per pot. Then, agricultural service operations were carried out, including irrigation, weeding, pest control and fertilization, according to the recommended quantities.

Soil Characteristics	Unit	Value
Electrical Conductivity (ECe)	Des.m ⁻¹	3.32
pH	-	7.6
Organic Matter	%	0.19
Na ⁺	mg. g ⁻¹	1.9
P		0.3
K ⁺		0.9
Sand	g kg ⁻¹ soil	112
Silt		450
Clay		438
Soil Texture	-	Silty Clay

Estimation of Microorganism Numbers

Soil samples were gathered during harvesting time from the rhizosphere area. The total numbers of both bacteria and fungi were estimated based on the weight of dry soil as follows:

1. 1 g of soil was taken from each pot and set in a test tube containing 9ml of sterile distilled water then shaken well until the soil is completely dissolved to obtaining a dilution of 1/10.
2. 1 ml was taken from the first tube and inserted into a second test tube containing 9 ml of sterile distilled water and shaken well to obtaining a dilution of 1/100.
3. The previous process was repeat to obtaining a dilution of 1/1000 (Three replicates for each dilution).

4. A 1ml was taken from the last dilution and placed on the surface of bacterial media NA (HiMedia Company) and fungal media PDA (HiMedia Company) supplemented with antibiotic, then the petri plates moved with a rotating motion to ensure the distribution of 1ml overall the surface of the medium.
5. Petri plates were placed in the incubator at 25 and 28 degrees for fungi and bacteria respectively and examined after 3 days.
6. The numbers of fungal and bacterial colonies are calculated using the Colony Counter device (IUL Micro-Spain).
7. The quantity of soils microorganisms were estimated using the following equation:

$$\text{Viable cells/g dry Soil} = \frac{\text{Mean Plate Count} * \text{Dilution Factor}}{\text{Dry weight of soil}}$$

Germination Percentage

After the third day of planting, the seedlings in the pots were counted daily for a week (Until the tenth day of planting), where the germination percentage was calculated according to the following equation:

$$\text{Germination percentage G.P} = \frac{\text{Number of seedlings}}{\text{Number of sowing seeds}} 100\%$$

Plant Growth Traits

After the third week of sowing, two seedlings were kept in each pot and the rest were removed. During the first appearance of the spike, the measuring of leave area was conducted for the flag leave.

$$\text{Flag Leave Area (cm}^2\text{)} = \text{Length} * \text{Width Area} * 0.95$$

In the end of flowering period, stem diameter in the third internode and plant height from the top of the soil to the upper edge of top spike were measured.

By using a graduated ruler, the lengths of the spikes of each plant were measured. Total spikes per plant and quantity of grains in each spike were measured too.

Soil Properties

In the end of the experiment, examination of some soil properties carried out with the aim of finding out the effect of leaf compost on soil, soil samples taken out from the pots for each replicates including control treatment, cleaned from the residue of wheat roots, pH value was determined, the organic matter was assessed according to Walkley-Black method, Na^+ , P and K^+ were determined according to (Jackson, 1958) ^[16], (Olsen and Sommers, 1982) ^[20] and (Ryan, 1969) ^[40] respectively.

Results and Discussion

(Table 2) displays the results of quantitative calculation of bacterial and fungal colonies in soil samples isolated in the laboratory, which demonstrate the level of microbial activity after treatment with compost. We note that the highest bacterial and fungal activity was recorded in LC and SC compared to the Con. treatment, while MC soil contained the lowest activity of the microbial community. This can be elucidated by the fact that adding compost of the

leaves of the two plants, *Leucaena* and *Sesbania* to the soil increased the activity of the microbial activity due to the high protein and organic content of these two plants belonging to the legume family Fabaceae (Leguminosae). On the other hand, although *Moringa* trees belong to the legume family and their leaves have a relatively high protein content, the MC treatment showed less activity for the microbial community in the soil compared to the rest of the treatments. These results are consistent with what was reached by (Rehman, *et al.* 2020, Vongsaka, *et al.* 2023) ^[28, 37] regarding the antimicrobial effect found in the *Moringa* leaf extract, which was assigned to the dominance of phenolic acids.

Table 2: Quantitative analysis of soil microbial community

Treatments	No. Bacterial Colonies	No. Fungi Colonies
LC	13 ^b	30 ^a
SC	18.25 ^b	27.25 ^a
CC	8.375 ^{cb}	16.525 ^{ba}
EC	5.125 ^{cd}	15 ^{bc}
MC	3.75 ^{cd}	9.875 ^c
Con.	3 ^d	23.62 ^{ba}
LSD($P < 0.05$)	4.67	8.87

Means with common letter in each column are not significantly different at $p < 0.05$

The results of (Table 3) showed the growth characteristics of wheat plants under the impact of different compost treatments, where the CC treatment had the highest germination percentage (90.25%), while the LC treatment showed the lowest germination percentage value (70%). However, there were no significant differences between the different treatments compared to the Con. treatment, in which the germination percentage rate was (70.75%). Based on the previous results, we cannot judge the presence of an allelopathic effect of plant leaf added to soil because it is not significantly different from the control treatment in terms of germination rate.

Regarding the leaf area, the treatment MC was the superior, as the average area was (81.98 cm²), while the control treatment was (53.97 cm²). Also, adding compost of *Sesbania* leaves SC and *Moringa* leaves MC to the soil gave the highest height for the cultivated wheat plants which reached (81.3 cm) and (80 cm) respectively. While the average height of the Con. treatment plants reached (72 cm). For the stem diameter rate, the treatments SC and MC with (0.55 cm) for each showed a significant superiority overall treatments, the lowest of which was the Con. treatment with a value of (0.29 cm). Likewise, the MC treatment was significantly superior to the other treatments in spike length, as its average reached (16 cm). Likewise, the SC and LC treatments were significantly superior to the Con. treatment, as the values were (13.67 cm), (13 cm) and (10.67 cm) respectively. The No. of spikes per plant was close in all treatments, such that no significant differences appeared as it reached the highest value was 33.33 in SC and MC treatments, while the Con. treatment was (2.66). No. of grains per spike was the least in the Con. treatment where its average was (20.333) grains, while the SC and MC treatments showed a clear significant superiority where the average of grains per spike was (50.333) and (46.666) respectively.

Table 3: Germination Percentage and Plant Growth Traits

Treatments	Germination Percentage %	Leave Area cm ²	Plant Height cm	Stem Diameter cm	Spike Length cm	No. of Spikes/plant	No. of Grains/Spikes
LC	70 ^b	67.6 ^{bac}	74 ^b	0.35 ^b	13 ^b	3 ^a	37.333 ^a
SC	80 ^{ba}	70.4 ^{bac}	81.3 ^a	0.55 ^a	13.67 ^b	3.33 ^a	50.333 ^a
CC	90.25 ^a	59.54 ^{bc}	66.7 ^c	0.35 ^b	11 ^{cd}	3 ^a	34.667 ^{ba}
EC	80 ^{ba}	76.56 ^{ba}	64.7 ^c	0.36 ^b	12.33 ^{cb}	3 ^a	43 ^a
MC	70.75 ^{ba}	81.98 ^a	80 ^{ba}	0.55 ^a	16 ^a	3.33 ^a	46.666 ^a
Con.	70.75 ^{ba}	53.97 ^c	72 ^{ba}	0.29 ^b	10.67 ^d	2.66 ^a	20.333 ^b
LSD(<i>P</i> <0.05)	10.79	18.35	6.695	0.08	1.452	0.72	16.887

Means with common letter in each column are not significantly different at *p*<0.05

Through the results of this study, we find that the treatment of compost of Sesbania and Moringa leaves has a significant positive effect on most growth characteristics of wheat plants. The high nitrogen content of Sesbania makes it one of the promising environmental plants for use in sustainable agriculture due to its properties in improving poor soils and supplying them with important nutrients. In the study of (Sharma and Ghosh, 2020) [31] found that using Sesbania as an intercropped rice is useful for replacing urea fertilizer up to 40 kg N ha⁻¹. 36 also found that planting Sesbania optimized the soil properties and increased its nutritional content, where the organic matter content increased by 11.8%, available nitrogen by 4.7%, available phosphorus (kg/ha) by 3.3% and available potassium (kg/ha) increased by 4.9%.

Many recent studies document the high content of nutritional and mineral elements and plant growth stimulants in Moringa leaves, making it a promising source for the production of green fertilizers and a safe alternative to traditional fertilizers. Aqueous extracts of Moringa leaves contain a range of antioxidants and rich in mbyproducts. Moringa leaves are also a source of several vitamins and oils, in addition to indole-3-acetic acid

(IAA), cytokinins, gibberellins (GAs), and a range of minerals such as phosphorus, calcium, potassium, magnesium, iron, copper, zinc, and manganese (Rady, *et al.* 2015, Howladar, 2014, Abd El-Hack, *et al.* 2018) [26, 15, 1].

As shown in the Table 4, a Notable improvement in soil properties was carried out with amendment with leaf compost. There was a decreasing effect on pH level of soil, SC and MC treatment showed a significant effect on alkalinity with pH (7.4) for each compared to Con. treatment which was (7.6). All treatments showed a significant results in increasing organic matter content of treated soil, CC treatment was the highest with (4.11%) followed by MC and EC which reached (3.86) and (3.72) respectively. Organic Matter (OM) played an important role in repairing high alkalinity soils, the decomposition of organic substances can discharge organic acids, which can leads to decreasing soil pH (Tülp, *et al.* 2009) [35]. However, the continued add-on organic matter over the long term can contribute to reducing soil acidity by improving overall soil health, as shown by the study of (Chen, *et al.* 2022) [7] that adding organic fertilizer to soil for three years increased the surface soil pH by 0.49 to 0.75 units, compared to soils that were not fertilized.

Table 4: The effects of Leaf Compost on soil properties

Treatments	pH	Organic Matter %	Na+ mg. g-1	P mg. g-1	K+ mg. g-1
LC	7.5 ab	3.21 d	3.0 b	0.47 a	1.2 ab
SC	7.4 b	3.41 c	3.3 a	0.43 c	1.3 a
CC	7.5 ab	4.11 a	2.1 c	0.433 bc	1.2 ab
EC	7.6 a	3.72 b	2.2 c	0.446 b	1.03 b
MC	7.4 b	3.86 b	3.3 a	0.443 c	1.3 a
Con.	7.6 a	0.18 e	1.73 d	0.32 d	0.8 c
LSD(<i>P</i> <0.05)	0.19	0.155	0.19	0.014	0.167

Means with common letter in each column are not significantly different at *p*<0.05

The content of macronutrients NPK was increased significantly in all treatments, SC and MC showed the heist content of Na⁺ (3.3 mg. g-1) for each, while the Con. soil was (0.19 mg. g-1) only. The SC and MC treatments was superior in K⁺ content too. While the highest value of phosphorus (P) was in the LC treatment (0.47 mg. g-1) followed by EC, MC, CC and SC where reached (0.446, 0.443, 0.433 and 0.43 mg. g-1) respectively, compared to Con. treatment (0.167 mg. g-1). Hence, we find that compost of the leaves of legume plants (SC, MC and LC treatments) has outperformed other plants in increasing the nitrogen content of the soil.

Conclusion

The treatment of organic fertilizer extracted from Leucaena leaves (LC) and Sesbania (SC) resulted in a positive and stimulating effect on the microbial community in the soil,

while the addition of Moringa fertilizer (MC) reduced the activity of fungi and bacteria community. As for the growth of wheat plants, the Sesbania (SC) and Moringa (MC) treatments achieved the highest effect in improving growth and production rates. The study concluded the importance of Leucaena, Moringa and Sesbania trees in improving the properties of Iraqi soils that suffer from high salinity and alkalinity, indicating the possibility of using these trees and shrubs in intercropping with economic crops as one of the sustainable agricultural methods.

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