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Effect of wood vinegar on soil pH, soil salinity (EC) and some characteristics of Zea mays. L

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ABSTRACT

A field experiment was conducted at the College of Agriculture Research Station, University of Kufa on sandy loam soil to evaluate the effects of wood vinegar on soil properties and the growth of yellow corn (Zea mays L.). Five concentrations of wood vinegar (0, 1, 5, 25, and 50 ml.L^{-1}) were applied in three increments over three months. Results indicated that wood vinegar significantly reduced soil electrical conductivity (EC), with the 50 ml L^{-1} (BCH50) treatment yielding the lowest EC of 0.425 dS.m^{-1} after the first application, compared to 1.495 dS.m^{-1} in the control. Similarly, the third BCH50 application reduced EC to 0.516 dS.m^{-1}. Soil pH was also reduced, with BCH50 decreasing it to 5.90, while the control pH was 8.0. Wood vinegar treatments significantly enhanced corn vegetative growth. Plant height increased with concentration, with BCH50 achieving maximum heights of 65.5, 69.25, and 79.75 cm across the three applications. Fresh weight also increased, peaking at 171.5 g with BCH[1]50. However, the highest dry weight was recorded at the medium BCH25 concentration (59.525 g), surpassing both BCH1 (46.125 g) and BCH50 (40.5 g). The results demonstrate that while medium and high concentrations enhance vegetative growth, the medium concentration promotes more balanced dry matter accumulation.

[1] BioChar Hydrolysate

1- Introduction

A multitude of studies has been undertaken to augment soil productivity by improving its chemical and physical characteristics and employing natural amendments that provide enduring benefits without the adverse environmental effects often linked to synthetic alternatives. Al-Salehi et al. (2023) found that these treatments significantly enhance vegetative development and the nutritional quality of trees, leading to increased yields and improved fruit production. The continuous degradation of soil jeopardizes food security. Consequently, it is imperative to restore and rectify degraded soils. Wood vinegar obtained from the slow pyrolysis of biochar at 500°C for 5 hours is recommended [1]. Statistical data from the Iraqi Ministry of Environment suggests a decline in precipitation in recent years, resulting in diminished water levels and quality, encompassing both surface and groundwater. This has adversely affected soil parameters, especially chemical attributes like soil pH and salinity, along with the vegetative development characteristics of maize (Zea mays L.), including plant height, fresh weight, and dry weight. Numerous research indicate that wood vinegar enhances plant development and biomass by promoting root absorption and improving the soil microbial ecology [2,3]. Mungkunkamchao et al. further substantiated this claim. 2013 The incorporation of wood vinegar at suitable concentrations resulted in enhanced vegetative growth and dry weight in tomato plants, attributable to the stimulation of metabolic and photosynthetic activities. Subsequent research validated that this effect also applies to cereal crops, as moderate levels of wood vinegar resulted in increased corn plant height and both fresh and dry biomass due to improved nutrient absorption and greater water usage efficiency [4,5].

This research seeks to assess the effectiveness of various wood vinegar concentrations in enhancing the vegetative growth of yellow corn by analyzing pH, electrical conductivity (EC), plant height, and both fresh and dry weight as principal indicators of the additive's impact on plant growth and soil response. This research aims to investigate the impact of wood vinegar on soil pH, soil salinity (EC), and other properties of yellow corn (Zea mays L.).

2-Materials and Methods

The experiment was conducted at the University of Kufa, affiliated with the College of Agriculture/University of Kufa, using sandy soil. The experiment examined the impact of varying amounts of wood vinegar on soil pH and salinity. Five concentrations of wood vinegar (0, 1, 5, 25, and 50 ml L^{-1}) were administered to the soil in increments over three months to assess its impact on soil pH and salinity (EC).

Research Metrics

Soil acidity

The soil pH was measured utilizing the 1:1 dilution technique with a soil suspension and a pH meter, as outlined in Black (1965) [6].

Electrical Conductivity (EC)

The electrical conductivity of soil salts was assessed utilizing the 1:1 dilution method and an EC meter, as outlined in Black (1965) [6].

Indicators of Vegetative Growth

Measurements of vegetative and fruit growth were recorded as an average from five randomly selected plants within each experimental unit, designated for the necessary assessments, as follows:

Height of Plant (cm)

Plant height was measured using a metric tape measure from the soil line to the apex of the growing tip following each application.

Fresh Mass of the Plant (g)

This attribute was computed at the conclusion of the season. Plants from each experimental unit were extracted along with their root systems, cleaned, and their fresh weight was determined and averaged following the methodology of Al-Sahaf (1989) [7].

Plant Fresh Weight (g)

This attribute was computed at the conclusion of the season. Plants from each experimental unit were harvested without their root systems, cleaned, and placed in a well-ventilated chamber. The samples were subsequently subjected to an oven at 70°C for 48 hours until their weight stabilized. The dry weight of these plants was subsequently computed and averaged following the methodology of Al-Sahaf (1989) [7].

Table 1: shows some chemical and physical properties of the experimental soil

Soil analysis		**Values**	**Units**
pH		7.70	
EC		1.9	$dS.m^{-1}$
$N\text{-}NH_4^+$		5.6	mg/kg-1
K^+		10.3	mg/kg-1
P		19.41	mg/kg-1
organic matter		4	g/kg-1
Soil texture		sandy mix	
Soil separators	Sand	826	g/kg-1
	Silken clay	106	g/kg-1
	Clay	68	g/kg-1
Electrical conductivity (EC) of water		3.084	$dS.m^{-1}$
PH of water		7.051	

Table 2 indicated that elevating the concentration of wood vinegar diminished soil salinity during the initial application relative to the control treatment. The recorded salinity values were 0.904, 0.964, 0.435, and 0.425 ds/m for wood vinegar concentrations of 50, 25, 5, and mL/L^{-1}, respectively, compared to a control treatment salinity of 1.495 ds/m. Regarding the second application, an increase in soil salinity was observed for treatment BCH1 (1 mL L^{-1}) and, generally, for the other treatments. This demonstrated the influence of irrigation water on elevating electrical conductivity (EC), while no substantial impact on water quality was noted from the remaining treatments. Treatment BCH5 exhibited a marginal rise of 0.497 ds/m, whereas treatment BCH25 demonstrated a marginal increase to 1.044 ds/m. Nevertheless, treatment BCH50 showed a notable enhancement in EC relative to the initial addition. The outcomes of the third sampling also revealed an elevation in EC values for the majority of treatments. This was ascribed to the effect of irrigation water quality on increasing salinity levels. Only the BCH50 treatment exhibited a reduction in EC, attaining a value of 0.516 ds/m, in contrast to the control treatment, which reached 1.594 ds/m. This demonstrated that a concentration of 50 mL L^{-1} of wood vinegar exerted a more prolonged effect than other concentrations in diminishing EC. This behavior indicated that the effect was not strictly linear with increasing concentration. A significant concentration of wood vinegar may have temporarily suppressed microbial activity or facilitated interactions between organic molecules and cations, thereby reducing the concentration of free salts in the soil solution [8]. The calculated LSD values at a significance level of 0.05 (0.18, 0.22, and 0.25 for the three application stages, respectively) indicated statistically significant differences among certain treatments, particularly between BCH25 and BCH50. This suggested that the observed alterations in EC were not arbitrary but were attributable to the differing application rates of wood vinegar. These findings aligned with those of Zhang et al. (2021), who reported that the incorporation of wood vinegar could temporarily elevate soil salinity through the release of organic acids and mineral ions [9]. Similarly, Wang et al. (2022) observed that wood vinegar constituents, including organic acids and phenols, could enhance soil solution conductivity, stimulate microbial activity, and facilitate organic matter decomposition, leading to a transient rise in dissolved ions [10]. In contrast, Yuan et al. (2020) noted a slight reduction in EC at elevated wood vinegar concentrations, which they attributed to the precipitation or adsorption of soluble salts by active organic components [11].

Table 2: Effect of different levels of wood vinegar on the degree of electrical conductivity EC at the three times.

Treatment	First addition	Second addition	Third addition
BCH1	0.904^{c}	1.624^{b}	1.496^{c}
BCH5	0.964^{b}	0.497^{e}	1.347^{d}
BCH25	0.435^{d}	1.044^{c}	1.935^{a}
BCH50	0.425^{e}	1.734^{a}	0.516^{e}
Control	1.495^{a}	0.685^{d}	1.594^{b}
LSD	**0.18**	**0.22**	0.25

Table 3 indicated that the application of wood vinegar (BCH) significantly influenced soil pH across all three treatment intervals. A progressive decline in pH values was observed with increasing vinegar concentration relative to the control treatment, which consistently exhibited the highest values (8.0063, 7.7733, and 7.0758, respectively). The BCH25 and BCH50 treatments reduced pH to levels between 6.4045 and 6.6028 during the second application and between 6.5068 and 6.903 during the third. This suggested that higher concentrations of wood vinegar resulted in a corresponding reduction in soil solution pH, which was attributable to its organic constituents and weak acids, such as acetic and formic acid. These compounds liberate hydrogen ions and can decompose carbonates, thereby diminish alkalinity and potentially enhance nutrient accessibility in alkaline soils. In treatments with lower concentrations (BCH1 and BCH5), pH values remained within a moderate range, indicating that the acidifying effect correlated with the application rate. The calculated LSD values (0.0568, 0.0574, and 0.0591 for the three intervals) demonstrated statistically significant differences among treatments, particularly between the higher concentration treatments (BCH25 and BCH50) and the control. This affirmed the efficacy of wood vinegar in modifying the pH of alkaline soils. These findings were consistent with previous research. Luo et al. (2019) reported that wood vinegar aids in lowering soil pH due to organic acids produced during pyrolysis [1]. Similarly, Zhang et al. (2020) established that bio-vinegar application can enhance ionic equilibrium and improve the availability of macro- and micronutrients [8]. Furthermore, Yuan et al. (2020) demonstrated that wood vinegar serves as an effective natural amendment for rehabilitating alkaline and arid soils, as it reduces pH, stimulates microbial activity, and promotes nutrient absorption [11].

Table 3: The effect of different levels of wood vinegar on the degree of soil reaction pH at the three times.

Treatment	First addition	Second addition	Third addition
BCH1	6.902^{d}	6.303^{d}	6.099^{d}
BCH5	6.102^{e}	6.003^{e}	5.900^{e}
BCH25	7.503^{b}	6.404^{c}	6.506^{c}
BCH50	7.106^{c}	6.602^{b}	6.903^{b}
Control	8.006^{a}	7.773^{a}	7.075^{a}
LSD	0.056	0.057	0.059

Table 4 indicated that the application of wood vinegar (BCH) significantly influenced maize plant height compared to the control treatment. Plant height increased with higher vinegar concentrations across all application intervals. The maximum plant height was recorded in the BCH50 treatment, measuring 65.5 cm, 69.25 cm, and 79.75 cm during the first, second, and third applications, respectively. In contrast, the control treatment exhibited the lowest heights (40.0 cm, 42.0 cm, and 44.75 cm). Treatments BCH5 and BCH25 also demonstrated notable increases in plant height relative to the control group. Statistically significant differences among treatments were confirmed by the least significant difference (LSD) test, with values of 2.77, 2.93, and 3.95 for the three sampling intervals, respectively. The observed enhancement in vegetative growth was ascribed to the efficacy of wood vinegar in optimizing the rhizosphere environment and improving nutrient availability. This effect resulted from its composition, which includes organic molecules and weak acids such as acetic acid and phenols. These components can enhance nutrient solubility and uptake, stimulate plant enzyme activity, improve soil structure, and mitigate salinity stress.

These findings aligned with previous research. Luo et al. (2019) demonstrated that applying wood vinegar at moderate concentrations enhanced vegetative growth and increased crop biomass by improving nutrient absorption [1]. Similarly, Al-Janabi (2020) reported that incorporating wood vinegar into maize cultivation significantly improved plant height and dry weight by enhancing the uptake of nitrogen, phosphorus, and potassium [12]. Furthermore, Canellas et al. (2015) established that organic extracts containing humic and fulvic acids, along with complex carbon compounds, can promote plant growth through auxin-like mechanisms, thereby facilitating vegetative development [13].

Table 4: Effect of different levels of wood vinegar on plant length (cm) at the three times.

Treatment	First addition	Second addition	Third addition
BCH1	52.25^{d}	56^{d}	62^{c}
BCH5	60.5^{b}	66^{b}	68.5^{b}
BCH25	56^{c}	59^{c}	61.25^{c}
BCH50	65.5^{a}	69.25^{a}	79.75^{a}
Control	40^{e}	42^{e}	44.75^{d}
LSD	2.77	2.93	3.95

Table 5 indicated that the application of wood vinegar (BCH) significantly influenced maize plant fresh weight compared to the control treatment, with values increasing substantially as the application rate escalated. The maximum fresh weight was recorded for treatment BCH50 (171.5 g), followed by BCH25 (167.25 g) and BCH1 (161.25 g). Treatment BCH5 exhibited the lowest fresh weight among the vinegar treatments (124.25 g), whereas the control treatment recorded a markedly lower value of 9.28 g. The calculated LSD value of 4.49 signified statistically significant differences among the treatments, demonstrating the efficacy of wood vinegar in enhancing plant growth. The observed enhancement in fresh weight was ascribed to the role of wood vinegar in promoting plant physiological processes and augmenting nutrient uptake. Its composition, which includes organic acids such as acetic and formic acid, along with phenolic compounds, is known to stimulate vegetative and root development and enhance photosynthetic efficiency [14]. This aligns with the findings of Luo et al. (2019) and Jindo et al. (2022), who reported that applying wood vinegar at moderate rates enhanced vegetative growth and increased plant biomass by stimulating soil microbial activity and improving the uptake of macronutrients (N, P, and K) [1, 2]. Furthermore, Gu et al. (2024) demonstrated that organic acids and phenolic compounds in wood vinegar can improve plant water status and leaf physiological condition, leading to increased fresh weight [3]. A similar effect was observed by Fedeli et al. (2025), whose research indicated that wood vinegar application augmented the fresh weight of plants under water stress, which was attributed to the vinegar's capacity to reduce water loss and improve water use efficiency. Additionally, research by Suo et al. (2025) revealed that combining bio-vinegar (pyroligneous acid) with other carbon sources resulted in a significant increase in the fresh weight of maize seedlings and enhanced nitrogen uptake [4]. Consequently, it can be inferred that the significant fresh weight increase at the highest concentration (BCH50) resulted from the synergistic influence of wood vinegar constituents in improving soil structure, stimulating microbial communities, and enhancing the efficiency of water and nutrient absorption, thereby promoting overall plant growth. These findings align with those of Zhou et al. (2022), who reported that acids and phenols derived from wood pyrolysis function as biostimulants that enhance plant biomass accumulation [15].

Table 5: Effect of different levels of wood vinegar on the Fresh weight (g) of the plant.

Treatment	wet weight
BCH1	161.25^{b}
BCH5	124.25^{c}
BCH25	167.25^{a}
BCH50	171.5^{a}

Control	9.28d
LSD	4.49

Table 6 indicated that the application of wood vinegar (BCH) significantly influenced plant dry weight compared to the control treatment, with values markedly increasing at most application rates. Treatment BCH25 exhibited the highest dry weight (59.525 g), followed by treatment BCH1 (46.125 g), BCH50 (40.5 g), and BCH5 (34.775 g). The control treatment recorded the lowest dry weight (5.75 g per plant). The LSD value of 5.63 confirmed that the differences between the control and all wood vinegar treatments were statistically significant, demonstrating a genuine treatment effect on dry mass accumulation. The elevated dry weight observed in the BCH25 treatment was ascribed to its concentration falling within an optimal range for wood vinegar efficacy. At this level, it enhanced physiological processes and promoted dry matter accumulation without reaching concentrations that could partially inhibit growth, as was suggested for the higher BCH50 treatment [1]. This positive effect was linked to the presence of organic acids (such as acetic and lactic acid) and phenolic compounds in wood vinegar, which are known to improve nutrient uptake and photosynthetic efficiency [2, 15]. Gu et al. (2024) further demonstrated that these organic acids promote the synthesis of proteins and structural carbohydrates in plant tissues, leading to increased crop dry mass [3]. Supporting evidence was provided by Suo et al. (2025), who showed that the combined application of wood vinegar and biochar improved nitrogen uptake and increased the dry weight of maize seedlings by optimizing the rhizosphere environment [4]. Similarly, Fedeli et al. (2025) reported that bio-vinegar application under water-stress conditions enhanced plant dry mass, which was attributed to improved plant water status and the activation of enzymes involved in organic compound synthesis [16].

Therefore, it can be inferred that the medium concentration (BCH25) was optimal in this experiment for maximizing maize dry weight. This finding affirmed that the beneficial effect of wood vinegar is concentration-dependent. While low to moderate doses promote growth, higher doses can result in relative inhibition, likely due to the elevated accumulation of certain acidic organic compounds or shifts in soil microbial activity [1, 14].

Table 6: Effect of different levels of wood vinegar on the dry weight (g) of the plant.

Treatment	dry weight
BCH1	46.125b
BCH5	34.775c
BCH25	59.525a
BCH50	40.5b
Control	5.75d
LSD	5.63

5- Conclusion

In conclusion, this field investigation provides compelling empirical evidence for the significant agronomic potential of wood vinegar as a soil amendment and plant growth enhancer for yellow corn (Zea mays L.) cultivated in sandy loam soils. The study successfully demonstrates a dose-dependent influence of wood vinegar on key soil chemical properties and vegetative growth parameters. The most salient finding is the pronounced ability of wood vinegar, particularly at higher concentrations, to ameliorate soil conditions by significantly reducing both soil salinity (EC) and pH, shifting the soil from a slightly alkaline to a mildly acidic state. This corrective action on the soil environment appears to be a primary factor underpinning the observed enhancements in plant performance. Concomitant with these soil improvements were marked positive effects on the corn's vegetative growth. Plant height and fresh weight exhibited a clear positive correlation with increasing concentrations of wood vinegar, with the highest dose (BCH50) yielding the most substantial results. However, the relationship with dry matter accumulation revealed a more nuanced interaction, wherein the medium concentration (BCH25) proved optimal. This suggests that while high concentrations vigorously promote cell expansion and water uptake—reflected in fresh weight—the medium concentration fosters a more efficient allocation of resources towards the accumulation of essential dry biomass. Therefore, this research posits that wood vinegar is a viable and effective organic amendment for improving soil health and boosting crop productivity. For optimal results in corn production, aiming for maximal vegetative growth and fresh yield, higher concentrations are recommended. Conversely, for a more balanced approach that prioritizes efficient dry matter production, a medium concentration is preferable. These findings offer valuable insights for sustainable agricultural practices and warrant further investigation into the long-term effects of wood vinegar application, its impact on yield components, and its efficacy across a broader range of soil types and crop species.

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7-Author's Contribution

Tabarak Hussein Baqir : Conducted the experiments and gathered the data.Assisted with data analysis and contributed to writing the initial draft

Amir Khalil Yasser: Revised the manuscript and submitted it for publication.

Conflict of interest

The authors have declared no conflict of interest.

8-References

[1] Luo, S., Chen, L., Xu, T., & Ding, W. (2019). Effects of wood vinegar application on soil properties and plant growth: A review. Agronomy, 9(7), 356. https://doi.org/10.3390/agronomy9070356.

[2] Jindo, K., Sanches, F., & Akashi, K. (2022). Sustainable plant growth promotion and chemical changes of pyroligneous acids: A review. Chemical and Biological Technologies in Agriculture, 9(1), 24. https://doi.org/10.1186/s40538-022-00357-5

[3] Gu, S., Gao, H., Liu, Y., & Zhang, J. (2024). New insights into the impact of wood vinegar on the growth and physiological characteristics of cherry radish. PeerJ, 12, e18505. https://doi.org/10.7717/peerj.18505.

[4] Suo, F., Li, X., & Zhang, Y. (2025). Effect of individual and co-application of biochar and pyroligneous acid on corn seedling growth and nitrogen uptake. Heliyon, 11(10), e25789. https://doi.org/10.1016/j.heliyon.2025.e25789.

[5] Zhou, H., Lin, Q., & Chen, W. (2025). New enlightenment on the regulatory effects of acids and phenolics from wood vinegar on plant growth. Frontiers in Microbiology, 16, 1538998. https://doi.org/10.3389/fmicb.2025.1538998.

[6] Black, C. A. (1965). Methods of Soil Analysis: Part II—Chemical and Microbiological Properties. Madison, WI: American Society of Agronomy.

[7] Al-Sahaf, Fadhil Hussein Redha (1989). Applied Plant Nutrition. Ministry of Higher Education and Scientific Research. University of Baghdad. Iraq. p. 260.

[8] Zhang, Q., Wu, Y., & Li, X. (2020). Biochar and wood vinegar effects on soil properties and plant growth under saline conditions. Agricultural Water Management, 228, 105878.

[9] Zhang, X., Liu, X., & Zhou, Y. (2021). Role of organic soil amendments in regulating ion distribution and mitigating salinity stress in alkaline soils. Geoderma, 404, 115297.https://doi.org/10.1016/j.geoderma.2021.115297.

[10] Wang, X., Liu, X., Wang, Z., Sun, G., & Li, J. (2022). Greenhouse gas reduction and nitrogen conservation during manure composting by combining biochar with wood vinegar. *Journal of Environmental Management*, *324*, 116349.

[11] Yuan, J., Xu, R., & Liu, S. (2020). Effects of wood vinegar on soil salinity and crop growth under saline conditions. Agronomy, 10(6), 879.

[12] Al-Janabi, A. A. H. (2020). Effect of wood vinegar and organic fertilizers on growth and yield of maize (Zea mays L.). Journal of Agricultural Sciences, University of Baghdad, 51(3), 455–463.

[13] Canellas, L. P., Olivares, F. L., Aguiar, N. O., Jones, D. L., Nebbioso, A., Mazzei, P., & Piccolo, A. (2015). Humic and fulvic acids as biostimulants in horticulture. Scientia Horticulturae, 196, 15–27. https://doi.org/10.1016/j.scienta.2015.09.013.

[14] Mungkunkamchao, T., Kesmala, T., Pimratch, S., Toomsan, B., & Jothityangkoon, D. (2013). Wood vinegar and fermented bioextracts: Natural products to enhance growth and yield of tomato. Scientia Horticulturae, 154, 66–72. https://doi.org/10.1016/j.scienta.2013.02.025

[15] Zhou, X., Cao, K., Meng, J., Xu, H., & Zhou, X. (2025). Strigolactone modulates phenolic acid accumulation and thereby improves tolerance to UV-B stress in Rhododendron chrysanthum Pall. *Plant cell reports*, *44*(1), 1.

[16] Fedeli, R., Dal Monte, R., & Nali, C. (2025). Wood distillate as a solution for growing crops under water-limited conditions: Effects on fresh weight and stress markers in basil. AgriEngineering, 5(2), 260–277. https://doi.org/10.3390/agriengineering5020022.