Research Article

The Effectiveness of Tryptophan and Foliar Spraying in Improving some Production and Quality Characteristics of Oats

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Abstract | During the winter agricultural season (2022–2023), an experiment was carried out in one of the fields in the Al-Mahawil district (30 km north of the Babil Governorate) to investigate the efficacy of the seaweed extract and the amino acid tryptophan in enhancing certain oat production and quality indicators. a randomized Complete block design (RCBD) were used in a factorial experiment with Three replicates. Spraying three concentrations of the amino acid tryptophan (0, 50, and 75 mg L^{-1}) and seaweed extract (0, 1, and 20 ml L^{-1}) were the first and second components in the investigation, respectively. The data were summarized as follows after the means were compared using the least significant difference test at a 5% probability level. The statistical analysis revealed significant differences among tryptophan concentrations across all yield and quality traits. The concentration of 75 mg L^{-1} resulted in the highest means for the weight of 1000 grains, the number of panicles, the number of grains per panicle, the total grain yield, the percentage of protein in the grains, and the percentage of carbohydrates in the grains, reaching 322.88 panicles m^{-2}, 58.86, 36.17 (g), 4.53 (mega h^{-1}), 11.53, and 59.44, respectively. Similarly, the application of 20 ml L^{-1} of seaweed extract produced higher means in the same traits: The corresponding values were 321.60 (plant m^{-2}), 58.46 (plant grain^{-1}), 36.83 (g), 4.33, 9.00, and 61.49. The interaction between tryptophan and seaweed extract showed a synergistic effect. The seaweed extract and the amino acid tryptophan had a substantial dual interaction that affected every aspect of the production and quality components, The characteristics of the number of panicles, the number of grains in the panicle, the weight of 1000 grains, the total grain yield, the percentage of protein in the grains, and the percentage of carbohydrates in the grains were all higher in the treatment plants (75 mg L^{-1} + 20 ml L^{-1}) than in the control plants. These values were 335.30 (plant m^{-2}), 65.17 (plant grain-1), 40.30 (g), 4.90, 12.10, and 65.03, respectively.

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Introduction

One of the most important cereal crops in the Poaceae family is oats (*Avena sativa* L.). It is typically grown as a winter cereal crop. Oats are ranked seventh among cereal crops in terms of importance and yield. Oats have recently gained popularity due to their numerous health benefits and ability to prevent a wide range of ailments. Every 100 grams of oats contains 60.75% carbohydrates, 14.55% protein, 10.5% fat, 2.27% fiber, and 397 mg potassium (Legesse *et al*., 2020). Seaweed extracts are among the most important foliar nutrients. They are natural extracts from plants, herbs, and seaweeds, and their use has recently become widespread to reduce or eliminate the use of chemical fertilizers. They are widely used as an active nutritional supplement to improve production, yield, and quality (Hamid, 2025a). They are also an important source of nutrients and organic matter, in addition to containing many important growth promoters (auxins, cytokinins, and gibberellins), organic and amino acids, and a group of complex sugars and some vitamins that affect plant physiological processes (Hundi *et al*., 2025). Marine extracts increase growth by stimulating root growth, vegetative branches, early flowering, increasing yield, and increasing leaf chlorophyll and antioxidant content (Jafaar *et al*., 2022; Dre *et al*., 2022). To expand the cultivation of this crop, it is necessary to use tryptophan because of its importance in increasing and improving plant growth. Tryptophan is known as an important amino acid. Protein production involves the utilization of this aromatic amino acid. It is a nonpolar aromatic amino acid because it has an aliphatic amino group, a carboxyl group, and an indole side chain (Jafaar *et al*., 2020; Majeed *et al*., 2023). Indole acetic acid (IAA) is formed in part by tryptophan. It plays a crucial role in accelerating growth by forming plant tissues as a result of break down complex compounds and promote on plant growth and flowering (Khattab *et al*., 2016; Al-Hasnawi *et al*., 2020). Tryptophan contains roughly 14% nitrogen, which is released during the plant's metabolism or in the root zone. It contributes to increased field crop productivity (Mustafa *et al*., 2018; Hamid, 2025b). Spraying plant leaves with tryptophan stimulates growth regulators and photosynthesis, resulting in improved plant development (Hassan *et al*., 2023). In plants, the tryptophan pathway has both defensive and protective functions (Dre *et al*., 2023). This study aimed to evaluate the effectiveness of seaweed extract and the amino acid tryptophan in enhancing certain yield and quality indicators.

Materials and Methods

During the winter agricultural season (2023–2024), an experiment was conducted in a field in Al-Mahawil District (30 km north of Babil Governorate) located between longitudes (44°-30°-44°) east and latitudes (3°-32°-33°) north. The goal was to investigate the efficacy of (tryptophan) and seaweed extract in increasing oat production and quality parameters. Before planting, random soil samples were collected from various sites in the experimental field at depths ranging from (0-30) cm, and a series of physical and chemical tests were performed at the soil analysis laboratory.

Table 1: *Field soil's physical and chemical characteristics.*

Characteristic		Values
pH		7.4
E.C		7.4 ds m^{-1}
O.M		1.4 %
Available Nitrogen		32.60 mg kg^{-1}
Available Phosphorus		8.7 mg kg^{-1}
Available Potassium		324 mg kg^{-1}
Soil- separators	Sand	282
	Clay	91
	Silt	627
The texture		Silty Loam

A factorial-experiment was applied using a Randomized Complete Block Design (RCBD) with three replicates. The study factors involved two factors: the first factor was spraying three concentrations of tryptophan (0, 50 and 75) mg L^{-1}, the second factor was spraying seaweed extract at three concentrations (0, 10 and 20) ml L^{-1}, the fertilizer used in our research is in the form of a dark black powder that is sprayed on the green groups of plants and is locally called algae. Its trade name is Alga21ST, produced by a Chinese company. The experimental plot was divided according to the field plan into experimental units (3 x 3 x 3 = 27) with an area of 4 m^2 (2 x 2 m). There were eight rows in each experimental unit, spaced 20 cm apart. On November 12, 2022, seeds were planted in rows at a rate of 120 kg ha^{-1}, yielding 6 gm per row.

Characteristics studied

- Number of panicles per m^2: The panicles were counted in an area of 1 m^2, randomly selected during the harvest phase.

- Number of grains per panicles: calculated using the mean of ten mature panicles randomly picked from each treatment at the physiological maturity stage.
- Weight 1,000 grains (g): 1,000 grains were counted at random for each treatment and weighed on an electronic balance that is sensitive.
- Grain Yield (megagrams h^{-1}): Based on the collected grain weight, an estimate from the center lines per square metre previously harvested for each experimental unit after manual threshing and separation of straw from grains. The yield per square meter was calculated and then converted to megagrams h^{-1}.
- Grain protein percentage: A 0.2 g sample was digested using a mixture of concentrated sulfuric and perchloric acids in a 1:1 ratio, following the method of Gresser and Parson (1979). After digestion, the protein content was estimated using a Micro-Kjeldahl device, and calculated as: protein % = nitrogen content × 6.25
- Grain carbohydrate percentage (%): A ground sample of 0.2 g was prepared, and carbohydrate content was measured at a wavelength of 490 nm using a spectrophotometer, following the Joslyn (1970).

Results

Table 2 shows that there were significant difference between concentrations of tryptophan in the number of panicles m^{-2}, with the concentration (75 mg L^{-1}) achieving the highest mean number of panicles, reaching 322.88 (panicles m^{-2}), while the control - treatment plants produced the low mean, reaching 298.49 panicles m^{-2}. The plants treated with seaweed extract at a concentration of 20 ml L^{-1} had the largest mean number of panicles (321.60 panicles m^{-2}), while the control - treatment had the low mean (297.74 panicles m^{-2}). significantly affected the number of panicles, with the treatment (75 mg L^{-1} + 20 ml L^{-1}) producing the highest value (335.30 panicles m^{-2}), and the control the lowest (290.10 panicles m^{-2}. The number of panicles was significantly impacted by the interaction between the seaweed extract and tryptophan, as the treatment plants (75 mg L^{-1} + 20 ml L-1) produced the high mean number of panicles, 335.30 (panicle m^{-2}), whereas the control - treatment produced the low mean, 290.10 (panicle m^{-2}).

Table 2: *The effectiveness of tryptophan and seaweed extract in the number of panicles (panicle m^2).*

Seaweed extract/ Tryptophan	0	10	20	Mean
0	290.10	293.07	300.30	294.49
50	298.03	313.27	329.20	313.50
75	305.10	328.23	335.30	322.88
Mean	297.74	311.52	321.60	
L.S.D0.05	0.180	0.180	0.312	

In the characteristic of the number of grains per the panicle, the concentration of tryptophan (75 mg L^{-1}) produced the high mean, amounting to 58.86 (panicle $grain^{-1}$), while the control - plants produced the lowest mean, amounting to 47.13 (panicle $grain^{-1}$). Table 3 results demonstrate that there were significant differences between the concentrations of tryptophan. The concentration of seaweed extract (20 ml L^{-1}) produced the high mean in the characteristic of the number of grains in the panicle for the plants treated with it, 58.46 (panicle $grain^{-1}$); in contrast, the control - treatment produced the low mean, 45.89 (panicle $grain^{-1}$). The number of grains in the panicle was significantly impacted by the dual interaction between the seaweed extract and tryptophan. The treatment plants (75 mg L^{-1} + 20 ml L^{-1}) produced the high mean number of grains in the panicle, 65.17 (spike $grain^{-1}$), while the control treatment plants produced the low mean, 42.10 (spike $grain^{-1}$).

Table 3: *The effectiveness of tryptophan and seaweed extract in the number of grains (panicle m^2).*

Seaweed extract/ Tryptophan	0	10	20	Mean
0	42.10	48.17	51.13	47.13
50	45.27	51.30	59.07	51.88
75	50.30	61.10	65.17	58.86
Mean	45.89	53.52	58.46	
L.S.D0.05	0.155	0.155	0.269	

According to Table 4, the concentrations of tryptophan in the 1000-grain weight characteristic showed significant differences. The concentration (75 mg L^{-1}) produced the highest mean, measuring 36.17 (g), while the control plants produced the low mean, measuring 28.87 (g). In the 1000-grain weight characteristic, the plants treated with seaweed extract exhibited the highest mean (36.83 g) at a concentration of 20 ml L^{-1}, whereas the control had the lowest mean of (27.52 g). The two-way interaction between tryptophan and seaweed extract significantly increased 1000-grain weight, with the (75 mg L^{-1} + 20 ml L^{-1}) treatment yielding 40.30 g, and the control only 24.30 g. The low mean, 24.30 (g), was obtained from the comparative treatment.

Table 4: *The effectiveness of the tryptophan and seaweed extract in the 1000-grain weight (gm).*

Seaweed extract/ Tryptophan	0	10	20	Mean
0	24.30	29.17	33.13	28.87
50	28.10	33.23	37.07	32.80
75	30.17	38.03	40.30	36.17
Mean	27.52	33.48	36.83	
L.S.D 0.05	0.166	0.166	0.287	

In the total grain yield characteristic, the concentration of tryptophan (75 mg L^{-1}) produced the high mean of 4.53 (Mg h^{-1}), while the control - treatment plants produced the lowest mean of 3.51 (Mg h^{-1}). These results in Table 5 showed significant differences between the concentrations of tryptophan. Regarding the seaweed extract-treated plants, the concentration (20 ml L^{-1}) produced the high mean of 4.33 (mega h^{-1}) in The combination of 75 mg L^{-1} tryptophan and 20 ml L^{-1} seaweed extract resulted in the highest yield (4.90 Mg ha^{-1}), while the control yielded only 3.50 Mg ha^{-1}. The treated plants (75 mg L^{-1} + 20 ml L^{-1}) performed better, yielding 4.90 (mega h^{-1}), whereas the control produced the low mean of 3.50 (mega h^{-1}). This indicates that the dual interaction between tryptophan and the seaweed extract had a considerable impact on the overall grain production.

Table 5: *The effectiveness of tryptophan and seaweed extract in the total grain yield (mega h^{-1}).*

Seaweed extract/ Tryptophan	0	10	20	Mean
0	3.50	3.22	3.80	3.51
50	3.70	3.98	4.30	3.99
75	4.20	4.50	4.90	4.53
Mean	3.80	3.90	4.33	
L.S.D0.05	0.045	0.045	0.090	

Table 6 shows that the percentage of protein in grains varies significantly depending on the concentration of tryptophan. The concentration (75 mg L^{-1}) produced the high mean of 11.53 (%), while the control plants produced the low mean of 8.27 (%). The concentration of seaweed extract (20 ml L^{-1}) produced the high mean percentage of protein in grains (9.00%) for the plants treated with it, whereas the control treatment produced the low mean (7.30%). The treated plants (75 mg L^{-1} + 20 ml L^{-1}) outperformed, producing the largest amount of 12.10 (%), while the control treatment supplied the low mean of 7.30 (%), indicating that the dual interaction between tryptophan and seaweed extract had a substantial impact on the total grain yield.

Table 6: *The effectiveness of tryptophan and seaweed extract in the grain's protein content (%).*

Seaweed extract/ Tryptophan	0	10	20	Mean
0	7.30	8.50	9.00	8.27
50	8.20	9.70	10.90	9.60
75	10.70	11.80	12.10	11.53
Mean	7.30	8.50	9.00	
L.S.D0.05	0.096	0.096	0.192	

Table 7 shows that the percentage of carbohydrates in the grains varies significantly depending on the concentration of tryptophan. The concentration of 75 mg L^{-1} produced the high mean percentage of carbohydrates in the grains, reaching 59.44 (%), while the control treatment plants produced the low mean, 50.87 (%). The concentration of seaweed extract (20 ml L^{-1}) produced the high mean percentage of carbohydrates in the grains (61.49) % for the plants treated with it, whereas the control produced the low mean (49.77) %. The percentage of carbohydrates in the grains was significantly impacted by the dual interaction between the seaweed extract and tryptophan. The treatment plants (75 mg L^{-1} + 20 ml L^{-1}) produced the high mean of 65.03 (%), while the control treatment produced the low mean of 44.17 (%).

Table 7: *The effectiveness of the tryptophan and seaweed extract in the grains carbohydrates content (%).*

Seaweed extract/ Tryptophan	0	10	20	Mean
0	44.17	50.30	58.13	50.87
50	51.07	54.10	61.30	55.49
75	54.07	59.23	65.03	59.44
Mean	49.77	54.54	61.49	
L.S.D0.05	0.175	0.175	0.304	

Discussion

The impact of tryptophan on panicle number could be because amino acids enhance growth characteristics and yield. This is because amino acids are biostimulants that promote plant growth and nutrient uptake (Queiroz *et al*., 2023). Amino acids are essential for maintaining cllular pH balance and fostering plant cell development since they include both basic and acidic groups. The production of auxins and of indole acetic acid (IAA), which are essential for stimulating plant growth, is closely linked to tryptophan application. According to (Saad and Alrubaiee, 2023; Mahmoud *et al*., 2021; Hamid *et al*., 2025), the rise in panicles was a significant reflection of this. Since tryptophan promotes cell division, it contributes to plant growth, cell elongation, protein synthesis, and nutrient absorption. This helps explain why there are more grains in the panicle. Water makes the new cell walls more elastic and flexible, which enables them to lengthen and expand in size a process promoted by tryptophan-induced IAA synthesis. This is consistent with Al-Myali *et al*. (2020), and it was demonstrated by the notable rise in the quantity of grains per panicle. Tryptophan's ability to increase the weight of 1000 grains may be due to its role as an amino acid. involved in plant growth and development (Ali *et al*., 2021; Alaamer *et al*., 2023; Alnuaimi *et al*., 2019). Amino acids also improve protein and carbohydrate formation by enhancing carbon metabolism, chlorophyll production, and enzyme synthesis. This is supported by improvements in weight of 1000 grains, panicle number, and grain number per panicle (Tables 2-4). An essential and crucial component in the production of proteins is the amino acid tryptophan. The characteristics of the crop and its constituent parts, which are crucial for the manufacture of vital compounds like porphyrins and nucleotides, as well as a class of auxiliary enzymes known as enzyme Co- and activating hormones, are impacted when sprayed on leaves. The continuation of vital processes that lead to the synthesis of organic materials and the accumulation of dry matter within plants depends on amino acids. This was evident from the increase in grain yield. This is consistent with the findings of Mahmoud *et al*. (2021) and Hassoon *et al*. (2021). Tryptophan ether's ability to raise the proportion of protein and carbohydrates. Tables 6, 7 through improving nutrient availability has a significant effect on nitrogen concentration. Phosphorus, potassium, protein, and carbohydrate content, are enhanced by amino acids, which are vital compounds for plant metabolism, and tryptophan contains the element nitrogen, which the plant absorbs directly when sprayed on the leaves. This in turn activates the root system and increases the absorption of elements, including potassium and phosphorus. This explains the increase in carbon metabolism, which increases the efficiency of absorption of nutrients in the leaves. Spraying amino acids stimulates of the formation of hormones and growth regulators, so it is considered a biostimulant, as it stimulates growth and encourages plant growth under unfavorable climatic conditions (Dogara *et al*., 2024; Hussain *et al*., 2019). Amino acids have a significant impact on plant quality traits due to their role as a source of energy and carbon. Tryptophan is considered one of the important amino acids for the formation of IAA. Tryptophan has an effect on photosynthetic pigments, and thus leads to a rise in the percentage of carbohydrates. As a result of the transfer of amino acids in the plant, it leads to an increase in protein, and it has a role in the process of photosynthesis. This is consistent with what has been concluded (Alrubaiee *et al*., 2020; Mohammed *et al*., 2019; Hassan *et al*., 2021). In addition to the quantity of nutrients, seaweed extracts have high potassium concentrations, which may be the cause of the increase in vines. This, in turn, may have contributed to good vegetative growth and photosynthesis. This triggered carbohydrate synthesis and transfer, improving nutrient flow to developing panicles and boosting grain yield, and this is consistent with what was mentioned by Sunarpi *et al*. (2010), Major elements (potassium being the most important), minor elements (boron being the most important), and growth regulators (cytokinin being the most important) are the components of the algal fertilizer that helped form flowers, pollinate them, and fertilize them, which in turn increased the number of grains. This agrees with Thangaraju (2008) and Ali *et al*. (2021). The addition of algal fertilizer may enhance nutrient availability and thereby increase 1000-grain weight (Rani *et al*., 2024; Hassan *et al*., 2020). Apart from potassium's function in transporting produced materials from the leaves (the source) to the grain storage areas (the estuary), the plant's capacity to transform the net result of photosynthesis into stored dry matter and transport it to the estuaries (grains) also helped to increase assimilates materials, especially carbohydrates (Kavitha *et al*., 2008; Akol *et al*., 2024).

Conclusions and Recommendations

Based on the results, the study showed that the use of both seaweed extract and the amino acid tryptophan, either alone or in combination, led to a significant improvement in oat productivity and quality indicators. The combined treatment, containing 75 mg/L^{-1} of tryptophan and 20 ml/L^{-1} of seaweed extract, recorded the highest values for spike number, number of grains per spike, 1000-grain weight, total yield, and protein and carbohydrate content in grains. Therefore, the study recommends adopting this treatment as an effective option for improving oat production under conditions similar to the study area, while emphasizing the need to conduct additional experiments in different environments and agricultural seasons to ensure the stability and effectiveness of the results on a larger scale.

Novelty Statement

This study shows that foliar application of tryptophan combined with seaweed extract significantly enhances oat yield and quality traits, offering a practical biostimulant strategy for winter oats under Iraqi field conditions.

Author's Contribution

Ahmad Thamer Kamil Al-Sultani: Conceptualization, investigation, data curation, formal analysis, writing original draft.
Ali S. Hassoon: Methodology, supervision, project administration, Validation, writing, review and editing.
Farah A. Almosawi: Resources, visualization, literature review, data curation

Generative AI and AI-assisted technology statement
The authors have declared there is no generative AI and AI-assisted technology used in this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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