Journal of Research in Ecology

ISSN No: Print: 2319 –1546; Online: 2319– 1554

An International Scientific Research Journal

Original Research

Foliar application of humic acid, it's components and effect on grain yield in *Sorghum*

Authors:
Al-Beiruty RZ[1], Finekher BM[2] and Khrbeet HK[1]

Institution:
1. College of Agriculture, University of Baghdad, Iraq.
2. Middle Technical University, Institute of Technical Anbar, Iraq.

Corresponding author:
Al-Beiruty RZ

ABSTRACT:

A field experiment was conducted at the experimental fields in the College of Agriculture, University of Baghdad during spring and autumn seasons of 2016 to study the effect of humic acid concentrations (0, 1, 2 and 3 $cm^3.L^{-1}$) and three stages of foliar application (vegetative growth, booting and 25% flowering) on grain yield and its components of *Sorghum* (CV. Bohooth.70). The experiment was applied using RCBD arranged in split plots with three replications. Foliar application stages were used as main-plot, while humic acid concentrations were used as sub-plot.

The highest grain yield in both season was 4.395 and 5.213 $ton.ha^{-1}$ respectively when plants were sprayed at the concentration of 3 cm^3L^{-1}. Foliar application at the stage of vegetative growth gave highest mean in plant height, leaf area, biological yield, grain weight $head^{-1}$, number of $grain.head^{-1}$ and grain yield ($ton.ha^{-1}$). The highest grain yield in spring and autumn seasons was 4.120 and 4.928 $ton.ha^{-1}$ respectively by foliar application at vegetative growth. The results showed a significant interaction between application stages and humic acid concentrations in means of grain yield. The higher grain yield of 6.070 and 5.380 $ton.ha^{-1}$ were obtained when *Sorghum* plants were sprayed with humic acid at the concentration of 3 $cm^3.L^{-1}$ in vegetative growth stage in spring and autumn seasons respectively.

Keywords:
Bohooth.70, Grain weight, Biological yield.

Article Citation:
Al-Beiruty RZ, Finekher BM and Khrbeet HK
Foliar application of humic acid, it's components and effect on grain yield in *Sorghum*
Journal of Research in Ecology (2018) 6(2): 2032-2043

Dates:
Received: 10 June 2018 **Accepted:** 04 Aug 2018 **Published:** 21 Sep 2018

Web Address:
http://ecologyresearch.info/documents/EC0567.pdf

Journal of Research in Ecology

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is a summer crop cultivated in Iraq to produce green forage and grain. Its cultivation spreads at different regions of the world like Asia, Africa, America and Australia, but its cultivation in Asia started to be reduced. But production in these regions have not much changed due to the release of a new improved variety with high yield (Reddy *et al*., 2010). In Iraq, the cultivated area for grain production was about 34, 000 ha with the productivity mean of 2580 $kg.ha^{-1}$ according to the Ministry of Agriculture statistics in 2016 (Statistical booklet of field crops data, 2016), and the provinces of Missan, AL-Nasirya, Wasit and Thi-Qar occupied the foreground rank in production. Sorghum grains are used as human food in many poor countries after mixing it with wheat flour in the percentage of 50%, whereas, in the agriculturally advanced countries such as United States of America, this crop is considered the second among food grain crops and used in biofuel production (Dantas *et al*., 2007). In addition to its use in producing starch and derivatives of dye and alcohol. Despite the importance of this crop, its grain and green forage production was still less than required level and this is due to the limited studies in this field especially new genotype entry and breeding and improvement processing methods done under the Iraqi conditions. A new genotype of sorghum was imported from abroad at 2010 on which breeding and vegetative qualities improvement processes were applied under Iraqi conditions in collaboration between Field Crop Department, College of Agriculture, University of Baghdad and Agricultural Researches Office, Ministry of Agriculture. After five years of field work, this genotype was registered and adopted by the Iraqi Ministry of Agriculture as the best species for its high productivity in green forage and named as Bohooth.70 (National committee for recording and protecting agricultural varieties, 2016).

It was known that developing the cultivation technique for any cultivar and spreading its cultivation among farmers needs to know how to produce the cultivar grains. Many studies were conducted in this species with in regard to the effect of some nutrients and growth regulators on grain yield by some scholars in field crop department (Jaddoo and Alwan, 2015).

But there are some aspects still away from researchers attention such as effect of organic fertilizer as alternative to chemical fertilizers which became well known with their harmful effect on human health and environment which requires the use of organic alternatives (Shehata *et al*., 2011) such as humic acid which has an importance in increasing plant growth when added as foliar application through its effect on photosynthesis and respiration. It also increases plant resistance to abnormal environmental conditions and increases cellular membrane permeability and stimulates many biological reactions (Dantas *et al*., 2007; Fathy *et al*., 2010) and some studies indicated humic acid importance in increasing dry matter production in *Sorghum* (Rao, 1987) and grain yield (Al-Khafagy, 2015). Humic acid has a great effect on the viability and production of pollen and increasing oocytes nodes ratio and also contributing in ovules fertility transfer to active regions of growth during plant reproductive stage (Shehata *et al*., 2011). So this study was aimed at increasing grain yield by using humic acid and knowing the best concentration and the suitable stage for spraying on *Sorghum* crop.

MATERIALS AND METHODS

A field experiment was conducted in the experimental field at Field Crop Department, College of Agriculture, University of Baghdad in spring and autumn seasons of 2016 using sorghum cultivar (Bohooth.70) which is registered and adopted recently by Iraqi Ministry of Agriculture. Layout of the experiment was Completely Randomized Block Design (CRBD), arranged in split plot with three replications. Foliar application stag-

Table 1. Effect of humic acid and spraying stages on plant height (cm) in spring and autumn seasons

S. No	Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
		Spraying stages				Spraying stages			
		Vegetative growth	Booting	25% Flowering	Mean	Vegetative growth	Booting	25% Flowering	Mean
1	(H_0) 0	209.7	202.3	198.0	203.3	229.7	219.0	217.0	221.9
2	(H_1) 1	245.3	228.7	230.7	234.9	268.7	249.0	251.7	256.4
3	(H_2) 2	271.7	272.0	236.0	259.9	299.0	282.0	264.3	281.8
4	(H_3) 3	291.0	264.7	234.3	263.3	329.7	292.7	258.3	293.6
	L.S.D.5%		20.6		10.2		17.0		9.8
	Mean	254.4	241.9	224.8		281.8	260.7	247.8	
	L.S.D.5%		17.7				11.9		

es (vegetative growth, booting and emergence of 25% of flowers from flag leaf sheath) were used as main plots, while humic acid concentration (0, 1, 2 and 3 $cm^3.L^{-1}$) were used as sub-plots. The experimental unit area for both seasons was 9 m^2 with dimension of 3×3 m, 6 lines were opened in each experimental unit with distance of 50 cm between each line and length of 3 m. The seeds were planted in pits at a distance of 25 cm between each hole by putting 3-5 seed in each hole. Thinning each plant in the hole (after three weeks in spring season and two weeks in autumn which due to the slow growth of sorghum plants in spring cultivation), was done in the last week of March for spring season and in the mid of July for autumn season.

Chemical fertilizers was added as recommended by Ministry of Agriculture and corn borer was controlled by using dyazanone fluid for two times, the first in the stage of 3-4 leaves and the second after two weeks of the first control with dyazanone as recommended by the Iraqi Ministry of Agriculture (Hamdan, 2006). The solution of humic acid was prepared according to the required concentrations from the commercially known nutritional solution (AL-Basha humic acid) which contains 18% of this acid. The spraying was done at morning till complete wet of the whole plant according to the determined concentrations whereas control treatment was sprayed with water only.

The studied characters : Leaf area (cm^2)

Six plants were selected randomly from the two mid lines at full flowering stage. By measuring leaf length and width for all plant leaves the leaf area was calculated by using the following formula:

$A = L \times W \times 0.75$

where, A: leaf area (cm^2); L: leaf length (cm); W: the widest part in leaf (cm); 0.75: standard (Liang *et al*., 1973).

Plant height and stem diameter (cm)

Plant height was measured at maturity stage for a sample of six randomly selected plants from mid lines. The length was measured from soil surface to plant top, stem diameter was also measured for these plants by measuring circumference of plant stem from the middle

Table 2. Effect of humic acid and spraying stages on leaf area (cm^2) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	4006	4019	4166	4064	4459	4433	4638	4510
(H_1) 1	5454	4928	5641	5341	6072	5354	6168	5865
(H_2) 2	6191	6582	5515	6096	6872	7153	6118	6714
(H_3) 3	7117	6172	5471	6254	7876	6731	6054	6887
L.S.D.5%		352		210		388		228
Mean	5692	5425	5198		6320	5918	5745	
L.S.D.5%		220				256		

of the first internode from soil surface by using measuring tape depending on the relation between the circumference and diameter (Quinby, 1963).

Yield and its components

Six heads were selected extracting their grains and the means of production was measured for each head in each experimental unit; samples were taken to measure 1000 grains weight by calculating the number of grains in each head from the relation between 1000 grains weight and the weight of grains of each head (Shihab, 2011).

The total grain yield (ton.ha^{-1}) was measured from grain weight of one plant × plant density. Biological yield was measured after drying six plants and then harvest index was calculated according to the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100 \quad \text{(Rao, 1987)}$$

Data were analysed by analysis of variance as described by Stee and Torrie (Steel and Torrie, 1980). Means were compared using LSD at the 5% level of significance. Simple correlation analysis was carried out using SPSS software version 20.

RESULTS AND DISCUSSION

Plant height

As indicated in Table 1, there was significant effect of humic acid concentration and stages of spraying and their interaction on this character for both seasons, at the concentration of 3cm^3.L^{-1} gave the highest mean of plant height reaching 263.3 cm in spring season but it didn't differ significantly at concentration of 2 cm^2.L^{-1} which in turn differs from the spraying treatment with concentration of 1 cm^3.L^{-1} and control treatment and the percentage of increase in plant height at the used concentrations of 1, 2 and 3 cm^3.L^{-1} compared with control treatment reached 15.5%, 27.8% and 29.5% respectively. Whereas in autumn season the plant height achieved linear significant increase with increased concentrations of acid sprayed reaching highest plant height of 293.6 cm and the percentage of increase in spraying concentrations 1, 2 and 3 cm^3.L^{-1} compared with control treatment were 15.8%, 26.9% and 32.3% respectively and the reason behind the increase in plant height with increasing the concentrations of humic acid may be due to the role of this acid in improving cell division and cell elongation which has a direct effect on different biological operations as it affects photosynthesis and respiration. These results are in agreement with the results found by Al-Khafagy (2015) in *Sorghum* plants and in beans plants (El-Chamry *et al.*, 2009; Al-Fahdawi, 2013).

Regarding the effect of spraying stages, Table 1 indicated significant differences between arithmetic means in both seasons. In spring season spraying stage at vegetative growth exceeded in giving the highest mean in plant length of 254.4 cm but didn't differ significantly from spraying at booting stage in which plant height reduced up to 13 cm, whereas differed significantly from spraying stage at 25% flowering in which plant height reached 224.8 cm. This may be due to spraying at booting stage or stage of 25% flowering which may transfer to reproductive organs in which growth and development started.

Table 1 also indicated a significant interaction between both factors for both seasons, and this interaction could be explained based on the difference in relative response to acid concentrations according to spraying stages as in both seasons plant height increased while spraying at vegetative growth stage with increase in acid concentrations, whereas delaying spray at booting stage or 25% flowering stage the highest mean of plant height was at concentration 2 cm^3.L^{-1}.

Leaf area

Table 2 indicated that there was a significant effect of concentrations of humic acid and stages of spraying and interaction between them in this character

Table 3. Effect of humic acid and spraying stages on stem diameter (cm) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	1.73	1.70	1.72	1.72	1.86	1.84	1.90	1.86
(H_1) 1	1.83	1.94	1.84	1.87	2.00	1.96	1.98	1.98
(H_2) 2	2.21	1.99	1.82	2.01	2.18	2.28	2.14	2.20
(H_3) 3	1.85	1.77	1.67	1.76	2.62	2.21	2.08	2.30
L.S.D.5%		N.S.		0.20		N.S.		0.12
Mean	1.90	1.85	1.76		2.16	2.07	2.03	
L.S.D.5%		0.09				0.10		

in both seasons. This table also showed that spraying plant with humic acid with high concentration of 3 $cm^3.L^{-1}$ gave the highest in leaf area reaching 6254 cm^2 and 6887 cm^2 in both seasons respectively and differed significantly from all concentrations except for concentration of 2 $cm^3.L^{-1}$, the mean of increase in leaf area at concentrations of 1, 2 and 3 $cm^3.L^{-1}$ compared with control treatment in spring (31.4%, 50% and 53%) and autumn seasons (30%, 48.8% and 52.7%) respectively. The increase in plant leaf area when spraying acid may be due to acid content of nitrogen which has a significant role in increasing the mass production of each vegetative organ and the roots which increased the consumption efficiency of water and absorption of necessary elements from soil (Sifola *et al*., 2002; Mohammed, 2009).

This result agreed with the results of Al-Khafagy (2015) and Daur and Bakhashwain (2013). This character was affected significantly by acid spraying stages in both seasons. In spring seasons, the plants sprayed at vegetative growth stage gave the highest mean in leaf area and reduced significantly when spraying stage was delayed and this reduction was about 4.7% compared with spraying at vegetative growth stage, 8.7% at both stages of booting and 25% flowering respectively. Whereas in autumn season, spraying at vegetative growth stage also exceeded as leaf area reached 6320 cm^3 and significantly differed from other spraying stages which didn't differ from each other. This may be due to spraying at vegetative growth which will provide enough time for plants to benefit from the nutrients found in the acid composition which will decrease the number of active leaves increasing plant vegetation and then increasing carbon representation system which was produced by leaves and then increased leaf area; in addition, spraying in late stages will be inactive in sustaining lower leaves activeness because it caused fall of some of these leaves especially as measuring this character was done at the end of flowering. Concerning the significant interaction between the two factors may be interpreted based on the difference in the relative response of each spraying stage and

Table 4. Effect of humic acid and spraying stages on biological yield ($ton.ha^{-1}$) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	17.24	17.03	17.17	17.15	18.63	18.62	18.10	18.45
(H_1) 1	18.85	18.31	18.05	18.41	22.00	20.85	21.03	21.29
(H_2) 2	20.62	20.24	19.21	20.02	24.64	23.43	22.13	23.40
(H_3) 3	20.98	20.62	19.45	20.35	26.65	24.42	21.72	24.26
L.S.D.5%		N.S.		0.41		1.28		0.71
Mean	19.42	19.05	18.47		22.98	21.83	20.74	
L.S.D.5%		0.40				0.96		

different concentrations, so we find that the difference were higher in response among spraying concentrations in vegetative growth stage, whereas it was lower between concentrations in late spraying stages.

Stem diameter

The results of Table 3 indicated a significant effect in all humic acid concentrations and stages of spraying in the character of stem diameter for both seasons. As in spring season, the plants sprayed at the concentration of $2cm^3.L^{-1}$ humic acid gave highest level in stem diameter reaching 2.0 cm and differed significantly from all concentrations except for the concentration of 1 $cm^3.L^{-1}$ in which stem diameter reached 1.87 cm. Whereas in autumn season, the high concentration of humic acid at $3cm^3.L^{-1}$ gave the highest stem diameter reaching 2.30 cm and differ significantly from all other concentrations except for the concentration $2cm^3.L^{-1}$ in which stem diameter reached 2.20 cm. The reason behind the increase in stem diameter after spraying with acid may be due to nitrogen content in acid which lead enhanced the ability of plants to absorb nutrients from soil as a result to increase the total root as indicated by Mohammed (2009) and this may reflect positively in increasing stem diameter. Table 3 showed that the highest mean of stem diameter were 1.90 cm and 2.16 cm at spraying in vegetative growth stage in both seasons respectively and differed significantly only in spraying stage at 25% flowering, and this may be due to spraying at vegetative growth which can give the stem an opportunity to benefit more from photosynthesis products; whereas, delayed spraying after this stage may lead to increase in competition on these products between vegetative parts such as stem and reproductive parts. No statistical evidence was available about significant interaction between the two factors.

Biological yield

The results of Table 4 indicated that in spring seasons the highest mean of biological yield was obtained when plants were sprayed at the concentration of 3 $cm^3.L^{-1}$ reaching 20.353 $ton.ha^{-1}$ and differ significantly from all concentrations except for 2 $cm^3.L^{-1}$, whereas the control treatment gave the lowest mean in biological yield with 17.151 $ton.ha^{-1}$. Whereas in autumn season, the increased concentration of spraying caused a significant linear increase in biological yield at the concentrations of 1, 2 and 3 $cm^3.L^{-1}$ compared with control treatment with 15.4%, 26.8% and 31.5% respectively. This increase in biological yield due to the role of humic acid in increasing vegetation though increasing averages of plant height, leaf area and stem diameter in plants (Tables 1, 2, 3) which caused increasing in plant ability to intercept sun radiation, increase photosynthesis and provide metabolized materials (El-Sahookie, 2004). This can also be interpreted by the positive relation between biological yield and each of plant height and leaf area in both seasons (Table 10). Table 4 also indicated the significant effect of biological yield with different stages of humic acid spraying for both seasons. As in spring season, the biological yield increased when plants were early sprayed at vegetative growth stage. Then, the yield was decreased when the plants were sprayed at booting stage, but this decrease were insignificant whereas the decrease was significant when spraying was delayed to 25% flowering stage. Concerning autumn season, the spraying stage at vegetative growth exceeded in giving the highest mean of biological yield with 22.98 $ton.ha^{-1}$. The yield reduced significantly in delayed spraying stages. This was due to the increase in leaf area and plant height which increased effective vegetation in unit area that was capable of intercepting the highest mean of light in early time of growth which increased plant photosynthesis and growth level causing increase in dry matter which had a positive correlation with leaf area, and that was promoted by the positive correlation of biological yield in both plant height and leaf area (Table 10).

Grains weight per head (g)

Weight of grains increased quickly after fertili-

Table 5.Effect of humic acid and spraying stages on grain weight per head (g) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	36.67	33.40	34.53	37.78	46.13	43.20	43.80	44.38
(H_1) 1	42.73	39.27	38.77	40.26	52.67	53.27	48.13	51.36
(H_2) 2	59.50	49.73	46.83	52.02	71.78	62.13	55.40	63.13
(H_3) 3	67.30	53.40	44.27	54.99	75.30	65.30	54.43	65.22
L.S.D.5%		6.71		3.92		7.67		4.51
Mean	51.55	43.95	41.10		61.65	55.98	50.44	
L.S.D.5%		4.48				4.16		

zation and three quarters of dry weight accumulated at the end of the phase and the weight reached maximum level at physiological maturity phase (Vanderlip, 1993). The results of Table 5 indicated that the highest mean of grains weight in head was when sprayed with high concentrations of humic acid 3 $cm.L^{-1}$ and the lowest mean of grain weight was in control treatment which differed significantly only in autumn season than other concentrations. From that it was noted as grains weight increased generally in autumn season than in spring season. Concerning the increase in grains weight when spraying plants with humic acid may be due to the increase in the content of chlorophyll of the leaves (Al-Fahdawi, 2013; Sifola *et al*., 2002). They indicated a significant effect of chlorophyll increase in the leaves. This will help in keeping the leaves green and active for a long time and delaying leaves aging which helped in increasing the period of grain fullness.

Concerning the effect of spraying with humic acid, Table 5 indicated a significant effect of spraying stages on this character as spraying stage at vegetative growth stage exceeded by giving the highest mean of grains head in both spring and autumn seasons with 51.55 g 61.65 g respectively and differed significantly from other stages , whereas the delayed spraying stages (25% flowering) gave the lowest mean of grains weight in head. As the delay of spraying may reduce the benefit from the acid because it never gave a sufficient time for the plants to absorb the acid , and didn't give time for the acid to contribute in the plant biological processes especially with the high decrease in leaf area at stage 25% flowering (Table 2). Table 5 also showed a significant interaction between the two factors in both seasons. The reason behind this interaction may be due to the difference in relative response to acid concentrations in different spraying stages as it was generally noted that all concentrations gave the highest mean when spraying at vegetative growth stage and started to be decreased with the progress in plant growth stages and this decrease was more clear at high concentrations compared with the low concentrations and control treatment in both seasons.

Table 6. Effect of humic acid and spraying stages on 1000 grains weight (g) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	30.33	30.73	30.67	30.58	31.05	31.24	31.56	31.28
(H_1) 1	30.87	30.77	30.17	30.60	32.66	32.58	32.81	32.69
(H_2)2	29.37	30.33	29.40	29.70	32.35	33.06	32.82	32.74
(H_3) 3	29.30	29.73	28.83	29.29	31.62	31.69	31.97	31.76
L.S.D.5%		N.S.		0.73		N.S.		0.66
Mean	29.97	30.39	29.71		31.92	32.14	32.29	
L.S.D.5%		N.S.				N.S.		

Table 7. Effect of humic acid and spraying stages on grains number / head in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1)}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	1211	1088	1125	1141	1484	1382	1388	1418
(H_1) 1	1385	1276	1285	1315	1613	1637	1464	1573
(H_2) 2	2055	1738	1606	1800	2222	1877	1689	1929
(H_3) 3	2297	1846	1526	1895	2403	2063	1702	2056
L.S.D.5%		240		136		235		138
Mean	1737	1491	1385		1930	1740	1562	
L.S.D.5%		171				152		

Weight of 1000 grains (g)

The results of Table 6 indicated that this character affected significantly only by the concentrations of humic acid in both seasons. As in spring season the plants sprayed with humic acid at concentration of 3 $cm.L^{-1}$ gave the lowest mean in the weight of 1000 grains with 29.29 g and significantly differed from all concentrations except for 2 $cm.L^{-1}$ whereas the concentration 1 $cm^3.L^{-1}$ exceeded significantly on the concentrations 2 $cm.L^{-1}$ and 3 $cm.L^{-1}$ and gave the highest mean in the weight of 1000 grains with 30.60 g but didn't differ significantly from control treatment.

In the autumn season the treatment with high concentration of humic acid gave lower grains weight compared with the two concentrations of 1 and 2 $cm.L^{-1}$ and significantly differed between them but didn't differ from control treatment. This may be due to the fact that spraying acid caused increase in number of grains in head especially in the high concentration of acid (Table 7). This caused competition on produced materials which resulted in decreasing the weight of 1000 grains at high concentrations whcih means that plants had a specific ability in maintaining a limited number of grains in one head. These results agreed with the results of Saleh (2016) on sorghum also.

Number of grains in head

Table 7 showed, that this character was significantly affected by concentrations and spraying stages and their interaction. It was noted that the high concentrations of spraying with this acid at 3 $cm^{3.}L^{-1}$ in seasons gave the highest mean of grains in individual head reaching 1895 and 2056 in spring and autumn season respectively and significantly different than other concentrations except for the concentration of 2 $cm^3.L^{-1}$ whereas control treatment gave the lowest mean of grains number in head reaching 1141 and 1418 for spring and autumn seasons respectively and differed significantly from all concentrations.

The reason behind the increase in number of grains in head with increasing humic acid concentrations may be due to the increase in the dry matter, which began to transfer to the reproductive parts and this will increase

Table 8. Effect of humic acid and spraying stages on grains yield ($ton.ha^{-1}$) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	2.930	2.720	2.720	2.807	3.687	3.373	3.500	3.520
(H_1) 1	3.413	3.137	3.097	3.216	4.210	4.260	3.847	4.106
(H_2) 2	4.757	3.973	3.743	4.158	5.743	4.947	4.427	5.046
(H_3) 3	5.380	4.267	3.538	4.395	6.070	5.220	4.350	5.213
L.S.D.5%		0.522		0.311		N.S.		0.449
Mean	4.120	3.527	3.285		4.928	4.455	4.031	
L.S.D.5%		0.329				0.429		

Table 9. Effect of humic acid and spraying stages on harvest index (%) in spring and autumn seasons

Humic acid concentrations ($cm^3.L^{-1}$)	Spring season				Autumn season			
	Spraying stages				Spraying stages			
	Vegetative growth	Ventricular	25% Flowering	Mean	Vegetative growth	Ventricular	25% Flowering	Mean
(H_0) 0	17.07	16.04	16.10	16.40	19.82	18.13	19.38	19.11
(H_1) 1	18.09	17.12	17.15	17.45	19.14	20.46	18.28	19.29
(H_2) 2	23.09	19.63	19.48	20.73	23.30	21.26	21.01	21.52
(H_3) 3	25.64	20.69	18.21	21.51	22.80	21.35	20.03	21.39
L.S.D.5%		N.S.		1.81		N.S.		2.10
Mean	20.97	18.37	17.74		21.27	20.30	19.42	
L.S.D.5%		2,05				N.S.		

their ability on pollination and fertility and increasing the fertility percentage (Serenella *et al*., 2002). This result agreed with the results of (Al-Khafagy, 2015) in sorghum plants.

Table 7 indicated that spraying stage at vegetative growth gave the highest mean in number of grains in head reaching 1737 and 1930 for spring and autumn respectively and significantly differed from other spraying stages. The reason behind the increase in number of grains in head when the acid sprayed at vegetative growth may be due to the role of this acid in increasing nitrogen in treated plants (Verlinden *et al*., 2009) which leads to increase the number of active leaves and stay for a long time and thus contributing in metabolism of produced materials and transferring them to the reproductive parts which increased fertility percentage and then increasing seeds set. as for interaction between the two factors was due to the difference in relative response of acid concentrations in different spraying stages.

Grains yield ($ton.ha^{-1}$)

Grain yield is regarded the most important aim for which grain crops are planted and represents the final outcome for all biological processes in the plant through its lifetime and were affected significantly whether positively or negatively by environmental conditions , plant growth and the ability of that cultivar to utilize it (Kaye *et al*., 2007). For that, the addition of

Table 10. Correlation coefficient values, of the spring and autumn season

Characters	Plant height (cm)	Leaf area (m^2)	Stem diameter (cm)	Biological yield ($ton.ha^{-1}$)	Grains weight in head (g)	Grains number per head	Weight of 1000 grains (g)	Grains yield ($ton.ha^{-1}$)
Plant height	-							
Leaf area	0.91**	-						
	0.92**							
Stem	0.38*	0.32^{NS}	-					
diameter	0.80**	0.82**						
Biological yield	0.89**	0.90**	0.35*	-				
	0.98**	0.93**	0.81**					
Grains weight	0.82**	0.37*	0.84**	-				
in head	0.83**	0.74**	0.88**					
Grains number	0.84**	0.84**	0.36*	0.85**	0.98**	-		
in head	0.87**	0.80**	0.73**	0.86**	0.99*			
Weight of 1000	-0.25^{NS}	-0.38*	-0.07^{NS}	-0.39*	-0.46**	-0.52**	-	
grains	0.19^{NS}	0.31^{NS}	0.11^{NS}	0.19^{NS}	0.15^{NS}	0.15^{NS}		
Grains yield	0.82**	0.83**	0.37*	0.84**	0.99**	0.98**	-0.46**	-
	0.87**	0.80**	0.71**	0.85**	0.97**	0.97**	0.13^{NS}	
Harvest index	0.71**	0.72**	0.34*	0.70**	0.97**	0.95**	-0.45**	0.97**
	0.50**	0.44**	0.39*	0.47**	0.80**	0.79**	0.06^{NS}	0.85**

* : significant at level 0.05; * : significant at level 0.01; NS : not significant

nutrients is necessary and one of them is humic acid which contains many major and minor elements, the importance of addition represented by its effect on grain yield (Kaye *et al*., 2007). The results of Table 8 indicated a significant effect of concentrations and spraying stages in both seasons but the interaction between the two factors was significant only in spring season. It was noted that the highest mean of grains yield was at spraying with high concentrations of humic acid at $3cm^3.L^{-1}$ in both seasons reaching 4.395 and 5.213 $ton.ha^{-1}$ for spring and autumn seasons respectively and differed from all other concentrations except for 2 $cm^3.L^{-1}$, whereas the lowest mean of grains yield was at control treatment which gave as yield of 2.807 and 3.520 $ton.ha^{-1}$ for spring and autumn seasons respectively, This treatment differed significantly from all acid concentrations. Spraying humic acid at the concentrations of 1, 2 and 3 $cm^3.L^{-1}$ caused increase in grains yield compared with control treatment (14.6%, 48.1% and 56.5%) and (48.1%, 43.3% and 16.6%) for spring and autumn seasons respectively .

The increase in grains yield by spraying humic acid at high concentrations of 1, 2 and 3 $cm^3.L^{-1}$ was due to the increase in dry matter, grains number and weight in head (Tables 4, 5 and 7) and this was confirmed by positive correlation value of correlation coefficient between these characters and grains yield which reached +0.84, +0.99 and +0.98) in spring season and +0.85, +0.97 and +0.97) in autumn season for the mentioned characters respectively. These results agreed with the results of Hanafy (2010) on sorghum plants and AL-Fahdawi (2013) in beans and Ali and Elbordiny (2009) in wheat. Concerning the effect of spraying stages , table 8 indicated that the highest mean of grains yield were when sprayed in vegetative growth stage and reached 4.120 and 4.928 $ton.ha^{-1}$ for spring and autumn seasons respectively and significantly differed when compared with spraying at booting stage and 25% flowering stage in both seasons. The mean of yield decreased when spraying delayed until booting stage or 25% flowering when compared with spraying in vegetative growth stage, the decrease reached 14.4% and 20.3% in spring and 9.6% and 18.2% in autumn, from which it was concluded that delaying acid spray after the end of vegetative growth phase can give an indicator that delaying never give a sufficient time for plants to absorb the nutrients available in the acid and transfer them to active regions from that stage to take their role in metabolic processes. Concerning the interaction between concentrations and acid spraying stages, Table 8 indicated a significant interaction and the reason behind that may be due to the different response to acid concentrations by different spraying stages as it appears that low acid concentration and spraying water alone (control treatment) was significantly unaffected by different spraying stages , on the contrary of the concentrations of 2 and 3 $cm^3.L^{--1}$ in which grains yield decreased significantly when spraying delayed to booting stage or 25% flowering stage.

Harvest index

Harvest index expresses plants ability in transforming dry matter resulting from photosynthesis to dry matter stored in grains and this sometimes referred to as migration coefficient or in other words as nutrient transfer coefficient to the plants economic parts Table 9 indicated a significant effect of harvest index with humic acid concentrations for both seasons. From that it was noted that the highest mean of harvest index was at acid concentration of 2 $cm^3.L^{-1}$, but they didn't differ significantly in both seasons. Whereas the lowest mean of harvest index was at control treatment which reached 16.4% and 19.11% for spring and autumn seasons respectively but didn't differ significantly from the concentration of $1cm^3. L^{-1}$.

This may be due to the increase in grains yield at the concentrations of 2 and 3 $cm^3.L^{-1}$ of acid and that was clear in the high significant positive correlation between harvest index and grains yield reaching 0.97** and 0.85 ** in spring and autumn seasons respectively (Table 10). Stages of spraying affected harvest index significantly in spring season only as spray stage gave the highest mean in harvest index reaching 20.97% at vegetative growth stage and differed from all other stages. The superiority of this stage in harvest index may be due to its increase in grains yield compared with other stages and this is clear also from the positive and significant correlation between grains yield and harvest index (Table 10).

CONCLUSION

Significant changes in plant height, leaf area, biological yield, seed weight.head^{-1}, number of grain.head^{-1} and seed yield was recorded after foliar application of humic acid at different concentrations.

REFERENCES

AL-Fahdawi, HH. 2013. Effect of humic acid on growth and yield of four beans varieties (*Visia* faba L.). M.Sc. thesis - University of Al-Anbar – College of Agriculture – Field Crops Department. 68 p.

Ali KML and Elbordiny MM. 2009. Response of wheat plants to potassium hamate application. *Journal of Applied Sciences Research*, 5(9): 1202-1209.

AL-Khafagy HH. 2015. Effect dates and concentrations of spraying with humic acid on growth and yield of sorghum *Zea* mays L. *AL-Koufa Journal of Agricultural Researches*, 7(1): 155-170.

Dantas BF, Pereira MS, Ribeiro LD, Maia JLT and Bassoi LH. 2007. Effect of humic substances and weather conditions on leaf biochemical changes of fertigated guava tree, during orchard establishment. *Revista Brasileira de Fruticultura,* 29(3): 632-638.

Daur I and Bakhashwain AA. 2013. Effect of humic acid on growth and quality of maize fodder production. *Pakistan Journal of Botany*, 45(S1): 21-25.

El-Chamry AM, Abd KM and Ghoneem K. 2009. Amino and humic acid promote growth yield and disease resistance of faba bean cultivated in clay soil. *Australian Journal of Basic and Applied Sciences*, 3(2): 731 -739.

El-Sahookie MM. 2004. Approaches of selection and breeding for higher yield crops, *The Iraqi Journal of Agricultural Sciences*, 35(1): 71-78.

Fathy MA, Gabr MA and El Shall SA. 2010. Effect of humic acid treatments on 'Canino' apricot growth, yield and fruit quality. *New York Science Journal*, 3(12): 109-115.

Hamdan MI. 2006. Extension in sorghum crop agriculture and production. General Commission of Agricultural Extension and Cooperation. Project of developing sorghum researches. Extension publication No.19.

Hefny EM. 2010. Effect of saline irrigation water and humic acid application on growth and productivity of two cultivars of cowpea (*Vigna unguiculata* L. Walp). *Australian Journal of Basic and Applied Sciences*, 4 (12): 6154-6168.

Jaddoo KA and Alwan AL. 2015. Hormonal regulation of tillering in sorghum and its effect on grain yield and its components. *Journal of Agricultural Sciences*, 46(3): 300-311.

Kaye NM, Mason SC, Jackson DS and Galusha TD. 2007. Crop rotation and soil Amendment alerts sorghum grain quality. *Crop Science*, 47: 722-729.

Liang GH, Chu CC, Reddi NS, Lin SS and Daton AD. 1973. Leaf blade area of sorghum varieties and hybrids 1. *Agronomy Journal*, 65(3): 456-459.

Mohammed HA. 2009. Effect of nitrogen fertilizer and boron in raising water efficiency in sorghum plants. *AL-Anbar Journal of Agricultural Sciences*, 7(4): 30-42.

National Committee for Recording and Protecting Agricultural Varieties. [cited 2016 June 08]. Ministry of Agriculture – Republic of Iraq.

Quinby JR. 1963. Manifestation of hybrid vigor in sorghum. *Crop Science*, 3: 258-291.

RAO MM, Govindasamy R and Chandrasekeran S. 1987. Effect of humic acid on sorghum vulgare var. CSH-9. *Current Science*, 56(24): 1273-1276.

Reddy BVS, Kamar AA and Reddy PS. 2010. Recent advance in sorghum improvement research at ICRISAT. *Kasetsart Journal* (*Natural Science*), 4(4): 499-509.

Saleh AH. 2016. Effect of soaking grains in peroxide and spraying nitrogen on growth and yield of grains and their components in sorghum plants. Ph.D. thesis – AL-Anbar University – College of Agriculture – Field Crops Sciences. 104 p.

Serenella N, Pizzeghelloa D, Muscolo N and Vianello A. 2002. Physiological effects of humic substances on higher plants. *Soil Biology and Biochemistry*, 34(11): 1527-1536.

Shehata SA, Gharib AA, El-Mogy MM, Abdel Gawad KF and Shalaby EA. 2011. Influence of compost, amino and humic acids on the growth, yield and chemical parameters of strawberries. *Journal of Medicinal Plants Research*, 5(11): 2304-2308.

Shihab HA.2011. Effect of plant density on tillering of grain sorghum. M.Sc. thesis- University of Baghdad – College of Agriculture – Field Crops Department. 116 p.

Sifola MI, Mori M and Xeccon P. 2002. Biomass and nitrogen partitioning in Sorghum as affected by nitrogen fertilization. *Italian Journal of Agronomy*, 1(2): 115-121.

Statistical booklet of field crops data. 2016. Ministry of Agriculture. Agricultural Researches Office - Agricultural Economic researches.

Steel RGD and Torrie JH. 1980. Principles and procedures of statistic 2nd ed. McGraw- Hill, Book, Co. Tnc. London. 560 p.

Vanderlip RL. 1993. How a sorghum plant develops. Kansas State University. 20 p. https://www.bookstore.ksre.ksu.edu/pubs/s3.pdf

Verlinden G, Pycke B, Mertens J, Debersaques F, Verheyen K, Baert G, Bries J and Haesaert G. 2009. Application of humic substances results in consistent increases in crop yield and nutrient uptake. *Journal of Plant Nutrition*, 32(9): 1407–1426.