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Response of some Sorghum (*Sorghum bicolor*, L. Moench) Cultivars to Foliar Spraying of Riboflavin Growth, Grain Yield and Proline Content

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ABSTRACT

Recently, many environmental fluctuations affecting sorghum production such water shortage, increases in temperatures, soil salinization, drought, improper use of soil and hyper-fertilization. There were Many studies attempted to solve these problems. Thus, this study is conducted to investigate the effect of foliar spraying riboflavin at different concentration on growth traits, proline content in the plant, grain yield and yield components of three sorghum cultivars. Results revealed that Rabih cv. was significantly superior in most studied traits, such as plant height, leaf area, leaf area index, flag leaf area, leaves proline content and number of grains per head. This increment in the traits mentioned previously reflected positively on grain yield per unit area in both seasons as it produced 7.05 and 7.12 ton/ha, respectively. Foliar application of riboflavine improved most of vegetative growth traits including plant height and leaf area, while it reduced the proline content in plant which make it able to avoid stress during its life time. This in turn increased the grain yield and its components. In both season, foliar application of riboflavin at the conc. of 300 mg l^{-1} gave the highest grain yield amounted to 7.29 and 7.22 ton h^{-1}, respectively. There were significant interaction between cultivars and riboflavin conc. in most traits. It can be concluded from this study that high grain yield can be obtained by sowing Rabih cv. and spraying with riboflavin at concentration of 300 mg L^{-1}

Keywords: Riboflavin, grain sorghum, yield, growth, proline concentration.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench**)** is an old field crop cultivated to feed millions of people in arid, semi-arid and desert regions of the world (Haussman *et al*., 2002) due to the advantages of its tolerance to the hard environmental conditions such as high soil and water salinity, temperature and water scarcity. It is characterized by the high proportion of protein in the seeds, thus it is used in human food in many countries all over the world. Grain sorghum is used as feed concentrates or the use of plant as green feed of animals, especially in the summer when the scarcity of green feed and the production of fuel, fiber and energy (Kimber *et al*., 2013). The drought stress is one of the most important constraints of production in many regions of the world, especially in recent times, where many of the world's lands are unsuitable for agriculture, especially strategic crops such as wheat, rice and maize. The lack of water and high temperatures and salinization soil agricultural land caused by intensive practices and irregular irrigation which lead to a shortage of agricultural land suitable for agriculture (Lepold and Kriedemann, 1979 and Flowers and Flowers, 2005). This requires alternative to the cultivation of these lands to satisfy the growing numbers of people in the world and requirements of plant and animal food.Therefore, many researchers have tended to cultivate the white maize crop in such lands due to it is tolerant to such conditions more than C4 plants. In addition, they give a number of crops during the growing season if they are used for animal feed (Bukantis, 1980).Recently, it was also possible to plant white maize once in the Spring season and give seeds yield in the Spring and Autumn seasons without field operations and planting for the Autumn season. The crop can be adapted with low fertility soil and other growth determinants. However Iraq is still below the required level because of the lack of studies on the efficiency of varieties to resist the environmental inappropriate conditions as saline soil, water, drought and high temperature. A study, by Azooz *et al*. (2004), was conducted to know which cultivars are tolerant to salinity. They found that the cultivar Jeeza 113 was more susceptible to salinity, proline accumulation, growth and chlorophyll decrement while the other cultivars were distinguished by their salinity tolerance and the lowest concentration of proline (Nawaz *et al*., 2010 and AL-Taher *et al*., 2012). However, the use of nutrients in terms of quality and method of addition and their appropriate level as well as the selection of the most appropriate to the prevailing environmental conditions that most responsive to the addition of nutrients are the basic important requirements that raise the production of crop area unit to reduce this gap. Recently, interest in the diversification of the food product increased, and environmental and food pollution from fertilizers and pesticides aggravated. The issue of producing crops free from the residual effects of fertilizers and pesticides emerged. Vitamins are one of the nutrients necessary for humans, animals, and plants to promote normal growth. They are helpful agents, enzymes or antioxidants in many physiological and biological processes. In addition they are osmotic regulators within the plant and their effect is by low concentrations and resistance to certain conditions such as drought and salinization as well as plant resistance to some diseases (Abo Al-Yazied, 2011 and Abrahamian and Kantharajah, 2011). Riboflavin is considered a key contributor to many metabolic enzymes and electrons transport as well as it has an important role in the cycle of citric acid, oxidation of fatty acids, photosynthesis and DNA repair (Fischer and Bache, 2005). According to the study, conducted by Azooz (2009) on Hibiscus plant, it was found that spraying 100 ppm of riboflavin increased plant antioxidants content of carbohydrates and enzymes and decreased plant content of hydrogen peroxide and proline. The researcher concluded that riboflavin might be an active antioxidant through regulating osmotic and ionic balance and promoting plant resistance to salt stress. Thus, the current study is conducted to examine the most tolerant sorghum cultivars to such conditions through their content of proline, vegetative growth, and yield as well as the effect and response range of these cultivars to riboflavin spraying on physiological traits and yield and its components of sorghum.

MATERIALS AND METHODS

Two field experiments were conducted during the Autumn seasons of 2015 and 2016 seasons at the experimental farm of College of Agriculture - Abu Ghraib (Anbar University Alternative Site). The goals of this investigation was aimed to study the effect of spraying of riboflavin (vitamin B2) on some physiological and yield and its components for three sorghum cultivars. Split plots, based on Randomized Complete Block Design (RCBD) with three replicates, were used. The main plots for riboflavin concentrations (0, 100, 200, and 300 mg.L^{-1}) sprayed on plant by three stages. Sub - plots were allocated for the Cultivars (Rabih, Lilo, and Al-Warkaa). The experimental units were 36 with three replicates. The land was prepared by plowing, pulverizing and leveling. a sample was taken randomly prior to planting to identify some of the chemical and physical traits shown in Table (1). The experimental unit area was divided into experimental units of 9 m^2. Planting was in lines of 50 cm distance between a line and another, and 25 cm between the hole and another to obtain plant density of 80000 plants ha^{-1}. Seeds were planted at the 1st of August for both seasons by placing three seeds in one hole. Then they were reduced to one plant at the four leaves emergence stage. The field was irrigated depending on soil moisture. Nitrogen fertilizer was added in the form of urea (46% N) at a rate of 100 kg N in four batches. Phosphate fertilizer was added at 200 kg P_2O_5ha^{-1} in the form of super phosphate (46% P_2O_5) as one batch during soil preparation. When the plants reached milk phase, the shoots were encased in pouch bags to protect them from birds attack.

Table 1. Chemical and physical traits of experimental soil and water of irrigation.

Sample	Soil Texture	EC ds.m^{-1}	pH	Mmol.L^{-1} Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	SO$_4^{=}$	HCO$_3^{-}$
2015 season	Clay Loam	3.6	7.9	14.5	8.2	13.8	0.12	9.4	16.8	10.2
2016 season	Clay Loam	3.9	8.1	14.8	9.1	14.3	0.11	9.2	15	11
Well water	–	4.23	7.9	36.3	16.8	29.8	1.3	32.4	26.3	25.6

The traits, number of days from planting to 75% flowering, plant height, area and index of the leaf, flag leaf area, leaf proline content, grains number in the top, the weight of 500 grains, grains yield (ton/ha), and biological yield (ton/ha), were studied. Statistically, data were analyzed using analyzing variation method and the means were compared using Least Significant Difference (LSD) at 5 % (Elsahookie and Wuhaib, 1990). The values of simple correlation, among the studied traits, were calculated to identify the most correlative traits with grain yield based on SPSS program.

RESULTS AND DISCUSSION

Number of days from planting to 75 % flowering

The results presented in Table (2) indicated that the use of vitamin B2 (riboflavin) reduced the duration to reach 75% flowering for the years 2015 and 2016. The high concentration sprayed plants recorded 300 mg.L^{-1}. The lowest time to reach 75% flowering was 71 and 70.61 days for the both seasons, respectively. The results also indicated a difference between the two cultivars, of this trait, in the second season only when the cultivar Rabih recorded the least time to reach 75% flowering (71.67 days), which had no significant difference with Al-Warkaa. Lilo cultivar recorded the longest period (72.75 days). These differences in number of days to 75 % flowering might be due to difference of cultivars in their genetic composition. The interaction between the two factors of the study resulted in a significant effect of this trait for the second season only (Table 2). A shorter period to reach that stage at 70.37 days from Rabih cultivar at 30 mg/L. While the plants of Lilo, at the control treatment, recorded the longest period of 74 days.

Table 2. Effect of riboflavin on the number of days from planting to 75% flowering of three sorghum cultivars for Autumn seasons of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	75.33	72.33	72	71	72.67
Al-Warkaa	74.33	72.67	72.33	72	72.83
Rabih	74.33	73.33	71	70	72.17
L.S.D 0.05 Interaction	NS				L.S.D 0.05 Cultivars
Vit. Average	74.66	72.78	71.78	71	NS
L.S.D 0.05 (Vit.)	1.03				
Cultivars	**Riboflavin Concentrations (2016 season) 0 mg. L^{-1}**	**100 mg.L^{-1}**	**200 mg.L^{-1}**	**300 mg.L^{-1}**	**Average**
Lilo	74	73.67	72.33	71	72.75
Al-Warkaa	72.33	72.33	71.67	70.67	71.75
Rabih	73.67	72.33	70.33	70.33	71.67
L.S.D 0.05 Interaction	2.07				L.S.D 0.05 Cultivars
Vit. Average	73.33	72.78	71.56	70.67	0.87
L.S.D 0.05 (Vit.)	1.18				

Plant height (cm) :

The results presented in Table 3 showed that plant height increased with increasing concentrations of vitamin B2 (riboflavin) for both seasons. The plant sprayed with a higher concentration of 300 mg.L^{-1} gave a higher average of plant height (143.9 and 149.73 cm) in the first and second seasons, respectively. These results can be attributed to that riboflavin spraying which had a role in the mechanism of natural active auxins for growth within the plant and activated the carbonation process, then increased cell division and parasites elongation which led to an increase in the plant height. There were significant differences among cultivars on plant height and Al-Warkaa recorded a higher average (153 and 146.3 cm) in the first and second seasons, respectively. Lilo cultivar was recorded the shortest plants (124.4 and 132 cm) in the first and second seasons, respectively. The results reveled that there was a significant interaction between the studied cultivar and riboflavin spraying of this trait for the second season (2016) only. Where Al-Warkaa cultivar sprayed with a higher concentration of 300 $mg.L^{-1}$, recorded the tallest plants (155.6 cm) and Lilo plants recorded a higher height average (123.1 cm) at the control treatment i.e. distilled water only.

Table 3. Effect of riboflavin on plant height of three sorghum cultivars for Autumn season of 2015 and 2016.

Cultivars	Riboflavin Concentrations (2015 season) 0 $mg.L^{-1}$	100 $mg.L^{-1}$	200 $mg.L^{-1}$	300 $mg.L^{-1}$	Average
Lilo	116.6	124.2	125.4	131.3	124.4
Al-Warkaa	142.5	153.2	156.2	160.1	153.0
Rabih	127.8	134.2	137.5	140.1	134.9
L.S.D 0.05 Interaction		NS			L.S.D 0.05 Cultivars
Average (Vit.)	129.0	137.2	139.7	143.9	6.4
L.S.D 0.05 (Vit.)		6.5			
Cultivars	**Riboflavin Concentrations (2016 season) 0 mg. L^{-1}**	**100 mg. L^{-1}**	**200 mg. L^{-1}**	**300 mg. L^{-1}**	**Average**
Lilo	**123.1**	**130.8**	**133.6**	**140.5**	**132**
Al-Warkaa	138.2	146.7	146	155.6	146.4
Rabih	135.7	139.1	147	153.4	143.8
L.S.D 0.05 Interaction		11.5			L.S.D 0.05 Cultivars
Average (Vit.)	132.3	138.9	142.2	149.7	5.7
L.S.D 0.05 (Vit.)		6.1			

Leaf Area (cm^2)

The results presented in the Table (4) showed a superiority of spraying of riboflavin at ratio 300 mg.L -1 and recorded the highest average leaf area (38.13 and 37.89 cm^2) for the years of 2015 and 2016, respectively. The control treatment recorded the lowest average leaf area (3152 and 3217 cm^2) in the first and second seasons, respectively. The increment in leaf area with spraying of B2 vitamin, this might be attributed to that the vitamin is one of carbonation process components, participates in the transfer of electrons (oxidation and reduction) and acts as a catalysts (FAD and FMN), which are used in the biological oxidation within the plant and have a role in the formation of auxins within the plant, elongation of cells, and cells preservation of side effects, then increasing the leaf area. Sorghum cultivars differed in leaf area for the both seasons and Rabih cultivar recorded a higher leaf area average (3700 and 3828.7 cm^2) in the first and second seasons, respectively. Al-Warkaa cultivar recorded the lowest leaf area (3365 and 3223 cm^2) in the first and second seasons, respectively, without significant difference with Lilo cultivar, at the first season (3378 cm^2). The interaction of this trait was significant where the Rabih cultivar, sprayed with 300 $mg.L^{-1}$ of riboflavin, recorded the highest leaf area (3889 and 4078 cm^2) in the first and second seasons, respectively. While Al-Warkaa cultivar in the control treatment recorded the lowest leaf area (2963 and 2794 cm^2) in the first and second seasons, respectively.

Table 4. Effect of riboflavin on leaf area of three sorghum cultivars for Autumn season of 2015 and 2016.

Cultivars	Riboflavin concentrations (2015 season) 0 $mg.L^{-1}$	100 $mg.L^{-1}$	200 $mg.L^{-1}$	300 $mg.L^{-1}$	Average
Lilo	3074	3188.	3517	3733	3378
Al-Warkaa	2963	3213	3466	3818	3365
Rabih	3420	3630	3861	3889	3700
L.S.D 0.05 Interaction		260			L.S.D 0.05 Cultivars
Average (Vit.)	3152	3344	3615	3813	102
L.S.D 0.05 (Vit.)		237			
Cultivars	**Riboflavin concentrations (2016 season) 0 mg. L^{-1}**	**100 $mg.L^{-1}$**	**200 $mg.L^{-1}$**	**300 $mg.L^{-1}$**	**Average**
Lilo	3215	3407	3432	3701	3438
Al-Warkaa	2794	3118	3394	3588	3223
Rabih	3641	3682	3914	4078	3828
L.S.D 0.05 Interaction		278			L.S.D 0.05 Cultivars
Average (Vit.)	3217	3402	3580	3789	156
L.S.D 0.05 (Vit.)		189			

Leaf Area Index

The results in Table (5) indicated that increasing concentrations of riboflavin spraying on the cultivars was accompanied by an increase in the leaf area index and the highest riboflavin concentration of 300 $mg.L^{-1}$ produced the highest leaf area index (3.077 and 3.03) in the first and second seasons, respectively. Rabih cultivar gave the higher leaf area index (2.96 and 3.06) in the 2015 and 2016 seasons, respectively. While Al-Warkaa cultivar gave the lowest values of leaf area index (2.69 and 2.58) in the first and second seasons, respectively. The difference between cultivars in this trait may be due to the difference in the leaf area (Table 4). The interaction between the two factors had a significant effect on this characteristic in the first season only and Rabih cultivar gave the higher average of leaf area index (3.11) at 300 $mg.L^{-1}$ while Al-Warkaa cultivar which sprayed with distilled water only, gave the lowest average of leaf area index (2.37).

Table 5. Effect of riboflavin on leaf area index of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	2.46	2.55	2.81	2.99	2.70
Al-Warkaa	2.37	2.57	2.77	3.05	2.69
Rabih	2.74	2.90	3.09	3.11	2.96
L.S.D 0.05 Interaction		0.208			L.S.D 0.05 Cultivars
Average (Vit.)	2.52	2.68	2.89	3.08	0.08
L.S.D 0.05 (Vit.)		0.19			
Cultivars	**Riboflavin concentrations (2016 season) 0 mg. L^{-1}**	**100 mg.L^{-1}**	**200 mg.L^{-1}**	**300 mg. L^{-1}**	**Average**
Lilo	2.57	2.73	2.75	2.96	2.75
Al-Warkaa	2.24	2.49	2.72	2.87	2.58
Rabih	2.91	2.95	3.13	3.26	3.06
L.S.D 0.05 Interaction		N.S			L.S.D 0.05 Cultivars
Average (Vit.)	2.57	2.72	2.86	3.03	0.11
L.S.D 0.05 (Vit.)		0.27			

Flag Leaf Area (cm^2)

The results presented in Table 6 showed a superiority of foliar spraying of riboflavin at 300 mg.L^{-1} which recorded the highest flag leaf area/cm^2 (1985 and 190.67 cm^2) in the first and second seasons, respectively. The lowest flag leaf area/cm^2 was in the treatment of control (149.9 and 146.1 cm^2) in the first and second seasons, respectively. Rabih cultivar had a superiority in flag leaf area (195.9 and 180.3 cm^2) in the first and second seasons, respectively. Al-Warkaa cultivar recorded the lowest flag leaf area values (152 and 156.4 cm^2) in the first and second seasons, respectively. There was a significant interaction between the factors of the study in this trait in 2016 season only Rabih cultivar which sprayed with the high concentration, gave a higher average (207.3 cm^2) of flag leaf area while Al-Warkaa cultivar which sprayed with distilled water and produced the lowest average of flag leaf area (138.6 cm^2).

Proline (mg.plant^{-1})

The results presented in Table (7) showed a significant decrease in the amount of proline in the leaves by increasing the concentrations of riboflavin spraying. The control treatment recorded a higher proline content (4.41 and 4.066 mg.plant^{-1}) in the first and second seasons, respectively, highest ribolavin spraying decreased significantly to reach the lower content in the leaves (3.41 and 2.91 mg.plant^{-1}) in the first and second seasons, respectively. This is due to plants exposed to stress, soil salinity, irrigation water or high temperatures, Thus high level of amino acids appeared and caused by protein decomposition or lack of accumulation resulting from decreasing the use of these acids in the composition of protoplasm, where the increment in proline led to increasing osmosis of the cell, or the role of riboflavin in preservation the water balance of plant cells.In addition, the regulation of antioxidant enzymes or perhaps it is an effective antioxidant by regulating the osmotic and ionic balance, enhancing plant resistance to stress and disposing the plant from free radicals, which promotes better plant growth (Azooz *et al*., 2009).

Table 6. Effect of riboflavin on flag leaf area of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	147.1	171.7	187.8	210.5	179.3
Al-Warkaa	133.7	145.8	163.4	164.9	152,0
Rabih	167.5	186.2	210,0	220,0	195.9
L.S.D 0.05 Interaction		N.S			L.S.D 0.05 Cultivars
Average (Vit.)	149.4	167.9	187.1	198.5	15. 9
L.S.D 0.05 (Vit.)		9.0			
Cultivars	**Riboflavin concentrations (2016 season) 0 mg. L^{-1}**	**100 mg.L^{-1}**	**200 mg.L^{-1}**	**300 mg. L^{-1}**	**Average**
Lilo	143.4	157.5	175.7	194.1	167.7
Al-Warkaa	138.6	144.6	171.8	170.6	156.4
Rabih	156.3	171.8	185.7	207.3	180.3
L.S.D 0.05 Interaction		19.1			L.S.D 0.05 Cultivars
Average (Vit.)	146.1	157.9	177.7	190.7	10.4
L.S.D 0.05 (Vit.)		14.6			

Table 7. Effect of riboflavin on proline leaf content of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	4.07	3.44	2.77	2.76	3.26
Al-Warkaa	4.46	3.99	3.88	3.87	4.05
Rabih	4.69	4.22	3.82	3.59	4.08
L.S.D 0.05 Interaction		0.31			L.S.D 0.05 Cultivars
Average (Vit.)	4.41	3.88	3.49	3.41	0.128
L.S.D 0.05 (Vit.)		0.27			
Cultivars	Riboflavin concentrations (2016 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	4.31	3.62	3.30	2.85	3.52
Al-Warkaa	3.78	3.82	3.46	3.11	3.54
Rabih	4.11	3.71	3.02	2.74	3.39
L.S.D 0.05 Interaction		0.29			L.S.D 0.05 Cultivars
Average (Vit.)	4.07	3.72	3.26	2.90	N.S
L.S.D 0.05 (Vit.)		0.19			

In the first season only, sorghum cultivars were significantly differed in proline content and Lilo cultivar recorded the lowest proline leaves content (3.26 mg.plant^{-1}). While Rabih cultivar recorded the highest proline content (4.081 mg.plant^{-1}). This might be due to the difference in the genetic composition, proline content, and the extent of resistance and adaptation of the varieties to the environmental conditions prevailing in the experiment area (Nawaz *et al.,* 2010). The interaction between the sorghum cultivars and spraying of riboflavin was significantly affected the proline content. Lilo and Rabih cultivars sprayed with 300 mg.L^{-1}, recorded the lowest proline contents (2.763 and 2.741 mg.plant^{-1}) while they recorded the higher content (4.693 and 4.313 mg.plant^{-1}) at the control treatment in the first and second seasons, respectively.

Weight of 500 grains

The results in Table (8) indicated a superiority of highest riboflavin concentration of 300 mg L^{-1} with a higher average of 500 grains weight (14.09 and 14.88 g) in the first and second seasons, respectively, which had no significant difference with 200 mg L^{-1}, while the control treatment was recorded (12.22 and 12.44 g) in the first and second seasons, respectively. That might be due to the role of riboflavin in enhancing the ability of the root to absorb the nutrients and then store them in the leaves increase the leaf area and this increasing synthesis process and movement of synthesized materials from the source to the downstream. Al-Warkaa cultivar recorded the highest average of a weight of 500 grains (14.39 and 14.52 g) in the first and second seasons, respectively. While Rabih cultivar was recorded the lowest weight of 500 grains (11.45 and 13.18 g) in the first and second seasons, respectively. This was due to the superiority of Al-Warkaa cultivar by having fewer seeds in the top (Table 9).

Table 8. Effect of riboflavin on the weight of 500 grains of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season)				
	0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	12.7	13.4	13.9	14.9	13.8
Al-Warkaa	13.7	14.5	14.8	14.5	14.4
Rabih	10.3	10.5	12.3	12.8	11.5
L.S.D 0.05 Interaction		1.0			L.S.D 0.05 Cultivars
Average (Vit.)	12.2	12.8	13.7	14.1	0.5
L.S.D 0.05 (Vit.)		0.8			
	Riboflavin concentrations (2016 season)				
Cultivars	0 mg. L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg. L^{-1}	Average
Lilo	11.7	13.2	13.9	14.7	13.4
Al-Warkaa	13.5	14.0	14.7	15.8	14.5
Rabih	12.1	13.2	13.3	14.1	13.2
L.S.D 0.05 Interaction		1.5			L.S.D 0.05 Cultivars
Average (Vit.)	12.4	13.5	13.9	14.9	0.4
L.S.D 0.05 (Vit.)		1.0			

In addition, cultivars had a difference in the genetic composition where every cultivar had an ability, in synthesis and distribution of nutrients and absorption of leaves to the downstream (seeds), differing from the others. The weight of the seed expresses a function of the rate of photosynthesis and the transmission of its products. There was a significant interaction between the cultivar and spraying with riboflavin in both seasons, where Lilo plants had a superiority in both seasons and Al-Warkaa cultivar in the second season at the high concentration of 300 mg.L^{-1} which gave a higher average of 14.90 and 15.82 g in the first and second seasons, respectively. While Rabih and Lilo cultivars was sprayed with distilled water only, gave a lower average of 10.26 and 11.72 g in the first and second seasons, respectively.

Number of the grains head

The results presented in Table (9) showed that the number of grains in the head increased with sprayed with vitamin B2 and until reaching the highest average of number of grain/head at the high level of vitamin (300 mg.L^{-1}), which was 3933 and 3514 grains/head^{-1} in the first and second seasons, respectively. While, the differences was significant with concentrations of 100 and 0 mg.L^{-1} for both seasons, the control treatment showed lowest number of grains/head (2992 and 3053 grains.head^{-1}) in the first and second seasons, respectively. The increase in the number of grains/head with the increase of riboflavin may be attributed to the positive role of the material in increasing the leaf and flag leaf area (Table 4 and 6). As well as the efficiency of the carbonation process and production of carbohydrates then supplying the grains emerged with their requirements of synthesized food, contributed effectively in the sustainability and fullness.

Table 9. Effect of riboflavin on the number of grains in the head of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season)				
	0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	3019	3159	3685	4094	3489
Al-Warkaa	2361	2492	2904	3039	2699
Rabih	3595	3730	4175	4665	4041
L.S.D 0.05 Interaction		N.S			L.S.D 0.05 Cultivars
Average (Vit.)	2992	3127	3588	3933	187
L.S.D 0.05 (Vit.)		389			
	Riboflavin concentrations (2016 season)				
Cultivars	0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	3318	3370	3670	3543	3475
Al-Warkaa	2435	2621	3001	3118	2793
Rabih	3422	3671	3715	3882	3672
L.S.D 0.05 Interaction		188			L.S.D 0.05 Cultivars
Average (Vit.)	3058	3220	3462	3514	101
L.S.D 0.05 (Vit.)		167			

The results of Table (7) showed that the cultivars differed significantly in this trait in both seasons. Rabih cultivar had a superiority of number of grains/head

(4041 and 3672 grains.head^{-1}) in the first and second seasons, respectively. While Al-Warkaa cultivar recorded the lowest number of grains/head (2699 and 2793 grain.head^{-1}) in the first and second seasons, respectively. The superiority of Rabih cultivar in both seasons may be due to its superiority in the leaf area (Table 4), which effectively contributed to supplying the new growth sites (flowers and grains) with the requirements of growth and decreased abortion.

Thus the number of grains increased. In this context, an efficient plant can hold and mature seeds that can be supplied with photosynthesis products. The interaction between the riboflavin vitamin and sorghum cultivars significantly affected the number of grains/head for the season 2016. In addition, there was an increment in the number of seeds of Rabih cultivar until reaching a higher average of 3882 grains/head when spraying the plants with the high concentration of 300 mg.L^{-1} which had no significant difference of the same cultivar when sprayed at the concentration of 200 mg.L^{-1}. While Al-Warkaa cultivar recorded the lowest average of 2435 grains/head at the control treatment.

Grain yield (ton/ha) :

The results in Table (10) showed that Rabih cultivar had a superiority in grain yield (7.05 and 7.120 tons/ha) with an increase of 3.67 and 26.57% in 2015, and 5.63 and 30.64 ton/ha in the season of 2016 for Lilo and Al-Warkaa, respectively. The superiority of Rabih cultivar may be attributed to its superiority in flag leaf area and number of grains/head (Tables 6 and 9). There is highly positive and significant correlation coeficient between the grain yield and the two previous traits was confirmed by this result (Appendix1 and 2).Table (10) showed that the grain yield increased with increasing the concentrations of sprayed riboflavin until reaching the higher average (7.29 and 7.22 tons/ha) at 300 mg.L^{-1} in the first and second seasons, respectively.

The control treatment showed the lower grain yield average (5.55 and 5.63 t/ha) in the first and second seasons, respectively. The superiority of the higher level may be attributed to its superiority in the weight of 500 grains and the number of grains/head (Tables 8 and 9). This result is confirmed by the high correlation among the cultivars and for both seasons (Appendix 1 and 2). The interaction among cultivars significantly affected the grain yield for the second season only (Table 10), Rabih cultivar which sprayed with a high concentration of 300 mg.L^{-1}, recorded the highest grain yield average of 7.82 tons/ha. While Al-Warkaa cultivar recorded the lowest grain yield 4.76 tons/ha in the control treatment.

Biological yield/ha :

The results presented in Table (11) indicated that the studied cultivars significantly differed in biological yield/ha for the season of 2015 only. Rabih cultivar recorded the highest average of the biological yield (15.47 tons/ha), which had no significant difference with Lilo cultivar. Al-Warkaa cultivar recorded the lowest grain yield (14.78 tons/ha). There was an increase in the biological yield with increasing concentration of vitamin B sparaying for both seasons, at rate of 300 mg.L-1 and recorded the highest average of the biological yield (17.24 and 15.63 tons/ha) in the first and second seasons, respectively. While the control treatment recorded the lowest biological yield (13.22 and 13.79 tons/ha) in the first and second seasons, respectively.

Table 10. Effect of riboflavin on grains yield of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivars	Riboflavin concentrations (2015 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	5.83	6.68	7.21	7.477	6.80
Al-Warkaa	4.53	5.04	5.97	6.75	5.57
Rabih	6.31	7.01	7.24	7.63	7.05
L.S.D 0.05 Interaction		NS			L.S.D 0.05 Cultivars
Average (Vit.)	5.55	6.25	6.81	7.29	0.31
L.S.D 0.05 (Vit.)		0.41			
Cultivars	**Riboflavin concentration (2016 season) 0 mg. L^{-1}**	**100 mg.L^{-1}**	**200 mg.L^{-1}**	**300 mg. L^{-1}**	**Average**
Lilo	6.01	6.72	7.16	7.05	6.74
Al-Warkaa	4.76	4.91	5.34	6.79	5.45
Rabih	6.11	6.95	7.63	7.82	7.12
L.S.D 0.05 Interaction		0.93			L.S.D 0.05 Cultivars
Average (Vit.)	5.63	6.19	6.71	7.22	0.51
L.S.D 0.05 (Vit.)		0.71			

Table 11. Effect of spraying of riboflavin on the biological yield of three sorghum cultivars for Autumn season of 2015 and 2016

Cultivar	Riboflavin concentrations (2015 season) 0 mg.L^{-1}	100 mg.L^{-1}	200 mg.L^{-1}	300 mg.L^{-1}	Average
Lilo	13.37	14.74	15.00	17.90	15.25
Al-Warkaa	13.56	14.59	15.21	15.78	14.78
Rabih	12.74	14.74	16.33	18.05	15.47
L.S.D 0.05 Interaction		0.84			L.S.D 0.05 cultivars
Average (Vit.)	13.22	14.69	15.51	17.24	0.37
L.S.D 0.05 (Vit.)		0.68			
Cultivars	**Riboflavin concentrations (2016 season) 0 mg. L^{-1}**	**100 mg.L^{-1}**	**200 mg.L^{-1}**	**300 mg. L^{-1}**	**Average**
Lilo	14.01	14.33	14.72	15.88	14.74
Al-Warkaa	13.52	14.07	14.83	14.72	14.29
Rabih	13.83	13.93	15.27	16.31	14.83
L.S.D 0.05 Interaction					L.S.D 0.05 Cultivars
Average (Vit.)	13.79	14.11	14.94	15.63	N.S
L.S.D 0.05 (Vit.)		1.12			

The superiority of the high concentration of riboflavin may be attributed to its superiority in plant height, leaf area and grain yield (Tables 3, 4 and 10).

There is a significant effect of the interaction in the first season only (Table 10). Rabih cultivar sprayed with 300 mg.L-1 recorded highest average of biological yield (18.05 tons/ha). While the same cultivar at the control treatment was recorded the lowest average of biological yield (12.74 tons/ha).

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Appendix 1. Correlation coefficient values of studiedtraits of Autumn season of 2015

Studied Traits	Days of 75% flowering	Plant Height	Leaf area	Leaf Area Index	Flag Leaf Area	Leaves Proline Content	Grains in the head	500 grains weight	Grain Yield	Biological Yield
Biological Yield	- 0.885**	0.236	0.05	0.770**	0.810**	-0.657**	0.671**	0.376*	0.689**	1
Grain Yield	- 0.706**	-0.254	0.369 *	0.832**	0.923**	-0.597**	0.904**	-0.166	1	
500 grains weight	-0.367*	0.456**	0.495** -	-0.06	-0.137	-0.555**	-0.3 40*	1		
Grains in the head	-0.642**	0.316 *-	0.333*	0.788**	0.960**	-0.416*	1			
Leaves Proline Content	0.723**	0.189	0.359*	-0.361*	-0.565**	1				
Flag Leaf Area	-0.800**	0.170-	0.246	0.843**	1					
Leaf Area Index	-0.757**	0.255	0.400*	1						
Leaf area	0.005	0.043	1							
Plant Height	-0.244	1								
Days of 75% flowering	1									

Appendix 2. Correlation coefficient values of studied traits of Autumn season of 2016

Studied Traits	Days of 75% flowering	Plant Height	Leaf area	Leaf Area Index	Flag Leaf Area	Leaves Proline Content	Grains in the head	500 grains weight	Grain Yield	Biological Yield
Biological Yield	-0.752**	0.512**	0.737**	0.737**	0.922**	-0.889**	0.586**	0.486**	0.686**	**1**
Grain Yield	-0.456**	0.188	0.873**	0.875**	0.815**	-0.656**	0.928**	0.105	1	
500 grains weight	-0.731**	0.758**	0.146	0.148	0.440**	-0.716**	-0.144	1		
Grains in the head	-0.233	-0.024	0.864**	0.866**	0.751**	-0.442**	1			
Leaves Proline Content	0.895**	-0.678**	-0.642**	-0.644**	-0.883**	1				
Flag Leaf Area	-0.752**	0.517**	0.875**	0.877**	1					
Leaf Area Index	-0.550**	0.425**	1	1						
Leaf area	-0.550**	0.427**	1							
Plant Height	-0.856**	1								
Days of 75% flowering	1									

Appendix 3. Climate data of 2015

Month	Date	Rainfall mm	Max. Temperature C°	Min. Temperature C°	Max. Relative Humidity %	Min. Relative Humidity %
	10/08/2015	0	47.57	32.22	25.31	7.93
August	20/08/2015	0	46.64	28.98	36.91	10.14
	30/08/2015	0	44.75	26.42	38.55	9.88
	10/09/2015	0	44.67	27.41	38.29	10.77
Sept.	20/09/2015	0	43.67	26.21	37.29	9.07
	30/09/2015	0	43.62	26	38.91	8.96
	10/10/2015	0	36.41	17.67	66.22	10.21
Octo.	20/10/2015	0.78	36.78	15.87	69.97	13
	30/10/2015	0.13	33.12	15.98	73.16	10.72
	10/11/2015	3.98	24.58	14.08	96.07	48.36
Nov.	20/11/2015	1	20.83	10.15	96.83	42.64
	30/11/2015	0.03	18.36	9.03	97.01	39.95

Appendix 3. Climate data of 2016

Month	Date	Rainfall mm	Max. Temperature C°	Min. Temperature C°	Max. Relative Humidity %	Min. Relative Humidity %
	10/08/2016	0	48.65	34.22	42.87	7.15
August	20/08/2016	0	47.32	29.98	44.09	7.68
	30/08/2016	0	45.87	27.42	43.65	8.33
	10/09/2016	0	45.56	24.41	41.29	11.22
Sept.	20/09/2016	0	44.87	23.21	39.78	10.43
	30/09/2016	0	44.02	22	41.17	11.64
	10/10/2016	0	38.33	18.13	76	12.13
Octo. 01	20/10/2016	0.78	36.67	18.87	67.77	13.76
	30/10/2016	0.13	35.34	17.54	71.14	11.54
	10/11/2016	0	31.17	7.14	86.16	7.93
Nov.	20/11/2016	0	24.34	5.8	84.88	10.14
	30/11/2016	0	26.2	6.13	88.1	9.88

إستجابة بعض أصناف السورجم للرش بالريبوفلافين على النمو ومحصول الحبوب ومحتواها من البرولين

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أقيمت تجربتان حقليتان بالمزرعة البحثية بكلية الزراعة جامعة الأنبار فى أبوغريب غرب بغداد – العراق خلال الموسمين الزراعيين 2015 و 2016 بهدف دراسة تأثير الرش بالريبوفلافين لبعض أصناف الذرة الرفيعة لأجل الحبوب على النمو والمحصول ومحتواها من البرولين. وإشتملت التجربة على الرش بأربع تركيزات من الريبوفلافين (صفر ، 100 ، 200 ، 300 ملجم/لتر) على ثلاثة أصناف من السورجم وهى (Rabih, Lilo, Al-Warkaa). وفيما يلى ملخص لأهم النتائج :أوضحت النتائج إلى تفوق الصنف Rabih فى معظم الصفات والمحصول ومكوناته ومحتوى النبات من البرولين مقارنة بالصنفين الآخرين.أشارت النتائج إلى أن زيادة الرش بالريبوفلافين حتى 300 ملجم/لتر أدى إلى زيادة معظم الصفات والمحصول ومكوناته بينما إنخفض تركيز البرولين بالنباتات.سجل التفاعل بين الرش بتركيزات الريبوفلافين وأصناف السورجم لتأثير معنوى لمعظم الصفات تحت الدراسة.

وتوصى الدراسة لتعظيم إنتاجية وحدة المساحة بزراعة الصنف Rabih والرش بالريبوفلافين بتركيز 300 ملجم/لتر.