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Growth, Productivity and Quality of Rice and Its Relation to Biochar and Abscisic Acid under Water Stress Conditions

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ABSTRACT: Biochar and Abscisic acid (ABA) are considered beneficial bio-stimulants for crop production. However, limited information is available on the effects of continuous applications of biochar as compared with ABA on rice. In this study, a field experiment was conducted in the two growing seasons 2020 and 2021. Grain yield and yield attributes of grown rice cultivar Sakha Super 300 were compared, with and without applications of biochar, ABA, and their interaction under water stress in both seasons. Two experiments were laid out in strip plot design based on randomized complete block design (RCBD) in four replications. Main plots were assigned to four different irrigation intervals as following: irrigation every four days (I_1), every six days (I_2),every eight days (I_3), and every ten days (I_4). While the sub-plots were allocated to the application of bio- stimulants as following (Untreated=control (B_1), Biochar (B_2), abscisic acid (ABA) (B_3), Biochar + abscisic acid (ABA) (B_4). The results showed that the application of bio- stimulants reduced the effect of water stress on yield and yield components of rice cultivar Sakha super 300, when plants irrigated every 4 days (I1 and every 6 days (I_2) with soil application of biochar and foliar application of ABA under studied conditions. Our study suggests that the positive effects of biochar and ABA application on rice yield and yield attributes depend on biochar and ABA application.

***Keywords**: Rice; yield; yield components; ABA; Biochar; abscisic acid*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crops in the world providing the staple food for up to half of the world's population **FAO (2019) and Gnanamanickam. (2009).** In Egypt, Rice is the second most important cereal crop after wheat as the main food for the Egyptian population **Badawi (1999)**. Rice is grown mostly in the northern part of the Nile Delta. Most of these areas are classified as saline soils and rice is the suitable crop to cultivate in the area. Increasing grain yield is considered the main objective in the rice breeding program to develop and produce new cultivars, it is dependent on component traits and economic return.

Water stress affects morphological and physiological processes in rice because water plays an important role in its growth. Plenty of water is essential for growth and drought-tolerant of rice (*Oryza sativa* L.) (**Usman *et al.*, 2013)**. Drought stress is a serious threat to global rice production. Drought stress lowers rice production by reducing growth, elongation, and cell expansion, and disrupts plant antioxidant function by promoting reactive oxygen species accumulation. Drought stress responses can be managed by adopting strategies such as breeding and marker assistant selection; modulating drought responses through the application of plant hormones like abscisic acid and other acids as well as generating transgenics for drought tolerance in rice (**Upadhyaya and Panda, 2019)**. Three common types of droughts affect rice production: early water stress that causes a delay in seedling transplantation, mild sporadic stress having cumulative effects, and late stress affecting late-maturing varieties. Drought stress induces various physiological and biochemical changes in rice at different developmental stages (**Tripathy *et al.*, 2000**). Water deficit induced degradation of photosynthetic pigments, reducing the amount of chlorophyll and the photosynthetic system will be destroyed.

Water stress at the vegetative stage reduced stomatal conductance, net photosynthesis, and thus the decreasing yield. Water deficit of the main factors limiting yield production in arid and semi-arid regions is considered (**Fathi and Tari 2016)**. Water stress during the critical growth stage of rice significantly reduces rice yield in all cultivars **(Adhikari *et al.*, 2019).**

Biochar is the solid product of the thermal decomposition of organic matter under a limited

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supply of oxygen **(Lehmann and Joseph 2015)**. Moreover, because biochar application has the potential to stimulate crop growth by enhanced water storage, improved nutrient supply, increased beneficial microbial activity, and disease suppression, it has been considered that biochar could be a beneficial soil amendment for crop production (**Glaser *et al*., 2015; Akhter *et al*., 2015; Olmo *et al*., 2016).** The beneficial effects of biochar application on rice yield may depend on the duration of application, or continuity of application.

ABA plays a direct role in respiratory photosynthesis in leaves as well as inhibiting lateral root growth. It has reported that under drought condition chlorophyll pigments decreased. The photosynthetic pigments decreased in drought-induced plants and drought with foliar application of ABA significantly increased with increasing concentration of ABA. **(Ramachandran and Arulbalachandran 2018).**

MATERIALS AND METHODS

Two field experiments on rice were laid out during 2020 and 2021 seasons at the Experimental Farm, Faculty of Agriculture, Saba Basha, Alexandria University, Abbes Region, Alexandria Governorate, Egypt, to study the effect of biochar and abscisic acid (ABA) on growth, productivity, and quality of rice grain under water stress conditions. The preceding crop was faba bean in the two seasons.

The experimental design:

The experiment was laid out in strip plot design based on RCBD in four replications. Main plots were assigned to four different irrigation intervals as follows.: irrigation every four days (I_1), irrigation every six days (I_2), every eight days (I_3), and every ten days (I_4). While the sub-plots were allocated to the application of bio- stimulants (Untreated, control (B_1), Biochar (B_2), abscisic acid (ABA) (B_3), Biochar + abscisic acid (ABA) (B_4).

Egyptian rice cultivar, Sakha Super 300, was planted on the 14th and 26th of June using the morsel method (Lokma). This variety was tested under four different irrigation intervals. Soil application of biochar was at the rate of 3.6 t/ha with soil preparation, and foliar application of abscisic acid (ABA) at the rate of 250 mg/L of water at 45 and 60 days after planting.

Table 1. Irrigation treatments.

Irrigation Intervals	Number of Irrigations	Added /Irrigation (m^3/ha)	Used (m^3/ha)	Consumption (%)	Saving (%)
(I_1)	20	480	9600	100 %	-
(I_2)	13	480	6240	65 %	35 %
(I_3)	10	480	4800	50 %	50 %
(I_4)	8	480	3840	40 %	60 %

(I1)= irrigation every four days, (I2)= irrigation every six days, (I3)= irrigation every eight days, and (I4)= irrigation every ten days.

All other agronomic practices were followed as recommended during the growing seasons. Some soil chemical and physical properties of the experimental sites are presented in **Table 2,** which were determined using the method outlined by **Page *et al*. (1982).**

Table 2: Some physical and chemical properties of the experimental soil before planting in 2020 and 2021 summer seasons.

Soil properties	2020	2021
A- Mechanical analysis		
Clay %	43.00	42.00
Silt %	42.00	41.00
Sand %	15.00	17.00
Soil texture	Clay loam	Clay loam
B- Chemical properties		
pH (1:1 soil suspension)	8.25	8.20
Ec ($ds.m^{-1}$)	4.50	4.10
1- Soluble anions ($meq.L^{-1}$) :		
HCO^-_3	2.70	3.00
Cl^-	19.30	19.00
SO^{--}_4	13.20	12.40
SAR	6.00	7.00
2- Soluble Cations ($meq.L^{-1}$) :		
Ca^{++}	15.50	14.40
Mg^{++}	11.10	11.00
Na^{++}	12.20	13.60
K^+	1.43	1.45
Available N (mg/kg)	1.30	1.20
Available P (mg/kg)	3.80	3.20
Available K (mg/kg)	18.0	11.0
$CaCO_3$	7.9	8.8
Organic Matter (O.M)%	1.40	1.50

Studied Characters:

1- Plant height (cm).
2- Number of panicles/m^2.
3- Tillering index (%).
4- Panicle length (cm).
5- Number of filled grains per panicle.
6- Number of unfilled spikelets/panicle.
7- 1000-grain weight (g).
8- Grain and straw yields (t/ha).
9- Biological yield (t/ha).
10- Harvest index (%).
11- Hulling (%).
12- Milling (%).

Statistical analysis:

Data obtained was analyzed using the appropriate method of statistical analysis of variance as described by **Gomez and Gomez (1984).** The treatment means were compared using the least significant differences test (LSD) at 5% level of probability. The statistical analyses of variance were calculated using **CoStat 6.311 (2005)** computer software package.

RESULTS AND DISCUSSION:

The results presented in **Tables (3, 4 and 5)** showed the influence of soil application of biochar and foliar application of ABA and their interaction on plant height (cm), panicle length (cm), number of panicles/m^2, filled grains /panicle(g), unfilled spikelets/panicle, tillering index (%), 1000- grain weight (g), grain yield (t/ha), straw yield (t/ha) biological yield (t/ha), harvest index (HI %), hulling (%) and milling (%) during 2020 and 2021 seasons.

The analysis of yield components indicated a trend of increasing the grain yield of rice using biochar due to the increase in the size of the basin (spikes per square meter). (**Huang *et al*., 2019**).

Concerning effect of irrigation intervals on plant height (cm), panicle length (cm), number of panicles/m^2, filled grains of rice panicles(g), number of unfilled spikelets/panicle, tillering index (TI %) ,1000 grain weight (g), grain yield (t/ha), straw yield (t/ha) biological yield (t/ha), harvest index (HI %), hulling (%) and milling (%) in both seasons 2020 and 2021, the results in Tables 3, 4 and 5 showed that irrigation of rice plants every four days (I_1) and irrigation every six days (I_2) recorded the highest values of plant height (116.0 and 112.0 cm), panicle length (21.3 and 20.1 cm), number of filled grains/panicle (178.0 and 145.0 g),1000- grain weight (28.3 and 31.2 g), grain yield (12.6 and 13.1 t/ha), straw yield (13.6 and 15.3 t/ha), biological yield (26.2 and 28.4 t/ha), harvest index (48.2 and 46.1 %), hulling (83.0 and 84.0 %) as well as milling (73.9 and 74.5 %) while the results in Tables 3 showed that irrigation of rice plants every eight days (I_3) and irrigation every six days (I_2recorded the highest values of number of panicles/m^2 (699.3 and 667.4 panicles), tillering index (95.1 and 97.4 %). while irrigation of plants every ten days (I_4) recorded the lowest ones of these characters except irrigation of plants every 4 days (I1) which recorded the lowest unfilled grains of rice panicles (4.06 and 4.25), respectively in both seasons. These results agree with those reported by **Usman *et al.* (2013)**; **Fathi and Tari (2016); Adhikari *et al. (*2019); Upadhyaya and Panda (2019).**

Regarding the effect of application of bio-stimulants (B_4) on plant height (cm), panicle length (cm), number of panicles/m^2, filled grains of rice panicles (g), unfilled spikelets/panicle, tillering index (%),1000 grain weight (g), grain yield (t/ha), straw yield (t/ha), biological yield (t/ha), harvest index (HI %), Hulling (%) and Milling (%) in both seasons 2020 and 2021. The results in Tables 3, 4 and 5 showed that biochar + abscisic acid (B_4) recorded the highest values of plant height (110.1 and 101.9 cm), panicle length (21.5 and 20.9 cm), number of panicles/m^2 (675.8 and 670.7), tillering index (95.6 and 97.4 %), filled grains of rice panicles (161.6 and 138.5 g),1000- grain weight (28.0 and 32.6 g), grain yield (12.1 and 12.2 t/ha),straw yield (13.6 and 14.4 t/ha) and biological yield (25.7 and 26.7 t/ha), harvest index (47.4 and 45.8 %), Hulling % (83.0 and 83.5) as well as Milling % (73.7 and 75.3) were recorded in the first and second seasons. Second season while the soil application recorded the lowest number of unfilled grains /panicle (4.87 and 6.12), respectively in both seasons. The application of biochar and ABA increased the yield and its components of rice due to the role of these bio- stimulants in the growth and production of plants. These results are in agreement with those reported by **Glaser *et al*. (2015); Akhter *et al*. (2015); Olmo *et al*. (2016); Ramachandran and Arulbalachandran (2018); Huang *et al*. (2019); Mannan and Shashi (2020); Yuan *et al*. (2021)** who reported that biochar and ABA treatments reduce the effect of water stress on crops.

With Regard to the interaction effect between irrigation intervals (A) and application of bio- stimulants (B) such as biochar and ABA on plant height (cm), panicle length (cm), number of panicles/m^2, unfilled spikelets/panicle, tillering index (TI%),1000 grain weight (g), grain yield (t/ha), straw yield (t/ha) biological yield (t/ha), harvest index (HI %), Hulling (%) and Milling (%) in both seasons 2020 and 2021. The results in **Tables 3, 4 and 5** showed that irrigation intervals (I_1), (I_2) and (I_3) + (B_4) recorded the highest values of plant height, panicle length, number of panicles/m2, tillering index (%), filled grains of rice panicles, 1000- grain weight, grain yield, and straw yield, biological yield (t/ha), harvest index (%), Hulling (%) and Milling (%). While the results in **Tables 3, 4 and 5** showed that irrigation interval (I_4) + application of bio- stimulants (B_1) and (B_3) recorded the lowest values of plant height (cm), panicle length (cm), number of panicles/m^2, unfilled spikelets/panicle, tillering index (%),1000 grain weight (g), grain yield (t/ha), straw yield (t/ha) biological yield (t/ha) and harvest index (HI %) in both seasons, which also recorded the highest unfilled grains/panicle, respectively in the first and second seasons.

Table (3) Effect of irrigation intervals, bio- stimulants, and their interaction on some character of rice during both seasons.

A). Irrigation intervals	Season 2020					Season 2021				
	B). Biostimulants					B). Biostimulants				
	(B1)	(B2)	(B3)	(B4)	Average (A)	(B1)	(B2)	(B3)	(B4)	Average (A)
Plant height (cm)										
(I1)	109.6	117.7	113.2	123.1	116.0a	105.7	112.8	110.2	117.4	112.0a
(I2)	107.6	115.6	110.3	119.4	113.2b	102.0	110.6	107.1	114.5	109.0b
(I3)	90.6	94.6	88.8	105.7	94.9c	81.6	92.7	85.3	102.0	90.4c
(I4)	85.9	87.8	82.9	92.2	87.2d	61.7	70.8	66.1	73.7	68.1d
Average (B)	98.4d	103.9b	98.8c	110.1a		87.7d	96.7b	92.2c	101.9a	
LSD at 0.05		A=0.54	B=0.31	AB= 0.98			A=0.60	B=0.78	AB= 2.04	
Panicle length (cm)										
(I1)	19.2	23.1	19.5	23.5	21.3a	18.1	22.1	18	22.3	20.1a
(I2)	19.1	23.1	19.3	23.5	21.2b	18.1	22.0	18	22.3	20.1a
(I3)	16.3	22.5	16.7	22.7	19.5c	15.2	22.0	15.3	22.3	18.7b
(I4)	12.4	16.1	12.5	16.5	14.4d	12.4	13.4	12.4	16.6	13.7c
Average (B)	16.7d	21.2b	17.0c	21.5a		15.9d	19.9b	15.9c	20.9a	
LSD at 0.05		A=0.31	B=0.28	AB= 0.71			A=0.83	B=0.63	AB= 1.41	
Number of panicles/m2										
(I1)	550.5	577.5	554.2	600.2	570.6c	473.7	498.5	478.2	585.7	509.0c
(I2)	582.5	683.7	579	728.7	643.5b	504.2	609.0	513.5	738.2	591.2b
(I3)	574.7	752.0	573.5	897.0	699.3a	544.7	692.7	556.2	876.0	667.4a
(I4)	242.7	394.5	273.2	477.2	346.9d	275.7	388.2	282.5	483.0	357.3d
Average (B)	487.6d	601.9b	495.0c	675.8a		449.6d	547.1b	457.6c	670.7a	
LSD at 0.05		A=8.94	B=7.60	AB=16.57			A=10.8	B=10.0	AB=21.61	
Unfilled spikelet										
(I1)	4.50	3.75	4.75	3.25	4.06d	5.25	4.0	5.50	2.25	4.25d
(I2)	5.75	4.75	6.25	4.25	5.25c	7.25	6.25	8.25	4.75	6.62c
(I3)	6.75	5.75	6.25	4.75	5.87b	9.75	8.50	9.25	7.25	8.69b
(I4)	10.25	7.75	9.0	7.25	8.56a	14.25	11.25	12.75	10.25	12.12a
Average (B)	6.81a	5.50c	6.56b	4.87d		9.12a	7.50c	8.94b	6.12d	
LSD at 0.05		A=0.35	B=0.48	AB= 0.85			A=0.47	B=0.39	AB= 0.86	
Tillering index										
(I1)	88.7	90.3	90.3	92.9	90.5d	93.9	95.2	93.9	95.9	94.7c
(I2)	92.3	94.7	93.3	96.5	94.2b	94.0	96.8	95.1	97.9	95.9b
(I3)	91.8	96.9	93.1	98.6	95.1a	95.2	97.9	96.5	100.2	97.4a
(I4)	88.6	93.5	90.4	94.5	91.7c	90.3	93.4	91.2	95.6	92.6d
Average (B)	90.3d	93.8b	91.8c	95.6a		93.3d	95.8b	94.2c	97.4a	
LSD at 0.05		A=0.70	B=0.90	AB=1.75			A=0.16	B=0.31	AB=0.48	

Table (4). Effect of irrigation intervals, bio-stimulants, and their interaction on some characteristics of rice during both seasons.

A). Irrigation intervals	Season 2020					Season 2021				
	B). Biostimulants									
	(B_1)	(B_2)	(B_3)	(B_4)	Average (A)	(B_1)	(B_2)	(B_3)	(B_4)	Average (A)
Filled grains										
(I_1)	172.7	176.5	174.7	188.2	178.0a	135.5	147.7	141.5	153.7	145.0a
(I_2)	154.5	164.2	155.5	165.2	160.0b	130.7	141.5	137.5	145.5	139.0b
(I_3)	141.5	147.5	144.5	149.0	146.0c	128.5	138.5	133.2	142.0	136.0c
(I_4)	104.2	123.0	117.2	144.0	122.0d	74.5	108.0	91.5	113.0	96.8d
Average (B)	143.2d	152.8b	148.0c	161.6a		117.3d	133.9b	125.9c	138.5a	
LSD at 0.05		A=2.964	B=3.978	AB= 10.1			A=1.813	B=1.957	AB= 3.88	
1000 Grain weight										
(I_1)	27.4	29.3	27.3	29.4	28.3a	29.1	33.2	29.1	33.3	31.2a
(I_2)	27.1	29.2	27.2	29.3	28.2b	29.4	33.2	29.4	33.3	31.3b
(I_3)	23.4	29.3	23.3	29.3	26.3c	28.5	33.3	28.4	33.5	30.9c
(I_4)	20.6	24.0	20.7	24.1	22.3d	22.1	30.3	22.2	30.5	26.3d
Average (B)	24.6c	27.9b	24.6c	28.0a		27.3c	32.5b	27.3c	32.6a	
LSD at 0.05		A=0.473	B=0.670	AB=1.225			A=0.280	B=0.385	AB= 0.843	
Grain yield t/ha										
(I_1)	12.4	12.8	12.4	12.9	12.6a	13.0	13.2	13.0	13.2	13.1a
(I_2)	12.2	12.7	12.2	12.8	12.5b	12.9	13.1	13.0	13.2	13.0b
(I_3)	8.41	12.4	8.31	12.5	10.4c	10.9	13.1	10.7	13.1	11.9c
(I_4)	6.51	10.1	6.52	10.2	8.33b	4.67	9.34	4.36	9.52	6.9d
Average (B)	9.90c	12.0b	9.86d	12.1a		10.4b	12.2a	10.3c	12.2a	
LSD at 0.05		A=0.266	B=0.211	AB= 0.67			A=0.825	B=0.518	AB=0.941	
Straw yield t/ha										
(I_1)	13.3	13.5	13.4	14.2	13.6a	15.1	15.4	15.2	15.5	15.3a
(I_2)	13.1	13.5	12.8	14.2	13.4b	14.9	15.3	15.1	15.4	15.2b
(I_3)	10.2	13.5	10.3	13.3	11.8c	12.5	15.1	12.8	15.2	13.9c
(I_4)	8.24	12.5	8.60	12.6	10.5d	9.30	11.5	9.82	11.7	10.6d
Average (B)	11.2d	13.2b	11.3c	13.6a		12.9d	14.3b	13.2c	14.4a	
LSD at 0.05		A=0.333	B=0.259	AB= 0.54			A=0.146	B=0.147	AB= 0.295	
Biological yield t/ha										
(I_1)	25.7	26.3	25.8	27.1	26.2a	28.1	28.6	28.2	28.7	28.4a
(I_2)	25.4	26.2	25.0	27.0	25.9b	27.8	28.4	28.1	28.6	28.2b
(I_3)	18.6	25.9	18.6	25.8	22.2c	23.4	28.1	23.5	28.3	25.8c
(I_4)	14.7	22.7	15.1	22.8	18.8d	13.9	20.9	14.2	21.3	17.6d
Average (B)	21.1c	25.3b	21.1c	25.7a		23.3d	26.5b	23.5c	26.7a	
LSD at 0.05		A=0.546	B=0.413	AB=1.108			A=0.932	B=0.558	AB=0.852	
Harvest index (%)										
(I_1)	48.4	48.6	48.2	47.5	48.2a	46.3	46.1	46.0	46.1	46.1a
(I_2)	48.2	48.5	48.6	47.4	48.2a	46.4	46.0	46.1	46.1	46.1a
(I_3)	45.1	47.9	44.7	48.4	46.5b	46.4	46.3	45.4	46.2	46.1a
(I_4)	44.1	44.7	43.2	44.8	44.2c	32.9	44.7	30.7	44.7	38.2b
Average (B)	46.4c	47.4a	46.2d	47.0b		43.0b	45.8a	42.0c	45.8a	
LSD at 0.05		A=0.590	B=0.538	AB=1.232			A=1.448	B=1.042	AB=2.117	

Table (5). Effect of irrigation intervals, bio- stimulants, and their interaction on some characteristics of rice during both seasons.

A). Irrigation intervals	Season 2020					Season 2021				
	B). Biostimulants									
	(B_1)	(B_2)	(B_3)	(B_4)	Average (A)	(B_1)	(B_2)	(B_3)	(B_4)	Average (A)
Hulling (%)										
(I_1)	81.5	83.8	82.1	84.7	83.0a	83.0	84.9	82.4	85.6	84.0a
(I_2)	81.5	82.9	82.3	83.3	82.5b	83.1	83.8	82.5	84.1	83.4b
(I_3)	79.8	81.9	79.3	82.3	80.8c	82.7	83.6	82.6	84.1	83.2c
(I_4)	79.4	80.1	78.4	81.7	79.9d	77.5	79.3	77.6	80.3	78.7d
Average (B)	80.5c	82.2b	80.5c	83.0a		81.6c	82.9b	81.3d	83.5a	
LSD at 0.05		A=0.187	B=0.225	AB=0.581			A=0.325	B=0.297	AB=0.544	
Milling (%)										
(I_1)	72.0	74.8	73.3	75.6	73.9a	73.2	75.7	72.5	76.6	74.5a
(I_2)	72.0	73.7	72.5	74.1	73.1b	71.6	74.7	71.5	75.1	73.2b
(I_3)	70.3	72.7	71.6	73.7	72.1c	70.5	74.2	71.4	75.6	72.9c
(I_4)	68.3	70.5	68.7	71.4	69.7d	69.6	73.5	70.5	74.1	71.9d
Average (B)	70.6d	72.9b	71.5c	73.7a		71.2d	74.5b	71.5c	75.3a	
LSD at 0.05		A=0.293	B=0.239	AB=490			A=0.212	B=0.221	AB=0.439	

CONCLUSION

The results obtained under this study showed that the use of bio- stimulants (B_2) and (B_4) at rates used in the experiment and irrigation of rice plants every four or six days achieved a significant increase in the mean values of rice traits under study of the rice cultivar Sakha super 300 under the conditions of Abbes Region, Alexandria governorate, Egypt.

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الملخص العربي

نمو وإنتاجية وجودة الأرز وعلاقتهم بالبيوشار وحمض الأبسيسيك تحت ظروف الإجهاد المائي

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أقيمت تجربتان حقليتان لمحصول الأرز خلال الموسمين الزراعيين 2020 و2021, وذلك في مزرعة كلية الزراعة سابا باشا جامعة الإسكندرية بمنطقة أبيس 10 – محافظة الإسكندرية – مصر. لدراسة تأثير استخدام الفحم الحيوي وحمض الأبسيسيك على نمو وانتاجية وجودة الأرز تحت ظروف الإجهاد المائي. وزعت المعاملات عشوائيا في تصميم الشرائح المنشقة مرة واحدة Strip plot Design في أربع مكررات ، فوزعت فترات الري في القطع الرئيسية كالتالي: الري كل 4 أيام (I1)، الري كل 6 أيام (I2)، الري كل 8 أيام (I3)، الري كل 10 أيام (I4) بينما وزعت معاملات الفحم الحيوي وحمض الأبسيسيك (المنشطات الحيوية) في القطع المنشقة كما يلي: مقارنة (بدون إضافة) (B1)، الإضافة الأرضية للفحم الحيوي (البيوشار) بمعدل 3.6 طن / هكتار مع الخدمة قبل الزراعة (B2)، الرش الورقي بحمض الأبسيسيك (بمعدل 250 مجم / لتر) (B3)، الإضافة الأرضية للفحم الحيوي + الرش الورقي بحمض الأبسيسيك بنفس المعدلات السابقة (B4). تم استخدام صنف أرز سخا سوبر 300 تحت طريقة زراعة اللقمة. تم تطبيق معاملات الري بعد الزراعة ب 20 يوم وحتى قبل الحصاد ب 15 يوم. وكانت عدد الريات خلال موسم النمو (20 – 13 – 10 – 8) لكل فترة من فترات الري السابقة....على الترتيب. وكانت كمية المياه المضافة بالمتر المكعب للهكتار هي 480 متر مكعب في الرية الواحدة. وأن كمية المياه المستخدمة بالمتر المكعب للهكتار (9600 – 6240 – 4800 – 3840) لكل من (20 – 13 – 10 – 8) رية.على الترتيب. وكانت النسبة المئوية لاستهلاك المياه (100 % – 65 % – 50 % – 40 %). في حين أن نسبة توفير المياه من خلال تطبيق معاملات الري كانت كالتالي (0 % – 35 % – 50 % – 60 %) لمعاملات الري كل 4، 6، 8، و10 أيام على الترتيب. وتوضح النتائج أن ارتفاع النبات (سم)، وطول الدالية (سم)، وعدد الداليات (م^2)، وعدد الحبوب الممتلئة في دالية الأرز (بالجرام)، والحبوب غير الممتلئة في الدالية، ودليل التفريع (٪)، ووزن 1000 حبة (جم)، ومحصول الحبوب (طن/ هكتار)، محصول القش (طن/هكتار)، المحصول البيولوجي (طن/هكتار)، دليل الحصاد (٪)، نسبة التقشير (٪) ونسبة الطحن (٪). أعطت نتائج عالية في كلا الموسمين 2020 و2021، بينما أظهرت النتائج لنباتات الأرز المروية كل أربعة الأيام (I1) وكل ستة أيام (I2) مع واستخدام المنشطات الحيوية (B2) و (B4) مع تطبيق فترات الري كل ستة أيام (I2) وكل ثمانية أيام (I3) قد حقق زيادة كبيرة ومتقاربة في متوسط القيم لمعظم مكونات محصول الحبوب، وبناءً عليه فإن الصنف سخا سوبر 300 تحت تطبيق فترات الري كل 4 أيام (I1) 6 أيام (I2) مع استخدام المنشطات الحيوية يمكن استخدامه لتحقيق إنتاجية عالية تحت ظروف منطقة أبيس – محافظة الإسكندرية – مصر.