Research Article

Effect of Schanginia Aegyptiaca Residues and Humic Acid Application on Soil Chemical Properties and Growth of Maize (*Zea mays* L.)

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Abstract | This study aims to investigate the combination effect of *Schanginia aegyptiaca* residues and humic acid on soil chemical properties and growth of Maize. The first factor included three levels of *Schanginia aegyptiaca* residues, namely without *Schanginia aegyptiaca* residues addition symbolled as L_0, addition 23 $mg.kg^{-1}$ soil of residues symbolled as L_1 and addition of 46 $mg.kg^{-1}$ soil of residues symbolled as L_2. whereas the second factor included three levels of humic acid, namely without humic acid 0.00 mg. L^{-1} symbolled as H_0, humic acid application of 0.75 mg. L^{-1} symbolled as H_1 and humic acid application of 1.5 mg. L^{-1} symbolled as H_2. A pot experiment was carried-out during the spring of 2023 and treatments were distributed according to a randomized complete block design (RCBD) with three replications. The plant height, dry weight, soil electrical conductivity (EC), soil reaction (pH), and the available NPK were measured. The study demonstrated a significant increase in both plant height and dry weight of maize. The study indicated a significant decrease in electrical conductivity and soil reaction after cultivation compared to higher values in the control treatment, the soil electrical conductivity and soil reaction decreased to 1.30 $dS.m^{-1}$ and 7.60 after planting compared to 1.53 dSm^{-1} and 7.80 before planting. Additionally, the study demonstrated an increase in the concentration of available soil NPK with higher levels of *Schanginia aegyptiaca* residues addition and humic acid levels.

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Introduction

Schanginia aegyptiaca, commonly referred to as seablites or seepweeds, is an herbaceous succulent plant that is known for its annual life cycle and its ability to accumulate salt. It belongs to the Chenopodiaceae family. With over 100 species identified, 27 of them have been extensively studied and documented. *Schanginia aegyptiaca* is one of the prevalent wild species in the central and southern regions of Iraq. It thrives extensively in uncultivated lands, including those with high salinity levels. Frequently, it is utilized as fresh fodder or animal feed in the regions where it naturally grows (An *et al*., 2019). It can also efficiently decrease surface soil salinity, increase soil organic matter, and enhance the soil Macronutrients levels (NPK) (Hundi *et al*., 2025). However, *Schanginia aegyptiaca* has not been commercially exploited, despite many studies that have utilized it as an extract sprayed on certain plants, yielding positive results in improving their growth conditions. Schanginia contains high levels of iron, zinc, and manganese. Soil is fundamental to life existence. The spatial variability distribution patterns of soil chemical properties offer a scientific groundwork for enhancing crop yield and nutrient management (Hamid, 2025b). Earlier investigations on the spatial variability of soil chemical properties have shown a significant correlation between yield and soil characteristics such as pH, organic matter, cation exchange capacity, and the availability of soil nutrients (Mohammed *et al*., 2019; Al-Maamori *et al*., 2024). In this context, the importance of studying the effect of Shanginia aegyptiaca plant residues and the addition of humic acid is highlighted, not only in modifying the chemical properties of the soil, such as organic content and element balance, but also in improving physical properties such as soil structure, porosity, and soil moisture retention. The organic matter resulting from the decomposition of plant residues and humic acid contributes to enhancing soil cohesion and aeration, creating an optimal environment for corn root growth and thus increasing its productivity. Therefore, linking the chemical and physical effects of these treatments is essential for understanding the mechanisms for improving corn production in an integrated manner (Hamid, 2025a). *Schanginia aegyptiaca* content of microelements makes it play an important role in organic fertilizers production and their sustainability. Climate change and unsuitable traditional farming methods are severely impacting soil health in arid and semi-arid regions., particularly extensive tillage. These rules not only lead to reduced soil fertility but also result in unpredictable crop yields, posing a threat to the sustainability of agriculture in these areas (Akol *et al*., 2024). Investing in improving the productivity of strategic crops, such as maize (*Zea mays* L.), is a priority for the agricultural sector. Research into natural and economic methods for improving soil properties is emerging as an effective tool for increasing the efficiency of agricultural production (Drebee *et al*., 2021).

The growth in corn production is an important indicator of the development of the agricultural sector and the achievement of food security. This growth depends on a number of interconnected factors, such as the use of modern technologies, improved seed quality, and the efficient provision of water resources. The topic we are discussing is directly related to this growth, as it contributes to enhancing agricultural efficiency and increasing productivity, which in turn leads to increased corn production rates and meeting the growing local and global demand for this strategic crop (Hassan *et al*., 2021; Drebee *et al*., 2023). Humic acids have been utilized on a worldwide scale to enhance soil fertility and promote the growth of plants. It could also serve as an adaptive approach to enhance soil microbial characteristics in both surface and subsurface soil layers to face global warming. Nevertheless, the effects of humic acid (HA) addition on soil health can significantly differ based on the soil texture, land use, and ecosystem (Abbott *et al*., 2018).

Therefore, this study aims to evaluate the combined effects of *Schanginia aegyptiaca* residues and humic acid application on improving soil chemical properties and enhancing maize growth. By integrating natural soil amendments with sustainable agricultural practices, the research seeks to offer practical solutions to enhance productivity, especially in arid and semi-arid environments facing climate stress and soil degradation..

Materials and Methods

Experimental design and soil preparation

The Pot experiment was carried out during the spring season of 2023, in the College of Agriculture field, University of Anbar. The study included two factors, the first factor involved the addition of *Schanginia aegyptiaca* residues with three levels, namely L_0 (without addition), L_1(23 mg.kg^{-1}), and L_2(46 mg.kg^{-1}). The second factor included three levels of humic acid with concentrations of H0: without addition, H_1(0.75 mg.L^{-1}), and H_2 (1.5 mg.L^{-1}). The experiment was carried out according to a randomized complete block design (RCBD) with three replications. The soil under study was collected from agricultural fields in the Sufiya/Al-Ramadi region from the topsoil horizon 0-30 cm. The texture of the considered soil was silty clay loam, which was previously exploited for crop cultivation. The soil under study was classified as Entisoil soil order and typic Torrifluvea ts as sub great soil group according to the modern American classification. The soil was air-dried and sieved through a 2 mm mesh to assess some soil chemical and physical properties. The results are shown in Table 1.

Table 1: *Some chemical and physical properties of the soil under study.*

Parameter		Value	Unit
pH		7.7	-
EC		2.6	$dS.m^{-1}$
Organic matter		12	$g.kg^{-1}$
Carbonates		276	
Ca^{+2}		9.8	$Mmol.l^{-1}$
Mg^{+2}		8.62	
Na^{+1}		0.89	
K^{+}		6.87	
SO_4^{-2}		9.44	
HCO^{-3}		4.50	
CO_3^{-}		-	
Cl^{-}		7.25	
Nitrogen (N)		23	$g.kg^{-1}$
Phosphorous(P)		17	
Potassium (K)		223	
Cation exchange capacity		27	cmolc/kg
Soil Particles	Sand	140	$g.kg^{-1}$
	Silt	550	
	Clay	310	
Texture Soil	Clay Silty Loam		
Water Content %	Saturation		44
	at 33 Kpa (field capacity)		25
	at 1500 Kpa (wilting point)		12

Organic residues

The *Schanginia aegyptiaca* was selected as a source of organic residues, which was collected from the agricultural lands affiliated with the College of Agriculture/University of Anbar. The *Schanginia aegyptiaca* residues were electrically shredded by a machine, then air-dried and subjected to a 90-day aerobic decomposition process. This was achieved by maintaining an appropriate moisture level after adding 1% nitrogen in the form of urea and 0.5% phosphorus in the form of superphosphate. The residues were kept in a pile on a nylon sheet while preserving the suitable moisture content. The pile was left for decomposition, with periodic moisturizing and turning every three days, while maintaining the temperature at 45-50 °C, according to (Caires *et al*., 2006). Some chemical properties of *Schanginia aegyptiaca* residues were determined before and after decomposition, as shown in Table 2.

Table 2: *Some chemical properties of Schanginia aegyptiaca residues.*

Status of organic decomposition	$gm.Kg^{-1}$				C/N Ratio
	Organic carbon	Total nitrogen	Phos-phorus	Potas-sium	
Before decomposition	348	3.8	2.7	6.5	68
After decomposition	352	19.6	8.5	4.1	17

Some soil chemical properties

The soil electrical conductivity (EC) and pH of the saturated soil-paste was determined using the HANNA-HI8820 electrical conductivity meter and HI 2211 pH meter according to (Richards, 1954). The soil texture was determined using the Bouyoucos hydrometer (Black *et al*., 1965). The percentage of moisture was estimated at saturation, field capacity, and wilting point according to (Richards, 1954). Soil organic matter was analyzed by wet digestion method, as described by (Page, 1982). Gypsum content was determined using the acetone precipitation method, and electrical conductivity was measured by the HANNA-HI8820 conductivity meter, according to (Page, 1982) The carbonate minerals were determined by measuring the CO_2 loss upon treating the soil with a 3.0 normal hydrochloric acid, according to (Richards, 1954). The available nitrogen was measured using a Kjeldahl apparatus, as described by (Page, 1982). While the available phosphorus was extracted from the soil using the Olsen method, as described by (Page, 1982) using a sodium bicarbonate solution, and the color was developed using ammonium molybdate and ascorbic acid, the reading was taken using a spectrophotometer (at a wavelength of 820 nm). Anions and cations were measured were measured in saturated soil-paste extract according to (Richards, 1954). Calcium and magnesium ions were determined by titration with versenate (Na_2-EDTA). Potassium and sodium were determined using the flame photometer. Chloride was quantified by titration with silver nitrate (0.01 N) in the presence of potassium chromate. Sulfate content was determined using the turbidity method with a spectrophotometer at a wavelength of 420 nanometers, employing barium chloride ($BaCl_2$). Carbonates and bicarbonates were quantified using the titration method with 0.01 N sulfuric acid.

Cultivation and fertilization

Plastic containers with a capacity of 15 kg were used for cultivation. Each container was filled with thoroughly mixed field soil that had been air-dried. A 0.05 m in diameter layer of gravel, was spread in the bottom of the pots to facilitate removing the excess water. Triple superphosphate (P_2O_5 46%) was applied as a source of phosphate fertilizer at a rate of 200 kg P_2O_5 ha^{-1}. While potassium sulfate (41.5%K) was applied as a source of K at the rate of 200 kg. ha^{-1}. Phosphate and potassium fertilizer were thoroughly mixed with the soil before planting. Seven seeds of corn variety D.C6022 were planted in each pot on 15 March 2023. After germination, the plants were thinned to five plants per pot. Nitrogen fertilizer in the form of urea (46% N) was applied at a rate of 320 kg N ha^{-1}. The dose of Nitrogen was applied immediately after thinning the plants, whilst the second dose was 40 days after the first batch. The fertilization was according to the recommendation provided by (Ali *et al*., 2014). According to the field capacity, the gravimetric method was adopted for the irrigation process. The pots were weighed daily, and the moisture loss was compensated by daily irrigation. Humic acid was added to the soil according to the experimental treatments. Weeds were manually controlled in addition, yellow maize stem borer was controlled using the pesticide Super Ethion at a rate of 1 ml per liter of water, sprayed on the plants. Furthermore, the granular pesticide Diazinon 10% was used as a soil application at a rate of 6 kg ha^{-1}. On 10 June 2023, the plants were harvested, where the plant stems were cut from the plant-soil contact point, height average of three plants was taken. The harvested plants were washed with distilled water and their dry weight was measured. The dried plants were then ground and preserved in plastic bags for chemical analyses. Subsequently, pots were emptied from the soil, dried, passed through a 2 mm sieve, and stored according to symbols of treatments for chemical analyses.

Statistical analyze

Gen Stat Release 12.1 program was used to statistically analyzed the obtained data. the least significant difference test L.S.D at the level of significance P = 0.05. was used to compare the averages.

Results and Discussion

Plant height

The application of *Schanginia aegyptiaca* residues and humic acid levels had a significant effect on maize plant height as shown in Table 3. In this context, the L_2 (46 mg.kg^{-1}) treatment gave the highest value reaching 37.25 cm, with increasing reached 20% compared to the control treatment (L_0) which recorded 31.12 cm. Regarding the humic acid levels, the results revealed significant differences in plant height, where the H2 treatment (1.5 mg.kg^{-1}) yielding the highest average of plant height reached 35.27 cm. This represents a 5% and 2% increase compared to the control treatment (H_0), which measured 33.50 cm, and H_1 (0.75 mg. l^{-1}), which measured 34.55 cm, respectively. Furthermore, the interaction between *Schanginia aegyptiaca* residues and humic acid levels was significant. The combined treatment L_2H_2 yielded the greatest plant height at 38.76 cm, compared to the control combination (L_0H_0), which measured 30.36 cm overall increase of 28%.

Table 3: *Effect of Schanginia residues and humic acid application on plant height (cm).*

Schanginia aegyptiaca	Humic acid levels (t.h^{-1})			Average	Average
decomposition levels	H_0	H_1	H_2	L	H
L_0	30.36	31.26	31.73	31.12	33.5
L_1	34.36	35.16	35.33	34.95	34.55
L_2	35.76	37.23	38.76	37.25	35.27
L.S.D (0.05)	L= 0.26		H = 0.26		L.H = 0.45

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference

Dry weight

The results presented in Table 4 illustrate the effect of *Schanginia aegyptiaca* residues application and levels of humic acid on the dry weight of Maize. The evidence shows significant differences in dry weight with increasing levels of residues addition. Where L_2 treatment gave the highest value of dry weight reached 11.24 g, representing a 54% increase compared to the control treatment (L_0), which measured 7.29 g. Regarding humic acid, the obtained results showed significant differences in dry weight, where H_2 treatment, exhibited the highest average of dry weight reaching 9.93g, with an increase of 10 and 5.2 % compared to the control treatment (H_0) and H_1 treatment, which gave 8.97 and 9.44 g respectively. Likewise, the interaction between treatments showed that L_2H_2 resulted in the highest dry weight at 11.81 g, compared to the L_0H_0 treatment which recorded 6.76g.

Table 4: *Effect of Schanginia residues and humic acid application dry weight (g).*

Schanginia aegyptiaca	Humic acid levels (t.h^{-1})			Average	Average
decomposition levels	H0	H1	H2	L	H
L_0	6.76	7.26	7.86	7.29	8.97
L_1	9.51	9.78	10.14	9.81	9.44
L_2	10.65	11.27	11.81	11.24	9.93
L.S.D (0.05)	L= 0.026		H = 0.026		L.H = 0.045

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference

The observed increase in the morphological characteristics of Maize, such as plant height and dry weight, under the effect of *Schanginia aegyptiaca* residues application, can be attributed to the role of residues in stimulating both vegetative and reproductive growth in plants.

Soil electrical conductivity (EC)

The effect of *Schanginia aegyptiaca* residue application and levels of humic acid on soil electrical conductivity is shown in Table 5. Significant differences in electrical conductivity were observed with an increase in the levels of residue addition. For instance, L_2 treatment gave the lowest value, measuring 1.25 dS.m^{-1}, representing a decrease of 15.5% compared to L_0, which recorded 1.48 dS.m^{-1}. The levels of humic acid cause a significant decrease in electrical conductivity. Where H_2 treatment recorded the lowest average, measuring 1.32 dS.m^{-1}. This represents a decrease of 6.4% compared to the control treatment, which recorded 1.41 dS.m^{-1}. Additionally, it showed a decrease of 4.25% compared to the H_1 treatment, which measured 1.35 dS.m^{-1}. Similarly, the interaction between the *Schanginia aegyptiaca* residues and humic acid addition shows a significant decrease in soil electrical conductivity Table 5. In this context, the L_2H_2 treatment resulted in the lowest electrical conductivity, measured 1.20 dS.m^{-1}., compared to the interaction of the control treatment (L_0H_0), which gave the highest value at 1.53 dS.m^{-1}. This represented a decrease of 21.56%.

Table 5: *Effect of Schanginia residues and humic acid application on soil electrical conductivity.*

Schanginia aegyptiaca	Humic acid levels (t.h^{-1})			Average	Average
decomposition levels	H0	H1	H2	L	H
L_0	1.53	1.47	1.45	1.48	1.41
L_1	1.41	1.32	1.33	1.36	1.35
L_2	1.30	1.27	1.20	1.25	1.32
L.S.D (0.05)	L= 0.011		H = 0.011		L.H = 0.020

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference.

Table 6: *Effect of Schanginia residues and humic acid application on soil reaction.*

Schanginia aegyptiaca	Humic acid levels (t.h^{-1})			Average	Average
decomposition levels	H0	H1	H2	L	H
L_0	7.80	7.79	7.76	7.78	7.71
L_1	7.73	7.71	7.70	7.71	7.69
L_2	7.60	7.58	7.54	7.57	7.66
L.S.D (0.05)	L= 0.037		H = 0.037		L.H = 0.064

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference

Soil reaction (pH)

The results presented in Table 6 illustrate the impact of *Schanginia aegyptiaca* residues application and levels of humic acid on soil reaction. Significant differences in soil pH were observed with an increase in the levels of residue addition. For instance, the lowest value of soil pH was observed at L_2 treatment reached 7.57, representing a decrease of 2.7% compared to L_0 (the control treatment), which gave a pH of 7.78. Similarly, significant decreases in soil pH was observed due to humic acid addition, in this regard, H_2 treatment resulted in the lowest average, measuring 7.66. This represented a decrease of 0.64% compared to the control treatment, which recorded a pH of 7.71, and a decrease of 0.26% compared to H_1 treatment, which measured 7.69. Regarding the interaction between *Schanginia aegyptiaca* residues application and levels of humic acid on soil pH, the results in Table 6 indicated a significant decrease resulting from L_2H_2 treatment. This interaction resulted in the lowest pH, measuring 7.54, compared to the L_0H_0 treatment, which recorded 7.80, representing a decrease of 3.3%.

Available nitrogen concentration

The results presented in Table 7 illustrate the impact of *Schanginia aegyptiaca* residues application and levels of humic acid on the concentration of available nitrogen in the soil. The results obtained showed a significant increase in soil nitrogen concentration with the increase in levels of residue addition. L_2 treatment recorded the highest value of available nitrogen, reaching 83.91 mg.kg^{-1}. This represented an increase of 29.75% compared to the control treatment (L_0), which measured 64.66 mg.kg^{-1}. Meanwhile, humic acid addition cause significant increases in the concentration of available nitrogen in the soil. Where H_2 treatment yielded the highest average, measuring 76.02 mg.kg^{-1}. This represented an increase of 7.54% compared to the control treatment, which measured 70.69 mg.kg^{-1}, and a 3.6% increase compared to H_1 treatment, which measured 73.22 mg.kg^{-1}. Regarding the interaction, the results listed in Table 7 show a significant increase in the concentration of available nitrogen in the soil under the effect of *Schanginia aegyptiaca* residues and levels of humic acid addition. The results indicate that the L_2H_2 treatment showed the highest concentration, reaching 89.76 mg.kg^{-1}. This was compared to the interaction between the control treatments (L_0H_0), which yielded 64.2 mg.kg^{-1}, representing an increase of 39.8%.

Available phosphorus concentration

Table 8 illustrates the effect of *Schanginia aegyptiaca* residues, humic acid, and their interaction on the concentration of available phosphorus in the soil. The results reveal a significant increase in soil phosphorus concentration linked with the increase in levels of residue addition. In this regard, the L_2 treatment recorded the highest value, reaching 1.76 mg.kg^{-1}. This represented an increase of 25.71% compared to the control treatment (L_0), which measured 1.40 mg.kg^{-1}. Meanwhile, levels of humic acid resulted in significant differences in soil available phosphorus concentration (mg.kg^{-1}). This represented an increase of 5.92% compared to the control treatment, which measured 1.52 mg.kg^{-1}, and a 3.2% increase compared to the second addition level (H_1), which measured 1.56 mg.kg^{-1}. Table 8 also shows the impact of the interaction between *Schanginia aegyptiaca* residues and levels of humic acid addition on soil-available phosphorus concentration. The results indicate that the L_2H_2 treatment showed the highest concentration, reaching 1.88 mg.kg^{-1}. This was compared to the interaction between the control treatments (L_0H_0) which yielded 1.39 mg.kg-^{1}

Table 7: *Effect of Schanginia residues and humic acid application on available nitrogen.*

Schanginia aegyptiaca	Humic acid levels (t.h^{-1})			Average	Average
decomposition levels	H0	H1	H2	L	H
L_0	64.2	64.6	65.2	64.6	70.7
L_1	69.4	71.5	73.2	71.4	73.2
L_2	78.5	83.6	89.7	83.9	76.0
L.S.D (0.05)	L= 0.0776		H = 0.0776		L.H = 0.1344

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference

Table 8: *Effect of Schanginia residues and humic acid application on available phosphorus.*

Schanginia aegyptiaca	Humic acid levels (t.h^{-1})			Average	Average
decomposition levels	H_0	H_1	H_2	L	H
L_0	1.39	1.40	1.42	1.40	1.52
L_1	1.53	1.56	1.54	1.54	1.56
L_2	1.65	1.73	1.88	1.76	1.61
L.S.D(0.05)	L= 0.01384		H = 0.01384		L.H = 0.02396

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference.

Available potassium concentration

Table 9 illustrates the impact of *Schanginia aegyptiaca* residues, humic acid, and their interaction on soil available potassium concentration. The results reveal a significant increase in soil-available potassium concentration linked with a direct relationship with the increase in levels of residue addition. Thus,

L_2 treatment recorded the highest value, reaching 32.74 mg.kg^{-1}. This represented an increase of 82.3% compared to the control treatment (L_0), which measured 17.96 mg.kg^{-1}. Meanwhile, the second factor (levels of humic acid) resulted in significant differences in soil available potassium concentration. Within this context, H_2 treatment yielded the highest average of soil available potassium concentration, reaching 26.63 mg.kg^{-1}. This represented an increase of 11.8% compared to the control treatment, which measured 23.82 mg.kg^{-1}, and a 3.2% increase compared to H_1 treatment (0.75 mg.kg^{-1}), which measured 25.8 mg.kg^{-1}. Table 9 also demonstrates the impact of the interaction between *Schanginia aegyptiaca* residues and levels of humic acid addition on the concentration of available potassium in the soil. The results indicate that the L_2H_2 treatment showed the highest concentration, reaching 34.26 mg.kg^{-1}, compared to the interaction between the control treatments (L_0H_0) which yielded 17.81 mg.kg^{-1}, representing an increase of 92.4%.

Table 9: *Effect of Schanginia residues and humic acid application on available potassium*

Schanginia aegyptiaca	**Humic acid levels (t.h^{-1})**			**Average**	**Average**
decomposition levels	**H_0**	**H_1**	**H_2**	**L**	**H**
L_0	17.81	17.82	18.23	17.96	23.82
L_1	22.40	26.85	27.39	25.54	25.80
L_2	31.25	32.71	34.27	32.74	26.63
L.S.D (0.05)	L= 0.0868		H = 0.0868		L.H = 0.1503

L is Schanginia aegyptiaca decomposition levels; H is humic acid levels, L.H is the interaction between Schanginia aegyptiaca residues and humic acid; L.S.D is least significant difference

Application of Schanginia residues and humic acid levels significantly affected the plant growth and physiological parameters of maize, as observed by increases in plant height, dry weight, and nutrient concentration availability in the soil.

Plant growth responses

The L_2 (46 mg.kg^{-1}) treatment gave highest plant height reaching 37.25 cm, which represented a 20% increase over the control (L_0), suggesting that the organic residues improves plant growth. The highest plants at 38.76 cm were observed from the interaction between L_2 and H_2 treatments, emphasizing the synergistic effect of combining residues with optimal levels of humic acid. Increasing the plant height may be due to the role of humic acid in increasing the permeability of cellular membranes promoting cellular division (Al Hasnawi *et al*., 2019; Al-Bayati *et al*., 2021). In addition, nutrient availability and soil structure improved as a result to *Schanginia aegyptiaca* residues application enhance root development and soil water retention. these findings were further corroborated by the dry weight results, with the L_2 treatment resulting in a 54% increase compared to the control. Such improvements probably due to increase the photosynthetic activity and nutrient uptake endorsed by organic residues and humic acids, which enhance soil biological activity such as respiration and protein synthesis.

This effect can be attributed to the presence of various chemical compounds including aliphatic acids, phenols, flavonoids, alkaloids, and amino acids, along with certain stimulating hormones. This finding is consistent with (Ali *et al*., 2014). Additionally, the residues of *Schanginia aegyptiaca* contain a high percentage of iron, zinc, and manganese elements. Where iron serves as a cofactor in the formation of chlorophyll and cytochromes, while zinc plays a crucial role in activating numerous enzymes, in addition to its importance in the production of IAA, essential for cell elongation and division (Cobb and Reade, 2011). Concerning the interaction between residues of *Schanginia aegyptiaca* and humic acid, it contributes positively to various biological processes in plants such as respiration, photosynthesis, and protein synthesis. This results in increase in vegetative growth. Consequently, reflects on the growth and yield of the plant's dry matter. This finding is consistent with (Caires *et al*., 2006; Budiastuti *et al*., 2023).

Soil nutrient availability

The soil nutrient availability of nitrogen, phosphorus, and potassium has notably increased due to *Schanginia aegyptiaca* residues.

The highest nitrogen concentration was observed at L_2 treatment, reaching 83.91 mg.kg^{-1} signifies the potential of these residues to enhance nitrogen availability, probably due to mineralization of organic matter. Similarly, increasing the phosphorus and potassium concentrations available refers to the role of organic amendments in improving soil fertility, promoting overall crop health as observed at L_2 treatment. The interaction of residues and humic acid also significantly influenced nutrient availability, as demonstrated by the highest nitrogen concentration of 89.76 mg.kg^{-1} in the L_2H_2 treatment. This result highlights the importance of integrating organic matter (*Schanginia aegyptiaca*) and humic acid to increase the availability of nutrients in the soil. In addition, the increased concentration of phosphorus and nitrogen can be attributed to the fact that organic residues have been a source for the release of these elements in the soil. Especially available nitrogen in the soil (Al-Maamori *et al*., 2024). Additionally, the humic acid addition increases the vegetative and root mass. Consequently, enhances the secretion of organic acids and enzymes, promotes the conversion of non-available (organic) nitrogen into available nitrogen in the soil (Al-Issawi *et al*., 2021). Regarding the increase in the soil potassium availability after cultivation, it may result from the fact that fulvic acid increases the availability of potassium in the soil due to the low fixation of potassium as a result of hydrogen ion substitution resulting from the breakdown of organic acids replacing potassium on exchange surfaces (Jafaar *et al*., 2022; Al-Falahi *et al*., 2022). The potassium availability increased as organic residues (*Schanginia aegyptiaca*) increase, probably due to the residues effect on promoting plant growth and development by enhancing nutrient absorption (Schaller *et al*., 2014). The third addition level H_2 yielded the highest average, measuring 1.61 mg.kg^{-1}, this finding is consistent with (Menajid *et al*., 2021).

Soil electrical conductivity and pH

A significant decrease in soil electrical conductivity values was observed as a result of the addition of organic matter, with the lowest value recorded in the L_2 treatment. This decrease in soil conductivity indicates improved soil structure and a more balanced ionic composition, which is beneficial for root health and nutrient uptake. The decrease in soil pH values in the L_2 (7.57) treatment indicates that organic additives may help maintain a more suitable soil environment for plant growth by mitigating alkalinity. Moreover, this interaction resulted in the lowest pH, measuring 7.54, compared to the L_0H_0 treatment, which recorded 7.80, representing a decrease of 3.3%. Decreasing soil reaction (pH) may be attributed to the role of humic acids resulting from the decomposition of added organic matter. This finding is consistent with (Nafawaah and Al Shamary, 2024).

Conclusions and Recommendations

Organic matter is an important factor in determining soil health, as soil with a high organic matter content is associated with increased yields, especially in areas with limited water resources. In this context, the results of the study obtained proved that adding organic matter led to increased plant growth, as evidenced by the increasing height and dry weight of maize. Similarly, an increase in the soil concentration of phosphorus, nitrogen and potassium was observed with the increase in the addition of the residue. Likewise, the combination of *Schanginia aegyptiaca* residues and humic acid application resulted an increase in the concentration of nitrogen, phosphorus and potassium in the considered soil. Regarding soil salinity, the combination of humic acid and *Schanginia aegyptiaca* residues addition mitigated the adverse effects of soil salinity on both plant growth and soil pH values.

Novelty Statement

The study highlights the effectiveness of combining *Schanginia aegyptiaca* plant residues with humic acid in improving maize growth and reducing soil salinity in water-limited environments.

Author's Contribution

Kamal H. Al-Dulaimi: Conceptualization, experimental design, data analysis, manuscript writing.
Salwa Hashim Khalaf Al Shamary: Data collection, field work, lab analysis.
Ahmed F.M. Al-Enzy: Supervision, experimental setup, statistical analysis, writing–review &editing.
Jabbar Sh. E. Al-Esawi: Soil samplin, resource management, review of literature.

Conflict of interest

The authors have declared no conflict of interest.

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