Research paper(Article)

Effect of foliar application of Humic acid on some Growth properties and forage yield of Oat cultivars (*Avena sativa* L.)

*Sabreen H. Alrubaiee[1] and Mohanad A. alsulaiman[2]**

1 Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq , sabreen.hazim@uobasrah.edu.iq.
2 Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq
**Correspondence: mohanadalsulaiman@gmail.com..*
http://dx.doi.org/10.21931/RB/2023.08.03.131

ABSTRACT

A field experiment was conducted in winter session of 2019-2020 at Almahawil, 10 Km north of Babylon governorate, Iraq (32° 29' 0.0024" N, 44° 26' 0.0024" E). The aim was to understand the effect of foliar application humic acid on some growth properties and forage yield of three Oat cultivars (*Avena sativa*), The experiment include two factors, the first one is humic acid at three levels (control, 2, 4 ml L^{-1}) which they are symbolized by H0, H1 and H2 respectively. The second factor is three Oat verities, (Shifaa, Ganzania, Carlop). The experiment design was applied as factorial experiment using randomized complete block design with three replicates. The results showed that, Ganzania under foliar application of H2 concentration of humic acid gave the highest leaf area index and crop growth rate by 7.847 and 14.661 g m^{-2} day^{-1} respectively. Moreover, foliar application of H2 and H1 on Ganzania cultivar gave highest green forage yield by 22.733, 22.500 t ha^{-1} without significant differences from foliar application of H2 on Shifaa by 22.733 t ha^{-1}. In addition, foliar application of H2 and H1 on Ganzania cultivars gave highest dry forage yield by 6.106 and 5.902 t ha^{-1} respectively.

Keywords: Oats, humic acid, cultivars, Forage yield

INTRODUCTION

Oat (*Avena sativa* L.) is a major winter forage and cereal crop. It ranks sixth in world cereal production, exceeded by wheat, maize, rice, barley, and sorghum [1]. The world production of oat has been trending downward, in one hand because the emphasis being placed on competitive crops that produce greater amounts of energy or protein, In other hand, because of decreased soil fertility due to continue cultivation of this crop with lack of attention to using a good nutrition program and lack of interest in applying appropriate soil and crop service operations [2]. Global grain production of oats was 22.19 million tons come from 9.41 million hectares by 2.36 t. ha^{-1} [3]. In most production countries, oat is usually cultivated in areas which are not optimal for wheat and barley, with less input. While, recently there is high interacted by Oat in order to produced green and dry forage during low forage production season. A large number of diverse materials can serve as sources of plant nutrients. The majority of nutrient input to agriculture comes from commercial mineral fertilizers. Organic manures are considered to play a significant but lesser role in nutrient contribution, leaving aside their beneficial effects on soil physicochemical and biological properties. For instance humates are organic fertilizer has great impact on growth and plants development in several crops [4, 5, 6, 7 and 8]. One of the forms of humates is humic acid, which is commercial organic fertilizer can be used as source of nutrients in order to improve and stimulants plants growth and production. In addition, humic acid is environmentally friendly as compared to chemical fertilizer [9]. Recently, studies revealed that treat Oat with humic acid lead to increased forage yield [10, 11 and 12]. Hence, the objectives of this study were to determine the effects of different concentrations of humic acid on growth and forage yield, and to evaluate Oat verities growth under experimental conditions.

MATERIALS AND METHODS

A field experiment was conducted during 2019-2020 season at Almahawil, 10 Km north of Babylon governorate, Iraq (32° 29' 0.0024" N, 44° 26' 0.0024" E). The aim was to investigate the effect of foliar application of humic acid on some growth properties and forage yield of three Oat cultivars (*Avena sativa* L.). A factorial experiment was applied according to the randomized complete block design with three replicates. The experiment include two factors, the first one is humic acid at three levels (control, 2, 4 ml L^{-1}) which they are symbolized by H0, H1 and H2 respectively. Deferent concentrations of humic acid applied at two times, tillering and stem elongation stage. The second factor was three Oat verities, (Shifaa, Ganzania, Carlop). The total number of experimental units are 27 with a distance of 6 m^{-2} (3 x 2). Experimental soil was prepared by two orthogonal tillage and then, the soil leveled and grained by disc harrows. Random samples were taken from field soil before planting (depth of 0-30cm), dried and passed in a 2 mm sieve to determine some physical and chemical properties of field (Table 1). Nitrogen fertilizer was added to the soil in form of urea, 46% N at 180 kg h^{-1} at two equal timing, the first one week after seed sowing, the second one at stem elongation stage. Phosphate fertilizer was added to the soil at seed sowing in form of triple superphosphate 21% P2O5 at 140 kg h^{-1}. Seeds were sowing as strip at 15 November 2019, the distance is 20 cm between line and another. Humic acid was used in form of humiplant fertilizer (80% HA) and spring at three timing 25, 50 and 75 days after planting. Tween 20 was used to decrease the surface tension of solution. Some growth and quality traits were measured, tellers m^{-2}, plant height of 10 plants , leaf area index of 10 plants, crop growth rate, relative growth rate and Green and Dry forage yield from one m^{-2} . The data were collected and analyzed statistically by GenStat statistical software 12. Data averages were compared by least significant difference (LSD) at probability level of 0.05 (LSD ($P<0.05$)).

Table 1. some physical and chemical properties of experimental soil before seeds sowing

Traits	Value	Traits	Value
Soil compensation	**g. Kg^{-1}**	**EC**	**1.5 (dS/m)**
sand	**443**	**N content**	**35.4 (ppm)**
Silt	**405**	**P content**	**8.8 (ppm)**
Clay	**152**	**K content**	**17.2 (ppm)**
Soil texture	**Silt loam**	**Na content**	**123.0 (ppm)**
Soil pH	**7.6**	**Ca content**	**126.8 (ppm)**

RESULTS

Tillers number (tillers m^{-2})

Tillers number per plant is a genetic trait and depends on the genetic ability of plant and its inter-action with field environmental conditions. The results of Table 2 revealed that humic acid (H) have significant effect on tillers m^{-2}. The increased of humic acid concentration to H2 significantly increased tillers m^{-2} by 633.67 tillers m^{-2} as compared to control (H0) 470.33 tillers m^{-2}. The results of Table 2 showed that Oat varieties differed significantly in tillers m^{-2} that is Ganzania variety produced highest tillers. m^{-2} by 615.78 as compared to Carlop which gave lowest mean by 502.22 tillers m^{-2}. The interaction of varieties and humic acid have a significant effect on tillers m^{-2} . Ganzania under H2 concentration of humic acid gave the highest increase of tillers m^{-2} by 682.00

as compared to the lowest tillers m^{-2} which have obtained by Carlop under control 454.67 tillers m^{-2}.

Plant height (cm)

Plant height is among the most important biomass yield components [13]. The results of Table 2 revealed that the foliar application of humic acid have significant effect on plant height, and the concentration of H2 gave the highest plant height by 81.81 cm as compared to control by 72.75 cm. Oat Cultivars differed significantly in plant heigh (Table 2). Carloop cultivar gave the highest plant height by 83.12 as compared to Ganzania which gave the lowest plant height reached to 72.88 cm. In addition, the results revealed that, the interaction of Oat cultivars and humic acid was significant. The cultivar of Carloop under H1 concentration of humic acid gave the highest plant height by 93.15. while under control treatment of humic acid the Ganzania and Carlop gave the lowest plant height by 69.29 and 69.55 cm respectively.

Leaf area index

The results of Table 3 showed that, foliar application of humic acid have significant effect on leaf area index, and the concentration of H2 gave the highest leaf area index (LAI) by 6.943 as compared to control 4.859. Oat Cultivars differed significantly in LAI (Table 2), Ganzania cultivar gave the highest leaf area index by 6.241 without any significant differences from Shifaa variety, whereas, Carlop gave the lowest leaf area index by 4.988. The interaction of cultivars and humic acid was significant; Ganzania under H2 concentration of humic acid gave the highest LAI by 7.847, whereas Carlop under control treatment produced the lowest LAI by 4.117.

Crop Growth Rate (g m^{-2} day^{-1})

Crop growth rate (CGR) is the gain in dry matter production on a unit of land in a unit of tune [14, 15]. The results of Table 2 showed that the addition of humic acid have a significant effect on crop growth rate (CGR), and the concentration of H2 gave the highest (CGR) by 13.652 g m^{-2} day^{-1} as compared to control which gave the lowest average by 8.312 g m^{-2} day^{-1}.Oat cultivars differed significantly in CGR (Table 2). Ganzania gave the highest CGR by 11.625 g m^{-2} day^{-1} as compared to Carloop which gave the low average by 10.480 g m^{-2} day^{-1}. The interaction between cultivars and humic acid has significant effect on CGR. Ganzania cultivar under H2 concentration of humic acid gave highest CGR by 14.661 g m^{-2} day^{-1}. Whereas, Carlop under control treatment of humic acid gave the lowest CGR of 8.013 g m^{-2} day^{-1}.

Relative Growth Rate (g g^{-1} day^{-1})

Relative growth rate (RGR) is growth rate relative to size that is, a rate of growth per unit time, as a proportion of its size at that moment in time[15]. It is also called the exponential growth rate, or the continuous growth rate. The results of Table 2 showed that foliar application of humic acid have a significant effect on Relative growth rate (RGR). The concentration of H2 gave the highest (RGR) by 15.030 g m^{-2} day^{-1} while the control the control treatment gave the low RGR by 10.559 g m^{-2} day^{-1} (Table 2). Oat cultivars differed significantly in RGR. Ganzania gave the highest RGR by 13.665 g m^{-2} day^{-1} with no significant differences with Shifaa by 13.560 g m^{-2} day^{-1} (Table 2).While Carlop gave the lowest average by 13.203 g m^{-2} day^{-1}.The interaction of cultivars and humic acid has significant effect on RGR. Ganzania and Shifaa cultivars under H2 and H1application of humic acid gave highest RGR by 15.653 and 15.497 g m^{-2} day^{-1} respectively. Whereas, Carlop under control treatment of humic acid (H0) gave lowest RGR by 10.237 g m^{-2} day^{-1}

Green forage yield (t ha^{-1})

The results of Table 2 showed that foliar application of humic acid lead to increased green forage yield (GFY). The concentration of H2 and H1 gave the highest (GFY) by 22.534 and 21.904 t ha^{-1} respectively. While, (H0) gave lowest (GFY) by 20.997 t ha^{-1}. The results of Table 2 indicated that there were significant differences between cultivars in GFY. Ganzania gave the highest green forage yield by 22.237 t ha^{-1}. Whereas, Carloop and Shifaa gave the lowest (G.F.Y.) by 21.538 and 21.661 t ha^{-1} respectively. The interaction of cultivars and humic acid has significant effect on GFY. Foliar application of H2 on Ganzania and shifaa, cultivars gave highest GFY by 22.963, 22.500 t

ha^{-1} without significant differences from foliar application of H2 on Shifaa by 22.733 t ha^{-1}. Whereas, shifaa under control treatment of humic acid (H0) gave lowest GFY by 20.747 t ha^{-1}.

Dry forage yield (t ha^{-1})

The results of Table 2 showed that foliar application of humic acid lead to increased dry forage yield (DFY). Foliar application of H2 and H1 gave highest DFY by 5.839 and 5.704 t ha^{-1}. While, the control treatment (H0) gave lowest DFY by 5.517 t ha^{-1}. The results indicated that there is a significant difference between cultivars in DFY. Ganzania gave the highest dry forage yield by 5.877 t ha^{-1}. Whereas, Carloop and Shifaa gave the lowest DFY by 5.589 and 5.594 t ha^{-1}. The interaction of cultivars and humic acid has significant effect on DFY. Foliar application of H2 and H1 on Ganzania cultivars gave highest DFY by 6.106 and 5.902 t ha^{-1} respectively. While under control treatment of humic acid, Shifaa and Carlop cultivars gave the lowest DFY by 5.402 and 5.525 t ha^{-1} respectively.

DISCUSSION

Humic acid

The results of Table 2 showed that, foliar application of humic acid lead to increased tillers m^{-2}, plant height (cm) and leaf area index. The concentration of H2 produced higher tillering m^{-2}, plant height (cm) and leaf area index by 34.00%, 12.45% and 42.89% respectively as compared to control. Foliar application of humic acid has positive effect on some growth properties probably due to hormone-like activity of humic acids [2], which increase the living activity of the plant: enzyme systems are intensified, cell division is accelerated [16].

Growth analysis parameters crop growth rate (CGR) and Relative growth rate (RGR) are one of the main growth factors which may directly reflect to forage and grain yield [15, 17]. CGR is a product of LAI. While, RGR measures the increase in dry matter with a given amount of assimilatory material at a given point of time. The results of table 2 showed that foliar application humic acid improved crop growth rate (CGR) and relative growth rate (RGR). The H2 concentration of humic acid increased CGR and RGR by 64.24% and 42.34% as compared to control respectively. This may be due to humic acid properties which lead to improved plant growth; tillers m^{-2}, plant height (cm) and leaf area index (Table 2). The study of [18] showed that, the addition of humic acid lead to increased enzymatic activity of photosynthesis as well as carbohydrate synthesis and so plant yield. Moreover, the results of Table 2 revealed that foliar application of humic acid lead to increased green forage yield. In addition foliar application of humic acid at H2 concentration lead to increase dry forage yield by 7.32% as compared to control. The positive role of foliar application of humic acid supported plant growth throw increased tillers numbers m^{-2}, as well as plant height and so lead to increase CGR and RGR consequently increased green and dry forage yield (Table 2 and Figure 1). The results indicated in Figure 1 showed that, there was high positive correlation in one hand between RGR and DFY and in other hand between CGR and DFY (R2=99). Our results agreed with those of [6] who reported that humic acid increased growth and productivity of crops.

Oat Verities

The results of Table 2 showed that oat varieties significantly differed in all most traits of this study. Ganzania produced higher tillers m^{-2}, leaf area index (LAI), crop growth (CGR), Relative growth rate (RGR) and green and dry forage yield by 22.13% as compared to Carlop, 25.12% as compared to Shifaa, 10.93% as compared to Carlop, 3.50% as compared to Carlop, 3.25% as compared to Carlop and 5.15% as compared to Carlop respectively. This is could be due to the different between cultivars in their genetic ability. The results revealed that Ganzania was more suitable than other cultivars that have been studded to produce dry forage yield (Table 2). These results are consistent with what was found by [19, 20 and 21], their results indicated that Oat verities differed significantly in growth properties and yield.

Interactions

The results of Table 2 revealed that the interaction of humic acid and Oat varieties have significant effect on all treaties that have been studied. Foliar application of humic acid (H2) lead to increase all the traits that have been studded for all Oat cultivars as compared to control (H0) .Ganzania at H2 concentration gave high tillers m^{-2} , leaf area index, crop growth rate (CGR), relative growth rate (RGR), green forage yield (GFY) and dry forage yield (DFY) by 40.88%, 61.22%, 66.04%, 45.11%, 8.08%, 8.55% as compared to control treatment of humic acid (H0). This indicated that

Ganzania cultivar appear high response for foliar application of humic acid as compared to other varieties (Table 2). That maybe due to single effect of the treatments [22,23].

Table 2 Effect of foliar application of humic acid Oat varieties and their interaction on some growth properties; Ti =Tillers (m-2); P.h (cm)= plant height (cm); LAI= leaf area index; CGR (g g-1 day-1)=Crop Growth Rate (g m-2 day-1); RGR (g m-2 day-1)= Relative growth Rate (g m-2 day-1); G.F.Y. (t h-2)=Green Forage yield (t h-1); D.F.Y. (t h-1)= Dry Forage yield (t h-1)

Treatment		Traits measured						
		Ti (m^{-2})	**P.h (cm)**	**LAI**	CGR **($g\ g^{-1}day^{-1}$)**	RGR **($g\ m^{-2}\ day^{-1}$)**	GFY **($t\ h^{-1}$)**	DFY **($t\ h^{-1}$)**
H0		470.33	72.75	4.859	8.312	10.559	20.977	5.517
H1		601.11	78.09	5.447	10.882	14.840	21.904	5.704
H2		633.67	81.81	6.943	13.652	15.030	22.534	5.839
LSD (P<0.05)		8.908	1.052	0.251	0.3943	0.1665	0.7665	0.138
Shifaa		585.11	77.65	6.020	10.741	13.560	21.661	5.594
Ganzania		615.78	72.88	6.241	11.625	13.665	22.237	5.877
Carlop		504.22	83.12	4.988	10.480	13.203	21.538	5.589
LSD (P<0.05)		4.905	2.052	0.250	0.7943	0.3943	0.4665	0.245
Shifaa	H0	468.00	79.41	5.593	8.693	10.653	20.747	5.402
	H1	628.00	73.84	5.820	10.560	15.497	21.503	5.620
	H2	659.33	79.69	6.647	13.370	14.530	22.733	5.760
Ganzania	H0	488.33	69.55	4.867	8.830	10.787	21.247	5.625
	H1	677.00	70.27	6.010	11.883	14.557	22.500	5.902
	H2	682.00	78.82	7.847	14.661	15.653	22.963	6.106
Carlop	H0	454.67	69.29	4.117	8.013	10.237	20.997	5.525
	H1	498.33	93.15	4.510	10.203	14.467	21.710	5.589
	H2	559.67	86.91	6.337	12.923	14.907	21.907	5.652
LSD (P<0.05)		8.496	1.821	0.433	0.6830	0.2875	0.7884	0.201

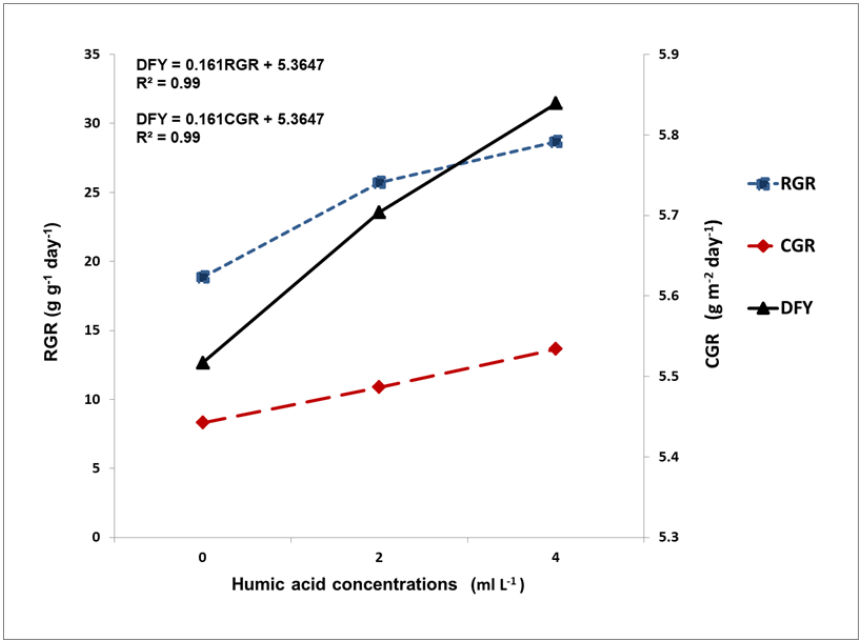

Figure 1: Effect of foliar application of humic acid on relative growth rate (RGR in g g-1 day-1), crop growth rate (CGR in g m-2 day-1) and dry forage yield (DFY in t ha-1) of three Oat cultivars. RGR and CGR data come from harvested plant of 0.5 m2. DFY data come from harvested plants of 1 m2

CONCLUSION

We conclude that humic acid considered as important source of nutrition for Oat cultivers. Foliar application of humic acid (4 ml L^{-1}) leads to increas green and dry forage of yield for all Oat

cultivars by increased leaf area index, crop growth rate and relative growth rate. Ganzania produced higher green and dry forage yield by 22.237 and 5.877 t ha^{-1} respectevely as compared to other Oat cultivars.

REFERENCES

1. Ma, B.-L., Zheng, Z., Ren, C., 2021. Crop physiology case histories for major crops. Elsevier, pp. 222-248.
2. Al-Taey, D.K.A., Al-Shareefi, M.J.H., Mijwel, A.K., Al-Tawaha, A.R., Al-Tawaha, A.R., The beneficial effects of bio-fertilizers combinations and humic acid on growth, yield parameters and nitrogen content of broccoli grown under drip irrigation system. Jornal of Bulgarian Journal of Agricultural Science ,**2019**; 25, 959-966.
3. USDA, 2022. World Agricultural Production. https://apps.fas.usda.gov/PSDOnline/Circulars/2022/02/production.pdf
4. Ali, H. H.; AL-Rawi, K.; Khalaf, Y.; Alaaraji, S.; Aldahham, B.; Awad, M.; Al-ani, O.; Al-ani, F.; Ali, A. T. Serum Caveolin-1 Level Is Inversely Associated with Serum Vaspin, Visfatin, and HbA1c in Newly Diagnosed Men with Type-2 Diabetes. Rep Biochem Mol Biol **2022**, 11 (2).
5. El-Sherbeny, S.E., Hendawy, S., Youssef, A., Naguib, N., Hussein, M. Response of turnip (*Brassica rapa*) plants to minerals or organic fertilizers treatments. Journal of Applied Sciences Research**. 2012**; 8, 628-634.
6. Daur, I., Bakhashwain, A.A. Effect of humic acid on growth and quality of maize fodder production. Jornal of Pak, **2013;**. J. Bot 45, 21-25.
7. Kandil, A.A., Sharief, A.E.M., Seadh, S.E., Altai, D. Role of humic acid and amino acids in limiting loss of nitrogen fertilizer and increasing productivity of some wheat cultivars grown under newly reclaimed sandy soil. Journal of Int. J. Adv. Res. Biol. Sci, **2016**; 3, 123-136.
8. Teileb, W.M.K., Mourad, K. Effect of different levels of humic acid and mineral fertilizers on growth and productivity of sunflower. Journal of Journal of Plant Production Sciences, **2019;** 8, 11-18.
9. Klučáková, M., Pavlíková, M. Lignitic Humic Acids as Environmentally-Friendly Adsorbent for Heavy Metals. Journal of Chemistry , **2017;**195-200.
10. Barsila, S.R. The fodder oat (*Avena sativa*) mixed legume forages farming: nutritional and ecological benefits. Journal Natural Resources of Agriculture, **2018;** 1, 206-222.
11. Alabdulla, S.A. Effect of foliar application of humic acid on fodder and grain yield of oat (*Avena sativa* L.). Journal of Research on Crops, **2019;** 20, 880-885.
12. Alfreeh, L.M. Influence of on Spraying Humic Acid and Number of Cutting Forage Yield of Oat (*Avena sativa* L.). Indian Journal of Ecology, **2021;** 48 86-89.
13. Fernandez, M.G.S., Becraft, P.W., Yin, Y., Lübberstedt, T. From dwarves to giants? Plant height manipulation for biomass yield. Journal of Trends in plant science, **2009;** 14, 454-461.
14. Barret, F. D., Justes, E., Machet, J. M. and Mary, B. Integrated Control of Nitrate Uptake by Crop Growth Rate and Soil Nitrate Availability under Field Conditions. Journal of Annals of Botany, **2000;** 86: 995±1005.
15. Rajput, A., Rajput, S. S. and Jha, G. Physiological Parameters Leaf Area Index, Crop Growth Rate, Relative Growth Rate and Net Assimilation Rate of Different Varieties of Rice Grown Under Different Planting Geometries and Depths in SRI. Int. J. Pure App. Biosci, **2017**; 5 (1): 362-367.
16. Al-Rawi, K. F.; Ali, H. H.; Guma, M. A.; Alaaraji, S. F. T.; Awad, M. M. The Relationships of Interleukin-33, Ve-Cadherin and Other Physiological Parameters in Male Patients with Rheumatoid Arthritis. Pertanika J Sci Technol **2022**, 30 (1), 123–140.
17. Al-Rawi, K. F.; Ali, H. H.; Guma, M. A.; Alaaraji, S. F. T.; Awad, M. M. The Relationships of Interleukin-33, Ve-Cadherin and Other Physiological Parameters in Male Patients with Rheumatoid Arthritis. Pertanika J Sci Technol **2022**, 30 (1), 123–140.
18. Canellas, L.P., Olivares, F.L. Physiological responses to humic substances as plant growth promoter. Jornal of Chemical and Biological Technologies in Agriculture, **2014;** 1, 1-11.
19. Alzarkani, M.S.M., **2017**. Effect of soaking seeds with pyridoxine and spraying boron on grain yield and its components for four oats (*Avena sativa* L.). Ph.D Thesis, Faculty of Agriculture, Baghdad University, Iraq.
20. Majid, H., Salim, H. Impact of Planting Distances and Humic Acid on Oat (*Avena sativa*). Journal of Biology, Agriculture and Health care, **2018**; 8, 2224-3208.
21. Hussien, S. A. .; Doosh, . K. S. . Extraction And Purification Of B-Galactosidase From (Ziziphus Spina-Christi). JLSAR 2022, 3, 12-22.
22. Ghanim, I. .; Ebrahim, S. E. . Preparing Of Bio-Cement Mortar By Using Bacillus Licheniformis Bacterial Cells. JLSAR 2022, 3, 23-29
23. Alrubaiee, S.H. Responce of three cultivars of Oat (*Avena sativa* L.) to humic acid and its effect on yield and its components. Int. J. Agricult. Stat. Sci, **2021;** 17, 2201-2205.

Received: 25 June 2023/ Accepted: 26 August 2023 / Published:15 September 2023

Citation: Alrubaiee S. H.; Alsulaiman, M. A. F.; Effect of foliar application of Humic acid on some Growth properties and forage yield of Oat cultivars (Avena sativa L.). Revis Bionatura 2023;8 (3) 131 http://dx.doi.org/10.21931/RB/2023.08.03.131