

The Role Of Humic Acid In Reducing The Effect Of Salinity Stress On Pea (*Pisum Sativum* L.) Yield

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Abstract

The experiment has been conducted to evaluate the yield response of pea plants (*Pisum sativum* L.) to salinity stress at three levels (0, 250, and 500 g.L⁻¹) and foliar application of humic acid at three concentrations (0, 1 mL, and 2 mL). The findings which have been obtained are as follows:

The results indicate that the increasing salinity levels led to a significant reduction in yield components. However, foliar application of humic acid—particularly at the 2 mL concentration—contributes to considerable improvements in both pod number and pod length compared to untreated plants. The H2S0 treatment records the highest number of pods (34.25) and the longest pods (15.77 cm), while the lowest values have been observed in high salinity treatments without humic acid, such as H0S2 and H1S2. In fact, these findings suggest that humic acid enhances the salinity tolerance of pea plants and may be adopted as an effective strategy for mitigating the adverse effects of salt stress and improving productivity in salt-affected environments.

Keywords: Pea (*Pisum sativum* L.), Humic acid, Salinity stress, Yield components, Osmotic stress, Legumes.

INTRODUCTION

Salinity is one of the most prominent abiotic stress factors affecting plant growth and productivity. Soil salinization has become a major global agricultural challenge, limiting crop development and reducing yields across various regions. What is more, Salt stress causes a range of physiological and metabolic disturbances in plants, including nutrient imbalance and ion toxicity (Koca et al., 2007). Some salt-tolerant plants, particularly those exposed to sodium chloride (NaCl), have developed adaptive responses involving morphological and physiological modifications, such as changes in root-to-shoot ratio and increased chlorophyll content (Manik et al., 2019). The early stages of plant development are particularly sensitive to salinity due to the elevated concentrations of sodium and chloride ions in the root zone, which raise osmotic pressure and reduce water uptake (Munns, 2002).

It is important to state that the Humic acid is a dark brown organic compound that is extracted from decomposed plant and animal matter in the soil. It is obtained through alkaline solutions and later precipitated as an amorphous gel under acidic conditions (Hayes & Chap, 2001). Humic acid is commonly used as a supplement to mineral and organic fertilizers. Its application helps reduce the amount of fertilizers needed, especially in soils rich in organic matter, due to its role in enhancing nutrient availability and uptake by plants. In addition, humic acid promotes microbial activity and contributes to the formation of humus, thereby improving overall soil fertility (Vista, 2015).

On the other hand, Pea (*Pisum sativum* L.) is a widely cultivated legume crop valued for its high nutritional content, including proteins, vitamins, minerals, and carbohydrates. Its production is influenced by various environmental factors such as drought and extreme temperature fluctuations, particularly during flowering and pod filling stages. However, seed quality can be maintained if harvest timing is optimized (Hasanuzzaman et al., 2013). Peas are used as food for humans and feed for animals and are also processed for consumption in both fresh and dry forms. The crop's maturity period varies with climate, typically ranging from 80 to 100 days. Several cultivars have been developed to meet the demands of fresh markets and food industries (Ismail, 1997).

The present study aims at assessing the effectiveness of humic acid in mitigating the adverse effects of salinity stress and improving yield characteristics in pea (*Pisum sativum* L.) plants.

***Materials and method of work**

This study has been conducted during the 2024–2025 agricultural season in the gardens of the scientific departments at the College of Education for Women, Tikrit University, to investigate the effect of foliar application of humic acid on the vegetative growth traits of pea plants under salinity stress conditions. Planting pots with a height of 30 cm and a diameter of 24 cm have been prepared at the experimental site and filled with loamy soil collected from the banks of the Tigris River. The experiment consisted of 9 treatment combinations with 3 replications, resulting in a total of 27 experimental units. Seeds of the Anward cultivar are purchased from Erbil and tested for quality at the Seed Testing Center in Tikrit. Seeds are sown on November 6, 2024, at a rate of 2–3 seeds per hole, with a spacing of 5 cm between holes (Al-Rawi & Khalaf Allah, 1981). After germination, seedlings have been thinned to one plant per hole. Treatments are randomly distributed using a Completely Randomized Design (CRD) with three levels of salinity and three concentrations of humic acid, each with three replications. All necessary agronomic practices and irrigation have been carried out as needed. At the end of the growing season, data are collected on yield traits by measuring the number of pods, number of seeds, and seed weight from three randomly selected plants in each experimental unit for all replications.

Experimental Factors

The experiment contains two factors:

Factor I: Salinity levels (NaCl concentrations)

1. S0: Control (no salt – distilled water)
2. S1: 250 g L⁻¹ NaCl
3. S2: 500 g L⁻¹ NaCl

Factor II: Humic acid concentrations

1. H0: Control (no humic acid – distilled water)
2. H1: 1 mL L⁻¹ humic acid
3. H2: 2 mL L⁻¹ humic acid

*** Measured Traits:**

Yield Traits

1. Total Number of Pods per Plant (pods plant⁻¹)

This trait has been measured by counting the total number of pods from three randomly selected plants within each experimental unit, followed by calculating the average.

2. Number of Seeds per Pod (seeds pod⁻¹)

The total number of seeds produced in each experimental unit is divided by the total number of pods to determine the average number of seeds per pod.

3. Weight of 100 Seeds (g)

A total of 100 seeds are randomly selected from each experimental unit and weighed, and the mean weight was recorded as the final value.

***Statistical Analysis**

The data are statistically analyzed using a Randomized Complete Block Design (RCBD). Differences among treatment means have been evaluated using Duncan's Multiple Range Test (DMRT) at significance levels of 0.05 and 0.01. The statistical analysis is performed using the SAS software and Microsoft Excel.

RESULTS

*** Yield Traits**

Number of pods per plant (pod/plant)

Table 1 summarizes the significant differences among the main factors and their interaction for pod number per plant. Salinity at 250 g L⁻¹ (S1) produced the highest mean value (25.97 pods plant⁻¹), which is significantly greater than the control (S0, 24.67 pods plant⁻¹); both treatments outperformed the high-salinity level S2 (500 g L⁻¹), which recorded the lowest mean (14.78 pods plant⁻¹). With respect to humic acid, foliar application at 2 mL L⁻¹ (H2) yielded the greatest pod

number (28.00 pods plant⁻¹), significantly exceeding H1 (20.19) and the untreated control H0 (17.22).

The salinity × humic-acid interaction indicates that plant response to humic acid depended upon salinity level. The H2S0 combination produces the highest pod count (34.25 pods plant⁻¹), whereas the lowest values have been observed under high salinity with little or no humic acid, namely H0S2 (13.24) and H1S2.(12.58) .

Table (1) shows the effect of salt stress and spraying with humic acid in the number of pods per plant (pod/plant-1).

Average S	Humic acids			Salt stress
	H2	H1	H0	
a 24.67	a 34.25	d22.50	c17.25	S0
a 25.97	31.25b	25.50d	21.16d	S1
b 14.78	e 18.50	f 12.58	13.25f	S2
	a 28.00	b 20.19	17.22c	Medium H
S0: Without addition (distilled water) S1: Addition at a concentration of (250 g L-1) S2: Addition at a concentration of (500 g L-1)			H0: Without adding (distilled water) H1: Adding at a concentration of (mL 1) H2: Adding at a concentration of (ml 2)	

* Averages with the same Similar letters mean no significant differences between them according to Duncan's test at the 0.05 probability level.

Number of seeds per pod (1 seed pod)

Table 2 shows the significant differences among the main treatments and their interactions for the number of seeds per pod. The salinity treatment S0 (control) recorded the highest average (10.90 seeds pod⁻¹), which is not significantly different from S1 (10.73 seeds pod⁻¹). Both treatments do not differ significantly from S2 (10.13 seeds pod⁻¹), which recorded the lowest mean value. Regarding the effect of humic acid, the H2 treatment (2 mL) resulted in the highest average number of seeds per pod (11.60), which is significantly higher than H0 and H1, which recorded 10.03 and 10.13 seeds pod⁻¹, respectively. The interaction between salinity and humic acid concentrations shows variation in plant response depending on salinity level. The H2S1 combination produced the highest number of seeds per pod (12.4), while the lowest values are observed in H0S1 and H1S2, which recorded 9.2 and 9.6 seeds pod⁻¹, respectively.

Table (2) shows the effect of salt stress and spraying with humic acid on the number of seeds per pod (pod seed-1)

Average S	Humic acids			Salt stress
	H2	H1	H0	
10.90a	11.6ab	10.2cd	10.09bc	S0
10.73a	12.4a	10.6bc	9.2d	S1
10.13a	10.8bc	9.6d	10.0cd	S2
	11.60a	10.13b	10.03b	Medium H
S0: Without addition (distilled water) S1: Addition at a concentration of (250 g L-1) S2: Addition at a concentration of (500 g L-1)			H0: Without adding (distilled water) H1: Adding at a concentration of (mL 1) H2: Adding at a concentration of (ml 2)	

* Averages with the same Similar letters mean no significant differences between them according to Duncan's test at the 0.05 probability level.

3. Seed weight (g seed-1)

Table 3 illustrates the important differences among the main treatments and their interactions for seed weight. The salinity treatment S1 (250 g L⁻¹) recorded the highest average seed weight (22.00 g), which is not significantly different from the control treatment S0 (21.33 g). Both treatments significantly outperformed the high salinity level S2, which recorded the lowest mean seed weight (1.190 g). Regarding the effect of humic acid, the H2 treatment (2 mL) produced the highest seed weight (1.503 g), significantly higher than H1 (1.237 g) and H0 (1.167 g).

The interaction between salinity and humic acid concentrations points out that plant response varied depending upon salinity level. The treatments H2S0 and H2S1 recorded the highest seed weights (1.65 g and 1.62 g, respectively), whereas the lowest weights are clearly observed in H0S1 (1.05 g), H0S2 (1.08 g), and H1S0 (1.01 g).

Table (3) shows the effect of salt stress and spraying with humic acid on the seed weight in the pod (g seed-1).

Average S	Humic acids			Salt stress
	H2	H1	H0	
1.343a	a 34.25	1.01c	1.37b	S0
1.373a	31.25b	1.42b	1.08c	S1
1.190b	e 18.50	1.28bc	1.05c	S2
	1.503a	1.237b	1.167b	Medium H
S0: Without addition (distilled water) S1: Addition at a concentration of (250 g L-1) S2: Addition at a concentration of (500 g L-1)			H0: Without adding (distilled water) H1: Adding at a concentration of (mL 1) H2: Adding at a concentration of (ml 2)	

* Averages with the same Similar letters mean no significant differences between them according to Duncan's test at the 0.05 probability level.

DISCUSSION

The results of the study proves that salt stress negatively affected most of the yield traits, while humic acid shows a positive effect, especially at a concentration of ml2, in reducing the effect of salinity and improving the yield components.

Out of the results of the number of pods per plant, the H2S0 treatment show the best result in the number of pods (34.25 pods/plant), while the H0S2 and H1S2 treatments recorded the lowest value. The decrease is due to the negative effect of salts on flowering, fertilization and pod formation (Zhu, 2001). The positive effect of humic acid is attributed to improving nutrient absorption and increasing the physiological activity of the plant (Karabulut et al., 2010). As for the number of seeds per pod, the H2S1 treatment achieved the highest number of seeds (12.4), while H0S1 recorded the lowest number. This decrease is attributed to poor fertilization under the influence of salt stress, while the improvement in seed number with humic is due to the activation of enzymes and the regulation of physiological processes associated with fruiting (Suh et al., 2001). Seed weight: The treatments H2S0 and H2S1 show the highest seed weight (1.65 and 1.62 g). The reason for the increase in seed weight is the addition of humic acid, which leads to an increase in the efficiency of photosynthesis resulting from an increase in the content of chlorophyll pigment and the ease of ion exchange in the soil and its availability to the plant as a result of using the acid, in addition to what the acid contains of nutrients contribute to increased plant growth and have a positive impact on crop components, including seed weight(Yassin et al., 2023). Potassium is also important in the formation, storage, and transport of starch, sugars, and proteins, which positively impacts grain weight (Yassin et al., 2023).

CONCLUSIONS

After all the explanations stated earlier, the following conclusions can be drawn:

1. Salt stress significantly reduces pea plant yield.
2. Spraying pea plants with humic acid helps mitigate the negative effects of salinity.
3. Humic acid enhances plant growth and its ability to withstand stressful conditions.

*Recommendations:

1. It is recommended to use humic acid to improve crop resistance to salt stress.
2. Adopt agricultural practices that include humic acid spraying in saline-affected soils.
3. Conduct additional studies to determine the optimal dosage and effective application time.

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