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Effect of abscisic acid concentrations and stages of spray on maize growth, seed yield and germination at late planting

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ABSTRACT

A field experiment was carried out in Al-Hajjaj district-Salah Al-Din Governorate, during the autumn season of 2021. The experimental design was randomized complete block design (RCBD) in three replications. It had three ABA concentrations of 0, 9 and 12 mg L-1 that sprayed on plants at 4 and 8 leaves and at the beginning of flowering. Results indicated that a concentration of 12 mg L-1 was superior in shortening the number of days from sowing until 50% of tasseling (male flowering) 38.33 days and silking (female flowering) 41 days. The same concentration recorded the highest stem diameter of 2.47 cm, seeds number per ear 682.89 seed ear-1, 1000 seed weight 373.77 g, single plant yield 165.64 g and seed yield 11.04 tons ha-1, protein content 9.80% and ash percentage 1.39%. However, control recorded the highest germination percentage and speed of 95.89 and 64.80, respectively. Spraying ABA at 4 leaves was superior in recording the least number of days from planting until 50% of tasseling 38.50 days and silking 43.55 days and also excelled in giving the highest stem diameter 2.35 cm. However, foliar application of ABA at the beginning of flowering showed the highest means of number of seeds per ear 664.99 seed ear-1, 1000 seed weight 361.80 g, single plant yield 158.70 g, seed yield 10.57 tons ha-1, protein percentage 10.03%, and ash percentage 1.36%. Hence, foliar spray at 4 leaves recorded the highest mean 84.81 of germination speed.

INTRODUCTION

Maize *Zea mays* L. considered as one of the most important cereal crops that is grown on a wide scale in the world, and it comes in importance after wheat and rice in terms of area and production. It is a crop of varied uses in human and animal nutrition and has dramatic entry into many industrial fields (2013, Orhun), and it is a source of glucose, starch and oil. The planted area of maize in Iraq for the year 2020 amounted to about 404.4 thousand dunams with a production rate of 419.3 thousand tons, and an average production of 1034.3 kg per dunams, Directorate of Agricultural Statistics (2020). Maize needs warm atmospheric conditions throughout the growth period, and its optimum temperature for growth is 30.5 °C Walne and Reddy (2022). During different growth stages, high and low temperatures adversely impact the crop. Maize is one of sensitive crops to low temperatures that negatively affect all its growth stages, and thus crop growth rate decreases and plant tends to increase the growth period. In addition, chilling stress impacts reproductive organs, all seed filling stages and development, and then leads to a significant decrease

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in seed yield in terms of quantity and quality (Hussain et al. 2019). Thus, the negative impact of stress due to low temperatures must be avoided, and one of the methods used to reduce environmental stress is the use of plant growth regulators.

Abscisic acid (ABA) has different effects in physiological regulations. It acts as an inhibitor when accumulates in large quantities under different stress conditions to help plant survival by inhibiting the processes of opening and closing stomata and reducing the expansion of plant size. However, the effect of encouraging plant growth appears when acid is in low concentrations and under natural conditions for plant growth (Finkelstein et al. 2002). Its presence is necessary for vegetative growth and development of seedlings, encouraging vegetative growth and increasing the total yield by increasing yield components (Yang et al., 2017). It has a significant effect in increasing plant tolerance to different stress conditions (Pantin et al., 2013), as well as its effect on increasing root growth, absorbing water and nutrients from the soil, improving relative water content, and increasing the effectiveness of antioxidant enzymes, which improve plant growth. It was indicated by Majeed et al, (2011) that ABA made some physiological modifications within plants for obtaining better results, such as giving the best flowering to plant in the shortest time. It reduces vegetative growth and increases the duration of seed growth, and this depends on the method and time of addition (Wilmowicz et al. 2008). It was found by Travaglia et al. 2012 that ABA had a significant effect in accelerating seed development when it was sprayed on maize. The results of Hassan 2014 showed that the addition of ABA led to an increase in stem diameter in sunflower. In addition, in a study conducted by Hashem, (2017), the increase in number of seeds per spike was obvious when plants were sprayed with ABA. Moreover, results of Al-Jawahiri, (2019) showed that spraying ABA on rice led to a significant increase in the mean number of seeds. In the same direction, results of Yang et al., 2014 showed that spraying shoots of wheat with ABA caused a significant increase in 1000 seed weight. Hashem, (2017) indicated that spraying wheat plants with ABA contributed to an increase in the weight of 1000 grains as well. Al-Jawahiri, 2019 indicated an increase in rice seed yield with application of ABA. Furthermore, Yang et al., 2013 showed a significant increase in the protein content of two wheat cultivars of wheat when ABA was sprayed. Primary seed dormancy found to be exist in a number of cereal seeds (Rodríguez et al 2015), and ABA found to be responsible for delaying germination in seed in addition to its correlation with physiological dormancy, Hilhorst 1995.

Iraq needs to increase production of maize, and this can be achieved through intensive cultivation of the crop twice a year, spring and autumn. Also, it is possible to plant a legume crop between the two seasons or after the winter crop, but this requires some time to prepare the field for late planting that may exceed the dates of autumn planting, which leads to exposing the plant to chilling stress, especially during flowering. To our knowledge and from information available, ABA has not been used before for avoiding maize crop the stress that caused by low temperatures when planting is late. Therefore, the aim of the study is to test the ability of ABA (as an avoidance strategy) to be sprayed with different concentrations and at different stages of growth in shortening the crop stay in the field, impacting on growth, and protecting the reproductive organs at the flowering stage, seed stages after pollination and the impact on germination.

MATERIAL AND METHODS

Experiment location

The field experiment was carried out in Al-Hajjaj district- Salah Al-Din Governorate, for the autumn season of 2021, at latitude of 34.31˚ North and longitude of 42.30˚ East. Random samples of soil were taken before planting at a depth of 0-30 cm and were analyzed for knowing its physical and chemical properties. Laboratory analyses were conducted in the laboratories of the Department of Soil and Water Sciences- College of Agriculture- Tikrit University, as shown in Table (1). Monthly averages of climatic data during growing season until harvest were recorded from the Meteorology organization, Table (2).

Table (1): Chemical and physical properties of the experimental soil before planting at a depth of (0-30) cm

Properties		units	Values
PH			7.33
EC		dS m^{-1}	2.55
Available N		mg kg^{-1} soil	21.50
Available P		mg kg^{-1} soil	4.60
Available K		mg kg^{-1} soil	89.20
Organic matter		g kg^{-1} soil	2.55
Soil Separators	Sand	g kg^{-1} soil	524.00
	Silt	g kg^{-1} soil	266.00
	Clay	g kg^{-1} soil	210.00
Texture	Sandy loam		

Table (2): Monthly averages of climatic data

Month	Rain falls	Max Temp °C	Min Temp °C
August	0.00	44.97	21.12
September	0.00	41.95	17.01
October	0.00	35.02	16.95
November	0.02	26.96	15.67
December	0.10	22.08	13.39

Abscisic acid solution preparation.

Commercial ABA was prepared from Sigma Chemical Company of American origin, and the solution was prepared according to the required concentrations in the Laboratory of Field Crops Department - College of Agriculture - Tikrit University. Spray was carried out in the early morning on the vegetative part, at the stages of 4 leaves, 8 leaves and at beginning of flowering, until complete wetness.

Experiment Factors and Design

Factors of the experiment were ABA concentrations of 0, 9 and 12 mg L^{-1} and spray stages of 4 leaves, 8 leaves, and beginning flowering. A randomized complete block design RCBD was applied with three replications. Each block included 9 experimental units, and the area of each unit was 3×3 m with 5 lines being planted. Distance between lines was 75 cm and between plants in each line was 20 cm. Experiment was fertilized with Urea 46% N at a rate of 400 kg ha^{-1}. The first batch of N was added at planting, second batch was a month after planting, and the third was at the beginning of silking formation. Triple calcium superphosphate 46% P_2O_5 was applied at a rate of 200 kg ha^{-1} at once and after plowing (Al-Alusi, 2005). Seeds of Sarah variety were sown on 1/Septembe/2021, and the crop was harvested after completion of physiological maturity. The granular diazinon pesticide, 10% as an active substance at a rate of 4 kg ha^{-1}, was used to control maize stem borer (Sesamia cretica) after plant height reached 20 cm. The plants were fed by placing the pesticide for each plant above the growing top. Data taken from 10 nominated midlines plants randomly for each experimental unit after, and characteristics of Number of days to 50% tasseling, Number of days to 50% silking, Plant height cm, Stem diameter cm, Number of seeds per ear (seed ear^{-1}), 1000 seed weight g, Single plant yield g, Seed yield ton ha^{-1}, Protein content %, ash content %, germination % and germination speed were studied.

Protein content determination

The percentage of protein was estimated according to the method of AACC using the Informatics, which was supplied by Perten company, and located in the General Company of Grain Processing. The method depends on the reflection of infrared rays (NIR) and as described before by Gomez et al, (2010) by taking 15 g of the previously prepared flour sample, and placing it in a small cube-shaped container after operating the machine as it gives results within a few minutes.

Ash content determination

Ash content in seeds was determined by following the standard methodof AACC in the General Company of Grain Processing by burning 5 g of flour at a temperature of 6000 °C for 5 hours and a muffle furnace oven type Gallenkamp was used for this purpose.

Germination

Germination of produced seeds was obtained according to International Seed Testing Association (ISTA) by placing 400 seeds moisture content of 14% from each treatment as 4 replications in germination containers. Seeds were placed on the top of germination paper and covered with sand, and then transferred to a germinator with stable temperature of 25 °C. Seeds were moistened as needed with around 7 of PH water and free of organic and in organic impurities. Germinated seeds were counted at fourth day and ended at seventh day. Germination percentage was calculated as following:

$$\text{Germination } \% = \frac{\text{number of norma seedlings at the final count}}{\text{total number of seeds}} \text{ x } 100$$

Germination speed was calculated as the following equation.

$$\text{Germination speed} = \frac{\text{number of norma seedlings}}{\text{days of first count}} + \cdots + \frac{\text{number of norma seedlings}}{\text{days of final count}}$$

Statistical Analysis

Data was statistically analyzed following F-test method and according to the design of randomized complete blocks (RCBD) in a factorial experiment as mentioned by Al-Rawi and Khalaf Allah (2000). Significant differences between means were compared with Duncan's multiple-range test at significance level of 0.05. The statistical analysis was done using the SAS program.

RESULTS AND DISCUSSION

Analysis of variance results in Table 3 indicated a significant impact of study factors and their interaction on most of the studied characteristics except for plant height, and germination percentage under the impact of spray time and the interaction between the two factors.

Flowering

It is a crucial characteristic of maize for many agricultural practices, and synchronized flowering is a useful key in successful pollination, achieving the aim in plant breeding programs and seed production. It is indisputable from results of silking (male flowering) and tasseling (female flowering) that early spray avoided plant reproductive organs the risk of chilling stress. The delay in flowering is one of plant phenomenon that are controlled by plant growth regulators and firmly established as basic elements in modulating and controlling flowering initiation and development. Table (4) showed that there were significant differences between means of ABA concentrations in the number of days from seeding until 50% tasseling. It was conspicuous that concentration of 12 mg L^{-1} recorded the shortest time of 38.33 days, and did not significantly differ from the concentration of 9 mg L^{-1}. The augmentation in concentration led to an initial flowering compared to control where more days (46.22) were required to reach 50% of tasseling. In addition, it was obvious that spray at 4 leaves impelled early flowering, and showed the shortest period (38.50 days) compared to spray at beginning of flowering, which required more days (55.45) to reach 50%. Moreover, it was perceived that there were significant differences between the two factors interaction means. The treatment of 12 mg L^{-1} and 4 leaves recorded the lowest mean (34.00 days) compared to the control treatment and beginning of flowering that gave the longest duration (46.33 days) to 50% flowering. Table (5) showed that there were significant differences between the concentrations of ABA in number of days from sowing to 50% silking. The number of days from planting to 50% silking was decreased by increasing the concentration of ABA, and 12 mg L^{-1} recorded the shortest mean of 41 days compared to control that gave 44.56 days. In addition, Spray at 4 leaves led to an early silking and showed the lowest mean of 55.43 days compared to the beginning of flowering which gave more days amounted to 33.50. Furthermore, interaction between 12 mg L^{-1} with spray time of 4 leaves recorded the lowest time to 50% silking of 36.66 days. However, control and 4 leaves stage showed the longest duration of 56.66 days. Results of this study came identical with previous results of (Al Jawahiri 2019; Hashem 2017; Majeed et al 2011; Wilmowicz et al., 2008). Presumably, the reason for that difference was attributed to the effect of ABA in insistence maize to move from vegetative stage to reproductive stage through influencing the physiological processes, as ABA has the ability to regulate the work of other growth hormones through signaling crosstalk. Spray of ABA, especially at early stages of plant life, stimulates flowering by affecting ethylene concentrations. It is well known and described before that ethylene is one of the hormones that controls and stimulates flowering in plants, and its relation with ABA is reciprocal. Therefore, and as described by the results of this study, ABA probably decreased the concentrations of ethylene and led to obstacle the inhibition of flowering stimulative role of ethylene and eventually early tasseling and silking as obvious in Tables 4 and 5.

Table (3): analysis of variance represented by mean squares of studied characteristics

Source of Variation	Replications	Abscisic Acid concentrations	Spray time	Interaction between concentrations and spray time	Error
d.f	2	2	2	4	16
Number of days to 50% tasseling	11.73	143.23**	115.89**	31.03**	3.53
Number of days to 50% silking	0.48	654.92**	108.59**	28.98**	0.64
Stem diameter cm	0.001	0.27**	0.08**	0.03**	0.002
Plant height cm	303.69	11.63ns	0.82ns	0.52ns	218.07
Number of seeds per ear	3.31	5224.62**	468.09**	328.20**	11.05
1000 seed weight g	2.28	2531.13**	221.21**	67.31**	2.17
Single plant yield g	7.90	2312.93**	302.27**	170.40**	1.08
Seed yield t ha^{-1}	0.04	4.80**	2.36**	0.69**	0.009
Protein content %	0.0004	0.21**	0.80**	0.20**	0.00006
Ash content %	0.0001	0.07**	0.04**	0.01**	0.00006
Germination %	19.00	80.44 **	24.11 ns	18.88ns	13.87
Germination speed	0.42	36.63**	18.34**	14.89**	0.698

Table (4): Effect of concentration and time of spraying ABA on the number of days until 50% tasseling

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	46.33 a	46.00 a	46.33 a	46.22 a
9	35.17 c	39.67 b	44.67a	39.83 b
12	34.00 c	37.00 bc	45.67 a	38.33 b
Spray time mean	38.50 c	40.39 b	45.55 a	

Table (5): Effect of concentration and time of spraying ABA on the number of days until 50% silking

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	56.66 a	56.33 a	56.33 a	56.44 a
9	37.33 e	42.33 c	47.66 b	42.44 b
12	36.66 e	39.33 d	47.00 b	41.00 c
Spray time mean	43.55 c	46.00 b	50.33 a	

Growth

Ideal plant growth could be positively reflected of the whole plant situation especially yield components and eventually seed yield. It was illustrated from the results of this study that the application of ABA at early growth stage could enhance the vegetative growth of the plants by avoiding them the chilling stress. Results in Table (6) obviously indicated that the addition of ABA at a concentration of 12 mg L^{-1} led to an increase in stem diameter to its highest mean of 2.47 cm compared to control treatment and 9 mg L^{-1} that recorded a stem diameter of 2.15 and 2.19 cm, respectively. In excess of that, plants sprayed at 4 leaves gave the highest mean of 2.35 cm. However, the application at the beginning of flowering gave the lowest mean of 2.16 cm. Interaction between concentration of 12 mg L^{-1} and spray time of 4 leaves recorded the highest mean of 66.2 cm compared 9 mg L^{-1} and beginning of flowering gave 2.12 cm. Results in Table (7) showed no significant differences between plant height means. This work indicated an increase in stem diameter which is can be considered as an evidence of increasing the capacity of the vascular bundles and then enhancing the utilization of nutrients and water. (Al-Sahoki, 1994). More than that, application of exogenous ABA found to increase the number of of vascular bundles of maize plant and then increasing and enhancing growth rate (Travaglia et al. 2012), and this is in consistence with results of this study and (Zhang et al; 2012 and Davies and Zhang, 1991).

Table (6): Effect of concentration and time of spraying ABA on stem diameter (cm)

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	2.16 de	2.15 de	2.15 de	2.15 b
9	2.25 c	2.20 cde	2.12 e	2.19 b
12	2.66 a	2.54 b	2.22 cd	2.47 a
Spray time mean	2.35 a	2.29 b	2.16 c	

Table (7): Effect of concentration and time of spraying ABA on plant height (cm)

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	280.13 a	281.07 a	281.20 a	280.80 a
9	279.93 a	280.67 a	279.87 a	280.15 a
12	287.43 a	278.40 a	278.93 a	278.58 a
Spray time mean	279.50 a	280.04 a	280.00 a	

Seed yield

Number of seeds per ear is one of the three most important yield components in maize and comes from two other components, number of grains per row and number of rows per ear. Results in Table (8) showed that the effect of ABA was significant. Concentration of 12 mg L^{-1} recorded the highest mean 682.89 seed ear^{-1}. Hence, control gave the lowest mean 653.14 seed ear^{-1}. In addition, spray at the beginning of flowering gave the highest 664.99 seed ear^{-1} compared 4 leaves, which gave the lowest mean 650.82 seed ear^{-1}. Means of interaction between the two factors shoed significant differences among each other where the interaction between 12 mg L^{-1} and spray at the beginning of flowering recorded the heights mean of 704.80 seed ear^{-1}. However, interaction between control and 8 leaves recorded the lowest mean. Similar results were reported by Bano et al., 2012. The reason for the increase in the number of seeds may be attributed to the effect of ABA and the time of application at the beginning of flowering in increasing the the other yield components that a positive relationship with this characteristics, which was positively reflected on the number of seeds in the ear.

Table (8): Effect of concentration and time of spraying ABA on number of seeds per ear (seed ear^{-1})

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	634.12 e	635.64 e	635.65 e	635.14 c
9	650.31 d	655.01 d	654.82 d	653.38 b
12	668.02 c	676.13 b	704.50 a	682.89 a
Spray time mean	650.82 c	655.60 b	664.99 a	

One thousand seed weight is a component of the basic seed yield in maize and it depends on the duration of seed of filling and the amount of processed materials that are affected by genetic composition and then by environmental conditions (Daynard et al. 1971). The results (Table 9) showed that the concentration of 12 mg L^{-1} gave the highest mean of 373.77 g, while control gave the lowest mean of 340.24 g. Also, spray at the beginning of flowering recorded the highest mean of 361.80 g compared 4 leaves, which showed the lowest mean of 351.88 g. Interaction of spray at the 12 mg L^{-1} and the beginning of flowering outperformed in giving the highest mean of 383.33 g compared to the interaction between control and beginning that gave the lowest 19.76 g. This may be due to the spraying of 12 mg L^{-1} of ABA at the beginning of flowering time leads to the deep penetration of roots into the soil, and then leads to an increase in the plants ability to absorb water and nutrients, and then providing the process of CO_2 with necessary elements for metabolism and facilitate the translocation of the products of carbon metabolism from the source of creation to the sink. These results agree with those of Mohammadi et al. (2013) and Yang et al. (2014).

Table (9): Effect of concentration and time of spraying ABA on 1000 seed weight (g)

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	340.33 g	340.33 g	340.07 g	340.24 c
9	350.33 f	356.66 e	362.00 d	356.33 b
12	365.00 c	373.00 b	383.33 a	373.77 a
Spray time mean	351.88 c	356.66 b	361.80 a	

Table (10) results showed that there were significant differences between the means of ABA concentrations in single plant yield. Concentration of 12 mg L^{-1} recorded the highest mean of 165.64 g, while control recorded the lowest mean of 134.48 g. Spray of ABA at the beginning of flowering gave the highest mean of 158.70 g compared to 4 leaves that gave 147.47 g. the highest mean of single plant yield was given by the interaction between 12 mg L^{-1} and spray at the beginning of flowering, but the lowest was given by control and 4 leaves stage. Seed yield is the most important characteristic as it is the final outcome of vital activities that occur during the life period of the plant that are affected by the genetic factor of the plant and the surrounding environmental conditions. Results of Table (11) showed that there were significant differences between ABA means. Concentration of 12 mg L^{-1} gave the highest mean (11.04 tons ha^{-1}), while control gave the lowest mean of 8.96 tons ha^{-1}. Spraying at flowering gave the highest mean of 10.57 tons ha^{-1} compared to 8 leaves which gave the lowest mean of 9.82 tons ha^{-1}. Interaction between spraying at the beginning of flowering and 12 mg L^{-1} excelled in giving the highest mean of 11.82 tons ha^{-1} compared the interaction between control and 4 leaves that gave the lowest mean 8.96 tons ha^{-1}. Results of this study came in agreement with other studies on single plant yield Al-Jawahiri 2019 and seed yield Marcinska et al. 2013; Wei et al. 2015; Travaglia et al 2012). One of the key reasons of increasing single plant yield and seed yield the proved role of ABA in protecting reproductive organs when applied at the beginning of flowering in maize as indicated by the results of this study. Furthermore, increasing single plant yield with increasing the concentration of ABA when applied at the beginning of flowering stage is evidence that this is an outcome of increasing the other yield components. In addition to that, seed yield is correlated with single plant yield. It may also be attributed the role of ABA in regulating the water condition of the plant by regulating the process of closing the stomata, which reduces water loss from the vegetative part and in this way avoids the water deficit Hussain et al. (2013).

Table (10): Effect of concentration and time of spraying ABA on single plant yield (g)

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	134.50 f	134.50 f	134.46 f	134.48 c
9	160.43 c	145.10 e	164.33 b	156.62 b
12	156.80 d	162.83 b	177.30 a	165.64 a
Spray time mean	150.57 b	147.47 c	158.70 a	

Table (11): Effect of concentration and time of spraying ABA on seed yield (ton ha^{-1})

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	8.96 e	8.96 e	8.96 e	8.96 c
9	10.69 f	9.67 c	10.95 b	10.43 b
12	10.45 bc	10.85 d	11. 82 a	11.04 a
Spray time mean	10.03 b	9.82 c	10.57 a	

Seed quality

Protein and ash are important indicators in seed quality. High protein content of corn seeds with balanced ratios of its essential amino acids is an important factor in increasing the quality of seed in terms of either using seeds is the field for planting or for human and animal nutrition. However, protein is a characteristic that impacted by environmental and genetic conditions (Nass et al., 1976). Table (18) showed that ABA had a significant effect on protein content in seed. Concentration of 12 mg L^{-1} recorded the highest mean 9.80% compared to control that gave the lowest mean of 9.51%. Spraying of ABA at the beginning of flowering scored the highest mean of 10.03%. However, spraying at 4 leaves reached 9.51%. Interaction between 12 mg L^{-1} and spray at the beginning of flowering excelled in giving the highest mean of 10.38% compared to the interaction between control and 4 leaves that gave the lowest mean of 9.50%. The reason may be due to the effect of ABA in stimulating the formation and growth of root and encouraging them to grow, which led to an increase in the absorption of elements from soil, especially nitrogen, and then an increase in its concentration in the leaves, which was reflected on the increase and accumulation of the dray matter in seed. These results are in agreement with what was found by Al-Fatlawi (2013) and Yang et al. (2013). The percentage of ash is one of the expressive qualities of the mineral elements that seed contains. Increasing ash content in maize seed illustrates the nutrition situation of the seed during filling and development at field conditions. Table (13) showed that the effect of ABA concentrations was significant on the ash content. Concentration of 12 mg L^{-1} gave the highest mean of 1.39%, while the control gave the lowest mean of 1.21%. Foliar application of ABA at the beginning of flowering gave the highest mean of 1.36% compared to 4 and 8 leaves that gave

1.24% . Interaction between 12 mg L^{-1} and spray at the beginning of flowering excelled and gave the highest mean of 1.54% compared to interaction between control and all stages of application that recorded 1.21%. The increase in percentage of ash in ABA treated seeds comparing to non-treated seed probably due to the increase in translocation of photosynthesis from leaves to seeds under the impact of ABA which was proved before by Travaglia et al 2012 to support that translocation in addition to enhancing nutritional situation of the plant.

Table (12): Effect of concentration and time of spraying ABA on protein content (%)

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	9.50 d	9.51 cd	9.51 cd	9.51 c
9	9.52 c	9.52 c	10.21 b	9.75 b
12	9.51 cd	9.51 cd	10.38 a	9.80 a
Spray time mean	9.51 b	9.51 b	10.03 a	

Table (13): Effect of concentration and time of spraying ABA on ash content (%)

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	1.21 d	1.21 d	1.21 d	1.21 c
9	1.21 d	1.22 d	1.35 b	1.26 b
12	1.32 c	1.31 c	1.54 a	1.39 a
Spray time mean	1.24 b	1.24 b	1.36 a	

Seed germination

Optimum seed quality permits obtaining a high percentage of germination. The results of this study confirmed the support of ABA concentration and time of foliar application to seed quality through viewing the results of seed yield components and seed quality characteristics. However, germination percentage was at its maximum 95.89 % at control where no application of ABA, and the lowest was at 12 mg L^{-1}. In addition, the highest germination percentage 96.00 was at control and 4 leaves stage of foliar application, and the lowest was 36.00 at 12 mg L^{-1} and spray at the beginning of flowering Table (14). Germination speed behaved the same germination percentage under the impact of ABA concentrations. The highest germination speed was recorded at the control, and the lowest was at 12 mg L^{-1}. Spray of ABA at 4 leaves showed the highest germination speed of 48.81, but the lowest was 43.30 at the beginning of flowering. Interaction between the two factors recorded the highest germination speed of 65.14 at the interaction of control and the beginning of flowering. Even at the end of last day of counting and as recommended by ISTA germination procedure, germination percentage and speed was significantly lower than control. The relationship between ABA content and seed size has previously been proved by Yang et al., 2014; Bano et al., 2012; Zhiqing et al., 2011. It is normally known that good in size with high quality seeds, as obtained here in this study, to show high percentage of germination and high values of germination speed. However, the results of this study indicated a kind of dormancy, which could be physiological. The relationship between seed size and ABA content has been proved before and moreover the relation between ABA content and dormancy of seed was extensively described by Dekkers and Bentsink; 2015. Therefore, the results of this study confirm the previous studies regarding the role of ABA in increasing maize seed quality and delay germination.

Table (14): Effect of concentration and time of spraying ABA on germination (%).

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	96.00 a	95.33 a	96.33 a	95.89 a
9	81.00 bc	84.33 b	76.67 c	80.67 b
12	40.67 d	37.67 d	36.00 d	38.11 c
Spray time mean	72.56 a	72.44 a	69.67 a	

Table (15): Effect of concentration and time of spraying ABA on germination speed

ABA mg L^{-1}	Spray time			ABA mean
	Four leaves	Eight leaves	Beginning of flowering	
0	64.89 a	64.39 a	65.14 a	64.80 a
9	54.43 b	49.60 c	41.61 d	48.55 b
12	27.10 e	24.74 f	23.15 g	25.00 c
Spray time mean	48.81 a	46.24 b	43.30 c	

CONCLUSION

It can be concluded from this study that early foliar application of ABA to maize can reduce crop period in the field, and this is a good matter and through which the crop can tolerate low temperatures. In addition, spray of ABA can improve the vegetative growth of the crop, according to the concentrations used in this study and when added early, which can support the components of the crop. The addition of ABA at late stages of plant growth, especially at flowering when the crop is subjected to stress resulting from low temperatures, was very effective in protecting reproductive parts and then the success of the process of pollination and double fertilization. Also, ABA seems to have a role in protecting seeds at different stages of their growth, which is reflected positively on seed yield. Moreover, it has played a major role in producing high quality seeds, but with low germination and speed.

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تأثير تركيز حامض الابسسك وموعد الرش في النمو وحاصل البذور والانبات في الذرة الصفراء عند الزراعة المتأخرة

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الخلاصة

نفذت تجربة حقلية في منطقة الحجاج بمحافظة صلاح الدين خلال الفصل الخريفي 2021. تم استخدام تصميم القطاعات العشوائية الكاملة بثلاثة مكررات. احتوت الدراسة على ثلاثة تراكيز من حامض الابسسك 0 و 9 و 12 ملغم لتر-1 حيث تم رشها على النباتات في مرحلة 4 أوراق و 8 أوراق وبداية التزهير. أشارت النتائج إلى تفوق تركيز 12 ملغم لتر-1 في تقصير عدد الأيام من الزراعة حتى 50٪ تزهير ذكري حيث بلغت المدة 38.33 و41 يوم حتى 50% تزهير اثوي. سجل نفس التركيز أعلى قطر ساق قدره 2.47 سم, عدد بذور في العرنوص بلغ 682.89 , وزن 1000 بذرة 373.77 غم, حاصل نبات فردي 165.64 غم, حاصل بذور 11.04 طن هـ-1, نسبة بروتين 9.80٪ ونسبة رماد 1.39٪. بينما سجلت معاملة المقارنة أعلى نسبة وسرعة إنبات 95.89 و 64.80,على التوالي. تفوق رش حامض الابسسك عند مرحلة 4 أوراق في تسجيل أقل عدد أيام من الزراعة حتى 50٪ تزهير ذكري 38.50 يوم وتزهير انثوي 43.55 يوم وتفوق أيضاً في إعطاء أعلى قطر للساق 2.35 سم. أعطت اضافة حامض الابسسك في بداية التزهير أعلى المتوسطات لعدد البذور في العرنوص 664.99 بذرة عرنوص-1, وزن 1000 بذرة 361.80 غم, حاصل نبات فردي 158.70 غم, حاصل بذور 10.57 طن هـ-1, نسبة بروتين 10.03 ٪ ونسبة رماد 1.36٪. سجل الرش الورقي عند مرحلة أربع أوراق أعلى متوسط لسرعة الإنبات بلغ 84.81. أعطى التداخل بين تركيز 12 ملغم لتر-1 والرش عند مرحلة 4 أوراق أقل عدد ايام من الزراعة حتى 50٪ تزهير ذكري 34.00 يوم وتزهير انثوي 36.66 يوم, بينما أعطى نفس التداخل أعلى قطر للساق 2.66 سم. أما التداخل بين التركيز 12 ملغم لتر-1 والرش عند بداية التزهير فقد سجل أعلى عدد بذور في العرنوص 704.50 بذرة عرنوص-1, وزن 1000 بذرة 383.33 غم, حاصل نبات فردي 177.30 غم, حاصل بذور 11.82 طن هـ-1, نسبة بروتين 10.38٪ ونسبة رماد 1.54٪. أعلى نسبة إنبات كانت عند التداخل بين معاملة المقارنة و 4 أوراق ولكن أعلى سرعة إنبات كانت عند التداخل بين معاملة المقارنة وبداية التزهير.

الكلمات المفتاحية:
الذرة الصفراء, حامض الابسسك, التزهير, النمو, حاصل البذور, الانبات.