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The Potential Effect of Amino Acids as By-Products from Wastes on Faba Bean Growth and Productivity Under Saline Water Conditions

Sayed A. Abdeen[1*] and Hassan H. H. Hefni[2]

[1] *Soils and Water Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt*
[2] *Petrochemicals Department, Egyptian Petroleum Research Institute, Cairo, Egypt*

THIS STUDY was conducted to examine the effect of amino acids solution (AAS) on faba bean growth and yield under different levels of saline water. AAS produced from shrimp shells wastes (deproteinization process). For achieve this purpose, AAS added at rates 0 (distilled water),1000,1500 and 2000 mg/L under 50 mM NaCl, 75 mM NaCl and 100 mM NaCl as compared to control (tap water). The plants sprayed by AAS at 25, 40, 55 and 70 days of sowing. The results obtained that there is a negative correlation between soil salinity and soil organic matter (r = - 0.814). Also, irrigated faba bean plants with saline water gave a significance reduction in growth parameter (plant height, number of seeds per plant, and number of pods per plant) and productivity. Furthermore, there is a negative correlation between soil salinity and protein content (r = - 0.645) and significance decrease in N, P and K concentrations. While foliar application of AAS recorded a significant increase in growth parameters and productivity. The highest percent increase of grain and straw yield were 71.94% and 49.05% at 50 mM NaCl; 102.36% and 41.8% at 75 mM NaCl, and 137.40% and 53.70% at100 mM NaCl, respectively under 2000 mg/L AAS. Foliar application of amino acids solution produced from shrimp waste considered a new technique for improving faba bean growth and productivity under salinity conditions. Furthermore, the application of amino acids solution at rates 1500 mg/L and 2000 mg/L was appeared a significant increase in faba bean productivity and water use efficiency.

Keyword: Salinity, Shrimp shells wastes, Faba bean (*Vicia faba L.*), Soil characteristics.

1. Introduction

Faced with rising global population and resulting food demand, as well as the negative effects of climate change on crop productivity, agricultural research has shifted its focus to gaining new scientific knowledge about the mechanisms involved in plant tolerance of abiotic stress to develop agronomic strategies that help crops survive and thrive under these conditions (Safdar et al., 2019*)*. One of the most severe abiotic factors affecting faba bean productivity is salt stress where salinity causes early senescence and reducing the photosynthetic leaf area to a point where it can no longer support growth (Erdal et al., 2011). Water is required for plant growth throughout its whole life cycle, from seed germination to the ultimate stage of development. As a result of the depletion of freshwater resources, numerous alternate water sources have been used (Abdrabou et al., 2022). In dry and semi-arid climates around the world, salinity is one of the most serious difficulties that agriculture faces and has a significant impact on agricultural productivity and harvest quality (Zhang et al., 2019). Most chemical processes occurring within plants are severely harmed by the presence of noxious ions in the soil (Ashraf and Tang, 2017*)*, particularly the Na^+/K^+ ratio due to increased quantity of Na^+ ions under salinity, as plants absorb more Na^+, resulting in enzyme inactivation (Sarwar and Shahbaz, 2020). Nonetheless, farmers, particularly in arid and semi-arid regions, are obliged to use low-quality irrigation water for agricultural cultivation *(*Nadeem et al., 2019). The increasing of NaCl in irrigation water can cause osmotic leaf turgor loss, toxicity in various plant tissues, and nutritional unbalance (Hussain et al., 2018).

*Corresponding author e-mail: dr.sayedabdeen@azhar.edu.eg
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The ability of plants to offset some of these effects determines their level of salt tolerance (Ghalati et al., 2020).

Among all waste types, food waste is regarded as one of the most pressing problems to solve globally because, as stated in the European Biorefinery 2030 vision, its resolution will have a substantial impact on all the Sustainable Development Goals (Platt et al., 2021). A particularly specific kind of residue is food waste that comes from the ocean. Crab, shrimp, and lobster shell trash are among the 6 to 8 million tonnes of seafood waste created each year worldwide. In wealthier nations, disposing of shell trash can be expensive in contrast to what occurs in developing nations where it is just discarded in landfills (Yan and Chen, 2015). The primary components of crustacean shells are 20–30% proteins, 30–40% calcium carbonate ($CaCO_3$), 20–30% chitin (Rodde et al., 2008), and the smallest quantity of astaxanthin. These natural substances have a great commercial worth, especially when you consider their primary applications. These natural substances have a great commercial worth, especially when you consider their primary applications. Hussain et al., (2009) has separated the proteins pats from shrimp shells and classified it to 16 essential types of amino acids as following; (Aspartic, Glutamic, Threonine, Serine, Arginine, Cysteine, Methionine, Proline, Glycine, Alanine, Isoleucine, Valine, Leucine, Lysine, Phenylalanine, and Histidine) to re-used it by reaction with chitosan and formation a new valuable material could use as agriculture fertilizer.

Faba bean plant highly nutritional value in terms of both calorie and protein content, it is one of Egypt's most significant crops (Fouda, 2017), and raising its production is one of Egypt's most critical agricultural policy goals. Furthermore, as a salt-sensitive plant, faba bean has a tolerance limit of 1.6 dS m^{-1} (Sahab et al., 2021). Addition that, faba bean is moderately sensitive to saline soil and/or saltwater water as well as no salt-tolerant Vicia faba cultivars have been developed for use in salt-affected soils (Hafez et al., 2021).

To mitigate the hazards of salinity on crops, many bio stimulants manufacturers use a variety of raw materials. Amino acids are one of these active materials (Alfosea-Simon et al.,2020). Amino acids are a cost-effective method among the many ways employed to mitigate abiotic stress where they play an important role in crop productivity as well as in reducing the negative effects of NaCl stress (Shahid et al., 2021). Foliar application of amino acids on plants are very important in all growth stages. It can be absorbed by plants through stomas. Additionally, amino acids are used to benefit plants by introducing them into the soil, which can enhance the soil's microflora and make it easier for plants to absorb nutrients (Mohamed et al., 2013). Furthermore, amino acids help plants grow and produce more through protein biosynthesis, phytohormones, enzyme activation, nutrient uptake, and assimilation, signaling activities, energy production, and gene transcription (Souri and Hatamian, 2019).

Egypt experiences a rise in food consumption as a result of population growth, yet there aren't many sources of fresh water (Abou Hussien et al., 2020). As a result, there are numerous initiatives to reduce salinity stress and grow cereal crops that can withstand salt by employing saline water. Foliar sprays of amino acids boosted the vegetative development, yield characteristics, and biochemical contents of common bean (Zewail, 2014).

There is an increasing need for a potential technique to applying cost-effectively promising approaches globally to use saline water in agriculture, especially for environmentally acceptable technologies. The current research aims to assess the potential effect of amino acids solution (produced from shrimp waste) as foliar application on faba bean growth, productivity and water use efficiency.

2. Materials and methods

***Preparation of amino acid solution from shrimp shells* (deproteinization process)**

The analysis of amino acids in the solution obtained from the deproteinization process using international official methods of analysis (William,2000) (Table 1). As was mentioned in the introduction section, the shrimp shells constituents are calcium carbonate (about 35% w/w), proteins (amino acids) (about 35% w/w), and chitin (about 30% w/w). So, the separation of amino acids from shrimp shells includes the next steps: One kg of dried shrimp shells is washing for three times with hot water to remove sands and any suspended matters, and then mixing with 10 litters of KOH aqueous solution (5% w/w) and stirring at 110 ^{o}C for 2hr.

TABLE 1. Characteristics of amino acids

Amino Acid	Aspartic (ASP)	Threonine (THR)	Arginine (ARG)	Methionine (MET)	Glycine (GLy)	Isoleucine (ILE)	Leucine (LEU)	Phenylalanine (PHE)
%	2.178	0.278	0.536	0.517	0.690	0.746	1.737	1.056
Status	Acidic	Neutral	Neutral	Neutral	Unique	Hydrophobic aliphatic	Hydrophobic aliphatic	Hydrophobic aliphatic
Amino Acid	Glutamic (GLU)	Serine (SER)	Cysteine (CYS)	Proline (PRO)	Alanine (ALA)	Valine (VAL)	Lysine (LYS)	Histidine (HIS)
%	3.217	0.254	0.132	0.968	1.264	1.168	1.370	0.750
Status	Acidic	Neutral	Neutral	Unique	Hydrophobic aliphatic	Hydrophobic aliphatic	Hydrophobic aliphatic	Basic

Separation of non-protenic amino acids was carried out by using the fully automated Eppendorf / Biotronic (LC 3000) amino acid analyzer at the Regional Center for Mycology and Biotechnology (RCMB) at Al-Azhar University based on ion exchange chromatography followed by post-column detection. The dark solution of amino acids mixture as potassium salts is separates by filtration. The separated natural product “potassium salt of amino acids produced from shrimp shells” was used as a source of amino acids for different fields (Hussain et al., 2009). Then the stock (Amino acids solution) was neutralized by phosphoric acid and diluted with distilled water to the studied rates.

Experimental design

A pot experiment was conducted at the Faculty of Agriculture, Al- Azhar University, Nasr city, Cairo, Egypt, during the winter season of 2020 in a factorial arrangement based on completely randomized design with three replicates. The experiment was conducted to assess the foliar application of amino acids solution as by-products of shrimp wastes on faba bean productivity under different levels of salinity. The pots were filled with 7 kg sandy loam soil (30 cm diameter). About 4 seeds of faba bean *(Sakha-3)* were sown per pot. After ten days of germination, 2 uniform plants were maintained per pot. The treatments were: 0.0 (distilled water), 1000, 1500 and 2000 mg/L of amino acids solution (AAS) which produced from shrimp shells under four levels of NaCl i.e., 50 mM NaCl, 75 mM NaCl and 100 mM NaCl as compared to control (tap water). Chemical analysis of tap water as follows; EC = 0.39 dSm^{-1}, pH= 7.41, Ca^{++}= 0.90 meq/L, Mg^{++} = 0.60 meq/L, Na^{+} = 1.70 meq/L, K^{+} = 0.30 meq/L, $CO^{=}_{3}$= 0.0 HCO^{-}_{3} = 0.30 meq/L, Cl^{-} = 2.50 meq/L and $SO^{=}_{4}$ = 0.70 meq/L. The level of soil moisture was monitored by weighing each pot, and any water loss was replenished continuously.

Agricultural practices

Agricultural practices of faba bean were added as recommended i.e., irrigation at field capacity, fertilization as follows; 475 kg ha^{-1} of P_2O_5 [$Ca(H_2PO_4)2$; 15.5% P_2O_5] during soil preparation as mixed with 24 t ha^{-1} of farmyard manure. Also,120 kg ha^{-1} of K_2O [K_2SO_4; 48% K_2O] were added after 45 days of planting and 50 kg ha^{-1} of N [$(NH4)_2SO_4$; 21% N] were added at three equal doses. Faba bean plants were sprayed by AAS extract by hand sprayer at 25, 40, 55 and 70 days of sowing. Each pot was sprayed with 25 ml at every time approximately as average. Total amount of water applied during the experimental season was versus 2720 $m^3.fed^{-1}$. The amount of irrigation water was calculated by using the weight of a sown pots at field capacity and then reweighing at regular intervals (Dumroese et al., 2015). Water use efficiency (WUE) in k gm^{-3} was calculated as follows: $\text{WUE}\ (kg\ m^{-3}) = \frac{\text{Grain yield}\ (kg\ ha^{-1})}{\text{WCU}\ (m^3\ ha^{-1})}$ **(**Ghane et al., 2010**)**, where WCU is water consumptive use.

Growth and yield parameters

At the physiological maturity, plant height (cm) was measured each pot. Plant shoots were oven-dried for 72 hours at 70 °C, then dry weights were weighted. Number of pods per plant, number of seeds per pod, total yield of seeds and straw biomass per pot were determined and converted into kg ha^{-1}.

Soil and plant analysis

Particle size distribution was determined using the Bouyoucous hydrometer method according to Gee and Bauder (1986). Bulk density, field capacity, wilting point and available water were determined as described by Blake and Hartge (1986). Soil pH was measured in 1:2.5 soil-water suspensions using a glass electrode pH meter. Total soluble salts were determined by measuring the electrical conductivity (EC) of 1:2.5 soil: water extracts. Soluble Ca^{++} and Mg^{++} were determined by EDTA titration method. Na^{+} and K^{+} were determined by using a flame photometer. Cl concentration was measured by silver nitrate titration. HCO^{-}_{3} and $CO^{=}_{3}$ contents were measured by acid-base titration and $SO^{=}_{4}$ content was calculated by difference. Organic matter content in soil was estimated by dichromate oxidation method (Burt, 2004). The data are presented in Table 2. Plant samples (Grains and straw) were oven dried at 70 C° for 72 h., grounded in a stainless-steel mill and taken for analysis. Half g of dry shoots and grains were wet digested by using mixture of perchloric and sulphuric acids (1:3) according to Chapman and Pratt (1961). Then the digest was diluted to a volume of 100 mL by distilled water. Total nitrogen was determined by Kjeldahl method. Total phosphorus was determined by the colorimetric method using a spectrophotometer and total potassium was determined photo-metrically using Flame photometer (Page, 1982), and the protein percentage was calculated by multiply % N × 6.25 (Mariotti et al., 2008).

TABLE 2. Some chemical and physical characteristics of the studied soil.

Parameters	**pH**	**EC dS.m^{-1}**	**CEC cmolc kg^{-1}**	**OM g.kg^{-1}**	**Particle size distribution of sandy loam soil % Sand**	**Silt**	**Clay**
Values	7.45	1.68	4.25	5.20	69.00	20.00	11.00
			Soil water constants (%)			Bulk density	
Parameters	Field capacity		Wilting point	Available water	Saturation percent	Mgm^{-3}	
Values	12.50		4.20	8.30	25.80	1.59	

Statistical Analysis

The data were statistically analyzed by Snedecor and Cochran (1980)**.** The data were statistically analyzed using SPSS package version 20 by one-way analysis of variance (ANOVA) and least significant difference (LSD) Statistical significance was considered when P ≤ 0.05.

3. Results and discussion

Soil chemical properties as affected by saline irrigation water after faba bean harvest

Considerable changes among treatments on some soil chemical properties were observed (Table 3). There is a little change in soil pH by application of different levels of saline water. While soil salinity increased significantly by increasing of NaCl in irrigation water. The highest EC value was observed at soil irrigated with the highest level of NaCl (100 mM). Also, the data indicated that Na^{+} and Cl^{-} concentration significantly increased by using saline water compared to control. Soluble cations and anions were increased gradually by increasing saline water (Murtaza, 2019). This could be owing to absorb more soluble and exchangeable cations from the saline solution (Cucci et al., 2013).

On the other hand, the organic matter content decreased significantly by increasing the concentration of NaCl in irrigation water as compared to control, where the lowest value (4.35g kg^{-1}) was observed at 100 mM NaCl. Similarly, results by Murtaza, (2019) were in the same directions by using saline water to grow sorghum crop where the high concentration of Na^{+} in soils resulted in a considerable depletion of OM, posing a serious threat to crop production. From Fig.1 it was noticed that there is a negative correlation between OM and soil salinity (r = - 0.814).

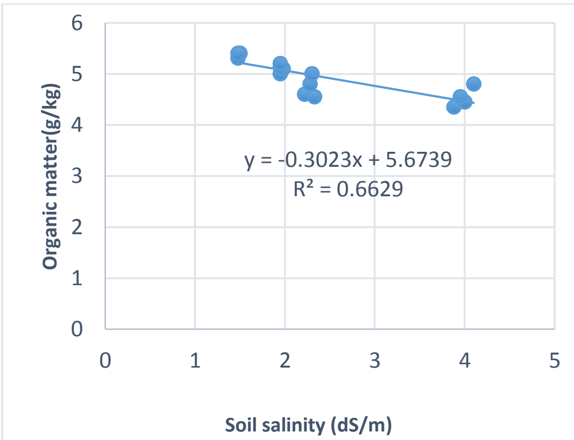

Fig. 1. The liner relationship correlation between soil salinity(dSm^{-1}) and organic matter (OM g kg^{-1}). Correlation coefficient = - 0.814.

Growth parameters of faba bean

Irrigated faba bean plants by the studied levels of saline water gave a significance reduction in growth parameter (Table 4). It could be noticed that the irrigation with saline water at 100 mM NaCl resulted in the lowest values of plant height, number of seeds per plant, and number of pods per plant, where the values were 78.45 cm ,2.65, and 4.25, respectively. This is due to that salt stress inhibits plant growth by interfering with a variety of processes (photosynthesis, low soil water potential, nutritional imbalance, excessive sodium and chloride concentrations, and oxidative stress) are all caused by salinity stress, which lowers soil quality and affects plant growth and production (Shrivastava and Kumar, 2015). On the contrary Filipovic et al., (2020) reported that the number of pods per faba bean plant was not significantly affected by irrigated with saline irrigation water at 50mM NaCl and 100 mM NaCl**.**

Foliar application of amino acids solution (AAS) recorded a significant increase in all growth parameters under all levels of salinity. The highest values of plant height were recorded 107 and 106.5, 102 and 101.30 cm, at 2000 mg/L of AAS under 0.0 and 50, 75 and 100 mM NaCl, respectively. This is due to the among of the tested AAS, Glutamic acids and Arginine, Aspartic and Proline are the most relevant in the bio stimulating activity (Hussain et al., 2009). These finding are confirmed by Sadak et al., (2015) who found that foliar application of amino acids significantly improved the growth parameters under salinity stress. While the highest values of No. of seeds/pod and No. of pods/ plant were 5.10; 9.90 and 4.50; 9.50 under 0.0 and 50 mM NaCl, respectively at 1500 mg/L AAS. But the highest values of No. of seeds/pod, and No. of pods/ plant were 4.5; 8.90 and 4.0; 7.0 under 75 and 100 mM NaCl, respectively at 2000 mg/L. AAS. Sadak and Abdelhamid, (2015) reported that foliar sprays of amino acids boosted the vegetative development, yield characteristics, and biochemical contents of faba bean under salt stress.

TABLE 3. Effect of saine water on soil chemical properties after faba bean harvest under foliar application of amino acids solution (AAS).

Parameters	Treatments			
	0.0 mg/L AAS	**1000 mg/L AAS**	**1500 mg/L AAS**	**2000 mg/L AAS**
	Control (tap water)			
pH (1:2.5 soil suspension)	7.69	7.70	7.73	7.73
EC dSm^{-1} (1:2.5 soil extract)	1.50b	1.50b	1.48b	1.48b
Na^+ meq/100g soil	4.88c	4.91c	2.85c	4.90c
Cl^- meq/100g soil	6.40d	6.33d	6.50d	6.50d
OM $g.kg^{-1}$	5.40a	5.40a	5.31a	5.40a
	50 mM NaCl			
pH (1:2.5 soil suspension)	7.71	7.73	7.70	7.70
EC dSm^{-1} (1:2.5 soil extract)	1.95b	1.98b	1.95b	1.95b
Na^+ meq/100g soil	6.11b	5.95b	6.15b	6.12b
Cl^- meq/100g soil	8.24c	8.50c	8.40c	8.33c
OM $g.kg^{-1}$	5.00b	5.10b	5.13b	5.20b
	75 mM NaCl			
pH (1:2.5 soil suspension)	7.70	7.70	7.71	7.70
EC dSm^{-1} (1:2.5 soil extract)	2.22b	2.28b	2.33b	2.30b
Na^+ meq/100g soil	6.33b	6.41b	6.30b	6.30b
Cl^- meq/100g soil	10.55b	11.80b	10.95b	10.90b
OM $g.kg^{-1}$	4.60c	4.80c	4.55c	5.00c
	100 mM NaCl			
pH (1:2.5 soil suspension)	7.63	7.63	7.64	7.63
EC dSm^{-1} (1:2.5 soil extract)	3.88a	4.00a	3.95a	4.10a
Na^+ meq/100g soil	6.82b	7.78a	7.80a	7.84a
Cl^- meq/100g soil	12.88a	13.25a	13.50a	13.50a
OM $g.kg^{-1}$	4.35d	4.45d	4.55d	4.80d

ASS; Amino acids solution. The values within a column have different letters are significant ($P<0.05$).

TABLE 4. Effect of amino acids solution (AAS) on growth parameters of faba bean under saline water conditions.

Parameters	0.0 mg/L AAS	1000 mg/L AAS	1500 mg/L AAS	2000 mg/L AAS
		Control (tap water)		
Plant height cm	97.85e	103.85b	105.40a	107.00a
No. of seeds /pod	3.20d	4.20b	5.10a	4.95a
No. of pods /plant	7.30d	8.25c	9.90a	9.40a
		50 mM NaCl		
Plant height cm	95.20d	101.85c	105.00a	106.50a
No. of seeds /pod	3.00c	3.85b	4.50a	4.50a
No. of pods /plant	6.86e	7.20e	9.50a	9.33a
		75 mM NaCl		
Plant height cm	83.85e	101.20c	101.20c	102.00c
No. of seeds /pod	2.78c	3.25c	4.50a	4.50a
No. of pods /plant	5.88f	6.33e	8.80c	8.90b
		100 mM NaCl		
Plant height cm	78.45f	98.60d	99.00d	101.30c
No. of seeds /pod	2.65d	3.10c	3.75b	4.00b
No. of pods /plant	4.25g	4.90g	6.30e	7.00e

ASS; Amino acids solution. The values within a column have different letters are significant (*P*<0.05)

Macronutrients content

Data in Table 5 obtained that macronutrients content (N, P and K) gradually decreased by increasing salinity levels to reach their lowest values at 100 mM NaCl. These findings are confirmed by Abdelhamid et al., (2010). Nitrogen content in straw and grains was lower under 100 mM NaCl than those grown under tap water. The ability of plant to absorb nutrients is decreased in saline conditions because it spends most of its energy secreting chemicals that protect it against salt stress (Ali et al., 2021**).** The reductions in nitrogen could be due to the antagonistic relationship between harmful Cl^- and NO_3^- (Rosales et al., 2020). Also, the lowest values of phosphorus content in straw and grains were 1.58 and 3.28 g kg^{-1}, respectively under 100 mM NaCl, while the highest values were 2.45 and 5.80 g kg^{-1}, respectively at tap water treatment.

TABLE 5. Effect of amino acids solution (AAS) on macro nutrients content of faba bean under saline water conditions.

Parameters gkg^{-1}	Shoots 0.0 mg/L AAS	Shoots 1000 mg/L AAS	Shoots 1500 mg/L AAS	Shoots 2000 mg/L AAS	Seeds 0.0 mg/L AAS	Seeds 1000 mg/L AAS	Seeds 1500 mg/L AAS	Seeds 2000 mg/L AAS
				Control (tap water)				
N	19.80^d	22.55^b	25.66^b	28.60^a	31.50^c	34.40^b	36.00^b	38.50^a
P	1.85^b	2.00^a	2.25^a	2.45^a	4.20^c	4.80^b	5.30^b	5.80^a
K	21.75^c	23.50^c	26.44^a	29.00^a	15.87^c	17.88^b	18.95^a	20.33^a
				50 mM NaCl				
N	19.00^d	21.40^c	23.55^b	27.70^a	30.00^d	31.56^c	33.50^c	34.65^b
P	1.76^b	1.90^b	2.10^a	2.37^a	4.10^d	4.35^c	4.65^c	4.95^b
K	18.75^e	20.65^d	22.68^c	24.85^b	14.70^c	15.67^c	17.00^b	18.65^a
				75 mM NaCl				
N	16.50^d	19.55^d	22.30^c	24.50^b	29.20^d	31.00^d	32.25^c	33.00^c
P	1.60^b	1.76^b	1.90^a	2.12^a	3.80^d	4.55^c	4.80^b	4.83^b
K	13.80^g	16.35^f	19.55^d	21.35^c	13.90^d	14.85^c	15.75^c	17.00^b
				100 mM NaCl				
N	15.60^e	16.65^d	18.60^d	20.65^c	27.50^e	29.20^d	31.45^d	31.50^d
P	1.58^b	1.64^b	1.77^b	1.80^b	3.28^e	3.90^d	4.10^d	4.25^d
K	10.85^h	13.00^g	15.60^f	17.00^e	13.15^d	14.00^d	15.44^c	16.10^c

ASS; Amino acids solution. The values within a column have different letters are significant (*P*<0.05).

Finally, the lowest values of potassium content in straw and grains were 10.85 and 13.15 g kg^{-1}, respectively under 100 mM NaCl, while the highest values were 29.0 and 20.33 g kg^{-1}, respectively at tap water treatment. This due to Na^+ is the most damaging ion in saline water for most plants. Transportation and partitioning of nutrients affected negatively by salinity, where salinity cause nutrient deficiencies or imbalances, due to the competition of Na^+ and Cl^- with some nutrients such (Niste et al., 2014). While foliar application of amino acids solution (AAS) significantly improved the concentration of N, P, and K in both grains and straw for growing faba bean under saline water as compared to control. Foliar application of amino acid significantly increased the concentrations of macronutrients content in faba bean plant (Sadak et al., 2015).

Protein content

Data illustrated in Fig. 2 and 3 show that the protein content of faba bean seeds were decreased with increased salinity levels. It was noticed that there is a negative correlation between salinity and protein content (r = - 0.645). Salinity adversely effects on faba bean proteins, lipids, and chlorophyll (Nasrallah et al., 2022). The lowest value (17.19%) was observed at 100 mM NaCl. On the other hand, foliar application of AAS improved the faba bean content of protein in all levels of salinity levels. This is referred to the amino acids help plants grow and produce more through protein biosynthesis, phytohormones, enzyme activation, nutrient uptake, and assimilation, signalling activities, energy production, and gene transcription (Souri and Hatamian, 2019).

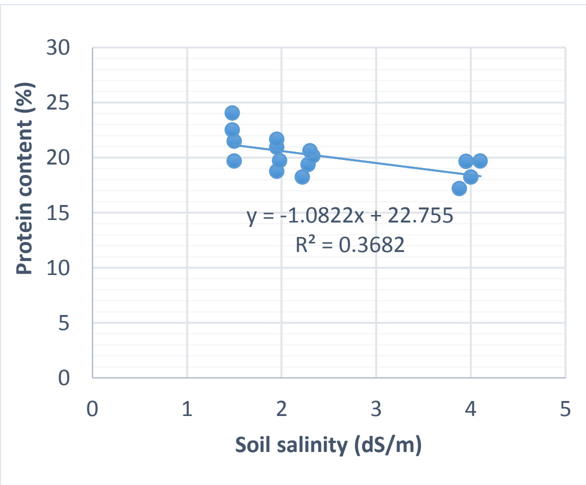

Fig. 2. The liner relationship correlation between soil salinity and protein content. Correlation coefficient = - 0.649.

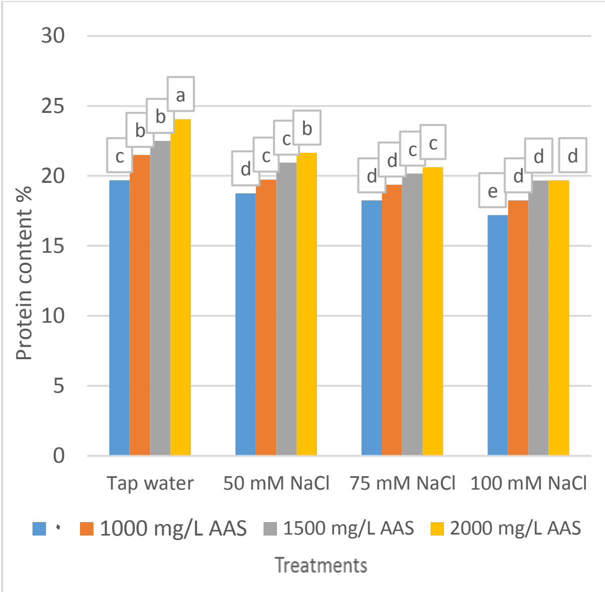

Fig. 3. Protein content of faba bean as affected by different salinity levels under foliar application of amino acids solution (AAS).

Faba bean productivity and water use efficiency

The effect of different levels of saline irrigation water on faba bean productivity under foliar application of amino acids solution (AAS) are presented in Table 6. Faba bean productivity decreased proportionally at 50 mM NaCl. But saline water at 75 and 100 mM NaCl gave a significant decreased in productivity. The values of grains yield g/plant and straw yield g/plant were 3.77 g/plant and 11.47 g/plant, respectively at 100 mM NaCl. Nasrallah *et al.*, (2022) obtained that the adversely effect of salinity on faba bean productivity referred to the induction of osmotic stress, ionic toxicity, that negatively impact cell functional integrity, and cause oxidation of cell molecules such as proteins, lipids, and chlorophyll.

Generally, foliar application of AAS recorded a significance increase faba bean yield. The highest values of grain and straw yield were observed at the highest rates of AAS (1500 and 2000 mg/L) under all levels of salinity. Shahid et al., (2021) found that amino acids play an important role in crop productivity as well as in reducing the negative effects of NaCl stress.

Also, the data in table 6 obtained that the highest percent increase in grains and straw yield were 69.77% and 47.28% under 1500 and 2000 mg/L AAS, respectively at control. Also, the highest percent increase of grain and straw yield were 71.94% and 49.05%, respectively under 1500 and 2000 mg/L AAS, respectively at 50mM NaCl. Behind that the highest percent increase of grain and straw yield were 102.36% and 41.8% under 2000 mg/L, respectively at 75mM NaCl. Finally, the

highest percent increase of grain and straw yield respectively at 2000 mg/L under 100 mM NaCl. Salinity had deleterious effect on plant yield with 55.9% reduction (Nasrallah et al., 2022).
From the data in Fig 3 It could be seen that amino acids are effective components to increase water use were 137.40% and 53.70%, efficiency under all levels of salinity. Amino acids can significantly increase their antioxidant capacity and tolerance to stressful conditions (Noroozlo et al., 2019).

TABLE 6. Effect of amino acids solution (AAS) on faba bean yield under saline water conditions

Treatments		Grains yield			Straw yield		
Salinity NaCl mM	Amino acids solution (AAS) mg/L	g/plant	kg ha^{-1}	Relative increase %	g/plant	kg ha^{-1}	Relative increase %
0.0 (Tap water)	0.00	15.02^{d}	4291.43^{d}	0.00	21.15^{c}	6042.86^{c}	0.00
	1000	18.35^{c}	5242.86^{c}	22.17	25.44^{b}	7268.57^{b}	20.28
	1500	28.25^{a}	8071.43^{a}	88.08	28.65^{a}	8185.71^{a}	35.46
	2000	25.50^{b}	7285.71^{b}	69.77	31.15^{a}	8900.00^{a}	47.28
50	0.00	13.58^{e}	3880.00^{e}	0.00	19.55^{c}	5585.71^{c}	0.00
	1000	15.89^{e}	4540.00^{e}	17.01	21.89^{c}	6254.29^{c}	11.69
	1500	23.35^{b}	6671.43^{b}	71.94	25.43^{b}	7265.71^{b}	30.08
	2000	23.15^{b}	6614.29^{b}	70.47	29.14^{a}	8325.71^{a}	49.05
75	0.00	6.35^{g}	1814.29^{g}	0.00	15.98^{d}	4565.71^{d}	0.00
	1000	8.05^{f}	2300.00^{f}	26.77	18.66^{c}	5331.43^{c}	16.77
	1500	12.00^{e}	3428.57^{e}	88.98	21.00^{c}	6000.00^{c}	32.16
	2000	12.85^{e}	3671.43^{e}	102.36	22.66^{b}	6474.29^{b}	41.80
100	0.00	3.77^{g}	1077.14^{g}	0.00	11.47^{e}	3277.14^{e}	0.00
	1000	4.55^{g}	1300.00^{g}	20.69	15.12^{d}	4320.00^{d}	31.82
	1500	7.63^{f}	2180.00^{f}	102.39	16.85^{d}	4814.29^{d}	46.90
	2000	8.95^{f}	2557.14^{f}	137.40	17.63^{d}	6042.86^{d}	53.70

The values within a column have different letters are significant (*P*<0.0

$$\boldsymbol{Relative\ increase} = \mathbf{1} - \frac{\boldsymbol{treated\ tretament}}{\boldsymbol{untreated\ treatment}} \times 100.\mathbf{Yield\ (kg/ha)} = \frac{\text{Yield per plant (g)} \times \text{Plant population per pot} \times 10000}{\text{Pot area (m2)} \times 1000}$$

Conclusion

Irrigated soil with saline water increases the salt stress of faba bean growth. In the current study a valuable method was evaluated to mitigate the side effects of saline water. Foliar application of amino acids solution produced from shrimp wastes increased the salt tolerance of faba bean growth and productivity at 100 mM NaCl, according to mitigate the harmful effects of salt by increasing macronutrient and protein contents. The data suggested that under low saline water (50 mM NaCl) conditions, total amino acids could be sprayed until 1500 mg/L at 25, 40, 55 and 70 days of sowing. Furthermore, under high saline water (75 and 100 mM NaCl) condition all levels of amino acids (1000,1500 mg/L and 2000 mg/L) are important to minimize the hazardous effects of sodium on growth and yield of faba bean plants. Use of amino acids produced from shrimp waste is one of new and safety-effective technologies being applied for improving crop yield and for minimizing salinity stress-related alterations.

Conflicts of interest

There are no conflicts to declare

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