RESPONSE OF SOME ROOT AND YIELD TRAITS TO WATER STRESS FOR SOME RICE VARIETIES

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ABSTRACT

Two field experiments were conducted at sakha research station- kafr Elsheikh- Egypt, during 2014 and 2015 to study the effect of water stress on the root and yield characters of five rice varieties under different irrigation intervals the varieties, were Giza 178, Giza179, GZ 8710-3-2-1-1, GZ 1368-5-S-4 and GZ 5121-5-2 in strip – plot design with three replications, the data were recorded on root length, root thickness, volume and root: shoot ratio, number of panicle/ hill, 1000- grain weight and grain yield (t/ fed).The data indicated that the varieties GZ 5121-5-2 and GZ 1368-5-S-4 showed the highly reduction in most of root characters as well as grain yield. In addition, the results of this study show that the interaction between irrigation treatments and varieties was significant for root length, root volume (ml), number of roots, root thickness (mm), root: shoot ratio, number of panicles/hill, 1000-grains weight (g), and grain yield (t/fed), in both seasons. The desirable root characters combined with grain yield were obtained from the varieties GZ 8710 and Giza179, implying that these varieties are considered as a donor to water stress tolerant in rice breeding program.

INTRODUCTION

Rice is the world's most important food crop and a primary source of food for more than half the world's population. Rice production increased by 130% from 257 million tons in 1996 to 600 million tons in 2000 **Khush, (2005).** It is a drought susceptible crop exhibiting serious deleterious effects when exposed to water stress at critical growth stages especially at reproductive stage **(Suriyan *et al*., 2010)**. Shortage of water for irrigation is one of the most crucial factors limiting growth and production of almost all the crops including rice worldwide and intensity of the issue is aggravating with the passage of time **Passioura, (1996)**, **Passioura, (2007)**, **Anonymous, (2010)**. Thus, the percentage of drought affected land has approximately doubled from the 1970s to the early 2000s, affecting grain yield and quality of various crops resulting in food shortages in the world **Isendahl and Schmidt, (2006).**

Rice production area in Egypt changes from year to year based on available irrigation water. Rice cultivated area occupies about 20% from the totall cultivated area during summar season, it reached to 1.35 million feddan and total production was 5.3 million ton. National

rice average has decreased over the past five years due to two main factors, the first a shortage of irrigation water, and the second there is some areas affected by salinity conditions more over, around 1/3 of the rice cultivated area expose to water shortage annually, these areas are located at the terminals, **RRTC (2015).**

The objective of this investigation was to study the effect of irrigation intervals on some, root and yield characters for some rice varieties.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt during 2014 and 2015 seasons to investigate the effect of three irrigation intervals, on root, yield and its components of some rice varieties.

The field experiments were laid out in strip-plot design with three replications. The horizontal plots were devoted to three irrigation treatments, i.e.: irrigation every 4 days, irrigation every 7 days, and irrigation every 10 days, the treated water was applied 10 days after transplanting, The vertical plots were allocated to five rice varieties i.e. Giza 178, Giza 179, GZ 8710-3-2-1-1, GZ 5121-5-2 and GZ 1368-5 -S-4. Each vertical plot consisted of five rows with 5m for each row and plant spacing was 20*****20 cm.

The experimental land was prepared by two ploughs and harrowing then, well dry leveled. Phosphorus fertilizer at the rate of 35.5 kg P2O5/ha were applied during the land preparation. Nitrogen at the rate of 144kg N/ha was applied 1/3 at land preparation, 1/3 two weeks after transplanting and 1/3 30 days after transplanting under each of irrigation treatment. Zinc sulphate at the rate of 25 kg (Zn So4) was applied immediately before transplanting. Weeds were chemically controlled by applying 2 liters Saturn/ feddan five days after transplanting. Data were recorded on five individual plants for each replicate as following, according to SES **(IRRI 1996)**.

1. **Maximum root length** (cm)**.**
2. **Root volume** (ml)**.**
3. **Root thickness** (mm)**.**
4. **Root: shoot ratio.**

$$\text{Root/ shoot ratio} = \frac{\text{root dry weight (g)}}{\text{shoot dry weight (g)}}$$

5. **Number of panicles** / hill
6. **1000-grain weight** (g)
7. **Grain yield** (t/fed)

Statistical analysis:

All the collected data were subjected to analysis of variance according to (Gomez and Gomez 1984). Treatment means were compared by Duncan's multiple range test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "COSTAT" computer soft war package

RESULTS AND DISCUSSION

The effect of irrigation treatments and rice varieties as well as their interactions on root length and volume during 2014 and 2015 seasons are showed in Table (1).

Root length was significantly affected by water stress over the treatment l (irrigation every 4 days). In the severe water stress (irrigation every 10 days), root length was significantly reduced to be 27.25 and 25.78 cm compared to 30.51 and 29.59 cm in 2014 and 2015 seasons, respectively. These results were in agreement with those reported by **Sedeek *et al* .(2011).**

Significant difference was observed in root length among the varieties studied at all irrigation treatment in both seasons. The most desirable mean values were obtained by GZ 8710-3-2-1-, in both seasons. The varieties GZ 8710 and Giza 179 gave the highest mean values of root length, the values ranged from 31.50 to 29.50. While, the variety

GZ 1368-5-S-4 gave the lowest mean values and ranged from 25.93 to 23.67 in the two seasons.

The decreased in root length was severely affected by water stress conditions, as shown in Table (1), root length in mild water stress (irrigation every 7 days) the differences in was as it was detected at irrigation every 10 days.

Table (1): The effect of irrigation intervals and rice varieties on root length and root volume during 2014 and 2015 seasons

Irrigation intervals (I)	Root length (cm)		Root volume (ml)	
	2014	2015	2014	2015
Irrigation every 4 days	30.51	29.59	65.76	67.68
Irrigation every 7 days	28.49	27.12	61.99	62.73
Irrigation every10 days	27.25	25.78	52.44	54.12
F. test	**	**	**	**
LSD at 0.05	0.31	0.86	1.40	3.98
Varieties (V)				
Giza178	28.22	27.26	64.74	65.93
Giza179	30.66	29.50	63.29	66.72
GZ 8710-3-2-1-1	31.50	30.44	72.99	70.99
GZ 5121-5-2	27.45	26.64	49.25	51.09
GZ 1368-5-S-4	25.93	23.67	50.07	52.82
F. test	**	**	**	**
Interaction (IXV)	NS	*	**	**
LSD at 0.05	0.95	0.79	2.56	2.68

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The results in Table (1) showed that root volume was significantly affected by irrigation treatments. The highest mean values of this trait were produced by using irrigation every 4 days (65.76 and 67.68) in the two seasons, respectively. While, the lowest mean values were obtained by using irrigation every 10 days (52.44 and 54.12), respectively.

In both seasons the results in Table (1) indicated that the studied varieties significantly differed in root volume. GZ 8710-3-2-1-1 gave the desirable mean values of root volume in both seasons. (72.99 and 70.99), respectively. There were significant differences among the rice varieties studied. GZ 5121-5-2 and GZ 1368-5-S-4 produced the lowest mean values of the root volume, the values ranged from 49.25 to 52.82 in both seasons. The differences in the performance varieties may be attributed to difference in their response to water stress conditions and this may be due to the differences in genetic background and constitution of these varieties.

In general, there were significant differences among the treatments studied for this trait. The results are in agreement with those obtained by **Gomez and Rangasamy (2003).**

Table (2): Means of root length (cm), root volume (ml) as affected by the interaction between irrigation treatments and varieties during 2014 and 2015 seasons.

Varieties	Irrigation intervals (day)								
	Root length (cm)			Root volume (ml)					
	2015			2014			2015		
	4	7	10	4	7	10	4	7	10
Giza 178	29.25	27.22	25.30	71.69	67.69	54.83	73.22	68.25	56.31
Giza 179	30.51	29.13	28.84	66.01	63.64	60.23	70.27	66.21	63.68
GZ 8710-3-2-1-1	32.23	30.09	29.01	77.33	73.33	68.31	75.33	70.33	67.31
GZ 5121-5-2	30.10	25.89	23.95	57.34	50.64	39.78	60.27	50.55	42.44
GZ 1368-5-S-4	25.88	23.30	21.82	56.44	54.68	39.08	59.31	58.30	40.86
F. test	*			**			**		
LSD at 0.05	1.37			4.44			4.65		

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The interaction between the irrigation treatments studied and varieties was highly significant in both seasons. The tallest roots were obtained from GZ 8710-3-2-1-1 under 4 days as irrigation intervals, implying that this variety, is considered as a drought tolerant rice variety. As shown in Table (2).

The interaction between irrigation treatments the results in Table (2) showed, and the varieties which had a significant effect on root volume. The highest values of root volume (77.33 and 75.33) in

the first and second season was recorded when using GZ 8710 under irrigation every 4 days. While, the lowest value of root volume (39.08 and 40.86) in the first and second season, respectively was detected when using GZ 1368-S-5-4. under irrigation every 10 days. Height root volume is indication of the ability to permeate a large volume of soil and to have thick roots. In sush case, the plant would have more water gathering potential for growth and survival.

The effect of irrigation treatments and rice varieties as well as their interactions on root thickness and root shoot ratio during 2014 and 2015 seasons are showed in Table (3).

The results obtained indicated that root thickness was significantly affected by water stress conditions. The highest root thickness (0.80 and 0.82) was produced when using irrigation every 4 days in the first and second seasons, respectively. On the other hand, irrigation every 10 days produced the lowest root thickness (0.74 and 0.75) in the first and second seasons, respectively. These results are in agreement with those reported by **Abd Allah (2010).**

There were significant differences between the two seasons for the studied varieties, while significant differences were observed among the varieties for this trait. In both season, the results indicated that the tested varieties GZ 8710 and Giza 179 produced the highest root thickness (0.91 , 0.92) and (0.85 , 0.86) in the first and second season, respectively. While, GZ1368-S-5-4 produced the lowest root thickness (0.66 and 0.68) in the first and second season, respectively. These results are in accordance with those reported by **Ganapathy *et al* . (2010).**

Table (3): The effect of irrigation intervals and rice varieties on root thickness and root: shoot ratio during 2014 and 2015 seasons

Irrigation intervals (I)	Root thickness (mm)		Root: shoot ratio (%)	
	2014	2015	2014	2015
Irrigation every 4 days	0.80	0.82	0.76	0.75
Irrigation every 7 days	0.77	0.78	0.72	0.71
Irrigation every 10 days	0.74	0.75	0.68	0.67
F. test	**	**	**	**
LSD at 0.05	0.017	0.018	0.008	0.012
Varieties (V)				
Giza178	0.71	0.72	0.73	0.72
Giza179	0.85	0.86	0.79	0.78
GZ 8710-3-2-1-1	0.91	0.92	0.83	0.82
GZ 5121-5-2	0.73	0.74	0.62	0.61
GZ 1368-5-S-4	0.66	0.68	0.62	0.61
F. test	**	**	**	**
Interaction (IXV)	**	**	*	**
LSD at 0.05	0.007	0.010	0.013	0.009

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

Root: shoot ratio was significantly affected by water stress over the treatment l (irrigation every 4 days). In the severe water stress

treatment (irrigation every 10 days), root: shoot ratio was significantly reduced to be 0.68 and 0.67 cm compared to 0.76 and 0.75 cm in 2014 and 2015 seasons, respectively. These results were in agreement with those reported by **Abd El-Lattef *et al*.(2006).**

Significant difference was observed in root: shoot ratio among the studied varieties at all irrigation treatment in both seasons as shown in Table (3). The most desirable mean values were obtained by GZ 8710-3-2-1-1 in both seasons. The varieties GZ 8710-3-2-1-1 and Giza 179 gave the highest mean values of root: shoot ratio, the values ranged from 0.83 to 0.78 .While, the varieties GZ5121-5-2 and GZ 1368-5-S-4 gave the lowest mean values and ranged from 0.62 to 0.61 in both seasons.

The results in Table (4) indicated that the interaction between the irrigation treatments and varieties had a significant effect on root thickness. The highest values of this trait (0.93 and 0.95) was recorded when using GZ 8710-3-2-1-1 with irrigation every 4 day in the first and second season. While, the lowest values of root thickness (0.65 , 0.66) and (0.67 ,0.68) was detected when using GZ 1368-5-S-4 and Giza 178 with irrigation every 10 day in the first and second season, respectively.

Table (4): Means of root thickness (mm) and root shoot ratio (%) as affected by interaction between irrigation treatments and varieties during 2014 and 2015 seasons

Varieties	Irrigation intervals (day)											
	Root thickness (mm)						Root: shoot ratio (%)					
	2014			2015			2014			2015		
	4	7	10	4	7	10	4	7	10	4	7	10
Giza 178	0.75	0.72	0.67	0.77	0.73	0.68	0.77	0.74	0.70	0.76	0.72	0.70
Giza 179	0.88	0.85	0.82	0.89	0.86	0.83	0.84	0.81	0.74	0.82	0.80	0.73
GZ 8710-3-2-1-1	0.93	0.91	0.89	0.95	0.92	0.90	0.88	0.83	0.79	0.87	0.82	0.78
GZ 5121-5-2	0.78	0.73	0.68	0.79	0.74	0.69	0.66	0.61	0.61	0.65	0.60	0.59
GZ 1368-5-S-4	0.69	0.66	0.65	0.70	0.68	0.66	0.67	0.63	0.58	0.66	0.61	0.57
F. test	**			**			*			**		
L S D at 0.05	0.013			0.017			0.022			0.016		

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The results in Table (4) indicated that interaction between water treatments and varieties had a significant effect on root: shoot ratio. The highest ratio (0.88 and 0.87) in the first and second season, respectively was recorded when using GZ 8710 and irrigation every 4 days **(AbdAllah *et al*. 2010)**. They found that, the varieties with high root: shoot ratio were more drought resistant, varieties with a high deep-root: shoot weight ratio exhibit enhanced drought resistance in drought conditions.

It could be concluded that the ideal drought to be composed of only a few thick and long roots with high root: shoot ratio capable of extracting water in the deep soil layers. This type root system is usually associated with high yielding ability.

The effect of irrigation treatments and rice varieties as well as their interactions on number of panicles / hill and 1000 grain weight during 2014 and 2015 rice growing seasons are presented in Table (5).

The results indicated that, number of panicles / hill was significantly affected by the irrigation treatments. The most effective treatment was irrigation every 10 days for this trait, the values ranged from 17.25 to 17.11 panicles / hill. While, irrigation every 4 days gave the highest number of panicles / hill (23.34 and 22.78) in the first and second season, respectively.

The results in Table (5) showed that the tested varieties differed significantly in number of panicles / hill. Giza 179 and GZ 8710-3-2-1-1 rice varieties produced the highest mean values for number of panicles/ hill (21.99 and 21.59) in the two season, respectively, while Giza 178 gave the lowest mean values (17.51 and 17.96) in the first and second seasons , respectively. The difference in the performance of these varieties may be attributed to the differences in the genetic back ground and constitution of the varieties. These findings are in agreement with those reported by **Rahman *et al*.(2002).**

Table (5): The effect of irrigation intervals and rice varieties on number of panicles/ hill and 1000-grain weight (g) during 2014 and 2015 seasons

Irrigation intervals (I)	Number of panicles/ hill		1000-grain weight (g)	
	2014	2015	2014	2015
Irrigation every 4 days	23.34	22.78	25.98	25.03
Irrigation every 7 days	20.35	19.52	24.57	23.77
Irrigation every 10 days	17.25	17.11	22.79	22.50
F. test	**	**	**	*
LSD at 0.05	0.39	0.92	0.34	1.52
Varieties (V)				
Giza 178	17.51	17.96	22.29	21.58
Giza179	21.99	20.49	25.99	24.92
GZ 8710-3-2-1-1	21.85	21.59	24.50	24.16
GZ 5121-5-2	19.62	18.64	25.44	24.89
GZ 1368-S-5-4	20.61	20.34	24.00	23.29
F. test	**	**	**	**
Interaction (IXV)	**	*	*	*
LSD at 0.05	0.89	0.63	0.52	0.61

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The results indicated that 1000-grain weight were significantly affected by the irrigation treatments. The most effective treatment was irrigation every 10 days for this trait. The values ranged from (22.79 g to 72.50 g). While, irrigation every 4 days gave the highest 1000-grain

weight (25.98 g and 25.03g) in the first and second season, respectively.

The results in Table (5) showed that the tested varieties differed significantly in 1000-grain weight. Giza 179 rice variety produced the highest mean values of 1000-grain weight (25.99 and 24.92 g) in the two season, respectively, while Giza 178 gave the lowest mean values (22.29 and 21.58 g) in the first and second seasons , respectively. The difference in the performance of these varieties may be attributed to the differences in the genetic background and constitution of the varieties. These findings are in agreement with those reported by **EL-Dalil (2007).**

The interaction between the irrigation treatments and varieties had a significant effect on number of panicles/ hill. As shown in Table (6). The highest number of panicles / hill (25.20 , 24.17) and (24.24 , 24.00) were recorded when using irrigation every 4 days with the varieties GZ 1368-S-5-4 followed by Giza 179 and GZ 8710**-**3-2-1-1 in the both season, respectively. On the other hand, the lowest value was obtained by using irrigation at 10 days with the varieties Giza 178. The results are in the same line with those reported by **Badawi (2008).**

Table (6): Means of number of panicles/ hill and 1000-grain weight (g) as affected by interaction between irrigation treatments and varieties during 2014 and 2015 seasons

varieties	Irrigation intervals (day)											
	Number of panicles/ hill						1000-grain weight (g)					
	2014			2015			2014			2015		
	4	7	10	4	7	10	4	7	10	4	7	10
Giza 178	22.47	16.57	13.49	20.86	17.88	15.15	23.64	22.16	21.07	22.47	21.51	20.75
Giza 179	24.17	22.14	19.66	24.00	19.14	18.34	27.12	26.06	24.80	27.08	24.03	23.66
GZ 8710-3-2-1-1	22.48	23.28	19.80	24.24	22.30	18.23	26.80	24.60	22.07	25.32	24.39	22.77
GZ 5121-5-2	22.38	19.35	17.12	21.60	18.28	16.06	26.82	25.90	23.62	26.16	25.50	23.02
GZ 1368-S-5-4	25.20	20.42	16.20	23.23	20.01	17.77	25.49	24.12	22.39	24.15	23.44	22.29
F. test	**			*			*			*		
LSD at 0.05	1.55			1.09			0.91			1.06		

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The interaction between the irrigation treatments and varieties had a significant effect on 1000-grain weight. As shown in Table (6). The highest 1000-grain weight (27.12 and 27.08g) followed by

(26.82 and 26.16g) in both seasons were recorded when using Giza 179 and GZ 5121-5-2 with irrigation every 4 days, respectively. On the other hand, the lowest 1000-grain weight (21.07 and 20.75g) in both seasons were obtained by using Giza 178 with irrigation every l0 days. Similar results were found by **Kumar *et al*. (2014).**

The effect of irrigation treatment, and varieties as well as their interactions on grain yield during 2014 and 2015 rice growing seasons are presented in Table (7). The results showed that, the highest mean values of this trait was produced by using irrigation every 4 days (4.466 and 4.459) in the two seasons, respectively. While, the lowest mean values were obtained by using irrigation every 10 days (3.452 and 3.402), respectively. In general, there were significant differences among the treatments studied for this trait. These results are in agreement with those obtained by **Hong and Serraj (2012).**

Table (7): The effect of irrigation intervals and rice varieties on number of panicles/ hill and 1000-grain weight (g) during 2014 and 2015 seasons

Irrigation intervals (I)	Grain yield (t/fed)	
	2014	2015
Irrigation every 4 days	4.466	4.459
Irrigation every 7 days	3.987	3.921
Irrigation every10 days	3.452	3.402
F. test	**	**
LSD at 0.05	0.216	0.109
Varieties (V)		
Giza178	4.008	3.928
Giza179	4.232	4.159
GZ 8710-3-2-1-1	4.293	4.211
GZ 5121-5-2	3.781	3.694
GZ 1368-5-S-4	3.527	3.643
F. test	**	**
Interaction (IXV)	**	**
LSD at 0.05	**0.146**	**0.115**

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The results indicated that the two tested varieties GZ 8710 (4.293 and 4.211) and Giza 179 (4.232 and 4.159) gave the desirable mean values of grain yield in both seasons, respectively. There were significant differences between the two seasons and among the varieties studied. GZ1368-5-S-4 and GZ5121-5-2 produced the lowest mean values of the grain yield, the values ranged from 3.527 to 3.694 in both seasons.

Table (8): Means of grain yield (t/fed) as affected by interaction between irrigation treatments and varieties during 2014 and 2015 seasons

Varieties	Irrigation intervals (day)					
	Grain yield (t/fed)					
	2014			2015		
	4	7	10	4	7	10
Giza 178	4.562	4.058	3.405	4.516	3.914	3.356
Giza 179	4.697	4.415	3.586	4.744	4.265	3.469
GZ 8710-3-2-1-1	4.596	4.311	3.972	4.552	4.288	3.793
GZ 5121-5-2	4.203	3.872	3.268	4.151	3.676	3.256
GZ 1368-5-S-4	4.271	3.282	3.028	4.331	3.461	3.136
F. test	**			**		
LSD at 0.05	0.25			0.19		

**,* Highly significant and significant at 0.01 and 0.05 levels, respectively. NS= Not Significant

The results in Table (8) indicated that the interaction between the irrigation treatments and varieties had a significant effect on grain yield. The highest mean value of this trait (4.697 and 4.744) season was recorded when using Giza 179 with irrigation every 4 day in the first and second, respectively. While, the lowest mean value of grain yield (3.028 and 3.136) it was detected when using GZ 1368-S-5-4 with irrigation every 10 day in the first and second season, respectively.

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استجابة بعض صفات الجذور والمحصول للاجهاد المائي لبعض أصناف الأرز

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الملخص العربي

أجريت هذه الدراسة في المزرعه البحثيه بمحطة بحوث سخا - كفر الشيخ - مصر خلال موسمي زراعة الأرز 2014- 2015 لدراسة تأثير الاجهاد المائي علي بعض صفات الجذور وصفات المحصول لخمسه من أصناف الأرز في تجربة قطاعات متعامدة حيث وضعت فترات الري كل 4 ، 7 ، 10 أيام في القطع الأفقيه وأصناف الأرز جيزة 178 وجيزة 179 سلالة 1-1-2-3- 8710 وسلالة 4-S-5 -1368 و سلالة 2-5 5121 في القطع الرأسيه .

أظهرت النتائج أن صفات الجذور و صفات المحصول للسلالتين GZ1368-5-S-4، GZ5121-5-2 كانت أعلي تأثرا تحت ظروف الاجهاد المائي، التفاعل بين معاملات الري والأصناف أظهر معنويا لكل من طول الجذر، حجم الجذر، سمك الجذر، نسبة المجموع الجذري الي الخضري، عدد السنابل، وزن الألف حبة، المحصول، في كلا الموسمين.

أظهرت الأصناف سلالة1-1-2-3- 8710، جيزة 179 أفضل وأعلي صفات الجذر وصفات المحصول، مما تشير الي أن هذه الأصناف تعتبر مصدر وراثي للتحمل للاجهاد المائي في برامج تربية أصناف الأرز.