RICE GRAIN QUALITY, AFFECTED BY A COMBINED FOLIAR SPRAY OF DIFFERENT BIOSTIMULATED COMPONENTS UNDER DIFFERENT LEVELS OF WATER STRESS

ABDEL MEGEED, T. M.[1*] – ELSHAMEY, E. A.[1] – GHARIB, H. S.[2] – HAFEZ, E. M.[2] – EL-SAYED, A.[2]

[1]*Rice Research and Training Center, Field Crops Research Institute, Agricultural Research Center, Kafrelsheikh, Egypt*

[2]*Agronomy Department, Faculty of Agriculture, Kafrelsheikh University, Kafrelsheikh, Egypt*

**Corresponding author*
e-mail: taher.mohamed2018@gmail.com; phone: +20-100-405-5681

(Received 20th Jun 2021; accepted 21st Mar 2022)

Abstract. A field experiment was conducted to find out the effect of some plant biostimulants and plant growth regulating substances on a Sakha108 rice cultivar grown under different irrigation intervals by determining the grain quality characteristics as well as the nutritional value after milling in the 2018 and 2019 growing seasons at the farm of Agricultural Research Station, Sakha, Kafrelsheikh, Egypt. The Experiment was conducted using Randomized Complete Block Design with Strip plot arrangements. Main plots consisted of the four irrigation intervals while sub plots contained the different plant biostimulants and plant growth regulators at different concentrations. Physical (husking yield, milling recovery, and head rice ratio), chemical (amylose and protein contents) and cooking parameters (gelatinous temperature, kernel elongation, amylose content, protein content, carbohydrate content, lipids content, ash, phosphorus and potassium) of the harvested grains were determined in the laboratory. The main results indicated that spraying plant substances during this study increased all studied characteristics as compared to control treatment. Spraying with Crop plus surpassed Cytokinin treatments and provided the highest value for all the studied characteristics. Spraying Crop plus under irrigation every 12 days for plants afflicted by water stress, relieves the harmful effects of stress and improves all grain quality characteristics and the nutritional value as compared with control. These results benefit for farmers who suffer from shortage of irrigation water in their rice field.
Keywords: *Crop plus, Cytokinin (CK), abscisic acid (ABA), plant biostimulants, milled grain quality*

Introduction

Rice (*Oryza sativa* L.) is considered to be one of the most important stable food crops in Egypt. It plays a critical role in Egyptian food security. Drought is a significant limiting factor that has a negative impact on rice production. Due to limited water supplies and a variety of biotic and abiotic difficulties, there is a high demand for sustainable rice production systems. During the summer season, rice occupies around 22% of Egypt's entire growing area and consumes roughly 20% of the country's total water resources. Because Egypt's water resources are restricted, in addition to the country's growing population, the overall water requirements for the rice crop are a severe challenge due to the river Nile's limited irrigation water supply. Some rice-growing areas, particularly those near the terminal irrigation canals in the northern part of the Nile Delta, have irrigation water shortages at various phases of growth, which is considered one of Egypt's most significant constraints to rice production (Abd Allah et al., 2009). Abdel-Megeed et al. (2017) also found that sprayed rice cultivar by Cytokinin prolonged the irrigation interval from 4 days up to 8 days that led to save reasonable amount of irrigation water. Rice is mostly considered a starchy food, but since animal products can be scarce or expensive in Egypt, it is often the most important source of protein in Egyptians diet as well. The Egyptian rice varieties vary in grain quality characteristics as well as nutritional value after milling (Metwally et al., 2016). Those characteristics are not important only to the consumers but, they are important to the marketer and miller. Although rice is consumed worldwide, there is no universal rice quality attribute (Vidal et al., 2007). Nevertheless, rice appearance and cooked rice texture are the characters considered as main quality attributes by consumers (Okabe, 1979; Rousset et al., 1999). Thus, measuring and understanding factors that influence appearance and texture properties are a great challenge for industries and breeders in meeting consumer preferences. Water is a major constituent of plant tissue as reagent for chemical reactions and solvent for translocation of metabolites and minerals as well as an essential component for cell enlargement through increasing turgor pressure (Cruscio et al., 2008). The occurrence of soil moisture stress affects many of the physiological processes such as photosynthesis and transpiration resulting in reduced growth and poor grain filling (Samonte et al., 2001). Mohapatra and Bal (2006) studied the cooking quality and instrumental textural attributes of cooked rice for different milling fractions of three rice varieties. They found that cooking qualities as well as textural attributes were found to be varied among the varieties. Frei and Becker (2005) reported that rice protein quality is determined by the amino acid composition and its digestibility. Rice protein quality is very high when compared to other crops. Rice has favorable amino acid compositions, a high amount of lysine and a high protein digestibility which makes it a fairly good source of protein in diets where animal protein is limited.

Several researchers have reported that the use of stimulating substances is one of the effective means of improving rice grain quality and enhancing the milled rice nutritional value. Pan et al. (2013) indicated that foliar application plant growth regulators (gibberellic acid, paclobutrazol, 6-Benzylaminopurine) enhanced yield, grain quality characteristics and antioxidant enzyme activities in super hybrid rice. Kamboj and Mathpal (2019) found that foliar application of plant growth regulators, i.e., gibberellic acid cytokinin enhanced the translocation of zinc from vegetative parts to the grains of the rice. They also reported a favorable effect of plant growth regulators on protein content in milled grains due to the translocation of synthesized proteins towards grain by increasing longevity of leaves thus resulted in higher grain protein content. Therefore, soil moisture stress appears to be a major factor for the gap in producing enough quantity of rice as well as grain quality (Tomlins et al., 2005). However, drought effect on crop is depending on soil nutrient content (Gandah et al., 2003) as well as climate and cultivar (Cooper et al., 1987).

Various studies show that water stress negatively affects plants including rice and reduce yields in crops. Application of hormones and growth regulators on the other hand, improves growth parameters in the plants under drought stress. Therefore, the present study aimed to investigate the effect of foliar different plant growth regulator and biostimulants on Sakha108 rice variety production and grain quality under different levels of drought stress under Egyptian conditions. Also, determine the most beneficial combined foliar spray for a rice cultivar grown in Egypt under water stress conditions, in order to aid farmers in their efforts to produce crops with the best possible quality characteristics as well as nutritional value.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Materials and methods

A field experiment was carried out in the farm of Agricultural Research Station, Sakha, Kafrelsheikh, Egypt, the latitude and longitude of the field experiment (31°05´17″N, 30°56´44″E) and the experimental conditions of the study have been described in *Table 1* during 2018 and 2019 in rice growing seasons to identify the impact of foliar application of bio-stimulants by different levels of seaweed extracts named commercially [Crop plus at rates 0.5, 1.00 and 1.5 ml/1 l water]. Biozyme Crop plus is a commercial formulation of seaweed extract (*Ascophyllum nodosum*), enzymes and hydrolyzed proteins whereas, spic cytozyme contain gibberellic acid, auxins, Cytokinins, seaweed extract (*Ascophyllum nodoum*), hydrolysed proteins and trace elements and plant growth regulator named i.e. [Cytokinin (CK) and Abscisic acid with concentration of 15, 20, 25 ppm] and Trafos-K (Trafos-K is a registered trademark of products Trade crop nutri-performance, Co., in Spain, it has been obtained from Perfect-Egypt Company, Al-Sadat City. The chemical composition of Trafos-K is Phosphorus “P2O5” 42% (w/v) and Potassium “K2O” 28% (w/v), in the form potassium phosphite at rates 1, 1.5 and 2 ml/l l water) to improve the vegetative and reproductive growth of Sakha108 rice cultivar under different irrigation intervals, i.e., irrigation every 3 days (I1), irrigation every 6 days (I2), irrigation every 9 days (I3) and irrigation every 12 days (I4) (water stress). From the previous studies Sahaka 108 rice variety consume about 5800 m^3 water following the normal way of irrigation (continuous flooding) under transplanting method but I did not use water meter to determine water consumption of Sakha 108 rice variety with different irrigation intervals during this study. The field experiments were laid out in a strip design with four replications. The irrigation treatments were applied in the main plots, while the plant growth biostimulating growth regulating substances (PGRs) and Trafos-K as shown in *Table 2* were placed in the sub- plots. Rice variety was sprayed with plant bio-stimulated, growth regulators (PGRs) and Trafos-K four time after 15, 30, 45 and 60 days after transplanting (DAT). Pre-germinated seeds of rice cultivar at the rate of 120 kg/ha, were broadcasted manually in the nursery on 10th of May in 2018 and 2019 seasons.

Nitrogen (Urea 46% N) was added according to the treatments in two splits. Two thirds added as basal and incorporated in dry soil before flooding (transplanting). The other 1/3 was applied as top-dress just before panicle initiation (about 30 days after transplanting). Phosphorus as a single super phosphate 15% at the rate of 36.89 kg P2O5/ha was added to the soil before tillage and zinc (ZnSO4) was applied as recommended at the rate of 24 kg ZnSO4/ha. Seedlings were manually pulled and transferred to the permanent field and transplanted in 20 × 20 cm between rows and hills. The sub plot size was 12 m^2. The number of seedling/hill was 2-3 seedling. Seven days after transplanting, the herbicide Saturn 50% at the rate of 4.8 l ha^{-1} was mixed with enough amount of sand to make it easy for homogenous distribution to control the weeds.

At harvest, the central area of 10 m^2 (2.5 m × 4 m)/plot was manually harvested then, dried for about five days, then mechanically threshed and the yield at the 14% moisture content was recorded and converted into (ton/ha). Grain quality characteristics: milling recovery, gelatinization temperature, kernel elongation and amylose content was estimated according to Cruz and Khush (2000): 150 (g) cleaned rough rice at 14% moisture content was dehulled using an Experimental Huller Machine (Satake - Japan). The brown rice was separated and weighed then the hulling percentage was calculated. The brown rice was milled using MC GILL Rice Miller No.2. (S.K. Appliances –

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

India). The total milled rice was weighed and milled rice percentage was calculated. Whole milled grains were separated from the total milled rice using a rice sizing device SKU: 61-220-50 (Seedburo – USA). The percentage of head rice was calculated.

Table 1. *Means of climate parameters of the experimental site during 2018 and 2019 seasons*

Years	Climatic condition	May	June	July	August
2018	Air temp (°C)	27.5	28.95	29.8	29.55
	RH (%)	59.75	61.75	66.8	66.9
2019	Air temp (°C)	28.65	30.5	30.95	31.55
	RH (%)	57.15	65.75	69.8	72.65

Table 2. *Plant bio stimulants and the amount of this components during period of rice plant growing*

No	Growth biostimulants	Dose	No	Growth biostimulants	Dose
1	Crop Plus (T_1)	0.5 ml/1 l water	8	ABA (T_8)	20 ppm
2	Crop Plus (T_2)	1.0 ml/1 l water	9	ABA (T_9)	25 ppm
3	Crop Plus (T_3)	1.5 ml/1 l water	10	Trafos K (T_{10})	1 ml/1 l water
4	Cytokinin (T_4)	15 ppm	11	Trafos K (T_{11})	1.5 ml/1 l water
5	Cytokinin (T_5)	20 ppm	12	Trafos K (T_{12})	2 ml/1 l water
6	Cytokinin (T_6)	25 ppm	13	Tap water (T_{13})	-----
7	ABA (T_7)	15 ppm			

Six grains of whole milled rice were placed in boxes containing 1.7% KOH and arranged so that the kernels do not touch each. The boxes were covered and incubated for 23 h at 30° C. The appearance and disintegration of endosperm were graded visually according to the numerical scale of the gelatinization temperature. Kernel elongation was measured using the Micrometer, the length of five milled grains was measured (mm) and their average was determined for each treatment (before cooking). Grains were left in a test tube filled with 30 ml of distilled water for 30 min, then for another 10 min in 98° C a water tub. After that, the tubes were placed in cold water until reaching room temperature. Grains were lifted from the distilled water, dried (by filter paper), and measured again by graph papers (after cooking). Kernel elongation percentage was calculated as the percentage of grain expanding before and after cooking.

Amylose content was determined by weighing accurately 100 mg of sample into 100 ml volumetric flask then carefully adding 1 ml of 95% ethanol and 9 ml 1 N Na OH. The mixture was heated for 10 min in a boiling water bath to gelatinize the starch; then cooled, and the content made up to volume 100 ml with water. Pipette 5 ml portion of the gelatinization starch solution, 1 ml of 1N acetic acid, and 2 ml of iodine solution were added and made up to a volume of 100 ml with distilled water. The content was shaken and stands for 20 min before reading the transmission at 620 nm by Spectronic 1201 Spectrophotometer (Milton Roy, USA)**.**

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Protein, carbohydrate, lipids, ash, phosphorus and potassium determination in rice grain: Plant samples were taken from the grain after milling (50 grams of milled rice). All plant samples were placed in paper bags and oven-dry at 70° C for 48 h. Grain samples were ground to powder and digested according to the method of Chapman and Pratt (1961) before chemical analysis as follows: the nitrogen content of milled grains was determined by using the Microkieldahl method (Jackson, 1967) to calculate protein content. Total carbohydrate was calculated by difference as mentioned by (Fraser and Holmes, 1959). Lipids was determined according to A.O.A.C. (2000). The phosphorus content of milled grain was determined using Spectronic 1201 Spectrophotometer (Milton Roy, USA) following the procedures of Watanabe and Olsen (1965). The Potassium content of grain was determined using Elico CL378 Flame Photometer (RHYS international LTD, India) according to Peterpurgski (1968) method. The energy composition was calculated according to A.O.A.C. (2000) and Singh and Singh (2019). Representative soil samples were taken from the experimental sites at (0-30 cm) depth from soil Surface. Chemical analysis were done and the results are presented in *Table 3* according to Black et al. (1965).

Table 3. *Soil mechanical and chemical properties of the experimental site*

Seasons of study	Soil texture (%)	pH	EC dS/m	Organic matter (%)	Available N (mg kg^{-1})	Available P (mg kg^{-1})	Available K (mg kg^{-1})
2018	Clayed	7.9	1.8	1.65	22.5	14.45	346
2019	Clayed	8.1	1.45	1.68	24.4	14.12	357

Statistical analysis: The collected data were subjected to statistical analysis and were tested at 5% level of significance to interpret the differences among the treatments, which adapted by Waller and Duncan (1969). All the collected data were subjected to statistical analysis according to procedure described by Gomez and Gomez (1984).

Results and discussion

Data present in *Tables 4* and *5* showed that hulling, milling and head rice percentage as affected by different water intervals and plant growth regulators (PGRs) in both 2018 and 2019 seasons. These characters are considered as the most important traits that affect rice quality and consumer demand.

Application of different plant growth regulators (PGRs) with different material and concentration at different growth stages of rice under different water irrigation significantly effect in hulling, milling and head rice %. Data indicated that rice plant which treated and irrigated every 3-days gave the highest hulling %, milling % and heading rice % more irrigated every 6-days. While the lowest value was obtained rice plant irrigated every 12-days. Using plant growth regulator at different growth of rice variety improving and gave the greatest hulling %, milling % and heading rice %, where rice variety treated by 1.5 cm concentration of Crop plus recorded the highest value of hulling %, milling % and heading rice % followed by when rice variety treated by 1.5 and 0.5 cm concentration of Crop plus, respectively. While the lowest value was obtained from T_{13} (Tap Water only). There results were hold true in the two studied seasons. Such findings had also been pointed out by Abdel-Megeed et al. (2017, 2020) and Zheng (2020).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Table 4. *Hulling %, milling % and head rice % of Sakha108 rice cultivars as affected by different irrigation intervals and growth regulators during 2018 and 2019 season*

Treatments	2018			2019		
	Hulling %	**Milling %**	**Heading %**	**Hulling %**	**Milling %**	**Heading %**
Irrigation interval (A):						
(I_1)	80.662a	71.646a	65.646a	79.144a	70.692a	67.56a
(I_2)	79.638b	71.077b	64.454b	78.592b	69.592b	66.65b
(I_3)	79.131c	70.338c	62.223c	78.015c	69.069c	65.22c
(I_4)	78.388d	69.738d	60.254d	77.236d	68.308d	63.98d
F Test	**	**	**	**	**	**
Growth regulates treatment (B):						
(T_1)	81.500c	72.650c	67.750c	80.025c	71.375c	68.30c
(T_2)	82.063b	73.075b	68.400b	80.925b	71.900b	69.00b
(T_3)	83.350a	74.075a	70.300a	81.600a	72.550a	69.50a
(T_4)	79.325f	71.400e	64.600f	78.900e	69.950e	66.58f
(T_5)	80.175e	71.550e	65.750e	79.350d	70.475d	67.15e
(T_6)	80.875d	71.900d	66.800d	79.425d	71.225c	67.60d
(T_7)	78.700g	69.850h	61.475i	77.950g	68.975f	65.13h
(T_8)	78.825g	70.325g	62.050h	78.142fg	69.175f	65.18h
(T_9)	79.250f	70.875f	63.075g	78.193f	69.750e	65.95g
(T_{10})	77.025j	68.000k	57.750l	75.775j	66.500i	62.43k
(T_{11})	77.500i	68.875j	58.025k	76.125i	67.600h	63.38j
(T_{12})	78.000h	69.375i	58.700j	76.600h	68.450g	63.93i
(T_{13})	76.325k	67.150l	56.200m	74.200k	64.475j	62.00l
F Test	**	**	*			**
Interaction: AXB	**	**	**	**	**	**

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

The interaction between different irrigation intervals and different PGRs had a significant influence on hulling %, milling % and heading rice %. From the results presented in *Table 5*, it could be concluded that plants which treated by Crop plus produced the highest hulling %, milling % and heading rice % respectively, in the table under different water irrigation every 3, 6, 9 and 12 days, followed by treated by Cytokinin and ABA, while treated by Trafos K come in the last rank of plant growth regulator. While the lowest hulling %, milling % and heading rice % were obtained when rice plant treated by Tap water treated under irrigation every 12 days. These results are in harmony with that recorded by Anjum et al. (2007), Cuevas et al. (2016), Gharieb et al. (2016), Singh (2011) and Zhao (2018).

Data in the same table showed also, that rice plants which irrigated every 3-days and treated with different dose of Crop plus and 25 ppm of Cytokinin recoded the same of panicle length. Nearly of the same values of panicle length were recorded when rice plants irrigated every 8 days and treated even planted sprayed with 1.5, 1.0 and 0.5 ppm of Crop plus and 25 ppm Cytokinin without any significant difference between them. It means that tested rice sprayed by Crop plus led to extend the irrigation interval from 3-days up to every 9 days consequently save reasonable amount of irrigation water without significant reduction in the sink capacity (No. of panicle). While the lowest

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

value of hulling %, milling % and heading rice % were found with irrigation every 12 days under control treatment (without any spray). These results are in coincidence with that reported by Akita (1989), Canady (2012), Anonymous (2013), Bhattacharya (2019) and Abdel-Megeed et al. (2020).

Table 5. *Hulling %, milling % and head rice % of Sakha108 rice cultivars as affected by the interaction between different irrigation intervals and growth regulators in 2018 and 2019 seasons*

	Irrigation intervals							
	I1	I2	I3	I4	I1	I2	I3	I4
	2018				2019			
	Hulling %							
(T_1)	84.100a	81.100uv	80.800uv	80.000vw	80.60ef	80.300fg	80.100gh	79.100k-m
(T_2)	84.300a	82.300d-f	81.600efg	80.050g-k	81.50bc	81.200cd	80.800de	80.200fg
(T_3)	84.600a	84.500bc	82.800cd	81.500g-k	82.10a	81.800ab	81.500bc	81.000de
(T_4)	79.800h-l	79.500a	79.100b	78.900de	79.90ghi	78.900l-n	78.800m-o	78.000rs
(T_5)	81.800cd	80.100j-n	79.600l-o	79.200m-p	80.00ghi	79.500i-k	79.400j-l	78.500n-r
(T_6)	82.800b	80.600g-j	80.500j-n	79.600k-o	80.00ghi	79.600h-j	79.100k-m	79.000k-n
(T_7)	79.700b	78.600f-h	78.400f-i	78.100j-n	78.700m-p	78.200r-s	78.100q-s	76.800vw
(T_8)	79.700i-m	78.800o-q	78.600o-r	78.200p-s	78.767m-o	78.300o-r	78.200p-s	77.300tu
(T_9)	79.700i-m	79.500n-p	78.900o-q	78.900p-s	78.800m-o	78.600m-q	78.300o-r	77.070uv
(T_{10})	77.800i-m	77.400j-n	76.500m-p	76.400m-p	77.000uv	76.100xy	75.200z	74.800z
(T_{11})	78.500q-t	78.100s-u	77.600vw	75.800vw	77.700st	76.400wx	75.200z	75.200z
(T_{12})	79.100o-q	78.100p-s	77.800rst	77.000wx	78.000rs	78.000rs	75.200z	75.200z
(T_{13})	76.700l-o	76.700p-s	76.500q-t	75.400tuv	75.800y	74.800z	74.300z	71.900z
	Milling %							
(T_1)	74.000c	73.300d	72.200ef	71.100ik	73.500b	71.300ef	70.700ghi	70.000jk
(T_2)	74.600b	74.100c	72.300ef	71.300h-j	73.800ab	71.900d	71.000fgh	70.900f-h
(T_3)	75.900a	74.200bc	73.500d	72.700e	74.000a	72.600c	72.500c	71.100f-h
(T_4)	72.500e	71.700gh	70.700k-m	70.700k-m	70.800f-h	70.000jk	69.700kl	69.300l-o
(T_5)	72.600e	72.000fg	70.700k-m	70.900j-l	71.700de	70.700ghi	69.900jk	69.600k-m
(T_6)	72.700e	72.300ef	71.500hi	71.100i-k	73.500b	71.200fg	70.300ij	69.900jk
(T_7)	70.400l-n	69.900o-q	69.700p-r	69.400r-t	69.500k-n	69.000n-q	68.900o-q	68.500qr
(T_8)	70.600k-m	70.500lm	70.300m-o	69.900o-q	69.800j-l	69.300l-o	69.000n-q	68.600p-r
(T_9)	71.700gh	71.500hi	70.300m-o	70.000n-p	70.600hi	69.800j-l	69.500k-n	69.100m-p
(T_{10})	69.000s-u	68.200xy	68.000y	66.800z	67.800st	66.900vw	66.600w	64.700y
(T_{11})	69.400r-t	68.900tuv	68.800u-w	68.400w-y	68.200rs	67.600t	67.500tu	67.100uv
(T_{12})	69.500q-s	69.400r-t	69.300r-t	69.300r-t	68.900o-q	68.400r	68.300r	68.200rs
(T_{13})	68.500v-x	68.000y	67.100z	65.000z	66.900vw	66.000x	64.000z	61.000z
	Head rice %							
(T_1)	68.700cd	68.100e	67.300gh	66.900hi	70.20c	69.20d	68.00g	65.80jk
(T_2)	69.100bc	68.700cd	67.900ef	67.900ef	71.00b	69.90c	69.00de	66.10ij
(T_3)	71.900a	71.500a	69.500b	68.300de	71.70a	70.10c	69.90c	66.30i
(T_4)	66.800i	65.300lm	63.300pq	63.000q	68.50f	67.90g	65.20mn	64.70o-q
(T_5)	66.900hi	66.300j	65.300lm	64.500o	69.70c	68.70ef	65.30l-n	64.90n-p
(T_6)	67.600fg	67.500fg	65.900jk	66.200j	70.00c	68.90def	66.00ij	65.50k-m
(T_7)	65.000mn	62.100r	60.200t	58.600v	66.80h	65.70jkl	64.70o-q	63.30t
(T_8)	65.600kl	63.700p	60.300t	58.600v	66.80h	65.70jkl	64.70o-q	63.50st
(T_9)	66.000jk	64.700no	62.000r	59.600u	67.80g	67.20h	64.60o-q	64.20qr
(T_{10})	61.200s	61.100s	57.600w	51.100z	63.80rs	62.80u-w	62.20x	60.90y
(T_{11})	62.200r	60.200t	57.500w	52.200y	64.30q	63.50st	63.00t-v	62.70vw
(T_{12})	62.200r	60.200t	56.000x	56.400x	65.00no	64.40pq	63.20tu	63.10tuv
(T_{13})	60.200t	58.500v	56.100x	50.000z	62.70vw	62.50wx	62.10x	60.70y

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

The Gelatinous temperature, kernel elongation and amylose content were varied the irrigation intervals by different stimulating compounds application (*Tables 6* and *7*). Irrigation every 3-days recorded the highest values of gelatinous temperature, kernel elongation and amylose content. While irrigation every 12-days come the last rank recorded the lowest value of gelatinous temperature, kernel elongation and amylose content. Starch is the main component of milled rice grain. It is made up of two starchy fractions: amylose and amylopectin. After cooking, rice grains with high amylose content are dry, fluffy, separate and hard, while those with low amylose content are glossy, soft and sticky. So, Amylose content is considered to be one of the most important predictors of the eating quality of cooked rice. Milled rice cultivars may be generally classified based on their apparent amylose content into waxy (1-2%), very low (2-12%), low (12-20%), intermediate (20-25%) or high (>25%) (Bao, 2012). Based on the results, the studied genotypes under the current study belong to low amylose content rice types that meet the Egyptian consumers' preferences. The significant variation in amylose content among the studied genotypes could be attributed to the genetic background of those varieties. These results are in harmony with that recorded by Okabe (1979), Rousset (1999), Samonte (2001), Anjum et al. (2007), Singh (2011), Cuevas et al. (2016), Gharieb et al. (2016) and Zhao (2018).

Table 6. *Gelatinous temperature, kernel elongation and amylose % of Sakha108 rice cultivars as affected by different irrigation intervals and growth regulators during 2018 and 2019 season*

Treatments	2018			2019		
	Gelatinous temperature	**Kernel elongation**	**Amylose %**	**Gelatinous temperature**	**Kernel elongation**	**Amylose %**
Irrigation interval (A):						
(I_1)	6.662a	57.95a	18.38a	6.17a	57.94a	18.27a
(I_2)	6.383b	56.67b	17.10b	5.89b	56.66b	16.99b
(I_3)	6.194c	56.46c	16.92c	5.70c	56.47c	16.80b
(I_4)	5.873d	56.24d	16.67d	5.38d	56.23d	16.56c
F Test	**	**	**	**	**	**
Growth regulates treatment (B):						
(T_1)	6.763ab	57.19c	17.69b	6.13b	56.79d	17.61a-c
(T_2)	6.963a	57.56b	17.76ab	6.24b	57.69b	17.69ab
(T_3)	7.063a	57.86a	17.84a	6.41a	57.89a	17.78a
(T_4)	6.303c	56.98e	17.27de	5.77c	56.70de	17.20d-f
(T_5)	6.403bc	56.98e	17.36cd	5.80c	56.79d	17.31c-e
(T_6)	6.483bc	57.08d	17.45c	5.83c	57.55c	17.39b-d
(T_7)	5.823d	56.44gh	17.15f	6.44a	56.55f	16.95f-i
(T_8)	6.113cd	56.46gh	17.15f	5.63d	56.56f	17.04e-h
(T_9)	6.253c	56.65f	17.22ef	5.63d	56.65ef	17.13d-g
(T_{10})	5.798d	56.31i	16.89h	5.29f	56.32g	16.62i
(T_{11})	6.108cd	56.42h	16.92h	5.41e	56.35g	16.70hi
(T_{12})	6.108cd	56.54g	17.03g	5.41e	56.42g	16.83ghi
(T_{13})	5.438e	56.32i	16.69i	5.21f	56.42g	16.75hi
F Test	**	**	**	**	**	**
Interaction: AXB	*	*	**	*	*	**

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Table 7. *Gelatinous temperature, kernel elongation and amylose % of Sakha108 rice cultivars as affected by the interaction between different irrigation intervals and growth regulators in 2018 and 2019 seasons*

	Irrigation intervals							
	I1	**I2**	**I3**	**I4**	**I1**	**I2**	**I3**	**I4**
	2018				**2019**			
	Gelatinous temperature							
(T_1)	7.02b-d	6.80d-g	6.52h-l	6.71e-i	6.39c-f	6.17f-j	5.89k-n	6.08g-k
(T_2)	7.22ab	7.00b-d	6.72e-h	6.91cde	6.50b-d	6.28d-g	6.00h-m	6.19f-i
(T_3)	7.32a	7.10a-c	6.82d-g	7.01bcd	6.67ab	6.45d-e	6.17f-j	6.36c-f
(T_4)	6.70e-i	6.42j-m	6.27l-n	5.82q-s	6.17f-j	5.89k-n	5.74m-p	5.29rs
(T_5)	6.80d-g	6.52h-l	6.37k-m	5.92p-r	6.20e-i	5.92j-n	5.77l-p	5.32rs
(T_6)	6.88c-f	6.60g-k	6.45i-m	6.00o-r	6.23e-i	5.95i-n	5.80l-o	5.35qrs
(T_7)	6.22mno	5.94p-r	5.79rs	5.34u	6.84a	6.56bc	6.41c-f	5.96i-n
(T_8)	6.51h-l	6.23m-o	6.08n-p	5.63st	6.03gl	5.75m-p	5.60o-q	5.15s
(T_9)	6.65f-j	6.37k-l	6.22m-o	5.77rs	6.03g-l	5.75m-p	5.60o-q	5.15s
(T_{10})	6.23mno	5.92p-r	5.75rs	5.29u	5.72n-p	5.41q-s	5.24s	4.78t
(T_{11})	6.54h-k	6.23m-o	6.06n-q	5.60st	5.84k-o	5.53 p-r	5.36q-s	4.90t
(T_{12})	6.54h-k	6.23m-o	6.06n--q	5.60st	5.84k-o	5.53p-r	5.36q-s	4.90t
(T_{13})	5.97o-r	5.62st	5.41tu	4.75v	5.74m-p	5.39q-s	5.18s	4.52u
	Kernel elongation							
(T_1)	58.33c	57.11k-m	56.30r-u	57.02l-n	57.80c-e	56.58lm	56.30n-s	56.49l-p
(T_2)	58.53b	57.31i-k	57.20j-l	57.22j-l	58.70b	57.48g-i	57.20j	57.39h-j
(T_3)	58.86a	57.64d-f	57.40g-j	57.55e-h	58.90a	57.68d-g	57.40h-j	57.59e-h
(T_4)	58.13c	56.85n-p	56.70p-q	56.25s-u	57.85cd	56.57lm	56.42n-r	55.97w-z
(T_5)	58.13c	56.85n-p	56.70p-q	56.25s-u	57.94c	56.66kl	56.51l-o	56.06t-y
(T_6)	58.23c	56.95m-o	56.80op	56.35r-u	58.70b	57.42hi	57.27ij	56.82k
(T_7)	57.11d-g	56.31r-u	56.16t-v	55.71x-z	57.70d-g	56.42m-r	56.27p-u	55.82z
(T_8)	57.31d-g	56.33r-u	56.18s-v	55.73x-z	57.71d-f	56.43m-q	56.28o-u	55.83z
(T_9)	57.64d	56.52qr	56.37r-t	55.92wx	57.80c-e	56.52l-n	56.37m-r	55.92xy
(T_{10})	56.85f-i	56.18s-v	56.01vw	55.55z	57.50f-h	56.19r-w	56.02v-z	55.56z
(T_{11})	56.85d-g	56.29s-v	56.12u-w	55.66yz	57.53f-h	56.22q-v	56.05u-z	55.59z
(T_{12})	56.95de	56.41rs	56.24s-u	55.78xy	57.60e-h	56.29n-t	56.12s-x	55.66z
(T_{13})	57.35h-j	56.00vw	55.79xy	56.13u-w	57.45hi	56.10s-y	55.89yz	56.23q-v
	Amylose %							
(T_1)	18.70a-c	17.48j-m	17.20n-r	17.39k-n	18.62ab	17.40g-n	17.12j-s	17.31h-o
(T_2)	18.77ab	17.55i-k	17.27m-p	17.46j-m	18.70ab	17.48f-m	17.20i-r	17.39g-n
(T_3)	18.85a	17.63ij	17.35k-o	17.54i-l	18.79a	17.57e-l	17.29h-p	17.48f-m
(T_4)	18.42d-f	17.14o-s	16.99r-u	16.54x-z	18.35a-d	17.07j-t	16.92l-u	16.47r-x
(T_5)	18.51c-e	17.23n-q	17.08p-t	16.63w-y	18.46a-d	17.18i-r	17.03k-t	16.58o-x
(T_6)	18.60b-d	17.32l-o	17.17n-r	16.72v-x	18.54a-c	17.26i-q	17.11j-s	16.66n-w
(T_7)	18.30e-g	17.02q-t	16.87t-v	16.42yz	18.10a-g	16.82l-v	16.67n-w	16.22u-x
(T_8)	18.30e-g	17.02q-t	16.87t-v	16.42yz	18.19a-f	16.91l-u	16.76m-v	16.31t-x
(T_9)	18.37ef	17.09p-t	16.94s-v	16.49yz	18.28a-e	17.00l-t	16.85l-u	16.40s-x
(T_{10})	18.07h	16.76v-x	16.59w-y	16.13z	17.80d-j	16.49q-x	16.32t-x	15.86x
(T_{11})	18.10gh	16.79u-w	16.62w-y	16.16z	17.88c-i	16.57o-x	16.40s-x	15.94wx
(T_{12})	18.21f-h	16.90t-v	16.73v-x	16.27z	18.01b-h	16.70n-w	16.53p-x	16.07v-x
(T_{13})	17.71i	16.36z	16.22z	16.49yz	17.78d-k	16.43r-x	16.22u-x	16.56o-x

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

Foliar spray of different stimulating compounds increased significantly gelatinous temperature, kernel elongation and amylose content. The highest values of gelatinous temperature, kernel elongation and amylose content were observed when rice plant treated with crop plus followed by cytokinin, ABA and Trafos K which come in the last rank and recorded the lowest value of gelatinous temperature, kernel elongation and amylose content. Data in the same table revealed that Plant growth regulators caused an increase in gelatinous temperature, kernel elongation and amylose content as compared with control. The highest gelatinous temperature, kernel elongation and amylose content were found when rice plants sprayed with Crop plus at 1.5 ml/1 l followed sprayer at concentration 1 ml/1 l while sprayer by crop plus by 0.5 ml/1 l water and Cytokinin with 25 and 20 ppm recorded nearly the same value followed by ABA which came in the third rank gave nearly the same value under different concentration of ABA in this aspect. Similar results were observed in the two seasons of study. These results are in line with that obtained by Pospíšilová (1999), Ramya et al. (2011) and Abdel-Megeed et al. (2020).

The interaction between different irrigation intervals and different PGRs had a significant influence on gelatinous temperature, kernel elongation and amylose content. From the results presented in *Table 7,* it could be concluded that plants which treated by Crop plus produced the highest gelatinous temperature, kernel elongation and amylose content under different water irrigation every 3, 6, 9 and 12 days, followed by treated by Cytokinin and ABA, while treated by Trafos K come in the last rank of plant growth regulator. While the lowest number of tillers were obtained when rice plant treated by Tap water treated under irrigation every 12 days. Data in *Table 7* show that foliar application of Crop plus by 1.5 or 1 ml/1 l under either the irrigation every 3-days or 6-days recorded nearly the highest values of gelatinous temperature, kernel elongation and amylose content in the two studied seasons.

It can be easily observed that there was any significant difference between the irrigation every 3-days and 6-days intervals in gelatinous temperature, kernel elongation and amylose content when treated rice by 1.5 or 1.00 ml/1 l of crop plus. It might be due to the role of these substances to help the plant for keeping the water inside the cell more time consequently extend the period of irrigation intervals that led to save reasonable amount of irrigation water. These results are in coincidence with that reported by Akita (1989), Singh (2011), Canady (2012), Anonymous (2013), Gharieb et al. (2016), Zhao (2018), Bhattacharya (2019) and Abdel-Megeed et al. (2020).

Data in *Tables 8* and *9* revealed significant differences among different water intervals, foliar spray stimulating compound and the interaction for protein, carbohydrate and lipids content percentage in both seasons. Within irrigation intervals, data in *Table 8* clarified that irrigation every 3 days produced the greatest contents of protein in 2018 season while in 2019 season irrigation every 6 and 9-days come in the first rank and recorded the highest value of protein content followed by irrigation every 3-days. Carbohydrates and lipids gave the highest value when irrigated every 3-days followed by irrigation every 6 days while irrigation every 12 days gave the least because of the injury of water stress under this treatment. The results showed that the protein, carbohydrate and lipids content percentage decreased under lower soil moisture level but the degree of reduction in different genotypes did not indicate the tolerance level of the genotypes. Decreased carbohydrate and lipids content percentage under lower soil moisture levels might be due to inhibition of translocation of assimilate to the grains due to moisture stress. Such findings had also been pointed out by Abdel-Megeed et al. (2017, 2020) and Zheng (2020).

Table 8. *Protein, carbohydrate and lipids content % of Sakha108 rice cultivars as affected by different irrigation intervals and growth regulators during 2018 and 2019 season*

Treatments	2018			2019		
	Protein	**Carbohydrate**	**Lipids content %**	**Protein**	**Carbohydrate**	**Lipids content %**
Irrigation interval (A):						
(I_1)	8.99a	76.41a	0.5718a	7.828c	77.88a	0.5396a
(I_2)	8.72b	75.13b	0.5428b	8.291a	76.60b	0.5118b
(I_3)	8.53b	74.94c	0.5234bc	8.147b	76.41c	0.4928bc
(I_4)	8.28c	74.70d	0.5046c	7.116d	76.17d	0.4685c
F. Test	*	**	*	*	**	*
Growth regulates treatment (B):						
(T_1)	9.57b	75.93b	0.57a-c	8.023d	77.04c	0.54ab
(T_2)	9.99a	76.03b	0.58ab	8.543b	77.12b	0.55ab
(T_3)	10.16a	76.18a	0.59a	9.183a	77.21a	0.57a
(T_4)	8.54de	75.43d	0.54c-f	7.836ef	76.87d	0.50cde
(T_5)	8.69d	75.70c	0.54d-e	8.163c	77.03c	0.50cd
(T_6)	9.11c	75.74c	0.55a-d	8.423b	77.04c	0.52bc
(T_7)	8.22ef	74.84e	0.52d-f	7.618g	76.67g	0.48cde
(T_8)	8.32ef	74.93e	0.52d-f	7.718fg	76.75f	0.49cde
(T_9)	8.51de	75.69c	0.53d-f	7.898de	76.81e	0.49cde
(T_{10})	7.62h	74.49h	0.49f	6.998j	76.28i	0.47e
(T_{11})	7.84gh	74.64fg	0.50ef	7.323i	76.29i	0.47de
(T_{12})	8.07fg	74.71f	0.51def	7.468h	76.53h	0.47de
(T_{13})	7.54h	74.53gh	0.50ef	6.804k	76.27i	0.47de
F. Test	**	**	*	**	**	*
Interaction: AXB	*	*	NS	*	*	NS

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

Data presented in *Table 8* assert that significant differences were found among the tested PGRs and biostimulated on protein, carbohydrate and lipids content percentage in both seasons of study. Within various PGRs and biostimulated application, plants which spraying with 1.5 ml/1 l Crop gave the highest value of protein, carbohydrate and lipids content percentage followed by spraying also with 1 ml/1 l of Crop plus while spraying with 25 ppm Cytokinin come in next rank without significant when plants spraying with 0.5 ml/1 l of Crop plus in the two seasons under study. The lowest protein, carbohydrate and lipids content percentage was obtained when rice did not receive any of PGR (control). These results are in line with that obtained by Pospíšilová (1999), Ramya et al. (2011) and Abdel-Megeed et al. (2020).

For the interaction of protein, carbohydrate and lipids content percentage clarified in *Table 9* that application of Crop plus under irrigation every 3-days produced the highest value of number of filled grains followed by irrigation every 9 days and surpassed both Cytokinin and ABA which perform the same trend. It can be also, noticed that the application of any of PGR to the tested cultivar caused an increase in protein, carbohydrate and lipids content percentage as compared with control. The application of different stimulating compounds increased significantly the contents of protein and

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

lipids over control treatment. Foliar application of crop plus recorded the highest values of protein content, carbohydrate and lipids content. There are highly significant differences in protein, carbohydrate and lipids content percentage with respect to different irrigation intervals × stimulating compound interaction suggesting that all irrigation intervals treatments responded differently to stimulating compound application. Khan et al. (2016) found that application of plant growth regulators (gibberellic acid, indole acetic acid and kinetin) significant increase in soluble protein contents of two rice cultivars. These results are in coincidence with that reported by Akita (1989), Canady (2012), Anonymous (2013), Abdel-Megeed et al. (2017, 2020), Gharieb et al. (2016), Bhattacharya (2019) and Metwally et al. (2020).

Table 9. *Protein, carbohydrate and lipids content % of Sakha108 rice cultivars as affected by the interaction between different irrigation intervals and growth regulators in 2018 and 2019 seasons*

	Irrigation intervals							
	I1	I2	I3	I4	I1	I2	I3	I4
	2018				2019			
	Protein							
(T_1)	9.83a-d	9.61b-f	9.33c-h	9.52b-g	8.28h-l	8.06k-n	7.78n-p	7.97m-o
(T_2)	10.25ab	10.03a-c	9.75a-e	9.94a-d	8.80c-e	8.58e-h	8.30h-l	8.49f-i
(T_3)	10.42a	10.20ab	9.92a-d	10.11ab	9.44a	9.22ab	8.94b-d	9.13b
(T_4)	8.94f-k	8.66h-m	8.51i-n	8.06l-s	7.88m-o	8.31h-l	8.16j-m	7.00u-x
(T_5)	9.09e-j	8.81g-l	8.66h-m	8.21k-r	8.03k-n	8.81c-e	8.66d-f	7.15s-w
(T_6)	9.51b-g	9.23d-i	9.08e-j	8.63h-m	8.13j-m	9.23ab	9.08b-c	7.25r-v
(T_7)	8.62h-m	8.34j-p	8.19k-r	7.74o-u	7.41q-t	8.34g-k	8.19i-m	6.53yz
(T_8)	8.72h-m	8.44j-o	8.29i-q	7.84n-u	7.51p-r	8.44f-j	8.29h-l	6.63yz
(T_9)	8.91f-k	8.63h-m	8.48i-o	8.03m-s	7.68o-q	8.63e-g	8.48f-i	6.80xy
(T_{10})	8.05l-s	7.74o-u	7.57q-u	7.11u	7.12t-w	7.43q-s	7.26r-v	6.18z
(T_{11})	8.27k-q	7.96m-t	7.79n-u	7.33s-u	7.24r-v	7.96m-o	7.79n-p	6.30z
(T_{12})	8.50i-o	8.19k-r	8.02m-s	7.56q-u	7.30r-u	8.19j-m	8.02l-n	6.36z
(T_{13})	7.82n-u	7.47r-u	7.26tu	7.60p-u	6.94wx	6.59yz	6.97v-x	6.72xy
	Carbohydrate							
(T_1)	76.94ab	75.72e-k	75.44j-m	75.63g-k	78.05cd	76.83lm	76.55q-t	76.74no
(T_2)	77.04ab	75.82d-i	75.54i-l	75.73e-t	78.13bc	76.91l	76.63p-q	76.82l-n
(T_3)	77.19a	75.97d-f	75.69e-k	75.88d-h	78.22a	77.00k	76.72o	76.91l
(T_4)	76.58c	75.30lm	75.15mn	74.70p-r	78.02de	76.74no	76.59q-s	76.14y
(T_5)	76.85bc	75.57h-l	75.42j-m	74.97n-p	78.18ab	76.90l	76.75m-o	76.30w
(T_6)	76.89b	75.61g-l	75.46j-l	75.01no	78.19ab	76.91l	76.76m-o	76.31vw
(T_7)	75.99de	74.71p-r	74.56q-t	74.11u-w	77.82g	76.54r-t	76.39uv	75.94z
(T_8)	76.08d	74.80o-q	74.65q-s	74.20uv	77.90fg	76.62p-r	76.47tu	76.02z
(T_9)	76.84bc	75.56i-l	75.41k-m	74.96n-p	77.96ef	76.68op	76.53st	76.08yz
(T_{10})	75.67f-k	74.36s-u	74.19uv	73.73x	77.46i	76.15xy	75.98z	75.52z
(T_{11})	75.82d-i	74.51q-t	74.34tu	73.88wx	77.47i	76.16xy	75.99z	75.53z
(T_{12})	75.89d-g	74.58q-t	74.41r-u	73.95vwx	77.71h	76.40u	76.23wx	75.77z
(T_{13})	75.56i-l	74.21uv	74.00v-x	74.34tu	77.30j	75.95z	75.74z	76.08yz

The ash, phosphorus and potassium contents in milled rice grains differed significantly among genotypes and stimulating compounds, with a significant interaction (*Tables 10* and *11*). Ash, phosphorus and potassium contents was higher when rice plant irrigated every 3-days followed by irrigation every 6-days and 9-days

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

without any significant between them, while irrigation every 12-days come in the last ranks and recorded the lowest ash, phosphorus and potassium contents. Stimulating compounds foliar application spray increased the content of ash, phosphorus and potassium in milled rice grains compared to control. Data indicated that Crop plus treatments of plant growth biostimulated at all tested growth stages with different concentration recorded the nearly the same value of ash, phosphorus and potassium contents and came in the first rank followed by when rice planted treated by Cytokinin which came in the second rank in the two seasons of study without any significant differences among them. The lowest value of ash, phosphorus and potassium contents recorded when rice plant not treated by any of plant growth regulator (Tap water only). These results are in coincidence with that reported by Akita (1989), Gemici (1993), Gemici et al. (1998), Canady (2012), Anonymous (2013), European Bio-stimulants Industry Council (2013), Bhattacharya (2019) and Abdel-Megeed et al. (2020).

Table 10. *Ash, phosphorus and potassium content % of Sakha108 rice cultivars as affected by different irrigation intervals and growth regulators during 2018 and 2019 season*

Treatments	2018			2019		
	Ash content %	**Phosphorus content %**	**Potassium content %**	**Ash content %**	**Phosphorus content %**	**Potassium content %**
Irrigation interval (A):						
(I_1)	0.64a	0.25a	0.23a	0.61a	0.26a	0.25a
(I_2)	0.61b	0.22b	0.20b	0.58b	0.23b	0.23b
(I_3)	0.59b	0.20b	0.18b	0.57b	0.21b	0.21b
(I_4)	0.57c	0.18c	0.16c	0.54c	0.19c	0.18c
F Test	**	**	**	**	**	**
Growth regulates treatment (B):						
(T_1)	0.67bc	0.26a	0.23a-c	0.64bc	0.26a-c	0.25a-c
(T_2)	0.69ab	0.26a	0.23ab	0.66ab	0.27ab	0.26ab
(T_3)	0.72a	0.26a	0.24a	0.68a	0.27a	0.26a
(T_4)	0.61ef	0.22bc	0.19d-f	0.58ef	0.22de	0.21de
(T_5)	0.62de	0.22bc	0.20c-e	0.60de	0.23cde	0.22c-e
(T_6)	0.65cd	0.23ab	0.20bcd	0.62cd	0.24bcd	0.23b-d
(T_7)	0.57g	0.20bcd	0.16ef	0.54g	0.20e	0.19e
(T_8)	0.58fg	0.20bcd	0.17d-f	0.56fg	0.21de	0.21de
(T_9)	0.60efg	0.21bcd	0.18d-f	0.57efg	0.21de	0.21de
(T_{10})	0.51h	0.18d	0.17d-f	0.51h	0.19e	0.20de
(T_{11})	0.52h	0.19cd	0.17d-f	0.51h	0.20e	0.21de
(T_{12})	0.54h	0.19cd	0.18d-f	0.51h	0.21de	0.21de
(T_{13})	0.51h	0.19cd	0.16f	0.50h	0.20e	0.18e
F Test	**	*	*	**	*	*
Interaction: AXB	*	*	*	*	*	*

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

Regarding the interaction effect data in *Table 11* revealed that statistical differences were found in ash, phosphorus and potassium contents due to the interaction between different irrigation intervals and various plant growth regulators in both seasons.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Table 11. *Ash, phosphorus and potassium content % of Sakha108 rice cultivars as affected by the interaction between different irrigation intervals and growth regulators in 2018 and 2019 seasons*

	Irrigation intervals							
	I1	**I2**	**I3**	**I4**	**I1**	**I2**	**I3**	**I4**
	2018				**2019**			
	Ash content %							
(T_1)	0.70a-d	0.68a-f	0.65c-i	0.67b-g	0.67a-e	0.65a-g	0.62b-j	0.64a-h
(T_2)	0.72a-c	0.69a-d	0.67b-g	0.69a-e	0.69ab	0.67a-f	0.64a-h	0.66a-f
(T_3)	0.75a	0.73ab	0.70a-d	0.72a-c	0.71a	0.69a-c	0.66a-f	0.68a-d
(T_4)	0.65c-i	0.62e-m	0.61f-o	0.56l-u	0.62b-j	0.59f-n	0.58g-p	0.53l-s
(T_5)	0.66b-h	0.63d-l	0.62e-m	0.57j-t	0.64a-h	0.61c-k	0.60e-m	0.55j-r
(T_6)	0.69a-e	0.66b-h	0.65c-j	0.60f-p	0.66a-f	0.63b-i	0.62b-j	0.57g-q
(T_7)	0.61f-n	0.58i-s	0.57k-t	0.52q-x	0.58g-o	0.55j-r	0.54k-s	0.49r-t
(T_8)	0.62e-m	0.59h-r	0.58i-t	0.53o-w	0.60e-l	0.57g-q	0.56i-r	0.51o-t
(T_9)	0.64d-k	0.61f-n	0.59g-q	0.55m-v	0.61d-k	0.58g-o	0.57h-r	0.52m-t
(T_{10})	0.55m-v	0.52r-x	0.50t-x	0.46x	0.55j-s	0.52n-t	0.50p-t	0.46t
(T_{11})	0.56l-v	0.53p-x	0.51s-x	0.47wx	0.55j-s	0.52n-t	0.50p-t	0.46t
(T_{12})	0.58i-s	0.55m-v	0.53o-w	0.49u-x	0.55j-s	0.52n-t	0.50p-t	0.46t
(T_{13})	0.54n-w	0.51s-x	0.48v-x	0.52r-x	0.53l-t	0.49q-t	0.47st	0.51o-t
	Phosphorus content %							
(T_1)	0.28ab	0.26a-e	0.23a-k	0.25a-g	0.29ab	0.26a-f	0.24a-l	0.25a-g
(T_2)	0.28ab	0.26a-e	0.23a-k	0.25a-g	0.29a	0.27a-f	0.24a-j	0.26a-g
(T_3)	0.29a	0.27a-d	0.24a-i	0.26a-e	0.30a	0.28a-d	0.25a-i	0.27a-f
(T_4)	0.26a-f	0.23a-k	0.21a-m	0.17h-n	0.26a-f	0.24a-l	0.22a-n	0.18h-n
(T_5)	0.26a-e	0.23a-j	0.22a-l	0.17g-n	0.27a-e	0.24a-j	0.23a-m	0.18g-n
(T_6)	0.27a-c	0.25a-g	0.23a-k	0.19e-n	0.28a-c	0.25a-i	0.24a-l	0.19f-n
(T_7)	0.24a-h	0.21a-l	0.20c-n	0.15k-n	0.24a-j	0.21b-n	0.20d-n	0.15mn
(T_8)	0.24a-h	0.21a-l	0.20c-n	0.15k-n	0.25a-i	0.22a-n	0.21c-n	0.16k-n
(T_9)	0.25a-g	0.22a-k	0.21b-m	0.16i-n	0.25a-h	0.23a-m	0.21b-n	0.17j-n
(T_{10})	0.22a-k	0.19d-n	0.17g-n	0.13n	0.24a-k	0.21b-n	0.19f-n	0.14n
(T_{11})	0.23a-k	0.20c-n	0.18e-n	0.14mn	0.24a-j	0.21f-n	0.19e-n	0.15n
(T_{12})	0.24a-j	0.20b-m	0.19e-n	0.14l-n	0.25a-i	0.22e-n	0.20c-n	0.16l-n
(T_{13})	0.21a-l	0.18f-n	0.16j-n	0.19d-n	0.23a-l	0.20c-n	0.17i-n	0.21b-n
	Potassium content %							
(T_1)	0.25a-c	0.23a-h	0.20a-m	0.22a-i	0.28a-c	0.25a-e	0.23a-i	0.24a-g
(T_2)	0.26ab	0.24a-f	0.21a-k	0.23a-h	0.28ab	0.26a-d	0.23a-i	0.25a-e
(T_3)	0.27a	0.25a-d	0.22a-j	0.24a-f	0.29a	0.27abc	0.24a-h	0.26a-d
(T_4)	0.23a-h	0.20a-m	0.19b-p	0.14j-p	0.25a-e	0.22a-i	0.21b-j	0.16h-j
(T_5)	0.24a-g	0.21a-l	0.19a-o	0.15i-p	0.26a-d	0.23a-i	0.22a-j	0.17f-j
(T_6)	0.24a-e	0.22a-j	0.20a-n	0.16h-p	0.27a-c	0.24a-h	0.23a-i	0.18d-j
(T_7)	0.20a-m	0.17d-p	0.16g-p	0.11p	0.23a-i	0.20d-j	0.19d-j	0.14j
(T_8)	0.21a-k	0.18b-p	0.17e-p	0.12n-p	0.25a-f	0.22b-j	0.20b-j	0.16ij
(T_9)	0.22a-j	0.19a-o	0.18c-p	0.13k-p	0.25a-e	0.23b-j	0.21b-j	0.17g-j
(T_{10})	0.22a-j	0.18b-p	0.17e-p	0.12op	0.25a-f	0.22c-j	0.20c-j	0.15ij
(T_{11})	0.22a-j	0.19b-p	0.17d-p	0.12m-p	0.25a-e	0.22b-j	0.20b-j	0.16ij
(T_{12})	0.22a-i	0.19a-o	0.17c-p	0.13m-p	0.25a-e	0.22b-j	0.21b-j	0.16ij
(T_{13})	0.19b-p	0.15i-p	0.13l-p	0.16f-p	0.21b-j	0.18ij	0.15ij	0.19d-j

I1: irrigation every3-days, I2: irrigation every 6-days, I3: irrigation every 9-days, I4: irrigation every 12-days, T_1: 0.5 ml Crop plus, T_2: 1.00 ml Crop plus, T_3: 1.5 ml Crop plus, T_4: 15 ppm Cytokinin, T_5: 20 ppm Cytokinin, T_6: 25 ppm Cytokinin, T_7: 15 ppm ABA, T_8: 20 ppm ABA, T_9: 25 ppm ABA, T_{10}: 1 ml Trafos K, T_{11}: 1.5 ml Trafos K, T_{12}: 2 ml Trafos K, T_{13}: Tap water

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Spraying Crop plus with different concentration even 1.5, 1.00 and 0.5 ml/1 l water gave the highest ash content under irrigation every 3, 6, 9 and 12-days and recorded nearly the same value without any significant difference between them. For phosphorus and potassium contents data showed that crop plus and cytokinin spraying with different concentration recorded nearly the same value of phosphorus and potassium contents under different irrigation intervals 3, 6 and 9-days while under irrigation every 12-days crop plus come in the first rank and recorded the highest value of phosphorus and potassium contents. Pan et al. (2013) reported that foliar application of different stimulating compounds could enhance the lodging resistance and increase root biomass and root activity to improve phosphorus and potassium accumulation in milled grains. These results are in harmony with that recorded by Anjum et al. (2007), Singh (2011), Cuevas et al. (2016), Gharieb et al. (2016), Metwally et al. (2016, 2020) and Zhao (2018).

Conclusion

The low availability of water during this work had less effect on the yields. This might be due to its late occurrence during the rice plants life cycles. Similar results were found by Boonjung and Fukai (1996). Husking yield gave an idea of the total amount of edible grains after husking. Results showed that this trait was very slightly affected by the occurrence of drought at ripening stage. Therefore, the occurrence of drought during grain ripening stage could be considered as a useful factor that might help to reduce broken grain in milled rice with high level of head whole. Several factors are generally recognized as probable cause of breakage of rice during milling.

The study clearly showed physico-chemical variation in rice grain when moisture stress occurs during grain maturity stage. There were significant differences among both the stressed and the check samples. Late drought that occurs during ripening stage appears to decrease the main characteristics defining rice grain quality including total milling rate, head rice ratio, and protein content. Since the criteria of choice of a given variety depend on each consumer, it might not be well advised to conclude that the occurrence of water deficit during ripening stage necessarily or not enhance rice grain quality. However, the reproducibility of this trial is possible only in the case where weather conditions remain similar throughout consecutive years. The progressive higher carbon dioxide concentration due to climate change might be a limiting factor since the biosynthesis of protein and amylose which are the key elements of grains component is significantly influenced by atmospheric conditions especially after heading stage. More investigations should be done on water stress at rice plant reproductive stage to better understand the physiological phenomenon that happened when this constrain occurs

Irrigation every 3 days gave the highest grain quality without any significant differences with irrigation every 6 days followed by 9 days while irrigation every 12 days recorded the lowest grain quality. According to the previous results, it can be concluded that sprayed Sakha 108 rice cultivar by Crop plus and Cytokinin under water stress increase the rice grain quality. Also, Sakha 108 rice cultivar responded to Crop plus application compared to other regulator growth under water stress. Crop plus prolonged the irrigation interval from 3 days up to 9 days without any significant difference in grain quality. These results are very important for the farmers whose have shortage of water in rice fields without any negative effective on grain quality.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

Finally, this study needed to more study to reach the best results about using different growth regulators under different water stress with more studies for determine the amount of irrigation intervals.

REFERENCES

[1] A. O. A. C. (2000): Official and Tentative Methods of Analysis. 2nd Ed. – American Oil Chemists Society, Chicago, IL.

[2] Abd Allah, A. A., Mohamed, A. A. A., Gab-Allah, M. M. (2009): Genetic studies of some physiological and shoot characters in relation to drought tolerance in rice. – J. Agric. Res. Kafrelsheikh Univ. 35(4).

[3] Abdel-Megeed, T. M., El-Habet Howida, B. I., Hashem, I. M., Badawy, S. A. (2017): Impact of some plant growth regulating substances on the yield and its components of Giza179 and Giza177 rice cultivars under different irrigation interval treatments. – J. Plant Production, Mansoura Univ. 8(3): 369-379.

[4] Abdel-Megeed, T. M., Gharib, H. S., Hafez, E. M., El-Sayed, A. (2020): Effect of some plant growth regulators and biostimulants on the productivity of Sakha108 rice plant (*Oryza sativa* L.) under different water stress conditions. – Applied Ecology and Environmental Research 19(4): 2859-2878.

[5] Akita, S. (1989): Field Evaluation of Cytozyme Crop Plus on Grain Yield of Rice. (Preliminary Results). Worldwide Research on Cytozyme Products. Abstract. – Cytozyme Laboratories Inc., U.S.A.

[6] Anjum, F. M., Pasha, I., Bugti, M. A., Butt, M. S. (2007): Mineral composition of different rice varieties and their milling fractions. – Pakistan Journal of Agricultural Sciences 44(2): 332-336.

[7] Anonymous (2013): Bio-Stimulants market - By Active Ingredients, Application, Crop Types & Geography-Global Trends & Forecasts to 2018. – www.marketsandmarkets.com.

[8] Bao, J. S. (2012): Toward understanding the genetic and molecular bases of the eating and cooking qualities of rice. – Cereal Foods World 57: 148-156.

[9] Bhattacharya, A. (2019): Effect of High-Temperature Stress on the Metabolism of Plant Growth Regulators. Chap. 6. – Indian Institute of Pulses Research, Kanpur, India, pp. 485-591.

[10] Black, C.A., Evans, D. D., Ensminger, L. E., Clark, F. E. (1965): Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. – American Soc. of Agronomy, Inc., Madison, WI.

[11] Boonjung, H., Fukai, S (1996): Effects of soil water deficit at different growth stages on rice growth and yield under upland conditions. – Phenol. Biomass Prod. Yield 48: 47-55.

[12] Canady, M. (2012): Effect of Crop plus on physiological response related to photosynthesis in citrus. – Technical Data Reports, Cytozyme Laboratories, Inc. 10(1).

[13] Cruscio, C. A. C., Arf, O., Soratto, R. P., Mateus, G. P. (2008): Grain quality of upland rice cultivars in response to cropping systems in the Brazilian tropical savanna. – Sci. Agric. (Piracicaba, Braz.) 65(5): 468-473.

[14] Chapman, H. D., Pratt, P. F. (1961): Method of Analysis for Soils Plant and Water. - California Citrus Experiment Station, Univ. of California, Division of Agricultural Sciences, USA.

[15] Cooper, P. J. M., Gregory, P. J., Keating, J. D. H., Brown, S. C. (1987): Effect of fertilizer, variety and location on barley production under rainfed conditions in northern Syria. 2. Soil water dynamics and crop water use. – Field Crops Res. 16: 67-84.

[16] Craigie, J. S. (2011): Seaweed extract stimuli plant science and agriculture. – J. Appl. Phycol. 23: 371-393.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

[17] Cruz, N. D., Khush, G. S. (2000): Rice Grain Quality Evaluation Procedures. – In: Singh, R. K. et al. (eds.) Aromatic Rices. Oxford & IBH Publishing, New Delhi, pp.15-28.
[18] Cuevas, R. P., Pede, V. O., McKinley, J., Velarde, O., Demont, M. (2016): Rice grain quality and consumer preferences: a case study of two rural towns in the Philippines. – PLoS ONE 11(3): e0150345. https://doi.org/10.1371/journal.pone.0150345.
[19] Duncan, B. (1955): Multiple range and multiple F. test. – Biometrics 11: 1-42.
[20] European Bio-stimulants Industry Council (2013): Economic Overview of the Bio-stimulants Sector in Europe. – https://biostimulants.eu/.
[21] Fraser, J. R., Holmes, D. C. (1959): Proximate analysis of wheat flour carbohydrates. IV Analysis of whole meal flour and some of its fractions. – Journal of the Science of Food and Agriculture 10(9): 506-512.
[22] Frei, M., Becker, K. (2005): On Rice, Biodiversity & Nutrients. – University of Hohenheim, Stuttgart. http://www. greenpeaceweb. org/gmo/nutrients. pdf.
[23] Gandah, M., Bouma, J., Brown, J., Hiernaux, P., Van-Duivenbooden, N. (2003): Strategies to optimize allocation of limited nutrients to sandy soils of the Sahel: a case study from Niger, West Africa. – Agric. Ecosyst. Environ. 94: 311-319.
[24] Gemici, M. (1993): Effect of Cytozyme Crop plus on Triticum durum (Wheat). – Doga-Tr. J. of Botany. 17. 133-139.
[25] Gemici, M., Güven, A., Katmerm, P. (1998): Effects of Cytozyme Crop Plus on Lycopersicum esculentum Mill. – Plant Yield. Tr. J. of Botany 22: 7-11.
[26] Gharieb, A. S., Metwally, T. F., Abou-Khadrah, S. H., Glela, A. A., El Sabagh, A. (2016): Quality of rice grain is influenced by organic and inorganic sources of nutrients and antioxidant application. – Cercetari Agronomice in Moldova (Agronomic Research in Moldavia) (4168): 57-68.
[27] Gomez, K. A., Gomez, A. A. (1984): Statistical Procedures of Agricultural Research. 2nd Ed. – John Wiley and Sons, New York.
[28] Hare, P. D., Cress, W. A., Van Staden, J. (1997): The involvement of cytokinins in plant responses to environmental stress. – Plant Growth Regul. 23: 79-103.
[29] Jackson, M. L. (1967): Soil Chemical Analysis. – Prentice Hall of India, New Delhi, pp. 144-197.
[30] Kamboj, S., Mathpal, B. (2019): Improving rice grain quality by foliar application of plant growth regulators under various mode of Zn application. – Plant Archives 19(2): 2181-2184.
[31] Khan, S. U., Gurmani, A. R., Qayyum, A., Abbasi, K. S., Liaquat, M., Zahoor, A. (2016): Exogenously applied gibberellic acid, indole acetic acid and kinetin as potential regulators of source-sink relationship, physiological and yield attributes in rice (*Oryza sativa*) genotypes under water deficit conditions. – International Journal of Agriculture and Biology 18(1): 139-145.
[32] Metwally, T. F., El-Zun, H. M., Abdelfattah, N. A. H. (2016): Performance of some rice genotypes sown on different dates in yield, quality traits and infestation by lesser grain borer. – Journal of Plant Production, Mansoura University, Egypt 7(9): 973-982.
[33] Metwally, T. F., Mohamed, A. A. E., Sorour, S. G. R., Elsayed, G. A. (2020): Stimulating compounds affect the grain quality characteristics and the nutritional value of rice (Oryza sativa). – Applied Ecology and Environmental Research 18(5):6829-6840.
[34] Mohapatra, D., Bal, S. (2006): Cooking quality and instrumental textural attributes of cooked rice for different milling fractions. – Journal of Food Engineering 73(3): 253-254.
[35] Okabe, M. (1979): Texture measurement of cooked rice and its relationship to the eating quality. J. Texture Stud. 10: 131-152.
[36] Pan, S., Rasul, F., Li, W., Tian, H., Mo, Z., Duan, M., Tang, X. (2013): Roles of plant growth regulators on yield, grain qualities and antioxidant enzyme activities in super hybrid rice (*Oryza sativa* L.) – Rice 6(1): 1-10.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112

[37] Peterpurgski, A. V. (1968): Handbook of Agronomic Chemistry. – Kolos Publishing House, Moscow, pp. 29-86 (in Russian).
[38] Pospíšilová, J., Rulcová, J. (1999): Can synthetic cytokinins alleviate water stress in Phaseolus vulgaris leaves? – Biol. Plant. 42(Suppl.): S77.
[39] Pospíšilová, J., Synková, H., Rulcová, J. (2000): Cytokinins and water stress. – Biologia Plantarum 43(3): 321-328.
[40] Ramya, S. S., Nagaraj, S., Vijayanand, N. (2011): Influence of seaweed liquid extracts on growth, biochemical and yield characteristics of Cyamopsis tetragonolaba (L.) Taub. – Journal of Phytology 3(9): 37-41.
[41] Rousset, S., Pons, B., Martin, J. M. (1999): Identifying objective characteristics that product clusters produced by sensory attributes in cooked rice. – J. Texture Stud. 30: 50-532.
[42] Samonte, S., Wilson, L. T., McClung, A. M., Tarpley, L. (2001): Seasonal dynamics of non-structural carbohydrate in 15 diverse rice genotypes. – Crop Sci. 41: 902-909.
[43] Singh, N., Pala, N., Mahajan, G., Singh, S., Shevkani, K. (2011): Rice grain and starch properties: effects of nitrogen fertilizer application. – Carbohydrate Polymers 86(1): 219-225.
[44] Singh, N., Singh, D. (2019): The nutritional composition of local rice varieties in Guyana. – Greener Journal of Agricultural Sciences 9(2): 138-145.
[45] Tomlins, K. I., Manful, J. T., Larwer, P., Hammond, L. (2005): Urban consumer preference and sensory evaluation of locally produced and imported rice in West Africa. – Food Qual. Preference 16: 79-89.
[46] Vidal, V., Pons, B., Brunnschweiler, J., Handschin, S., Rouau, X., Mestres, C. (2007): Cooking behavior of rice in relation to kernel physicochemical properties. – J. Agric. Food Chem. 55: 336-346.
[47] Waller, R. A., Ducan, D. B. (1969): Bayes rule for the Symmetric Malliple Comason problem. – J. Am. Stat. Assoc. 64: 1484-1499.
[48] Watanabe, F. S., Olsen, S. R. (1965): Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extracts from soils. – Soil Science Society of America Journal S29(6): 677-678.
[49] Zhao, D. S., Li, Q. F., Zhang, C. Q., Zhang, C., Yang, Q. Q., Pan, L. X., Ren, X. Y., Lu, J., Gu, M. H., Liu, Q. Q. (2018): GS9 acts as a transcriptional activator to regulate rice grain shape and appearance quality. – Nature Communications 9(1): 1-14.
[50] Zheng, C., Zhang, Z., Hao, S., Chen, W., Pan, Y., Wang, Z. (2020): Agronomic growth performance of super rice under water-saving irrigation methods with different water-controlled thresholds in different growth stages. – Agronomy 10: 239.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2003_20952112