

## **Effects of Potassium and Humic Acid on Amelioration of Soil Salinity Hazardous on Pea Plants**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Pots experiment were carried out in green house of National Research Centre, Dokki, Egypt, to study the effect of potassium and humic acid application to minimize the adversely effects of soil salinity on pea plants. Pots were divided into three main groups of soil salinity at levels (2.84, 6.03 and 8.97 dS m<sup>-1</sup>). These main groups were applied potassium sulfate at the rates 50 and 100 kg fed<sup>-1</sup>. Foliar application of humic acid was applied at a rate of 0.2%. Data presented that the application of K<sub>2</sub>SO<sub>4</sub> at a rate of 100 kg fed<sup>-1</sup> with humic acid a foliar spray at a rate of 0.2%, gave the highest values of plant growth parameters such as, Branch No., Leave No., Plant height, leaf area, Shoot fresh and dry weight. In addition to produce high chlorophyll a and b and carotene content as compared to other treatments and control under the different soil salinity levels. Application of K<sub>2</sub>SO<sub>4</sub> (100 kg fed<sup>-1</sup>) with foliar spray of humic acid under high and moderate soil salinity condition increased pod weight, seed weight, seed dry weight over application of 50 kg fed<sup>-1</sup> and control. The highest values of studied chemical constituents in shoots and greens were obtained due to the application of potassium sulfate at 100 kg fed<sup>-1</sup> with humic acid. The combined

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effects of potassium application and foliar spray of humic acid had a positive effect on increasing the ability of pea plant tolerance to soil salinity and increasing of growth and yield production under saline soil conditions.

**Keywords:** Soil salinity; potassium; humic acid; growth; nutrient content; pea plant.

## 1. INTRODUCTION

Salinity is became one of the most serious environmental problems that caused great reduction on growth and development of plant species. In fact Salinity is one of the major yield limiting factors for crop plants mainly in arid and semiarid regions of the world [1]. In Egypt the problem is aggregated due to overuse of fertilizers and shortage of good irrigation water. Therefore, many trails and approaches have been attempted to mitigate the well-known negative effects of salinity on plant growth and production [2,3]. Naghmeh et al. [4] conducted a series of experiments to evaluate the effect of HA on qualitative and quantitative characteristics of perennial ryegrass. Different concentrations of HA (0, 100, 400, and 1000 mg L<sup>-1</sup>) were applied monthly as foliar application. Results showed that leaf phosphorus (P), potassium (K), and zinc (Zn) content, fresh and dry weight, chlorophyll content, and root fresh weights were not affected by HA. Meanwhile, HA improved the root and shoot development, except for root fresh weight. While just 100 mg L<sup>-1</sup> improved height, visual quality, nitrogen (N) content, roots length, and surface of roots, all of HA concentrations were effective on iron content. These results suggest that HA foliar application might be of benefit to enhance some nutrients uptake and root development of ryegrass possibly leading to improved drought resistance.

Nitrogen, phosphorus and potassium are key nutrients that play a major role in crop production on intensively cultivated soils. The soil fertility is directly influenced by the type of fertilizer inputs [5].

Pea (*Pisum sativum* L.) is one of the most important leguminous vegetable crops grown during winter season in Egypt. Its seeds contain 18-20% dry matter whose 10-12% is carbohydrate and 5-8% is protein [6]. Pea is used as a fresh vegetable, frozen or canned. According to FAO 2004 data, about 12.2 million tons of pea production were achieved in 6.3 million ha agricultural lands of the world with an average yield of 1.930 kg ha<sup>-1</sup> (Anonymous, 2007). It occupies a great figure in the local

consumption and export. The total area grown with garden peas in Egypt was 47951 fed, which produced 180631 ton with an average yield 3.77 ton fed<sup>-1</sup>, while dry peas was 162 fed and average productivity 0.77 ton fed<sup>-1</sup> according to agricultural statistics, Ministry of Agriculture, 2012). Among those approaches is the improvement of plant nutritional status via external supplements to ameliorate salinity damages with exogenous application of K<sup>+</sup> in wheat [7]. Furthermore, some beneficial mineral nutrients have been studied that can counteract adverse effects of salt stress.

Potassium play vital role and stimulates biological process in the plant cell as enzymes activity, respiration, photosynthesis, chlorophyll, carbohydrate, formation, water amounts balance in leaves and regulate stomata opening as well as direct effect on the disease desistance [8]. One of the mechanisms for improving plant tolerance to salinity is to apply potassium, which seems to have beneficial effects potassium fertilization mitigates the adverse effects of salinity in plants by increasing translocation and maintaining water balance within plants (Greenwood and Karpinets, 1997). Hussein et al. [9] found that spraying pepper plants with potassium (200 ppm) increased the plant growth, biomass production, and fruit yield. While, chlorophyll content and total phenols significantly increased with foliar application with 100 ppm of potassium. Elsharkawy [10] indicated that foliage fresh and dry weights, No. of pods per plant, weight of pods per plant, total yield fed<sup>-1</sup>, N, protein and K content in green pea seeds were significantly and positively affected by increasing potassium levels and the maximum promotion was detected at 48 kg K<sub>2</sub>O fed<sup>-1</sup>. Balpande et al. [11] stated that significantly high seed yield and quality of pea plant were observed due to application of 30 kg K<sub>2</sub>O ha<sup>-1</sup>.

Humic acid is one of the most important components of bio-liquid complex, due to its molecular structure, it provides numerous to crop production. It helps break up clay compacted soils, assists in transferring micronutrients from the soil to the plant, enhance water retention, increases the rates of seed germination,

improves water, air and roots penetration and stimulates development of microflora population in soils [12]. Stumpe et al. [13] stated that the positive effect of humic acid on the yield capacity of soil consists of many components. Moreover, some researchers showed that the foliar spray of humic acid enhanced nutrient uptake, plant growth, yield and quality in a number of plant species [14] at least partially through increasing nutrient uptake, serving as a source of mineral plant nutrient uptake and regulator of their release [15]. Behzad Sania [16] studied the effects of the foliar application of humic acid on plant height in canola spring cultivar. The results showed that foliar application of humic acid significantly affected plant height and highest this parameter was achieved under 2% foliar application of humic acid and the lowest plant height was obtained under control conditions. Also, means comparison showed that plant height under 0.5% foliar application of humic acid and 1% foliar application of humic acid were in a similar statistical group. The results showed that foliar application of humic acid decreased nitrogen application in soil, that can be the most important for the non-pollution of soil by nitrogenous fertilizers.

Direct effect are those, the uptake of humic substances into the plant tissue resulting in various biochemical effects through elevate uptake and maintaining vitamins and amino acids level in plant tissues. Geris (2013) indicated that foliar spraying of onion plants with humic acid at the rate of 2 kg fed<sup>-1</sup> at 60, 80 and 100 days after transplanting markedly increased vegetative growth, bulb yield and its

components, onion quality and chemical composition in two seasons. The objectives of this study, to evaluate the effect of using potassium and humic acid on growth and nutrient content and seeds quality of pea plants under saline soil condition.

## 2. MATERIALS AND METHODS

Pot experiments were carried out in the green house of the National Research Centre, Dokki, Egypt, to study the effect of potassium and humic acid application to minimize the adversely effects of salinity on pea (*Pisum sativum* L.) plants. Plastic pots (30 cm in diameter) were filled with 10 kg soil deferred in their salinity levels (2.84, 6.03 and 8.97 dS m<sup>-1</sup>). Physical and chemical analyses of soils used in the experiment were determined according to the methods reported by Rebecca [17] and presented in Table 1.

Pots were divided into three main groups of soil salinity at levels (2.84, 6.03 and 8.97 dSm<sup>-1</sup>). These main groups were applied potassium sulphate at a rate of 50 and 100 kg fed<sup>-1</sup> to the soil surface beside plants after 1, 3 and 5 weeks after transplanting. Foliar of humic acid was applied at the rate 0.2% in the same times. Each pot received 2.2 g of calcium superphosphate (15.5% P<sub>2</sub>O<sub>5</sub>) before sowing and 3.0 g ammonium nitrate (33.5% N) added two weeks after sowing. In each pot, 8 grains of pea (*Pisum sativum* L.) cv. Master B plants were sown at 15 November 2017. The seedlings were thinned to three plants per pot two weeks after sowing. Plant samples were collected at 45 and 90 days after sowing.

**Table 1. Physical and chemical properties of soils used in the experiment**

Soil texture	EC in soil paste (dS m <sup>-1</sup> )	pH (1: 2.5)	Organic matter (%)	Ca CO <sub>3</sub> (%)
Sandy Loam	2.84 (Low salinity, LS)	7.65	0.28	2.2
Sandy Loam	6.03 (Medium salinity, MS)	7.82	0.55	2.97
Loamy Sand	8.97 (High salinity, HS)	7.91	0.34	4.18
Cations (meq l <sup>-1</sup> )	<b>Ca<sup>++</sup></b>	<b>Mg<sup>++</sup></b>	<b>K<sup>+</sup></b>	<b>Na<sup>+</sup></b>
	2.62	1.86	1.41	5.51
	3.22	0.92	0.73	8.34
	3.76	0.82	0.66	13.71
Anions (meq l <sup>-1</sup> )	<b>CO<sub>3</sub><sup>-</sup></b>	<b>HCO<sub>3</sub><sup>-</sup></b>	<b>Cl<sup>-</sup></b>	<b>SO<sub>4</sub><sup>-</sup></b>
	0.00	2.12	7.33	1.72
	0.00	2.44	8.63	2.77
	0.00	3.17	12.48	3.42

Chlorophyll a and b and carotene were estimated in the fresh leaves as described by Lichtenthaler and Wellburn [18]. Shoot weight, plant height and leaf area also estimated. Leaf area (LA) calculated by the model described by Erdogan [19] using the leaflet length (L) and width (W).  $LA = -1.6923 + (L \times 0.0161) + (W \times 0.0929) + (0.0062 \times L \times W)$ . At harvest, the following measurements were recorded: shoot weight, number of pods per plant and its weight, seed number per plant and its weight (g). Shilling percentage was calculated by dividing the seeds weight into 100 by pods weight. Total nitrogen, phosphorus, potassium, calcium and sodium estimated in the plant digest according to the method described by Faithfull [20].

## 2.1 Statistical Analysis

Data were statistically analyzed by using factorial completely randomized design. The means were compared using the least significant difference test (LSD) at 5% level according to Gomez and Gomez [21].

## 3. RESULTS AND DISCUSSION

### 3.1 Vegetative Growth Characters

Data presented in Table 2 that salinity had negative effects on all vegetative growth characters of pea plant. Moderately saline ( $6.03 \text{ dS m}^{-1}$ ) and strongly saline ( $8.97 \text{ dS m}^{-1}$ ) stress caused significant decreases in Branch No., Leave No., Plant height (cm), leaf area, Shoot fresh weight and Shoot dry weight as compared with non-saline stress treatment ( $2.84 \text{ dS m}^{-1}$ ). Therefore, data showed that the application of potassium sulfate at two different rates caused significant increase particularly at a rate of 100 ppm. Where the increase was about 16.3, 34.4, 17.9, 21.4, 21.1 and 18.7% for the above-mentioned parameters, respectively as compared with moderately saline soil treatment ( $6.03 \text{ dS m}^{-1}$ ). These results are in agreement with those obtained by Bekheta et al. [22]. The reduction in vegetative growth characters due to salinity may be attributed to the harmful effects of salinity on many metabolic processes including, activity of mitochondria and chloroplasts [23,24,25].

Application of potassium sulfate at a rate of  $100 \text{ kg fed}^{-1}$  with the humic acid a foliar spray at a rate of 0.2% gave the highest values of plant growth parameters such as, Branch No., Leave No., Plant height (cm), leaf area, Shoot fresh weight

and Shoot dry weight. Data in Table 2 show that spraying pea plants with humic acid produced the tallest plants and the highest values at about 19.6, 18.6, 26.1, 16.4, 12.5 and 26.5% respectively, as compared with application of potassium sulphate individual at a rate of 100 ppm. Humic substances have been reported to influence plant growth both directly and indirectly. The indirect effects of humic compounds on soil fertility include, increase in the soil microbial population including beneficial microorganisms, improved soil structure and increase in the cation exchange capacity and the pH buffering capacity of the soil [26]. Humic acid (HA) compounds may have various biochemical effects either at cell wall, membrane level or in the cytoplasm, including increased photosynthesis and respiration rates in plants, enhanced protein synthesis and plant hormone like activity [27]. HA may stimulate shoot and root growth, and improve resistance to environmental stress in plant, but the physiological mechanism has not been well established [28,29].

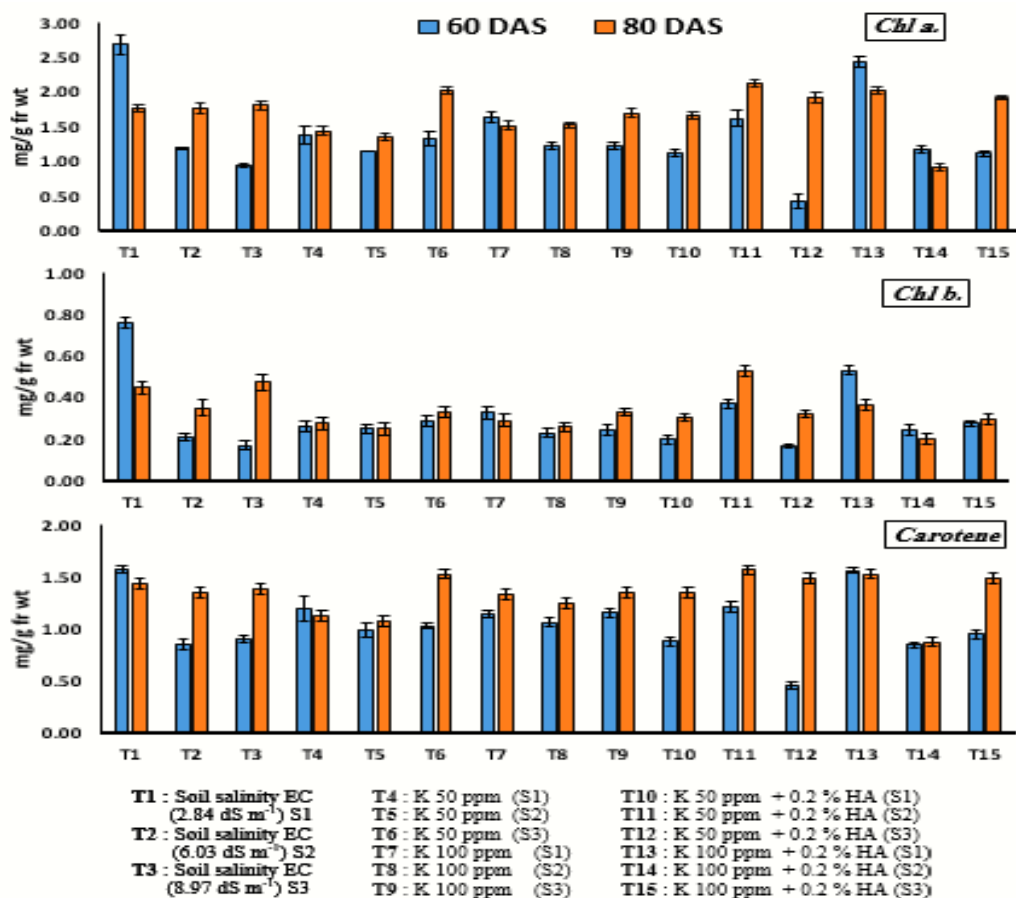
### 3.2 Chlorophyll Contents

Increasing the soil salinity levels from 2.84 and  $8.97 \text{ dS m}^{-1}$  significantly decreased the chlorophyll a and b and carotene contents. However, the application of potassium sulfate with HA as foliar spray decreased the deleterious effect of salinity on the chlorophyll content. Application of potassium sulfate at  $100 \text{ kg fed}^{-1}$  produced the higher chlorophyll a and b and carotene as compared to the other treatments and control under the different soil salinity levels (Fig. 1).

The reduction in plant growth and yield due to salinity might be attributed to the inhibiting effects of salinity on many metabolic processes including, activity of mitochondria and chloroplasts [23]. El-Bagoury et al. [30] suggested that, biosynthesis of chlorophylls in generally might be inhibited by the depressive effect of stress conditions on the absorption of some ions involved in the chloroplast formation, such as Mg and Fe and/or an increase of growth inhibitors, such as ethylene or abscisic acid production which enhance senescence. Carotene content was significantly reduced by increasing salt concentration of the growth compared with the control plants grown under low saline soil with  $\text{EC} = 2.84 \text{ dS m}^{-1}$ . These results agree with Ghassemi-Golezani et al. [31].

**Table 2. Effect of potassium and humic acid on vegetative growth of pea plant under saline soil conditions**

Treatments	Branch no.	Leave no.	Plant height (cm)	leaf area LA	Shoot fresh wt.	Shoot dry wt.
Soil salinity EC (2.84 dS m <sup>-1</sup> ) = S1	9.8	35.1	44.0	4.71	12.5	1.85
Soil salinity EC (6.03 dS m <sup>-1</sup> ) = S2	9.2	32.0	39.2	4.62	11.2	1.71
Soil salinity EC (8.97 dS m <sup>-1</sup> ) = S3	9.6	28.4	23.3	4.56	10.1	1.35
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	10.2	36.1	46.6	5.23	13.2	2.04
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	9.9	33.7	41.4	5.11	11.8	1.88
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	9.7	31.1	33.3	4.95	10.6	1.49
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	11.6	46.5	48.5	5.82	14.0	2.31
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	10.7	43.3	46.7	5.61	13.6	2.03
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	9.4	36.8	45.4	5.11	11.8	1.98
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	11.9	49.0	57.2	6.12	15.4	2.44
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	11.2	47.9	54.4	6.06	14.7	2.26
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	10.6	44.8	50.9	6.06	13.9	2.11
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	12.4	59.4	61.3	8.49	16.5	2.67
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	12.8	51.2	58.2	6.53	15.3	2.57
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	11.7	47.3	57.9	6.35	14.5	2.41
<b>LSD 0.05</b>	<b>0.082</b>	<b>1.13</b>	<b>2.05</b>	<b>0.034</b>	<b>0.116</b>	<b>0.059</b>

**Fig. 1. Effect of potassium and humic acid on chlorophyll content of pea plant under saline soil conditions**

**Table 3. Effect of potassium and humic acid on yield parameters of pea plant under saline soil conditions**

Treatments	Pod No/plant	Seed No/plant	Pods weight (g)	Seeds weight (g)	Seed Dry weight (g)
Soil salinity EC (2.84 dS m <sup>-1</sup> ) = S1	5.6.	23.1	15.5	12.4	2.07
Soil salinity EC (6.03 dS m <sup>-1</sup> ) = S2	5.3	21.0	14.6	11.0	2.02
Soil salinity EC (8.97 dS m <sup>-1</sup> ) = S3	3.3	19.1	12.1	9.8	1.84
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	6.8	24.6	17.5	13.6	2.28
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	5.9	23.4	16.6	12.1	2.22
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	4.7	21.3	14.1	10.8	2.03
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	7.4	26.5	21.2	14.4	2.53
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	6.1	25.7	18.5	13.3	2.45
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	6.8	21.2	16.1	11.7	2.13
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	8.2	31.4	22.3	15.6	3.22
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	7.3	30.8	20.5	14.3	3.06
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	6.4	29.9	19.4	12.9	2.96
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	9.3	33.5	25.5	17.7	4.07
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	8.7	32.9	24.6	16.3	3.49
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	7.8	31.7	21.5	15.9	3.27
<b>LSD 0.05</b>	<b>NS</b>	<b>1.38</b>	<b>0.92</b>	<b>0.115</b>	<b>0.081</b>

### 3.3 Yield Parameters

Data in Table 3 illustrated that, Soil Salinity stress caused significantly adverse in yield parameters (pod and seed number and weight per plant). However, decreased was lower at the salinity level of 2.84 than 6.03 and 8.97 dS m<sup>-1</sup>. Potassium application with foliar spray of humic acid caused significant improved pod yield and seed number per plant grown either in low saline soil (2.84 dS m<sup>-1</sup>) or in saline conditions 6.03 and 8.97 dS m<sup>-1</sup>. Concerning the effect of potassium with humic acid, the highest rate of potassium application (100 kg fed<sup>-1</sup>) resulted in pronounced increase on all of the studied yield components of Pea plant, especially at the highest level of soil salinity (8.97 dS m<sup>-1</sup>) over the lower rate of applied potassium sulfate (50 kg fed<sup>-1</sup>) and control treatment.

Application of potassium sulfate (100 kg fed<sup>-1</sup>) with foliar spray of humic acid in high salinity of soil (8.97 dS m<sup>-1</sup>) increased pod weight (21.5 g plant<sup>-1</sup>), seed weight (15.9 g plant<sup>-1</sup>), seed dry weight (3.27 g plant<sup>-1</sup>) over application of 50 kg fed<sup>-1</sup> and control. The enhancing effect of potassium sulfate treatments may be due to the role of potassium in photosynthesis, transpiration, opening and closing of stomatal, synthesis of protein, translocation of assimilates and activation of enzymes [8]. Obtained findings are in compliance by those reported by Doaa et al. [32] and Farid et al. [24].

### 3.4 Chemical Constituents in the Shoot and Grain

Data in Table (4 and 5) indicated that, soil salinity stress significantly decrease in N, P, K and Ca content, however reduction was lower at low salinity level (2.85 dS m<sup>-1</sup>) than the two levels (6.03-8.97 dS m<sup>-1</sup>). In grain also a gradual adverse in N contents were recorded with increasing salinity level. Nitrogen was accumulated in the plants grown under saline conditions especially at moderately saline (6.03 dS m<sup>-1</sup>) and strongly saline (8.97 dS m<sup>-1</sup>) compared to control values. It may be related to an adaptation mechanism developed by the plants to overcome osmotic stress caused by salinity while decrease in nitrogen may be due to the antagonistic relation between toxic Cl<sup>-</sup> and NO<sub>3</sub><sup>-</sup> [33].

Potassium content was lower in plants (shoot and grain) grown under saline soil conditions than those grown in low saline soil. Application of potassium sulfate at the two rates comber of control treatment (non application of potassium) significantly effected in N, P and K content of Pea shoot and grain. The highest mean values of studied chemical constituents in the leaves and seeds were obtained due to the application of potassium sulfate at 100 kg/fed with humic acid. The attractive effect of potassium at various rates on chemical constituents in shoot and grain may be due to the role of potassium in activation of

vegetative growth, yields, and its components as mentioned formerly, consequently enhancement chemical constituents in the shoot and grain. These results are in conformity with those reported by Balpande et al. [11]. Concerning, the effect of foliar application with humic acid on Pea chemical composition, results in the same table showed that foliar application with humic acid resulted in the highest values of N, P and K% as

compared with control treatment. Humic substances have much preformed influence on the growth of plant roots. When humic acids are applied to soil, enhancement of root initiation and increased root growth may be observed [34]. Stimulatory effects of humic substances have been directly correlated with enhanced up take of macronutrients, such as N, P and K and micronutrients, which are, Fe, Zn, Cu and Mn [27].

**Table 4. Effect of potassium and humic acid application macronutrient content of pea plants**

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Grain	Shoot	Grain	Shoot	Grain	Shoot
Soil salinity EC (2.84 dS m <sup>-1</sup> ) = S1	2.35	1.32	0.204	0.371	1.24	2.91
Soil salinity EC (6.03 dS m <sup>-1</sup> ) = S2	2.09	1.23	0.199	0.345	1.15	2.81
Soil salinity EC (8.97 dS m <sup>-1</sup> ) = S3	1.42	1.09	0.187	0.261	1.06	2.54
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	2.47	1.45	0.224	0.379	1.36	3.31
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	2.33	1.35	0.219	0.361	1.26	3.12
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	2.11	1.20	0.206	0.348	1.16	2.94
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	2.73	1.56	0.362	0.430	1.39	3.76
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	2.42	1.56	0.302	0.412	1.23	3.58
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	2.25	1.42	0.215	0.391	1.17	3.44
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	2.81	1.92	0.386	0.498	1.46	4.06
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	2.61	1.60	0.380	0.467	1.37	3.96
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	2.55	1.57	0.363	0.456	1.34	3.87
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	3.29	1.98	0.402	0.612	1.52	4.69
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	3.13	1.65	0.396	0.519	1.43	4.25
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	3.18	1.62	0.378	0.512	1.41	4.16
<b>LSD 0.05</b>	<b>0.057</b>	<b>0.0014</b>	<b>0.013</b>	<b>0.0014</b>	<b>0.021</b>	<b>0.18</b>

**Table 5. Effect of potassium and humic acid on sodium and calcium content of pea**

Treatments	Sodium (%)		Calcium (%)		Ca/Na ratio	
	Grain	Shoot	Grain	Shoot	Grain	Shoot
Soil salinity EC (2.84 dS m <sup>-1</sup> ) = S1	1.94	2.63	1.46	0.72	0.75	0.27
Soil salinity EC (6.03 dS m <sup>-1</sup> ) = S2	3.29	3.53	1.36	0.65	0.41	0.18
Soil salinity EC (8.97 dS m <sup>-1</sup> ) = S3	3.32	3.75	1.22	0.49	0.37	0.13
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	2.77	2.62	1.64	0.82	0.59	0.31
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	2.79	3.22	1.41	0.64	0.51	0.20
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm	2.93	3.39	1.28	0.56	0.44	0.16
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	2.61	2.54	2.18	1.04	0.84	0.41
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	2.63	2.77	2.18	0.94	0.83	0.34
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm	2.71	3.03	1.82	0.61	0.67	0.20
S1 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	2.57	2.22	2.71	1.35	1.05	0.61
S2 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	2.58	2.34	2.37	1.19	0.92	0.51
S3 + K <sub>2</sub> SO <sub>4</sub> 50 ppm + 0.2 % HA	2.6	2.73	2.03	1.01	0.78	0.37
S1 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	2.34	1.96	2.91	1.46	1.24	0.74
S2 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	2.36	2.02	2.55	1.28	1.08	0.63
S3 + K <sub>2</sub> SO <sub>4</sub> 100 ppm + 0.2 % HA	2.52	2.15	2.18	1.09	0.87	0.51
<b>LSD 0.05</b>	<b>0.0116</b>	<b>0.0203</b>	<b>0.025</b>	<b>0.011</b>		

Also, data in Table 5 show that, sodium content was increased with increasing soil salinity levels but calcium content was lower in plants (shoot and grain) grown under saline soil conditions than those grown in low saline soil. Calcium: Sodium ratio was significantly lower under salinity stress. Potassium application enhanced Ca/Na selectivity ratio in pea thus enhancing pod and shoot yield. Application of 100 kg/fed potassium sulfate in the high salinity soil increased the Ca: Na. The exclusion of Na<sup>+</sup> ions and a higher Ca: Na ratio in pea plants grown under saline conditions have been confirmed as important selection criteria for salt tolerance [35]. Therefore, the results shown in Table 5 agree with experimentations with Pea plant by Abdelhamid et al. [35] which indicate that salt tolerance is associated with an enhanced K: Na discrimination trait. The ability of plant to limit Na transport into the shoot is critically importance for the maintenance of high growth rates and protection of the metabolic processes in elongation cells from the toxic effects of Na [36].

#### 4. CONCLUSION

Potassium sulfate with foliar spray of humic acid under high and moderate soil salinity condition a promotive effect on growth parameters, Such as; pod weight, seed weight, seed dry weight over application of 50 kg fed<sup>-1</sup> and control. The highest values of studied chemical constituents in shoot and grains were obtained due to the application of potassium sulfate at 100 kg fed<sup>-1</sup> with humic acid. Generally, interaction between of potassium addition and foliar spray of humic acid had a positive effect on increasing the ability of pea plant tolerance of high salinity levels and increasing of growth and yield production under saline soil conditions.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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