RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
54 (5) 1183-1190, 2022
http://doi.org/10.54910/sabrao2022.54.5.19
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

EFFECT OF FOLIAR APPLIED AMINO ACIDS ON GROWTH CHARACTERISTICS OF OAT (*AVENA SATIVA* L.)

S.M.A. ALSHADIWI* and S.H.A. ALRUBAIEE

Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq
*Corresponding authors' emails: ali.nazem@uokerbala.edu.iq, saad.mh1986@gmail.com
Email addresses of co-authors: sabreen.hazim@uobasrah.edu.iq

SUMMARY

The progressive study on oat (*Avena sativa* L.) transpired during the crop season of 2021–2022 at the Agricultural Research Station, College of Agriculture, University of Basrah, Iraq. The study aimed to determine the effects of amino acids foliar application on two oat cultivars. Experimenting with a randomized complete block design included a split-plot arrangement. Two oat cultivars (Shafa and Genzania) grown and placed in secondary plates received seven treatments of three different amino acids (Control - No amino acid, 50 and 100 mg L^{-1} of L-Tryptophan, 50 and 100 mg L^{-1} of L-Glycine, and 50 and 100 mg L^{-1} of L-Lysine). The results revealed that oat cultivars and amino acid treatments differed significantly for most of the studied traits. The amino acid foliar application treatment of L-Tryptophan at the rate of 50 mg L^{-1} showed significant superiority, which boosted and provided the highest rate of flag leaf area, chlorophyll content, crop growth rate, and green fodder yield. However, the cultivar Shafa exhibited superiority for flag leaf area, chlorophyll content, and the green and dry fodder yield, with increased values of 7.15 cm^2, 8.11 µg cm^{-3}, and 8.01% and 5.61% t ha^{-1}, respectively.

Keywords: Oats (*Avena sativa* L.), amino acids, L-Tryptophan, L-Glycine, L-Lysine, oat growth traits

Key findings: The oat cultivars and amino acid treatments differed significantly for most growth traits. Oat cultivar 'Shafa' and foliar application of amino acid L-Tryptophan (50 mg L^{-1}) showed significant superiority for growth traits.

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: October 8, 2022; Accepted: December 15, 2022.

INTRODUCTION

Oat is a vital winter cereal crop that belongs to the Poaceae family. Its importance comes through its multiple uses in the human diet due to its high vitamins and protein percent and the manufacture of bread and pasta, and unsaturated fatty acids, in addition to high antioxidants compared with other cereals (Duda *et al*., 2021; Dvořáček *et al*., 2021). Oat is very limited in its cultivation and production rate compared with other cereals, and the best cultivars resulted from an assessment based on their performance through successful cultivation (Alrubaiee *et al*., 2018, 2019; Al-Yasari, 2022). Past studies comparing three cultivars of oats (Genzania, Shafa, and Carloup) showed the superiority of the oat cultivar through plant stature and crop growth rate (Al-Freeh *et al*., 2019). Also, the findings

To cite this manuscript: Alshadiwi SMA, Alrubaiee SHA (2022). Effect of foliar applied amino acids on growth characteristics of oat (*Avena sativa* L.). *SABRAO J. Breed. Genet.* 54(5): 1183-1190. http://doi.org/10.54910/sabrao2022.54.5.19.

of Alrubaiee *et al*. (2019) revealed the superiority of the cultivar in plant height, flag leaf area, and crop growth rate by comparing it with two other oat cultivars ('Shafa' and 'Oat11'). Hussein and Hashem (2021) also noted in their study comparing the oat genotypes and identified that 'Oat-11' proved superior in plant height and flag leaf area.

The Iraqi soil suffers from low fertility and high salinity, and the increased use of inorganic fertilizers leads to increasing environmental pollution, which impacts human health. The world continually searches for new and safe materials, such as amino acids, that increase yield and have no adverse effect on the environment. The plant can produce amino acids, but this synthesis requires a lot of energy, so spraying amino acids on the vegetative parts provides the plant with vitality, as well as, increases the development and construction of amino acids and to plant growth, especially in critical times and adverse environmental conditions (Helsel and Skrdla, 1983; Mohamed *et al*., 2019; Mirtaleb *et al*., 2021). Baqir and Al-Naqeeb (2019) also mentioned that in the foliar application of some amino acids (Tryptophan, Glycine, and Lysine) at three concentrations (0, 50, and 100 mg L^{-1}) on wheat, the Tryptophan (50 mg L^{-1}) showed superior in improving the growth traits and especially flag leaf area. Al-Badrawi and Alabdulla (2021) also found in their field study the effect of foliar spraying with four concentrations of tryptophan (zero, 60, 120, and 180 mg L^{-1}) on the growth of wheat that the concentration of 120 mg L^{-1} outperformed in the content of chlorophyll and the area of the flag leaf. El-Hosary *et al*. (2013) indicated in Egypt, in spraying wheat with three concentrations of tryptophan (zero, 50, and 100 mg L^{-1}) that there were significant differences between tryptophan concentrations, as the concentration exceeded 50 mg L^{-1}, giving the highest average number of shrapnel that reached 6.01 plant straws^{-1}. Meanwhile, the comparison treatment recorded the lowest average of 2.33 plant straws^{-1}, and the same treatment was superior in the green and dry fodder yields.

In Southern Iraq, with soils more affected by salt, a few studies have taken place about the effects of amino acids on the productivity of oats. Given the lack of studies related to amino acids and their impact on the growth and yield of oats and to determine the best combination (oat cultivar and amino acid), the latest study planned to assess the effects of foliar application of amino acids with different concentrations on oat cultivars and their interaction for growth characteristics.

MATERIALS AND METHODS

A field experiment on oat (*Avena sativa* L.) progressed during the crop season of 2021–2022 at the Agricultural Research Station, College of Agriculture, the University of Basra, Iraq. Acquiring random field soil samples and planting at a depth of 0–30 cm, their mixture provided the composite sample, with the soil's physical and chemical properties estimated in the laboratories according to Salim and Ali (2017) (Table 1). Experimenting with two factors laid out a randomized complete block design (RCBD) with a split-plot arrangement and three replications. Two oat cultivars (V1: Shafa, V2: Genzania) comprised the subplots, while the second factor included the foliar application of three amino acids with different concentrations (No spray of amino acids; L-Tryptophan, L-Glycine, and L-Lysine at 50 and 100 mg L^{-1}) remained in the main plots.

The field soil preparation included each block containing 14 experimental units, 1 m apart. Each experimental unit has an area of 6 m^2 (3 m × 2 m) with 12 lines 15 cm apart. Adding phosphate fertilizers (at the rate of 100 kg P_2O_5 ha^{-1}) occurred during the soil preparation (Abedi, 2011). Oat seed planting followed on 15 November 2021 at a seeding rate of 100 kg ha^{-1}. The irrigation used surface irrigation, with the weeds removed continuously from the field. Amino acid spraying on the vegetative parts of the plants ensued according to the required concentrations at three growth stages, i.e., a) at three leaves, b) at two nodes on the main

Table 1. Chemical and physical properties of the soil used for the study.

Objective	Value and unit	Objective		Value and unit
pH	7.60	E.C.		4.16 dS m^{-1}
N	42 mg kg^{-1} soil	Soil separators	Sand	278.40 g kg^{-1} soil
P	18.25 mg kg^{-1} soil		Silt	308.90 g kg^{-1} soil
K	137.4 mg kg^{-1} soil		Clay	412.70 g kg^{-1} soil
Organic matter	3.20 g kg^{-1} soil	Soil texture		Clay loam

stem, and c) at the blooming stage, with a 16-l portable sprinkler according to the scale developed by Zadoks *et al*. (1974). The control treatment remained with no foliar application of any amino acid.

Data recorded and analysis

The data recording on plant height (cm), flag leaf area (cm^2), chlorophyll content (μg cm^{-3}), crop growth rate (g m^{-2} day^{-1}), and yield of green and dry fodder (t ha^{-1}) used the following: measuring plant height (cm) used a meter rod from the surface of the soil to the base of the inflorescence of the main stem done randomly for 10 plants, then averaged. Calculating the flag leaf area (cm^2) consisted of an average of 10 plants taken randomly from each experimental unit upon completion of flowering, according to the following equation (Thomas, 1975).

$$\text{Flag leaf area} = \text{Flag leaf length} \times \text{Leaf width at the widest area} \times \text{correction factor } (0.95)$$

The estimated total chlorophyll content (μg cm^{-3}) resulted from chlorophyll extraction using acetone (80%) with the absorbance of the sample read by a spectrophotometer on a wavelength of 663 nm for chlorophyll a and 645 nm for chlorophyll b (Davies and Goodwin, 1976).

$$\text{Total Chlorophyll a } (mg\ L^{-1}) = (12.7\ [D663] - 2.69\ [D645] \times V / [100 \times W])$$

$$\text{Total Chlorophyll b } (mg\ L^{-1}) = (12.7\ [D645] - 4.68\ [D663] \times V / [100 \times W\})$$

$$\text{Total Chlorophyll } (mg\ L^{-1}) = 20.2D\ (645) + 8.02D\ (663).$$

The chlorophyll content calculation based on μg cm^{-3},
Where,
T. Chl = total chlorophyll content
D = optical density reading of the extracted chlorophyll based on wavelengths 663 nm and 645 nm, respectively
V = final volume of dilute acetone (80%)
W = sample soft weight (0.50) g

The crop growth rate (gm m^{-2} day^{-1}) calculation transpired during the growth period. Plant samples harvested from an area of 30 cm^2 from each experimental unit were placed in paper bags and dried in an electric oven at 65 °C for 48 h (Elsahookie, 2009).

$$CGR = 1/SA \times (W2-W1)/(T2-T1)$$

Where,
SA = Land area of the sample (cm^2)
W2 = dry weight of the plant sample for T2
W1 = dry weight of the plant sample for the period T1
T1 = period from planting to first seeding (56 days)
T2 = the period from planting to the second planting (116 days).

The calculated green and dry fodder yields (t ha^{-1}) comprised the harvest of an area of 0.50 m^2 randomly from each experimental unit during the 50% flowering stage, directly weighing the plants using an electronic scale to avoid moisture loss, then converting the weight to t ha^{-1}. The dry matter yield in the first batch (t ha^{-1}).

Calculating the dry fodder yield (t ha^{-1}) also came from the same plant sample taken to compute the wet weight after being dried in an oven at a temperature of 65 °C for 72 h until the weight was stable, with the weight converted to t ha^{-1}. The yield of dry matter in the second cutting (t ha^{-1}).

Statistical analysis

The data obtained from the field experiment and the results received statistical analysis using a split-plot design following the analysis of variance (ANOVA) (Gomez and Gomez, 1984). Using the test of least significant difference ($LSD_{0.05}$) compared and differentiated the mean differences, with the statistical program GenStat12 utilized for this purpose.

RESULTS

Plant height

The oat cultivars caused significant differences, and on average, the cultivar Genzania showed increased plant height by giving the highest average (101.26 cm) as compared with the cultivar Shafa (98.71 cm) (Table 2). Foliar application of amino acids also caused a significant effect, with amino acid L-Tryptophan at the rate of 50 ml L^{-1} providing the highest mean (102.57 cm^2), closely followed by L-Lysine (100 ml L^{-1}), L-Tryptophan (100 ml L^{-1}), and L-Glycine (50 ml L^{-1}), with values of 102.10, 101.37, and 101.32 cm, respectively, as compared with the control treatment which

Table 2. Effect of foliar application of amino acids on the plant height (cm) in oat.

Amino acids \ Cultivars	Shafa (V_1)	Genzania (V_2)	Means
No spray of amino acid	92.48	97.33	94.91
L - Tryptophan 50 mg L^{-1}	100.87	104.27	102.57
L - Tryptophan 100 mg L^{-1}	98.87	101.20	101.37
L - Glycine 50 mg L^{-1}	99.53	104.93	101.32
L - Glycine 100 mg L^{-1}	90.60	100.27	98.60
L - Lysine 50 mg L^{-1}	97.87	95.53	99.03
L - Lysine 100 mg L^{-1}	100.07	104.47	102.10
Means	98.71	101.26	
$LSD_{0.05}$ Cultivars (C) = 1.70, Amino acids (AA) = 2.29, Interaction C × AA = NS			

Table 3. Effect of foliar application of amino acids on flag leaf area (cm^2) in oat.

Amino acids \ Cultivars	Shafa (V_1)	Genzania (V_2)	Means
No spray of amino acid	44.64	44.70	44.67
L - Tryptophan 50 mg L^{-1}	52.95	53.28	53.11
L - Tryptophan 100 mg L^{-1}	51.55	45.50	48.52
L - Glycine 50 mg L^{-1}	49.00	44.24	46.62
L - Glycine 100 mg L^{-1}	51.52	45.74	48.63
L - Lysine 50 mg L^{-1}	51.67	43.94	47.81
L - Lysine 100 mg L^{-1}	50.27	50.74	50.50
Means	50.23	46.88	
$LSD_{0.05}$ Cultivars (C) = 0.59, Amino acids (AA) = 2.07, Interaction C × AA = 2.72			

gave the lowest mean (94.91 cm^2). The interaction of oat cultivars and amino acids had nonsignificant effects on plant height. However, numerically the highest plant height emerged from cultivar Genzania in combination with amino acids L-Glycine at 50 ml L^{-1} (104.93 cm), L-Lysine at 100 ml L^{-1} (104.47 cm), and L-Tryptophan at 50 ml L^{-1} (104.27 cm).

Flag leaf area

The oat cultivars differed significantly for flag leaf area, and on average, the cultivar Shafa provided the maximum flag leaf area (50.23 cm^2), whereas the lowest value appeared with cultivar Genzania (46.88 cm^2) (Table 3). Spraying of amino acids caused a significant effect, and amino acid L-Tryptophan at the rate of 50 ml L^{-1} gave the highest flag leaf area (53.11 cm^2), closely followed by L-Lysine at 100 ml L^{-1} (50.50 cm^2), compared with the lowest value obtained in the control treatment (44.67 cm^2). The interaction between the cultivars and foliar application of amino acids also significantly affected the flag leaf area. The combinations of amino acid L-Tryptophan (50 ml L^{-1}) with oat cultivars Genzania (53.28 cm^2) and Shafa (***52.95*** cm^2) revealed at par and leading by showing the maximum flag leaf area, compared with the lowest values obtained in the interactions of control with oat cultivars Shafa (44.64 cm^2) and Genzania (44.70 cm^2), and L-Lysine **(**50 ml L^{-1}) with cultivar Genzania (43.94 cm^2) for the said trait.

Chlorophyll content in flag leaf

The results revealed substantial differences between the two oat cultivars for chlorophyll content in the flag leaf. On average, the cultivar Shafa scored superior (188.0 µg cm^{-3}), whereas the lowest value came from the cultivar Genzania (173.9 µg cm^{-3}) for the said trait (Table 4). Amino acids foliar application also caused a significant effect on chlorophyll content in flag leaf. On average, the foliar application of L-Tryptophan at the rate of 50 ml L^{-1} displayed superior (200.9 µg cm^{-3}), followed by L-Lysine at the rate of 50 ml L^{-1} (195.0 µg cm^{-3}), whereas the lowest value obtained in the control treatment (142.7 µg cm^{-3}). The interaction between oat cultivars and amino acids foliar application caused a significant effect on chlorophyll content in flag leaf. The oat cultivar Shafa with L-Tryptophan (50 ml L^{-1}) exhibited superior (220.5 µg cm^{-3}) chlorophyll content in flag leaf, followed by Shafa with L-Lysine at 50 ml L^{-1} (201.8 µg cm-

Table 4. Effect of foliar application of amino acids on flag leaf chlorophyll content (μg cm^{-3}) in oat.

Amino acids \ Cultivars	Shafa (V_1)	Genzania (V_2)	Means
No spray of amino acid	148.7	136.7	142.7
L - Tryptophan 50 mg L^{-1}	220.5	181.2	200.9
L - Tryptophan 100 mg L^{-1}	198.2	186.8	192.5
L - Glycine 50 mg L^{-1}	154.7	180.1	167.4
L - Glycine 100 mg L^{-1}	199.1	169.4	184.2
L - Lysine 50 mg L^{-1}	201.8	188.1	195.0
L - Lysine 100 mg L^{-1}	193.2	175.2	184.2
Means	188.0	173.9	
$LSD_{0.05}$ Cultivars (C) = 7.63, Amino acids (AA) = 9.67, Interaction C × AA = 13.13			

Table 5. Effect of foliar application of amino acids on crop growth rate (g m^{-2} day^{-1}) in oat.

Amino acids \ Cultivars	Shafa (V_1)	Genzania (V_2)	Means
No spray of amino acid	6.24	6.45	6.34
L - Tryptophan 50 mg L^{-1}	11.20	9.50	10.35
L - Tryptophan 100 mg L^{-1}	10.26	9.21	9.73
L - Glycine 50 mg L^{-1}	10.45	9.41	9.93
L - Glycine 100 mg L^{-1}	10.10	9.42	9.76
L - Lysine 50 mg L^{-1}	10.19	9.18	9.68
L - Lysine 100 mg L^{-1}	10.11	9.35	9.73
Means	9.79	8.97	
$LSD_{0.05}$ Cultivars (C) = 0.40, Amino acids (AA) = 0.90, Interaction C × AA = NS			

^{3}), L-Glycine at 100 ml L^{-1} (199.1 μg cm^{-3}), and L-Tryptophan at 100 ml L^{-1} (198.2 μg cm^{-3}). However, the control with cultivars Genzania (136.7 μg cm^{-3}) and Shafa (148.7 μg cm^{-3}) gave the lowest chlorophyll content values.

Crop growth rate

Significant differences appeared between the oat cultivars for the crop growth rate (Table 5). On average, the cultivar Shafa achieved the highest average crop growth rate (9.79 g m^{-2} day^{-1}), whereas genotype Genzania provided the lowest average value (8.97 g m^{-2} day^{-1}) for the said trait. The foliar application of amino acids also caused a relevant effect on the crop growth rate, and L-Tryptophan (50 ml L^{-1}) produced the highest crop growth rate (10.35 g m^{-2} day^{-1}), followed by L-Glycine at 50 ml L^{-1} (9.93 g m^{-2} day^{-1}), compared with the control (6.34 g m^{-2} day^{-1}). The interaction of both factors caused a nonsignificant effect. However, the maximum crop growth rate came with the cultivar Shafa with L-Tryptophan at 50 ml L^{-1} (11.20 g m^{-2} day^{-1}). The minimum crop growth rate resulted in the control with cultivars Shafa (6.24 g m^{-2} day^{-1}) and Genzania (6.45 g m^{-2} day^{-1}).

Green fodder yield

The oat cultivars revealed nonsignificant differences in green fodder yield. However, numerically at 15.24 t ha^{-1}, cultivar Shafa showed a higher green fodder yield as compared with Genzania (14.11 t ha^{-1}) (Table 6). Foliar application of amino acids caused a significant effect in green fodder yield, with L-Tryptophan at the rate of 50 ml L^{-1} exhibiting the highest green fodder yield (16.32 t ha^{-1}), followed by L-Lysine at 50 ml L^{-1} (16.02 t ha^{-1}). Inversely, the minimum green fodder yield emerged at the control (12.45 t ha^{-1}). The interaction between the cultivars and amino acids also affected a significant effect on green fodder yield. The combinations of cultivar Shafa with L-Lysine at 50 ml L^{-1} (17.95 t ha^{-1}) and L-Tryptophan at 50 ml L^{-1} (17.31 t ha^{-1}) rated as superior and showed the maximum green fodder yields. The control interactions with oat cultivars Genzania (12.03 t ha^{-1}) and Shafa (12.87 t ha^{-1}) demonstrated the lowest green fodder yields.

Table 6. Effect of foliar application of amino acids on green fodder yield (t ha^{-1}) in oat.

Amino acids \ Cultivars	Shafa (V_1)	Genzania (V_2)	Means
No spray of amino acid	12.87	12.03	12.45
L - Tryptophan 50 mg L^{-1}	17.31	15.32	16.32
L - Tryptophan 100 mg L^{-1}	14.70	14.43	14.56
L - Glycine 50 mg L^{-1}	13.70	14.61	14.16
L - Glycine 100 mg L^{-1}	15.23	14.53	14.88
L - Lysine 50 mg L^{-1}	17.95	14.09	16.02
L - Lysine 100 mg L^{-1}	14.92	13.75	14.34
Means	15.24	14.11	
$LSD_{0.05}$ Cultivars (C) = NS, Amino acids (AA) = 0.90, Interaction C × AA = 1.34			

Table 7. Effect of foliar application of amino acids on dry forage yield (t ha^{-1}) in oat.

Amino acids \ Cultivars	Shafa (V_1)	Genzania (V_2)	Means
No spray of amino acid	4.51	4.15	4.33
L - Tryptophan 50 mg L^{-1}	7.79	7.09	7.44
L - Tryptophan 100 mg L^{-1}	7.49	7.25	7.37
L - Glycine 50 mg L^{-1}	6.88	6.94	6.91
L - Glycine 100 mg L^{-1}	7.37	7.05	7.22
L - Lysine 50 mg L^{-1}	7.22	7.25	7.24
L - Lysine 100 mg L^{-1}	7.48	6.41	6.95
Means	6.96	6.59	
$LSD_{0.05}$ Cultivars (C) = 0.07, Amino acids (AA) = 0.21, Interaction C × AA = 0.27			

Dry fodder yield

Oat cultivars differed significantly for the dry forage yield, and on average, the cultivar Shafa displayed superior performance by giving the highest dry fodder yield (6.96 t ha^{-1}), with genotype Genzania recorded with the lowest average value (6.59 t ha^{-1}) (Table 7). Foliar application of amino acids also caused a substantial effect on dry fodder yield, with the spraying of L-Tryptophan at 50 ml L^{-1} revealing superior by giving the maximum dry fodder yield (7.44 t ha^{-1}), followed by L-Tryptophan at 100 ml L^{-1} (7.37 t ha^{-1}), compared with the control with the minimum dry fodder yield (4.33 t ha^{-1}). The interaction between the oat cultivars and amino acids also caused a meaningful effect on dry fodder yield. The combination of cultivar Shafa with L-Tryptophan at 50 ml L^{-1} (7.79 t ha^{-1}) and 100 ml L^{-1} (7.49 t ha^{-1}), and L-Lysine at 100 ml L^{-1} (7.48 t ha^{-1}) proved superior and showed the highest dry fodder yields. Conversely, the interactions of control (No amino acid spray) with cultivars Genzania (4.15 t ha^{-1}) and Shafa (4.51 t ha^{-1}) provided the lowest dry fodder yields.

DISCUSSION

The recent results revealed that both oat cultivars performed differently and showed significant differences for almost all the growth traits under the environmental conditions of Basrah, Iraq. The findings of Alrubaiee *et al*. (2018, 2019) also revealed significant differences among the oat genotypes and superiority of the oat cultivar Genzania for plant height, flag leaf area, crop growth rate, chlorophyll content, and green and dry fodder yield. These results can also refer to the differences in the oat cultivars due to genetic makeup, response to environmental conditions, and the utilization of available nutrients (Al-Freeh *et al*., 2019).

Amino acids foliar application caused a significant effect, with L-Tryptophan at the rate of 50 ml L^{-1} showing superior by giving the highest mean values for the majority of the growth traits and green and dry fodder yields, compared with the control treatment with the lowest mean value for the said traits. Explanation of this may relate to the high level of N content in amino acids, which stimulates the plant to produce auxins and manufacture more proteins and enhancing cell division and elongation, which eventually increases the plant's stature and other growth traits of the oat plant. The increased level of internal auxin also works on the distribution of processed nutrients and thus leads to preventing leaf fall and aging and delay in chlorophyll destruction (Al-Badrawi and Alabdulla, 2021).

Also, El-Hosary *et al*. (2013) and Gutierrez-Micelli *et al*. (2007) findings showed that photosynthetic pigments (chlorophyll) increased significantly under the influence of amino acids. The increase in chlorophyll content means that the foliar application of amino acid (L-Tryptophan) also leads to an increase in the vital activities of the plant (Mustafa *et al*., 2018), and increases the plant nutrition, rooting growth, chlorophyll content, and efficiency of elements absorption (Gonzalez Perez *et al*., 2015). The process of photosynthesis with high efficiency leads to an increase in the representations used in leaf growth. The reason for the increase in the content of chlorophyll in leaves may indicate that it is related to nitrogen liberated from amino acids as N enters the formation of chlorophyll. Myint *et al.* (2010) confirmed that chlorophyll directly relates to the plant's N content. Similarly, Bierman and Rosen (2005) also authenticated that N concentration in leaves can result from their chlorophyll content, as most of the N in plants concentrates in leaves.

The leaf photosynthesis reacts well with an increase in chlorophyll. Representations of this process, exploited to increase the growth represented by expanding flag leaf area means an increase in the interception of sunlight led to an upsurge in the dry weight of the flag leaf (Table 3).

Amino acids are one of the main cellular components of the plant involved in metabolic pathways and regulating osmotic efforts. Regulating and improving the metabolic pathways and osmotic efforts increases tiller number and enhance growth variables (Mouhamad *et al*., 2016). The treatment of Tryptophan-L spray at a concentration of 52 mg L-1 led to an increase in vegetative growth represented by the height of the plant (Table 2) and the chlorophyll content of the flag leaf (Table 3). The superiority of the interactive effect of oat cultivar Shafa and amino acid L-Tryptophan in the flag leaf area, crop growth rate, and chlorophyll content caused significant enhancement in green and dry fodder yields.

CONCLUSIONS

Both oat cultivars and amino acid treatments and their interactions revealed significant differences for most growth variables. Oat cultivar Shafa and amino acid (L-Tryptophan - 50 mg L^{-1}) foliar application significantly improved the growth parameters and eventually enhanced the green and dry fodder yields.

ACKNOWLEDGMENTS

The authors thank and appreciate the Department of Field Crops, College of Agriculture, University of Basrah, Iraq for providing all the facilities for the said research.

REFERENCES

Abedi JA (2011). A Guide to the Uses of Chemical and Organic Fertilizers in Iraq. The General Authority for Agricultural Extension and Cooperation, Iraqi Ministry of Agriculture. pp. 93.

Al-Badrawi MM, Alabdulla SA (2021). Effects of foliar spraying of salicylic acid with tryptophan on yield and quality parameters in wheat. *Plant Arch*. 21(1): 854-857.

Al-Freeh LM, Alabdulla SA, Huthily KH (2019). Effect of mineral-biofertilizer on physiological parameters and yield of three varieties of oat (*Avena sativa* L.). *Basrah J. Agric. Sci*. 32: 08-25.

Alrubaiee SHA, Alfatlawy ZHC, Jasim AH (2019). Response of two oats varieties to foliar fertilization with potassium and urea. *Plant Arch*. 19(1): 334-338.

Alrubaiee SH, El-Edany TY, Jasim AH (2018). Response of two oat varieties to spraying of ascorbic and salicylic acids and their interactions with silicon. *Res. on Crops*. 19(4): 580-586.

Al-Yasari MNH (2022). Potassium and nano-copper fertilization effects on morphological and production traits of oat (*Avena sativa* L.). *SABRAO J. Breed. Genet.* 54(3): 678-685. http://doi.org/10.54910/sabrao2022.54.3.20.

Baqir HA, Al-Naqeeb MAS (2019). Effect of some amino acids on tillering and yield of three bread wheat cultivars. *Iraqi J. Agric. Sci*. 50: 20-30.

Bierman PM, Rosen CJ (2005). Nutrient management for fruit and vegetable crop production: Nutrient cycling and maintaining soil fertility. *Univ. of Minnesota Ext. Serv. Pub*. pp. 1-24.

Davies BH, Goodwin TW (1976). Chemistry and Biochemistry of Plant Pigments. *Carotenoids 2*: 38-165.

Duda M, Tritean N, Racz I, Kadar R, Russu F, Fițiu A, Muntean E, Vâtcă A (2021). Yield performance of spring oats varieties as a response to fertilization and sowing distance. *Agronomy* 11(5): 1-18.

Dvořáček V, Jágr M, Kotrbová KA, Capouchová I, Konvalina P, Faměra O, Čepková HP (2021). Avenanthramides: Unique bioactive substances of oat grain in the context of cultivar, cropping system, weather conditions, and other grain parameters. *Plants* 10(11): 2485.

El-Hosary AA, Hammam GY, El-Morsi A, Hassan EA, El-Awadi ME, Abdel-Baky YR (2013). Effect of some bioregulators on growth and yield of some wheat varieties under newly cultivated land conditions. *Sci. and Nat.* 2(3): 75-83.

Elsahookie MM (2009). Seed growth relationships. Baghdad University. Ministry of Higher Education and Scientific Research, Iraq, pp. 150

Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research. (2nd Edition). John Wiley and Sons, New York, pp. 680.

Gonzalez Perez P, Zhang R, Wang X, Ye J, Huang D (2015). Characterization of the amino acid composition of soils under organic and conventional management after the addition of different fertilizers. *J. Soils Sediments* 15(4): 890-901.

Helsel DG, Skrdla RK (1983). Breeding for grain yield in oats (*Avena sativa* L.). *SABRAO J. Breed. Genet.* 15(2): 139-145.

Hussein KD, Hashem MA (2021). Effect of spraying ethephon and amino acid on the characteristics of two varieties of *Avena sativa* L. In *IOP Conference Series: Earth Environ. Sci*. 923(1): 1-7.

Mirtaleb SH, Niknejad Y, Fallah H (2021). Foliar spray of amino acids and potassic fertilizer improves the nutritional quality of rice. *J. Plant Nutr.* 44(14): 2029-2041.

Mohamed HF, Abdel-Lattif HM, Abd-El-Salam RM (2019). Response of some wheat cultivars to foliar application of some nutrient compounds under sandy soil conditions in Wadi-el-Natron. *Plant Arch.* 19(2): 2301-2314.

Mouhamad RS, Iqbal M, Qamar MA, Mutlag LA, Razaq IB, Abbas M, Hussain F (2016). Effect of gravistimulation on the amino acid profile of pea, rice, corn, wheat during early growth stages. *Inform. Process. In Agric*. 3(4): 244-251.

Mustafa A, Imran M, Ashraf M, Mahmood K (2018). Perspectives of using L-tryptophan for improving the productivity of agricultural crops: A Review. *Pedosphere*. 28(1): 16-34.

Myint AK, Yama Kawa T, Kajihara Y, Zenmoy T (2010). Application of different organic and mineral fertilizers on the growth, yield, and nutrient accumulation of rice in a Japanese ordinary paddy field. *Sci. Word J.* 5(2): 47-54.

Salim SJ, Ali NS (2017). Guide to Chemical Analysis of Soil, Water, Plants, and Fertilizers. Ministry of Higher Education and Scientific Research, College of Agriculture, Univ. of Baghdad, pp. 407.

Thomas H (1975). The growth responses to weather of simulated vegetative swards of a single genotype of *Lolium perenne*. *The J. Agric. Sci.* 84(2): 333-343.

Zadoks JC, Chang TT, Konzak CF (1974). A decimal code for the growth stages of cereals. *Weed Res*. 14(6): 415-421.