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EFFECT OF ABSCISIC ACID (ABA) ON YIELD AND ITS COMPONENTS OF FOUR RICE VARIETIES (*ORYZA SATIVA* L.) UNDER AEROBIC CONDITIONS

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Abstract

This experiment was carried out at University of Baghdad / college of agricultural engineering sciences during the summer season of 2018 to evaluate the effect of foliar spraying of Abscisic acid (ABA) on four rice Varieties: Amber-33, Jasmine (local Varieties), Nagina-22 (N22) and Kinandang patong (KP) (introduced Varieties) under aerobic conditions. A randomized complete block design (RCBD) with three replicates, each one contained three concentrations of ABA (8, 16 and 24 mg.L^{-1}), which were symbolized as (A1, A2 and A3) respectively, as well as the control treatment which sprayed with distilled water only (A0), these concentration were applied to each of four Varieties in order to determine their effect on the studied traits which were: Tiller number, Panicle length, Panicle number, Panicle grain number, Weight of 1000 grains and total grain yield. Results showed a significant difference among the Varieties in all studied traits, the Variety Amber-33 gave the highest values in Panicle length (24.79 cm), while Variety (KP) gave the most significant values in Panicle grain number (123.06), weight of 1000 grains (22.05 gm) and total grain yield (6.34 ton.h^{-1}), the Variety N22 has given the highest values in total tiller number (580.59 tiller.m^{-2}) and panicle number (435.18 panicle.m^{-2}), Also the spraying of ABA in different concentration gave a significant effect on the studied traits, the A3 treatment gave the highest values in tiller number (487.94), panicle length (24.79 cm), panicle number (399.13), panicle grain number (119.89), weight of 1000 grains (20.42 gm) and total grain yield (7.52 ton.h^{-1}). Also the interaction between ABA and Varieties gave significant values in the studied traits.

Key words: Abscisic Acid, Yield, Rice.

Introduction

Rice (*Oryza sativa* L.) is a major crop and main source of food for many populations in the world, its importance lies in the high carbohydrate content (Liu *et al*., 2007). The water deficiency is one of the most important issues that encountering agriculture and in particularly rice crop. In Iraq there were nearly 58.28 thousand ha of cultivated areas at 2017 with grain yield of 48.98 thousand tons in rate of 0.9 ton.h^{-1} (FAO, 2019), after it was 150 thousand ha with 389.5 thousand tons of yield at 1998 (Authority of Planning, 2001), it can be observed that the production has been reduced as well as the cultivated area therefore, introduction of the upland rice which can grow and rise in the aerobic conditions can be one of the most important strategies to improve the cultivation and productivity of rice crop, these Varieties are qualified to be adopted to the environmental conditions as well as their high productivity and growth. They are also resistant to drought, diseases and insects compared to other rice varieties (Bonman *et al*., 2007). The foliar application of ABA on rice crop is one of the important applications to reduce the detrimental effects caused by abiotic stress including the available water deficiency by maintaining the plant water content by regulating the opening and closing of stomata and reducing the water loss through transpiration (Ren *et al*., 2017), As well as its role in increasing the antioxidant enzymes activity, also enhancing the growth of rooting system which leads to increase the water and nutrients absorption from the soil (Pantin *et al*., 2013). Researches revealed that rice Varieties are differs from each other in tiller number (Alogaidi *et al*., 2019), panicle number (Ahmad *et al*., 2017), Panicle length (Hadi and Salem, 2016), panicle grain number (Dawood *et al*., 2010), weight of 1000 grains (Shi *et al*., 2017) and total grain yield (Hadi and Salem, 2016 and Ahmed *et al*., 2017). As Win *et al*.,

(2017) observed that the application of plant growth regulators on Rice has been encouraged the plant to overcome the environmental stress such as the application of ABA for 24 hours caused an increase in total grain yield compared to non-treated plants. Also the foliar application of ABA on the plant has significantly increased the panicle number (Parent *et al*., 2009). Researches mentioned that the spraying of ABA on wheat significantly increased the tiller number (Ahmed and Hashim, 2017), Panicle length (Bano *et al*., 2012), weight of 1000 grains (Yang *et al*., 2014) and Panicle grain number (Marcinska *et al*., 2013). After all given above, this study aimed to evaluate the effect of ABA in reducing the environmental stress and its role in growth and yield of local and introduced rice Varieties under aerobic conditions, also comparing between rice Varieties by using different concentrations of ABA.

Materials and Methods

This experiment was carried out at an experimental station belongs to the department of Field Crops-college of agricultural engineering sciences -University of Baghdad during summer season in 2018 to evaluate the performance of four Varieties of Rice (Kinandang Patong (KP), Nagina (N22), Anbar-33 and Jasmine Jasmine) under aerobic conditions and using different concentrations of Abscisic acid to evaluate their effect on alleviating the environmental stress on growth and yield of the studied varieties under aerobic conditions. A factorial Randomized Complete Block design were applied with three replicates, each one occupied by three concentrations of Abscisic acid (8, 16 and 24) mg.L^{-1} sprayed on the vegetative growth which symbolized (A1, A2 and A3) respectively, as well as the control treatment (A0 spraying with distilled water) for each of the four varieties. The soil was initialized by plowing, smoothing and modifying, then the field was divided into three replicates, each replicate contained 16 plots, each was (2×2 m) with area of 4 m^2, each experiment unit contained 10 lines spaced by 20 cm in between and 2 m as a length for each line with keeping 1.5 m between each replicate to avoid the interaction. The samples were randomly taken from the soil from different areas in depth (0-30) cm before planting and analyzed in the Soil analysis laboratory -Research department -Ministry of Agriculture as their physical and chemical characteristics followed in table 1. After the land has been irrigated heavily (for calibration), Seeds were planted on 30/6/2018 in lines with 25 Kg.h^{-1} according to Condensation system bulletin for rice crop (Kirmasha *et al*., 2009) by using four Varieties of rice (Anbar-33 and Jasmine) which were recommended by Almiskhab research station -Najaf that belongs to the Iraqi ministry of agriculture, as well as two foreign varieties (Nagina-22) from India and (Kinandang Patong) from Malaysia (Table 2). NP compound fertilizer was applied while planting the seeds (18-46-0) in rate of 30 Kg.h^{-1} (Kirmasha *et al*., 2009). Then, the land was irrigated straight after planting. Then light irrigation continued daily until the third leaf appearance on the plant. After all, the irrigation accorded in plant need until the stage of physiological maturity.

Table 1: A few chemical and physical characteristics of field's soil before planting (Agricultural research station F - College of Agricultural Engineering Sciences- University of Baghdad).

Characteristics		Value	Unit
pH		7.67	-
Electrical conductivity (EC)		4.375	S m^{-1}
Organic matter		2.8	Gm Kg^{-1} soil
Positive soluble ions	Ca	1.40	cMall charge Kg^{-1}
	Mg	2.88	
	K	0.07	
	Na	0.25	
Negative soluble ions	Carbonates	Nil	cMall charge Kg^{-1}
	Bicarbonates	2.10	
	Sulfates	1.2	
	Chlorides	1.18	
Soil separators	Sand	316.7	gm Kg^{-1}
	Silt	390.2	
	Clay	293.1	
Texture		Silty clay soil	
Bulk density		1.35	Megagram m^{-3}

The Superphosphate fertilizer was applied in 100 Kg.h^{-1} during the plowing to all treatments (Al-rawi and Hammadi, 1997). While the Nitrogen (urea 46% N) was applied in three batches. The first was while planting by using 25% of recommended quantity. The second was 50% during the offshoot phase and the third was 25% in the flowering phase (Jaddoa, 1999). The weed control operation was carried out manually from time to time. The Abscisic acid was sprayed on the vegetative growth in the afternoon after 45 days of planting, specifically in branching stage (4-6 leaves), (Maleki, 2011). A 16 liter hand spray was used to spray the vegetative growth until the full wet and start dropping, which required 2.2 L for

Table 2: Rice varieties used in the experiment.

No.	Variety	Variety's Scientific background
1	Amber-33	Local Variety
2	Jasmine	Local Variety (originally from Vietnam)
3	Nagina 22 (N22)	introduced from India
4	Kinandang patong (KP)	introduced from Malaysia

each individual treatment plot. The solution was mixed by 2-3 drops of diffuser (washing liquid) to increase the adhesion of solution to the plant, while the control treatment was only sprayed by distilled water. All agricultural operations have been carried out until maturity. The variety Nagina 22 (N22) was harvested after maturity on 21/10/2018 while the rest of varieties were harvested on 27-28/10/2018 by reaching the certain stage of maturity. After harvest, the following traits were measured: Total tiller number, Panicle number, Grain number in panicle, 1000 grains weight and Panicle length (by measuring the distance from the node to the end of panicle). All traits were measured in field then the crop was harvested and the grains were weighed based on a moisture content of 14% and then converted to ($ton.h^{-1}$).

Preparing the spray solution of ABA

ABA (produced by American chemical company Sigma) was prepared by dissolving 2000 milligrams of ABA in distilled water directly with the addition of 10% sodium hypochlorite in a small beaker which mixed by a magnetic hot plate stirrer in order to complete the melting and then the volume completed to 1 Liter using 1 Liter volumetric beaker to obtain the concentration of 2000 $mg.L^{-1}$, then 30 liters of distilled water were prepared for each of the required concentrations which were (8, 16, 24) $mg.L^{-1}$. The required concentrations were founded according to the equation below:

$$\text{The volume taken from the standard solution} = \frac{\text{Required conc.} \times \text{Required volume}}{\text{Standard solution concentration}}$$

Results and Discussion

Total tiller number ($tiller.m^{-2}$)

Results in table 3, revealed a significant effect for the variety N22 by giving the highest values in tiller number (580.59) tiller m^{-2} with increasing percent reached 87.02%, 40.80%, 23.06% compared to the varieties (KP, Anber-33 and jasmine) respectively, while the variety KP recorded the lowest values reached 310.45 $tiller.m^{-2}$. It's illustrated that rice varieties was significantly contrasted in total tiller number which can be due to the genetic variance in their ability of branching or because of their difference in response to environmental factors such as light, water, Carbon dioxide and nutrients, which reflects on their ability to form new tiller and hence the variation in the number of tiller per planted area (Ihsan *et al*., 2016). These results are in agreement with Alogaidi *et al*., (2019) when pointed that tiller number differs from variety to another for many reasons including environmental and genetic.

Results in table 3, revealed a significant effect by the sprayed concentrations of ABA in total tiller number, the concentration A3 gave the highest value reached 487.94 $tiller.m^{-2}$ while the treatment A0 gave the lowest value reached 403.82 $tiller.m^{-2}$. The increasing of tiller number might be due to the effect of ABA on the apical dominance which leads to Redistribute the processed nutrients and boost the plant to increase the number of lateral tiller (Yang *et al*., 2013). This is in consistent with Ahmed and Hashim, (2017), who found that rising the concentrations of ABA acid lead to an increase in total tiller number per planted area.

Results in table 3, also indicated that the rice varieties are significantly interacted with the concentrations of spraying with ABA in this trait, the interaction between variety N22 and the concentration A3 were recorded highest values peaked at 659 $tiller.m^{-2}$, while the interaction KP + A0 gave the lowest value reached 285.05 $tiller.m^{-2}$ which was not differ significantly from the interaction KP+A1.

Panicle length (cm)

Results in table 4, showed a significant effect of rice varieties on Panicle length. The Amber-33 variety achieved the highest mean panicle length reached (24.79 cm), which significantly differs from the rest of varieties, While the variety N22 gave the lowest values 18.02 cm in a decrease percent reached 27.30, 13.65 and 4.45% in comparison with the rest varieties (Amber-33, KP and

Table 3: Effect of varieties and ABA and their interaction on total tiller number (tiller m^{-2}).

Varieties	ABA concentrations ($mg.L^{-1}$)				Averages
	A0 (0)	A1 (8)	A2 (16)	A3 (24)	
Amber-33	379.54	391.68	433.23	444.90	412.34
Kinandang patong	285.05	289.31	318.90	348.53	310.45
Nagina 22	510.21	560.51	592.64	659.00	580.59
Jasmine	440.46	463.56	483.82	499.33	471.79
Averages	403.82	426.27	457.15	487.94	-
L.S.D 0.05	Varieties *12.28		Concentrations *12.28		Interaction *24.576

Table 4: Effect of varieties, ABA and their interaction on panicle length (cm).

Varieties	ABA concentrations ($mg.L^{-1}$)				Averages
	A0 (0)	A1 (8)	A2 (16)	A3 (24)	
Amber-33	21.87	23.40	25.31	28.57	24.79
Kinandang patong	16.84	20.69	22.19	23.74	20.87
Nagina 22	16.88	17.78	18.30	19.11	18.02
Jasmine	16.28	17.64	19.60	21.92	18.86
Averages	17.97	19.88	21.35	23.34	-
L.S.D 0.05	Varieties *0.543		Concentrations *0.543		Interaction *1.086

Jasmine) respectively. The reason for the variance in panicle length between the varieties may be due to the genetic variance among them, which reflected on their difference in this trait (Rahman *et al*., 2013). This result is in consistent with the findings of Hadi and Salem, (2016) who indicated that there was a difference in panicle length between rice varieties.

As shown in table 4, there is a significant effect of the concentrations of spraying ABA. The panicle length has increased by rising the concentration of ABA, the concentration A3 recorded the highest value of panicle reached 23.34 cm while the concentration A0 gave the lowest value reached 17.97 cm in decrease percent reached 23.01, 15.83 and 9.61% compared with the concentrations (A1, A2 and A3) respectively. This increase may due to the role of ABA in increasing the panicle, this fact can be confirmed by further researches to find out the role of ABA on this trait. These results were in agreement with Marcinska *et al*., (2013) who recommended that the application with ABA on Rice has increased the Panicle length.

The results revealed a significant effect of interaction between varieties and concentrations, the interaction Amber-33 + A3 gave the highest values peaked at 28.57 cm, while the interaction Jasmine + A0 reached 16.28 cm as shown in table 4.

Panicle number (panicle.m^2)

Results in table 5, revealed a significant effect for varieties on panicle number, the variety N22 gave the highest value reached 435.18 m^2 with increase percent reached 67.16, 24.51 and 8.01% in comparison with the varieties KP, Amber-33 and Jasmine respectively, while the variety KP gave the lowest value of panicle number reached 260.33 m^2. The variance in panicle number between rice varieties may be due to their difference in branching ability per planted area under the typical environmental conditions, as well as their difference in tiller number which carry the panicle, that was in agreement with that of Ahmed *et al*., (2017) who mentioned the difference between rice varieties in panicle number.

Results in table 5, showed that the foliar application of ABA on rice can contribute in increasing the panicle number per square meter significantly. The treatment A3 recorded the highest value peaked at 399.14 m^2, while the treatment A0 gave the lowest value 329.23 m^2 and it might be due to the role of ABA in increasing tiller number (Table 3), as well as increasing the rooting system growth which rise the ability of water and nutrients absorption which positively reflected on increasing tiller number which holding the panicle and increase the panicle number (Parent *et al*., 2009). This result consisted with Gurmani *et al*., (2011) who mentioned that the application of ABA has increased the panicle number.

As it shown in table 5, there was a significant interaction between the experiment factors, the treatment (A3 + N22) gave the highest values reached 471.13 m^2, while the treatment (A0-N22) gave the lowest value reached 229.38 m^2.

Panicle grain number (grain.panicle^{-1})

Results in table 6, revealed a significant effect for varieties in studied trait, the variety KP gave the highest value reached 123.06 with non-significant difference with Amber-33 and an increase percent 38.20 and 36.20% comparing to N22 and Jasmine respectively, while the variety N22 gave the lowest value reached 89.04, the Early ripening varieties usually produce fewer grains compared to middle and late ripening varieties, also number of grain affected by the growth rate of the crop between the stage of growth and flowering, as well as the environmental conditions which might effect on pollination and fertilization which reflected on grain number (Hiroyuki *et al*., 2007), these results are in agreement with Ahmed *et al*., (2017), who mentioned a significant effects between rice arieties in grain number.

Also table 6, showed that the spraying of ABA

Table 5: Effect of varieties, ABA and their interaction on panicle number (panicle m^{-2}).

Varieties	ABA concentrations (mg.L^{-1})				Averages
	A0 (0)	A1 (8)	A2 (16)	A3 (24)	
Amber-33	330.00	329.86	359.33	378.56	349.44
Kinandang patong	229.38	238.02	273.72	300.21	260.33
Nagina 22	399.77	423.10	446.53	471.31	435.18
Jasmine	357.79	388.87	418.46	446.46	402.90
Averages	329.24	344.96	374.51	399.14	-
L.S.D 0.05	Varieties *13.21		Concentrations *13.21		Interaction *26.419

Table 6: Effect of varieties, ABA and their interaction on panicle grain number (grain panicle^{-1}).

Varieties	ABA concentrations (mg.L^{-1})				Averages
	A0 (0)	A1 (8)	A2 (16)	A3 (24)	
Amber-33	107.00	121.20	124.90	129.20	120.58
Kinandang patong	103.70	119.55	129.55	139.45	123.06
Nagina 22	77.35	87.20	93.10	98.50	89.04
Jasmine	79.45	87.55	98.50	100.40	90.33
Averages	91.88	103.88	110.36	116.89	-
L.S.D 0.05	Varieties *4.882		Concentrations *4.882		Interaction *9.764

Table 7: Effect of varieties, ABA and their interaction on the weight of 1000 grains (gm).

Varieties	ABA concentrations (mg.L^{-1})				Averages
	A0 (0)	A1 (8)	A2 (16)	A3 (24)	
Amber-33	18.65	19.44	20.13	21.03	19.81
Kinandang patong	19.58	21.99	20.09	24.53	22.05
Nagina 22	13.54	14.38	15.25	16.93	15.02
Jasmine	16.04	17.36	17.79	19.17	17.59
Averages	16.95	18.29	18.81	20.42	-
L.S.D 0.05	Varieties *0.636	Concentrations *0.636		Interaction *1.272	

Table 8: Effect of varieties, ABA and their interaction on total grain yield (ton ha^{-1}).

Varieties	ABA concentrations (mg.L^{-1})				Averages
	A0 (0)	A1 (8)	A2 (16)	A3 (24)	
Amber-33	4.89	5.77	6.70	7.66	6.25
Kinandang patong	4.78	5.70	6.77	8.08	6.33
Nagina 22	4.02	4.59	5.71	6.76	5.26
Jasmine	4.40	5.37	6.92	7.60	6.07
Averages	4.52	5.36	6.53	7.52	-
L.S.D 0.05	Varieties *0.406	Concentrations *0.406		Interaction *0.813	

significantly increased the panicle grain number, the treatment A3 gave the highest value reached 116.89 in increase percent 27.22, 12.52 and 5.91% comparing with (A0, A1 and A2) respectively, while the concentration A0 gave the lowest value 91.88. The increase in the number of grain may be due to the effect of ABA in regulating water content within the plant, As well as its role in increasing the length of the panicle (Table 5) which is positively reflected on the number of grain in panicle. These results are in agreement with (Ahmed and Hashim, 2017) who mentioned that the grain number has increased by the application of ABA.

Results in table 6, revealed a significant effect factors interaction, the treatment (A3+KP) gave the highest value 139.45 while the treatment A0+N22 gave the lowest value 77.35.

Weight of 1000 grains (gm)

Results in table 7, presented a significant effect of rice varieties on the studied trait. The variety KP recorded the highest value peaked at 22.05 gm, while the variety N22 gave the lowest value reached 15.02 gm in decrease percent 31.88, 24.17 and 14.61% in comparison with the varieties (KP, Amber-33 and Jasmine) respectively. The reason for the variation between varieties in the weight of 1000 grains may be due to the differences between varieties in the period of grain filling and source and sink efficiency in producing and reception of photosynthesis products (Shi *et al*., 2017). This is in agreement with Alogaidi *et al*., (2019) who concluded that this trait varies among rice varieties as well as being affected by some environmental conditions.

Also, the results shown in table 7, that spraying the ABA on the vegetative growth of rice varieties contributed a significant increase in the weight of 1000 grains, the concentration A3 gave the highest value peaked at 20.42 gm, while the treatment A0 (distilled water spray) gave the lowest value reached 16.95 gm. The reason for increasing the weight of 1000 grains may be due to the role played by ABA in increasing the plant's ability to absorb water and nutrients from the soil. Thus, it ease the transfer of photosynthesis products from source to sink Mohammadi *et al*., (2013). These results are in consistent with Yang *et al*., (2014) who confirmed that the application of ABA has increased the grain weight.

Results in table 7, revealed a significant effect for the interaction treatments, the combination (A3+KP) recorded the highest value reached 24.53 gm, in non-significant increase compared with (A0+N22) and (A1+N22) which gave the lowest values reached 13.45 and 14.38 gm respectively, with non-significant difference between each of them.

Total grain yield (ton.ha^{-1})

Results in table 8, revealed a significant effect among the varieties. The variety KP gave the highest values reached 6.34 ton.ha^{-1} with non-significant with Amber-33 and Jasmine, while the variety N22 significantly gave the lowest value reached 5.26 ton.ha^{-1}, in decreasing percent 16.88, 15.81 and 13.32% in comparison with KP, Amber-33 and Jasmine respectively. The difference in yield between varieties is the result of many variations in few traits, the most important of which is Panicle number, panicle grain number and weight of 1000 grains However, it appears in this study that the total grain yield was significantly affected by the panicle grain number (Table 6) and weight of 1000 grains (Table 7) which reflected on total grain yield of these varieties, these results are in agreement with (Hadi and Salem, 2016; Ahmed *et al*., 2017) who mentioned the rice varieties are vary in total grain yield trait.

Also results in table 8, shows significant affect of spraying ABA on studied trait, the concentration A3 has given the highest value reached 7.52 ton.ha^{-1}, while A0 (control treatment) gave the lowest value reached 4.52 ton.ha^{-1}. The reason for the increase in total grain yield by rising the concentration of ABA may be due to its role in regulating plant water content By regulating the opening and closing of stomata, which reduces the loss of water from the vegetative growth. This is consistent with Win *et al*., (2017) who founded that the application of ABA on rice has increased the total grain yield.

Table 8, revealed a significant effect by the interactions, the combination KP+A3 gave the highest value reached 8.09 ton.ha^{-1}, while the combination A0+N22 gave the lowest value reached 4.02 ton.ha^{-1}, which is non-significant from each of (A0+Jasmine) and (A1+N22).

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