The 8th Conf. of SSFOP "Technology and Innovation in The Fields of Ornamental, Medicinal and Aromatic Plants", ARC, Giza, Egypt, 27/4/2025
Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864 **doi: 10.21608/sjfop.2025.454932**

ENHANCING THE EFFICIENCY OF ACALYPHA SHRUBS TO TOLERATE IRRIGATION WATER SALINITY USING SOME SOIL ADDITIVES

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Scientific J. Flowers & Ornamental Plants, 12(2):105-118 (2025).

Received:
25/3/2025
Accepted:
20/4/2025

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ABSTRACT: This study investigated the effects of salinity (0, 2000, and 4000 ppm NaCl) and some soil additives (control, magnetic iron 6 g/pot, magnetic iron 6 g/pot + NPK fertilizer 3 g/pot, magnetic iron 6 g/pot + chicken manure 5 g/pot) on growth, physiological, and biochemical parameters of *Acalypha wilkesiana* during two consecutive seasons (2019/2020 and 2020/2021). Results demonstrated that increasing salinity significantly reduced fresh and dry weights of shoots and roots, chlorophyll a, b, carotenoids, leaf and branch numbers, plant height, and nutrient uptake (nitrogen, phosphorus, potassium). However, soil additives, particularly magnetic iron at 6 g/pot combined with chicken manure 5 g/pot, mitigated salinity-induced stress, enhancing plant resilience. For instance, under 4000 ppm salinity, magnetic iron 6 g/pot + chicken manure 5 g/pot increased shoot fresh weight by 43% compared to the control in the first season. Similarly, chlorophyll a and b, proline levels, and nutrient concentrations improved significantly with fertilization, indicating an improvement of photosynthetic efficiency and osmotic adjustment. The interaction effects of salinity and soil additives were significant, highlighting the role of organic amendments in alleviating salt stress. These findings suggest that magnetic iron-enriched chicken manure can enhance salt tolerance in *A. wilkesiana*, supporting its cultivation in saline-affected irrigation water.

Keywords: *Acalypha wilkesiana*, salinity, magnetic iron, soil additives, chemical fertilization, chicken manure

INTRODUCTION

Acalypha wilkesiana (Muell. Arg.) Fosberg belongs to the Euphorbiaceae family. *A. wilkesiana* is an ornamental plant which is commonly used for hedging in many parts of the world (Jekayinfa *et al*., 1997). The plant is known to have variety of ethno-medical uses such as treatments of skin rashes in babies and anti-bacterial effects (Gills, 1992). The juice or boiled decoction of the plant is used for the treatment of gastro intestinal disorders and skin infections caused by pathogenic such as *Pityriasis versicolor*, *Impetigo contagiosa*, *Candida intetrigo*, *Tinea versicolor*, *Tinea corporis* and *Tinea pedis* (Ogundaini, 2005).

Because salts in irrigation water decrease plant growth, it is important to develop a quick and easy method for evaluating salt tolerance that could be used in the greenhouse, and recommendations about salt tolerance state that plants have low, medium, or high salt tolerance. Salt tolerance can be assessed in terms of plant growth rate, which is appropriate for many plant species (Munns, 2002).

Growth and yield are dramatically reduced when roots are exposed to high salt levels. This is due to a decrease in the water potential in the soil, resulting in a reduction in water uptake by the roots. (Boursiac *et al*., 2005). Under normal growing conditions, the water potential in root cells is less than in the outer environment, and water moves into the roots (Luu and Maurel, 2005; Tournaire-Roux *et al*., 2003). Na levels ranging from 1 to 544 mg l^{-1} whereas Na levels in wastewater range from 124 to 384 mg l^{-1} (Karleskint *et al*., 2011). Because plant response mechanisms involved in salt tolerance are complicated, there is no standard method for evaluating salt tolerance. One method for measuring salt tolerance is to correlate changes in yield associated with soil EC levels. Other methods monitor changes in osmotic potential in the leaves or the uptake and translocation of Na in the plants (Levitt, 1980; Niu and Cabrera, 2010).

Under current climatic conditions and the scarcity of some irrigation water sources, environmental agencies and globally interested organizations are exploring alternative water sources for irrigation and developing management and strategies for landscape and garden parks. (Botequilla Leito and Ahern, 2002). To overcome drought and scarcity of water, the efficient use of alternative water resources is essential. Treated effluent may also contain nutrients essential for plant growth; if water quality is good (not too saline), treated effluent can improve plant growth and reduce fertilizer requirements (Gori *et al*., 2000). In coastal gardens and landscapes, salinity is also a reality and where plants are damaged by aerosols originating from the sea (Cassaniti *et al*., 2009a; Ferrante *et al*., 2011). Globally, approximately one third of agricultural land are salt affected, leading are makeable decrease in crop production (Ravindran *et al*., 2007). However, even though the importance of ornamental plants in Mediterranean areas, studies on salt tolerance of such plants have not been considered to be fully understood (Valdez-Aguilar *et al*. 2011).

Iron plays a vital role in plant metabolism as it participates in chlorophyll biosynthesis, electron transport, and enzymatic activation. Recently, magnetic iron (Fe-based magnetic or magnetite nanoparticles) has gained attention as a novel amendment to improve plant tolerance under abiotic stresses, particularly salinity. Salinity stress disrupts ion homeostasis, increases Na^+ and Cl^- accumulation, and induces oxidative damage, thereby limiting growth and productivity. Application of magnetic iron was reported to enhance photosynthetic pigments, water status, and antioxidant defense, while reducing Na^+ and Cl^- accumulation in leaves of citrus trees grown under saline soils (Alharbi *et al*., 2022). Similarly, foliar application of magnetite nanoparticles in wheat alleviated salinity-induced oxidative stress by boosting antioxidant activity and improving chlorophyll content (El-Saber *et al*., 2021). Also, Salinity stress is considered one of the most critical abiotic stresses limiting the growth and productivity of many plants worldwide, as it affects soil physicochemical properties, plant water relations, and overall physiological performance. High salinity levels disturb ion balance, photosynthesis, and metabolism, ultimately leading to growth reduction and yield loss (Mahdi *et al.,* 2010; Jabeen, 2018).

Fertilization practices, particularly the integration of organic and inorganic fertilizers, have been widely recognized as effective approaches to mitigate the adverse impacts of salinity. Chemical fertilizers provide a rapid nutrient supply but their excessive use may cause nutrient imbalances and environmental concerns. On the other hand, organic amendments such as compost improve soil structure, water-holding capacity, and microbial activity, thereby enhancing plant growth and tolerance under saline conditions (An *et al.,* 2022).

Ornamental plants are particularly important due to their aesthetic and economic value, but many species are sensitive to salinity stress. Previous studies have demonstrated variability in salinity tolerance among ornamentals. For instance, Kathari Lakshmaiah *et al*. (2018) reported that

Clerodendrum inerme and *Leucophyllum frutescens* were relatively tolerant to salinity, whereas *Acalypha hispida* showed sensitivity, with nearly 50% plant mortality under saline conditions. This highlights the necessity of adopting management strategies, including soil additives and fertilization practices, to improve the tolerance of sensitive ornamentals such as *Acalypha*.

This study was carried out to investigate the effect of different soil additive treatments (magnetic iron, NPK fertilizer and chicken manure) on *Acalypha wilkesiana* transplants grown in pots under varying salinity levels, to increase its tolerance to saline water while maintaining aesthetic and functional quality.

MATERIALS AND METHODS

This experiment was conducted at the open field of the nursery of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Egypt over two seasons of 2019 and 2020 to evaluate the effects of different soil additive treatments (magnetic iron, NPK fertilizer and chicken manure) on acalypha seedlings grown in pots under varying salinity levels.

Plant material and growth conditions:

Acalypha wilkesiana cuttings, each approximately 30 cm in height, were initially planted on 15th March each season in 15 cm diameter pots. After an initial growth period, the plants were transplanted on April 15th into larger 25 cm diameter pots for continued development. The experimental treatments were applied after transplanting. One month after planting, the application of NPK fertilizer was conducted (top-dressing). In addition, chicken manure was applied to a sandy clayey soil (Table, 1), using the top-dressing technique, after being well-characterized and processed. Furthermore, magnetic iron (Fe_3O_4 compound) was incorporated into the soil using the same top-dressing method. All treatments were applied uniformly and under controlled conditions to ensure consistency throughout the experiment**.**

Soil additive treatments:

1. Control (no additional treatment).
2. Magnetic iron.
3. Magnetic iron + NPK fertilizer.
4. Magnetic iron + chicken manure.

Magnetic iron was obtained from a private Egyptian company and applied at a concentration of 6 g/pot. Kristalon (19:19:19) was utilized as a source of N, P, and K nutrients at a rate of 3 g/pot. It was obtained from a private company in Egypt. Chicken manure was obtained from a private farm at a rate of 5 g/pot. These amendments were applied to the growing medium as a top-dressing, three times with two-week intervals.

Salinity levels:

1. Control (irrigation water with no salinity addition).
2. Saline water at 2000 ppm NaCl.
3. Saline water at 4000 ppm NaCl.

Sodium chloride (NaCl) was dissolved in irrigation water to achieve 2000 and 4000 ppm salinity levels and was applied three times per month at 250 cm³ of irrigation water/pot for each application.

Experimental layout:

The experimental design was a factorial arrangement in a randomized complete block design (RCBD) with three replications.

Table 1. Analyses of some physical, chemicals and characteristics of the growing media used in the plantation (Page *et al.* 1982).

Soil Type	Particle Size distribution (%)				S.P.	E.C (ds/m)	pH	Cations (meq/1)				Anions (meq/1)		
	Coarse sand	Fine sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO3	$C1^{-}$	$SO4^{--}$
Sand	86.02	5.06	4.44	4.48	26.00	1.77	7.35	5.13	1.07	5.19	1.32	1.97	7.98	1.79
Clay	8.51	21.29	30.12	40.08	41.00	1.96	7.82	4.95	3.11	10.62	1.06	1.03	1.33	7.47

Texture: Sandy clayey

Salinity levels (3 levels) represented factor A, while soil additive treatments (4 treatments) were allocated for factor B. So, this experiment contained 12 treatments with 3 replicates each one contained 5 pots.

Data collection:

At the end of the experiment (October 15th, each season), the following parameters were measured:

Growth parameters:

Plant height (cm), number of leaves per plant, number of branches per plant, fresh weight of shoots (g), dry weight of shoots (g), fresh and dry weights of roots (g).

Chemical and biochemical analyses:

Chlorophyll a, chlorophyll b, and carotenoids (mg/g fresh weight) were quantified following the method of Yadava (1986). For the dried samples, nitrogen content was determined according to Pregl (1945), phosphorus (P%) according to Luatanab and Olsen (1965), and potassium(K%), according to Jackson (1973). In addition, free proline content (mg/g fresh weight) was assessed using the method of Bates *et al*. (1973).

Statistical analysis:

Data was subjected to analysis of variance (ANOVA) at 0.05 level of probability using SAS software (2009) Means were compared by L.S.D. at 0.05 method according to (Steel and Torrie, 1980).

RESULTS

Plant height significantly decreased with increasing salinity in all used treatments compared with the control (Table, 2). The tallest plant was consistently recorded in the treatment with magnetic iron 6 g/pot + chicken manure 5 g/pot, followed by magnetic iron 6 g/pot + NPK 3 g/pot. The control group showed the lowest plant height under all salinity levels.

The number of leaves followed a similar trend as plant height, decreasing with increased NaCl concentration (Table, 3). The combined use of magnetic iron 6 g/pot + chicken manure consistently produced the highest number of leaves under all salinity levels. Leaf production was lowest in the control group, especially at 4000 ppm salinity.

Number of branches also declined with increasing salinity, though less drastically than height or leaf count (Table, 4). Again, the magnetic iron 6 g/pot + chicken manure 5 g/pot treatment showed the best performance under all conditions. The control group consistently had the fewest branches.

Table (5) shows that both salinity levels and soil additives significantly affected the fresh weight of *Acalypha wilkesiana*. Salinity stress reduced fresh weight, with the lowest values recorded at 4000 ppm NaCl, especially in the control group. However, soil additives, including fertilization mitigated this negative impact: magnetic iron 6 g/pot + chicken manure 5 g/pot consistently produced the highest fresh weight in both seasons, particularly under saline condition, suggesting improved water retention and growth. Magnetic iron 6 g/pot + NPK 3 g/pot also significantly enhanced fresh weight compared to the control and magnetic iron alone. The control group exhibited the lowest fresh weight under all salinity levels

The dry weight, data showed a similar trend to fresh weight (Table, 6). Salinity reduced dry matter accumulation, especially in untreated plants with soil additives. The highest dry weight was obtained from plants treated with magnetic iron 6 g/pot + chicken manure 5 g/pot indicating enhanced nutrient use efficiency and stress tolerance. Magnetic iron 6 g/pot + NPK 3 g/pot also effective but slightly less so than the organic combination. As expected, the control group showed the poorest performance under salinity stress. The interaction in both seasons between salinity and soil additives was statistically significant, confirming that proper fertilization is essential to counteract the negative effects of salinity on plant biomass.

Table 2. Effect of salinity, some soil additives and their interaction on plant height (cm) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	50.21	40.31	32.11	40.88	56.00	44.22	36.11	45.44
Magnetic iron (MI)	60.31	49.21	39.12	49.55	68.40	54.31	43.21	55.31
MI + NPK	72.22	59.15	44.20	58.52	80.31	64.00	48.33	64.21
MI + chicken manure	81.51	69.11	52.10	67.57	91.41	70.12	56.21	72.58
Mean (B)	66.06	54.45	41.88		74.03	58.16	45.97	
LSD at 0.05	A= 4.352 B= 5.890 A×B= 9.323				A= 5.025 B= 6.305 A×B= 10.281			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 3. Effect of salinity, some soil additives and their interaction on number of leaves of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	28.00	18.00	14.00	20.00	25.00	20.00	18.00	21.00
Magnetic iron (MI)	33.00	23.00	18.00	24.67	36.00	23.00	20.00	26.33
MI + NPK	38.00	26.00	20.00	28.00	40.00	26.00	23.00	29.67
MI + chicken manure	46.00	33.00	23.00	34.00	49.00	31.00	27.00	35.67
Mean (B)	36.25	25.00	18.75		37.50	25.00	22.00	
LSD at 0.05	A= 2.589 B= 3.123 A×B= 5.829				A= 3.273 B= 4.330 A×B= 6.708			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 4. Effect of salinity, some soil additives and their interaction on number of branches of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	5.00	5.00	3.00	4.33	6.00	4.00	3.00	4.33
Magnetic iron (MI)	9.00	9.00	7.00	8.33	8.00	6.00	4.00	6.00
MI + NPK	8.00	6.00	5.00	6.33	9.00	7.00	6.00	7.33
MI + chicken manure	9.00	7.00	6.00	7.33	10.00	8.00	6.00	8.00
Mean (B)	7.75	6.75	5.25		8.25	6.25	4.75	
LSD at 0.05	A= 0.380 B= 0.523 A×B= 0.855				A= 0.425 B= 0.614 A×B= 0.987			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 5. Effect of salinity, some soil additives and their interaction on fresh weight of plants of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	89.12	69.27	56.34	71.58	91.31	71.31	68.40	77.01
Magnetic iron (MI)	101.31	78.31	64.21	81.28	103.12	79.31	65.31	82.58
MI + NPK	108.21	84.41	70.44	87.69	115.51	86.41	72.21	91.38
MI + chicken manure	117.31	101.31	80.51	99.71	119.41	103.41	81.82	101.55
Mean (B)	103.99	83.33	67.88		10.34	85.11	71.94	
LSD at 0.05	A= 1.772 B= 2.045 A×B= 3.078				A= 1.890 B= 2.115 A×B= 3.130			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 6. Effect of salinity, some soil additives and their interaction on dry weight of plants of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	22.41	16.11	13.31	17.28	23.50	17.23	14.34	18.36
Magnetic iron (MI)	26.36	20.41	16.61	21.13	27.25	21.33	17.43	22.00
MI + NPK	30.11	24.21	19.21	24.51	32.31	25.41	20.51	26.08
MI + chicken manure	34.41	27.31	20.14	27.29	36.41	29.51	21.21	29.04
Mean (B)	28.32	22.01	17.32		29.87	23.37	18.37	
LSD at 0.05	A= 1.330 B= 1.781 A×B= 2.902				A= 1.540 B= 1.955 A×B= 3.015			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table (7) demonstrates that both salinity and soil additives significantly influence the fresh root weight of *Acalypha wilkesiana*. Increasing salinity led to a reduction in root fresh weight, with the lowest values at 4000 ppm NaCl across all treatments. However, soil additives, including fertilization alleviated this stress to varying degrees. Magnetic iron 6 g/pot + chicken manure 5 g/pot consistently resulted in the highest fresh roots in both seasons, even under salinity stress with mean values of 33.41 and 33.27 g, respectively. This implies a strong effect of organic inputs on root biomass and tolerance to saline conditions. Magnetic iron 6 g/pot + NPK 3 g/pot also enhanced fresh root weight but was slightly less effective than the organic treatment. The control group had the lowest root biomass under all salinity levels.

Dry root weight followed similar trends to root fresh weight, with salinity decreasing biomass and soil additives offering enhancement (Table, 8). The highest dry root weight in both seasons was recorded for plants treated with magnetic iron 6 g/pot + chicken manure 5 g/pot peaking at 11.80 g in the first salinity level (water) in the second season. Magnetic iron 6 g/pot + NPK 3 g/pot also effective, showing better performance than magnetic iron alone. The control had significantly lower dry weight especially at 4000 ppm salinity. The interaction between salinity and soil additives was statistically significant, indicating that the positive effects of fertilizers are more pronounced under salt stress.

Table 7. Effect of salinity, some soil additives and their interaction on fresh weight of roots of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	27.41	24.31	20.11	23.94	28.12	25.21	21.31	24.88
Magnetic iron (MI)	31.51	26.21	23.21	26.98	32.31	27.51	24.21	28.01
MI + NPK	35.31	38.11	24.51	32.64	36.51	28.31	25.41	30.08
MI + chicken manure	39.21	31.41	26.31	32.31	40.91	31.40	27.50	33.27
Mean (B)	33.36	30.01	23.53		34.46	28.11	24.61	
LSD at 0.05	A= 1.023 B= 1.570 A×B= 2.253				A= 1.078 B= 1.819 A×B= 2.960			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 8. Effect of salinity, some soil additives and their interaction on dry weight of roots of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	7.71	6.45	3.12	5.76	8.31	6.51	3.13	5.98
Magnetic iron (MI)	8.14	5.12	4.31	5.86	9.51	6.40	4.32	6.74
MI + NPK	9.41	6.22	5.13	6.92	10.91	6.12	5.41	7.48
MI + chicken manure	10.50	7.11	5.71	7.77	11.80	8.71	6.51	9.01
Mean (B)	8.94	6.22	4.57		10.13	6.94	4.84	
LSD at 0.05	A= 0.845 B= 0.932 A×B= 1.023				A= 0.889 B= 0.975 A×B= 1.109			

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

The control group exhibited the lowest chlorophyll a, b and carotenoids contents under all salinity levels, suggesting that salinity alone does not enhance chlorophyll synthesis and may instead limit it under stress (Tables, 9-11). However, the addition of soil additives, especially magnetic iron 6 g/pot combined with NPK fertilizer 3 g/pot or chicken manure 5 g/pot, significantly increased chlorophyll a, b and carotenoids in both seasons. Notably, the magnetic iron 6 g/pot + chicken manure 5 g/pot treatment showed the highest values across all salinity levels, indicating a strong ameliorative effect on photosynthetic pigments synthesis.

Nitrogen percentage was generally decreased with higher salinity levels in the control treatment, confirming in the negative impact of salinity on nitrogen uptake (Table, 12). However, soil additives, especially magnetic iron 6 g/pot + chicken manure 5 g/pot and magnetic iron 6 g + NPK 3 g/pot significantly improved nitrogen content at all salinity levels relative to control. The highest nitrogen percentage was observed with the magnetic iron 6 g/pot + NPK 3 g/pot treatment (1.66% and 1.81% in the 1st and 2nd seasons under no salinity addition), indicating its strong role in enhancing nitrogen assimilation under stress conditions.

Phosphorus percentage was declined with increasing salinity levels under untreated plants (Table, 13). However, the combined application of magnetic iron 6 g/pot + NPK 3 g/pot or chicken manure notably increased phosphorus (%). The highest value (0.52% in

Table 9. Effect of salinity, some soil additives and their interaction on chlorophyll a content (mg/g.f.w) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	0.54	0.61	0.64	0.60	0.57	0.67	0.70	0.64
Magnetic iron (MI)	0.55	0.64	0.68	0.62	0.69	0.70	0.74	0.71
MI + NPK	0.57	0.69	0.72	0.66	0.73	0.75	0.78	0.75
MI + chicken manure	0.61	0.70	0.80	0.71	0.76	0.76	0.86	0.79
Mean (B)	0.57	0.66	0.71		0.69	0.71	0.77	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 10. Effect of salinity, some soil additives and their interaction on chlorophyll b content (mg/g.f.w) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	0.17	0.20	0.22	0.20	0.24	0.25	0.27	0.25
Magnetic iron (MI)	0.18	0.21	0.23	0.21	0.27	0.30	0.32	0.30
MI + NPK	0.20	0.24	0.25	0.23	0.29	0.32	0.35	0.32
MI + chicken manure	0.21	0.25	0.28	0.25	0.30	0.34	0.37	0.34
Mean (B)	0.19	0.23	0.25		0.28	0.30	0.33	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 11. Effect of salinity, some soil additives and their interaction on carotenoids content (mg/g.f.w) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	0.42	0.44	0.51	0.46	0.45	0.48	0.54	0.49
Magnetic iron (MI)	0.44	0.45	0.53	0.47	0.50	0.52	0.57	0.53
MI + NPK	0.46	0.47	0.55	0.49	0.53	0.54	0.60	0.56
MI + chicken manure	0.48	0.49	0.58	0.52	0.55	0.58	0.63	0.59
Mean (B)	0.45	0.46	0.54		0.51	0.53	0.59	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 12. Effect of salinity, some soil additives and their interaction on nitrogen (%) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	1.11	1.00	0.81	0.97	1.30	1.21	1.01	1.17
Magnetic iron (MI)	1.31	1.12	0.90	1.11	1.50	1.33	1.13	1.32
MI + NPK	1.86	1.61	1.00	1.49	1.98	1.81	1.21	1.67
MI + chicken manure	1.42	1.71	1.02	1.38	1.63	1.90	1.27	1.60
Mean (B)	1.43	1.36	1.24		1.61	2.08	1.16	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 13. Effect of salinity, some soil additives and their interaction on phosphorus (%) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	0.38	0.31	0.27	0.32	0.40	0.34	0.30	0.35
Magnetic iron (MI)	0.48	0.38	0.29	0.38	0.51	0.41	0.32	0.41
MI + NPK	0.54	0.38	0.31	0.41	0.57	0.41	0.34	0.44
MI + chicken manure	0.68	0.45	0.34	0.49	0.71	0.48	0.37	0.52
Mean (B)	0.52	0.38	0.30		0.55	0.41	0.33	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

the 2nd season) was recorded with magnetic iron 6 g/pot + chicken manure 5 g/pot under 4000 ppm salinity, highlighting its effectiveness in sustaining phosphorus uptake even under high salt stress.

Potassium levels also declined with increasing salinity levels under untreated plants, but application of soil additives mitigated this harmful effect (Table, 14). Interestingly magnetic iron 6 g/pot + chicken manure 5 g/pot led to a marked increase in potassium percentage, especially at high salinity (up to 1.93% in the 2nd season at 4000 ppm) suggesting in strong influence on potassium uptake and regulation under stress.

Among the soil additives, magnetic iron 6 g/pot + chicken manure 5 g/pot consistently produced the highest proline content under all salinity levels, suggesting that this treatment may enhance the plant stress tolerance mechanisms more effectively than other treatments (Table, 15). In contrast, the control treatment (on additional fertilization) showed the lowest proline accumulation, especially under higher salinity, indicating lower stress resistance.

DISCUSSION

The study investigated the effects of salinity different soil additives and their interactions on various growth parameters of *Acalypha wilkesiana* over two seasons (2019/2020 and 2020/2021). The result revealed significant variations in plant height, number of leaves and branches, fresh and dry weight of plants and roots, highlighting the impact of soil additives under different salinity levels. The decline in plant height with rising salinity is likely due to osmotic stress and ion toxicity, which impair water uptake and cellular expansion (Zobayed *et*

Table 14. Effect of salinity, some soil additives and their interaction on potassium (%) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	1.42	1.11	0.90	1.14	1.53	1.23	1.05	1.27
Magnetic iron (MI)	1.71	1.23	0.96	1.30	1.80	1.34	1.12	1.42
MI + NPK	1.83	1.34	1.11	1.43	1.94	1.45	1.22	1.54
MI + chicken manure	1.41	1.51	1.81	1.58	1.52	1.62	1.93	1.69
Mean (B)	1.59	1.30	1.20		1.70	1.41	1.33	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

Table 15. Effect of salinity, some soil additives and their interaction on proline content (mg/g.f.w) of *Acalypha wilkesiana* in the two seasons (2019/2020 and 2020/2021).

Soil additives	1st season				2nd season			
	Salinity levels (ppm)							
	Water	2000	4000	Mean (A)	Water	2000	4000	Mean (A)
Control	5.737	6.301	6.584	6.207	6.215	6.821	6.928	6.655
Magnetic iron (MI)	5.984	6.463	6.785	6.411	6.408	7.020	7.233	6.887
MI + NPK	6.122	6.619	6.950	6.563	6.710	7.236	7.430	7.125
MI + chicken manure	6.929	7.112	7.365	7.135	7.389	7.722	7.930	7.680
Mean (B)	6.193	6.624	6.921		6.681	7.200	7.380	

Magnetic iron (MI) at 6 g/pot, NPK at 3 g/pot, chicken manure at 5 g/pot

al.,2007). Magnetic Iron possibly enhances soil structure and nutrient availability, while chicken manure adds Organic matter and microbial activity, promoting better growth even under stress (Alharbi *et al*.,2022). Salinity reduces leaf number due to inhibited cell division and premature leaf senescence (Abou El-Yazied and Mady, 2012) The synergy of magnetic iron and organic manure likely counteracts these effects by improving nutrient uptake and plant resilience (El-Saber *et al*., 2021). Branch development is sensitive to both nutrient availability and hormonal balance, both of which can be disrupted by salinity (Cassaniti, 2009a). The amendments, particularly the organic manure, may have provided hormonal precursors and nutrients necessary for lateral growth (Jabeen, 2018). Salinity reduced fresh weight, but fertilizers especially magnetic iron 6 g + chicken manure, significantly improved biomass (Suárez and Medina, 2008). Similar to fresh weight, dry weight decreased under salinity but was enhanced by fertilization.

The combination of magnetic iron 6 g/pot + chicken manure yielded the highest dry weights, emphasizing the role of organic amendments in stress mitigation. Salinity negatively affected root fresh and dry weights, but fertilizers, particularly magnetic iron 6 g + chicken manure, improved root growth. This indicates that organic fertilization supports root development under saline conditions, enhancing nutrient and water uptake (Beyk-Khormizi *et al.*, 2023). The second season generally exhibited better growth parameters compared to the first one, possibly due to improved soil conditions, plant acclimatization, or environmental factors. For example, the fresh weight of plants was higher in the second season across all treatments, suggesting cumulative benefits of fertilization and plant adaptation (Abou El-Yazied and Mady, 2012).

Magnetic iron at 6 g + Chicken Manure: This combination consistently outperformed others, particularly in root and shoot biomass, highlighting the synergistic effect of organic matter and micronutrients in alleviating salinity stress. Magnetic iron at 6 g/pot + NPK 3 g/pot showed notable results in leaf and branch production, indicating its role in enhancing photosynthetic capacity and branching under stress (Adekiya, *et al.* 2016).

Salinity negatively affected root fresh and dry weights, but fertilizers, particularly magnetic iron 6g + chicken manure, improved root growth. This indicates that organic fertilization supports root development under saline conditions, enhancing nutrient and water uptake (El-Saber *et al*.,2021)

Magnetic iron 6 g/pot + chicken manure 5 g/pot again yielded the highest carotenoid levels, reinforcing the role of organic fertilization in enhancing stress resilience (Mahdi *et al.*,2009)

Regarding phosphorus content, salinity reduced phosphorus uptake, likely due to ion competition e.g., Na^+ interfering with P absorption (El-Saber *et al*.,2021). Magnetic iron 6 g/pot + chicken manure 5 g/pot mitigated this effect, maintaining higher P percentage, possibly by improving soil P availability or root uptake efficiency.

Additionally, the potassium content declined with increasing salinity, as Na^+ competes with K^+ uptake, disrupting ionic homeostasis. Surprisingly, magnetic iron 6 g/pot + chicken manure 5 g/pot reversed this trend at 4000 ppm NaCl, showing higher K percentage than lower salinity treatments. This could indicate a unique role of chicken manure in enhancing K retention (Munns and Tester, 2008).

CONCLUSION

The study demonstrates that salinity stress adversely affects *Acalypha wilkesiana*, but fertilization can mitigate these effects. Organic fertilizers (e.g., chicken manure) combined with magnetic iron were particularly effective in enhancing growth and biomass under saline conditions. The significant interaction effects emphasize the need for integrated management approaches to optimize plant performance in saline environments. These findings are valuable for cultivating *Acalypha wilkesiana* in saline-affected regions, with implications for agricultural and landscaping practices.

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تحسين كفاءة شجيرات الأكاليفا لتحمل ملوحة ماء الري و ذلك بإستخدام بعض إضافات التربة

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تتناول هذه الدراسة تأثيرات الملوحة (٠، ٢٠٠٠، ٤٠٠٠ جزء في المليون من كلوريد الصوديوم) واضافات التربة (كنترول، حديد ممغنط ٦ جم/أصيص، حديد ممغنط ٦ جم/أصيص + السماد المركب NPK ٣ جم/أصيص، حديد ممغنط ٦ جم/أصيص+ سماد مخلفات الدواجن ٥ جم/أصيص) على النمو والصفات الفسيولوجية والكيميائية الحيوية لنبات *Acalypha wilkesiana* خلال موسمين متتاليين (٢٠١٩/٢٠٢٠ و ٢٠٢٠/٢٠٢١). أظهرت النتائج أن زيادة الملوحة تؤدي بشكل كبير إلى إنخفاض الوزن الطازج والجاف للأفرع والجذور، ومحتوى الكلوروفيل (أ، ب، الكاروتينويدات) وعدد الأوراق والفروع

وطول النبات و إمتصاص العناصر الغذائية (النتروجين والفسفور والبوتاسيوم). ومع ذلك فإن الاضافات الارضية خاصة الحديد الممغنط بتركيز ٦ جم/أصيص + مخلفات الدواجن بتركيز ٥ جم/أصيص خفف من أثار الإجهاد الناتج من الملوحة وعزز من مقاومة النبات. فعلي سبيل المثال، عند ملوحة ٤٠٠٠ جزء في المليون تسبب الحديد الممغنط ٦ جم/أصيص + مخلفات الدواجن ٥ جم/أصيص في زيادة الوزن الطازج للأفرع بنسبة ٤٣٪ مقارنة بالكنترول خلال الموسم الأول كما تحسنت مستويات الكلوروفيل أ،ب، الكاروتينويدات ومستويات البرولين وتركيز العناصر الغذائية بشكل ملحوظ مع التسميد مما يشير إلى تحسين كفاءة البناء الضوئي والضغط الأسموزي، وكانت المعاملات المشتركة بين الملوحة والتسميد معنوية مما يبرز دور التسميد العضوي في التخفيف من الأثر الضار للملوحة وقد لوحظت أختلافات موسمية حيث أظهر الموسم الثاني نموا أفضل بشكل عام. تشير هذه النتائج إلى أن التسميد العضوي بمخلفات الدواجن مع الحديد الممغنط يمكن ان يعزز تحمل نبات *Acalypha wilkesiana* للملوحة مما يساعد على زراعته في المناطق المتأثرة بالملوحة.