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WATER DEFICIT EFFECTS ON BEHAVIOR OF SOME NERICA RICE VARIETIES UNDER EGYPTIAN CONDITION

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ABSTRACT: The present study was carried out at the Experimental Farm of Sakha Agricultural Research Station, Kafrelsheikh, Egypt during season of 2019 and 2020 seasons, to study the effect of water deficit at the reproductive and ripening stages on performance of some rice genotypes. Fourteen genotypes were used in this investigation; two of them are used as checks, NERICA 7 as tolerant to drought and Giza 177 as sensitive to drought. The results of this research showed that all rice varieties and their traits were affected significantly by water stress at reproductive stage and ripening stage. The water stress at reproductive stage reduced significantly number of panicles plant^{-1}. While the drought stress at ripening stage decline significantly the number of filled grains panicle^{-1} and 1000-grain weight and grain yield tha-^{1}. The reductions in grain yield due to drought at the ripening stage were 53.14 and 54.00 % compared with well-watered in 2019 and 2020 seasons, while, the reduction in grain yield attributed to water stress at the reproductive stage is 38.55 and 43.50 % in both seasons. All rice varieties were affected significantly by water stress at ripening stage followed by the water stress at reproductive stage. The grain yield reduction differed among the rice varieties according to their level of tolerance, the reduction in grain yield due to water stress at both ripening and reproductive stages for the sensitive variety Giza 177 was about 81.3 and 54.8%, respectively compared with well-watered. Meanwhile, the lowest reduction percentage in grain yield under the same conditions was recorded for NERICA 7 and NERICA 8. The cultivar with the highest values of anatomical traits is considered as drought tolerant as NERICA 7 and Giza 178. Grain yield was positively correlated with root length, root dry weight, number of panicles plant^{-1} and 1000-grain weight under water stress at reproductive stage. However, grain yield was positive and highly correlated with root thickness, number of filled grains panicle^{-1} and 1000-grain weight under water stress at ripening stage.

Key words: **Rice, water stress at the reproductive and ripening stages.**

INDRODUCTION

Food security and water shortage are two major challenges facing Egypt particularly in the terminal areas. Water shortage is one of the most limiting factors in about 30% of rice cultivated areas in Egypt, where most of the developed varieties cannot perform well under water shortage (AbdAllah, 2010). In most crops, particularly cereals, the plants are more sensitive to water stress during the reproductive stage than at any other time (Salter and Goode, 1967). Water deficit is a major problem for crop production worldwide, limiting the growth and productivity of many crop species, especially in rainfed agricultural areas (>1.2 billion hectares) as mentioned by (Chaves and Oliveira, 2004) and (Passioura, (2007). Water stress is one of the most important abiotic stresses causing the reduction in yield in rainfed rice environments. A huge area of rice is grown under lowland and upland rainfed conditions, these areas respectively occupy 31 and 11% of the

global rice growing area (IRRI, 2001). Drought is one of the major abiotic stresses limiting plant production in rainfed ecosystem. (Evenson *et al.*, 1996), stated that the reduction in grain yield due to water stress in the world is around 18 million tons annually or 4% of total rice production, which equivalents US$ 3.6 billion at that time. (Jongdee *et al.*, 2006) reported that the selection of rice genotypes that maintain high spikelet fertility under water stress and/or a low rate of leaf drying under water stress is also common as indication for drought tolerance. Various evaluations have been reported for the estimation of drought tolerance based on plant body symptoms caused by water deficit, such as plant wilting, leaf rolling and yield loss (Gupta and Toole, 1986), and (Kon, 1990). The objectives of this research are to assess the effect of water stress on some of rice genotypes and their characteristics at the reproductive stage and ripening stages.

MATERIALS AND METHODS

The research work of the present study was carried out at the Experimental Farm of the Sakha Agriculture Research Station, Sakha, Kafr EL-Sheikh, Egypt, during the two successive rice seasons 2019 and 2020 to study the effect of water stress on root characters and yield and its components for some rice genotypes at different reproductive and ripening growth stages of rice. Fourteen genotypes with various genetic backgrounds, 11 upland rice varieties were introduced from AfricaRice Center and 3 Egyptian varieties were chosen for this study. These genotypes have a wide range of variations due to their different genetic background. The pedigree, group type and main characteristics of these varieties are listed in Table 1. Seeds of the 14 rice genotypes were sown on the of May 7th in both seasons of study and seedlings aged 30 days were individually transplanted with a spacing of 20 x 20 cm. The statistical design of the experiment was split- plot design with four replications. Water treatments were allocated in the main plots under the well-watering and two treatments of water stresses and rice varieties were distributed in the sub- plots. Each replication included seven rows for each genotype, the length of each row was 5 m, and harvested 5 m^2. In the well watered treatment, soil moisture content was kept at saturation point during the whole season. For water stress treatments, two consecutive cycles of stress were applied as follows; at reproductive stage (after 45 days of transplanting) for 15 days withholding till appear the drought susceptibility traits (leaf rolling and leaf drying score) on the tolerant variety and irrigated after water stress up to harvest. The second water stress was applied at the ripening stage (after complete heading) for 15 days then irrigated up to harvest. The rate of NP fertilizers applied as follows; 60 kg N/ha in the form of urea (46.5%N) was applied in two splits, the first dose 2/3 added as basal application and incorporated with soil during land preparation for fully irrigated and water stress replications. While the second dose was top-dressed after 30 days of transplanting, 30 kg P_2O_5/ha in the form of single super phosphate (15% P_2O_5) was applied in the permanent field and incorporated with soil during land preparation for fully irrigated and water stress replications. All recommended agricultural practices were applied as usual for the ordinary rice field. Weeds were chemically controlled. The following traits were recorded i.e., root length (cm) was determined as the length of the root from the base of the plant to the tip of the main axis of the primary root, root volume (cm^3) was determined for all root system per plant was determined in cubic centimeters using standard column., root thickness (mm) diameter of five roots

from the third node was measured at 2cm from the tip of the root to estimate the area for water absorption (Fujii, 1974). At harvest Number of panicles plant-^{1}, Number of filled grains panicle^{-1}, 1000-grain weight (g) and grain yield tha^{-1} was measured according to (IRRI, 1996).

The relationships among the studied characters were assessed statistically through simple correlation, according to (Gomez and Gomez 1983) using SPSS software version 16 for windows.

Anatomical Studies*:*

For anatomical responses to drought stress, root samples of some rice varieties were collected during the full maturing stage under water deficit conditions, root pieces 4–5 mm in length were taken from the root tip. Samples were fixed for 48 h in FAA (10 mL formalin, 5 mL glacial acetic acid, 50 mL ethyl alcohol 95%, and 35 mL distilled water). The samples were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax with 56 °C, sectioned to a thickness of 20 µm, double-stained with safranine-light green, cleared in xylem, and mounted in Canda Balsam. Ten sections per treatment were prepared, observed, and photomicrograph with a microscope (AxioPlan, Zeiss, Jena, Germany). Slides were microscopically examined and measurements and counts were taken and averages of 10 readings from 3 slides were calculated, according to (Gerlach, 1977).

RESULTS AND DISCUSSION

Root characteristics

Root length (cm)

The studied water schedules induced significant effect on root characteristics in both seasons. The root length was increased under water stress at reproductive stage followed by the water stress at ripening stage compared with well-watered treatment. This mainly due to the rice plant tended to absorb more water from deep soil layer thus increased the root length. The rice genotypes differed significantly in their response to water stress, the NERICA 7, Giza 178 and NERICA 14 recorded the highest values of root length compared with the other varieties under this investigation (Table 2). The interaction between rice varieties and water stress treatments had significant effect on root length, root volume, root thickness and root dry weight in both seasons (Table 2). It was clearly that the interaction effect came to support the superiority and tolerance of NERICA 7 and Giza 178 under water stress happened at both the reproductive and ripening stages. The longest roots were produced by Giza 178 when it was subjected to water withholding at reproductive stage followed by NERICA 7 at same stage and then latter variety at ripening stage. By the way, the possibility of strengthening root in soil in the deep layer of soil behind water is considered as a mechanism of water stress tolerance. In this concern, Giza 177, NERICA 13 and NERICA 8 were at a par under water withholding induced at reproductive stage. The water stress occurred at ripening stage is less affected since the plants during maturing stage is more tolerant for water stress. The rice varieties Giza 178 and NERICA 7 showed the longest roots under the water stress at both the reproductive stage and ripening stage in the two seasons. Meanwhile, the rice varieties Giza 177, NERICA 1and NERICA 8 were recorded the lowest values under the same conditions of water stresses (Table 3). The obtained results are in agreement with those obtained by (Sandhu *et al.* 2013) who indicated that root length, root volume, root thickness and root number of the tolerant parent were found to be higher than those of the susceptible parent under aerobic conditions.

Table 1: Origin and parentage of rice varieties utilized in the study.

No.	Variety	Parentage	Origin
1	Giza 177	Giza 171/ Yomji No.1//PiNo.4	Egypt
2	Giza 178	Giza 175/ Milyang 49	Egypt
3	GZ 10590-1-3-3-2	GZ8126-1-3-1-2/ HR 17570-21-5-2-5-2	Egypt
4	NERICA 1	WAB 56-104/ CG14//WAB56-104	AfricaRice
5	NERICA 2	WAB 56-104/ CG14//WAB56-104	AfricaRice
6	NERICA 3	WAB 56-104/ CG14//WAB56-104	AfricaRice
7	NERICA 4	WAB 56-104/ CG14//WAB56-104	AfricaRice
8	NERICA 6	WAB 56-104/ CG14//WAB56-104	AfricaRice
9	NERICA 7	WAB 56-104/ CG14//WAB56-104	AfricaRice
10	NERICA 8	WAB 56-104/ CG14//WAB56-104	AfricaRice
11	NERICA 9	WAB 56-104/ CG14//WAB56-104	AfricaRice
12	NERICA 11	WAB 56-104/ CG14//WAB56-104	AfricaRice
13	NERICA 12	WAB 56-50/ CG14//WAB56-50	AfricaRice
14	NERICA 14	WAB 56-50/ CG14//WAB56-50	AfricaRice

Table (2): Root length (cm), root volume (Ml), root thickness (mm) and root dry weight (g) as affected by water treatments of some rice genotypes during 2019 and 2020.

Factor	Root length (cm)		Root volume (Ml)		Root thickness (mm)		Root dry weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020
Well-watered	25.65	25.29	119.30	125.86	1.38	1.38	31.84	32.34
Reproductive	30.13	30.33	78.93	77.99	1.49	1.52	24.27	23.94
Ripening	28.20	28.01	92.87	97.76	1.55	1.53	30.76	29.02
L.S.D 0.05	0.266	0.696	1.42	0.94	0.0305	0.040	1.41	0.56
Variety								
Giza177	24.54	24.32	120.00	115.00	1.23	1.25	40.87	41.60
Giza178	31.37	31.76	104.08	117.64	1.53	1.54	42.86	43.72
GZ 10590-1-3-3-2	27.99	28.82	104.22	112.11	1.43	1.43	36.70	38.33
Nerica1	25.21	24.99	88.14	85.99	1.38	1.40	23.76	25.22
Nerica2	27.50	27.07	76.11	76.33	1.33	1.34	22.10	19.21
Nerica3	26.76	26.36	89.89	86.22	1.42	1.44	27.75	25.82
Nerica4	26.34	25.92	94.00	113.33	1.74	1.75	20.55	19.50
Nerica6	27.36	27.60	94.31	107.88	1.45	1.45	31.96	31.42
Nerica7	33.62	33.90	171.28	164.28	1.86	1.86	28.29	28.98
Nerica8	26.35	26.11	98.22	95.78	1.66	1.64	22.14	20.99
Nerica9	30.70	28.76	96.85	96.42	1.46	1.45	32.67	30.22
Nerica12	26.90	27.14	78.59	84.32	1.38	1.40	19.73	21.65
Nerica13	26.42	27.23	65.68	76.27	1.36	1.35	27.37	25.43
Nerica14	30.89	30.33	77.12	75.94	1.38	1.38	28.62	25.98
L.S.D 0.05	0.648	0.83	3.46	1.82	0.0751	0.080	2.32	2.18
Interaction	**	**	**	**	**	**	**	**

Well-watered,
Water stress at reproductive stage
water stress at ripening stage

The maximum root length is one of the most important root characteristics that play a vital role to absorb more water from deep soil layer it call drought avoidance and it's the second mechanism of drought tolerance (Abd Allah *et al.* 2010).

Root volume (cm^3)

Water stress treatments significantly restricted root volume in both seasons. All the rice varieties were affected significantly by water stress treatments at the different growth stages. Water withholding happened at the reproductive stage was the most restricting on root volume (Table 2). NERICA 7 rice variety gave the highest values of root volume under the two water stresses while NERICA 2 recorded the lowest values of it under the same conditions (Table 2). The interaction effect was significant regarding root volume in both seasons. Interestingly the interaction results came to confirm that the most affected stage by water stress was reproductive stage. The most tolerant varieties under water stress at reproductive stage and ripening stage were Giza 178, GZ 10590 and NERICA 7. It is mentioning here, rice varieties of Giza 178, NERICA 7 and GZ 10590 showed a significant increase in their root volume under withholding at reproductive stage during the two seasons of study. On the other hand Giza 177, NERICA 2 and NERICA 8 showed the lowest values in both seasons of study (Table 3). These results were similar with those obtained by (Sandhu *et al.* 2013).

Root thickness (mm)

Water withholding affected significantly on root thickness whereas. root was thickness increased with water stress, the highest values were observed with water stress at the ripening stage followed by water stress at the reproductive stage compared with well watered (Table 2). All the rice varieties recorded the highest values of root thickness at repining and reproductive stages compared to well-watered. The interaction effect was significant NERICA 7 followed by NERICA 4 gave the highest values of root thickness at ripening and reproductive stages. Meanwhile, Giza 177 gave the lowest values under the same conditions (Table 4). The rice varieties which have thicker roots are more tolerant to water stress; the same results were reported by (Abd Allah *et al* 2010).

Root dry weight (g)

Data in (Table 2) indicated that the root dry weight plant^{-1} was reduced significantly under reproductive stage. On the other hand root dry weight recorded the highest values under well-watered followed by water stress at the ripening stage. The current results confirmed the sensitivity of the reproductive stage to water stress then ripening stage.

All the rice varieties were affected significantly by water treatments and the reduction in dry weight differed significantly according to the genetic background of each variety and the level of tolerance. Giza 178 rice variety recorded the highest values of root dry weight under water stress at both the reproductive and ripening stages respectively, while, the sensitive rice variety Giza 177 exhibited the lowest values of root dry weight under water stress at the reproductive stage (Table 4). The results indicated that the tested genotypes varied from environment to the other and ranked differently from normal to stress conditions. (Kandil *et al.,* 2010), (Ghaz, 2012) and (AbdAllah *et al.,* 2010) indicated similar findings.

Table (3): Root length and root volume as affected by the interaction between some rice genotypes and water treatments in 2019 and 2020 studied seasons

Variety	Root length (cm)						Root volume					
	2019			2020			2019			2020		
	well	rep	ripening	well	rep	ripening	well	rep	ripening	well	rep	ripening
Giza177	22.06	27.37	24.20	20.53	27.90	24.53	215.00	60.00	85.00	225.00	55.00	65.00
Giza178	25.60	36.63	31.87	26.43	35.97	32.87	107.23	105.00	100.00	125.6	106.50	120.83
GZ 10590-1-3-3-2	25.83	30.26	27.87	23.70	32.70	30.06	107.33	105.33	100.00	121.33	102.67	112.33
Nerica1	22.53	27.17	25.93	22.50	27.10	25.36	97.33	77.10	90.00	100.00	78.30	79.67
Nerica2	26.13	28.43	27.93	27.20	27.90	26.10	95.00	50.33	83.00	95.00	49.00	85.00
Nerica3	25.13	28.73	26.43	23.87	29.30	25.90	101.67	78.00	90.00	100.00	77.00	81.67
Nerica4	24.43	28.60	26.00	23.50	29.30	24.97	110.00	90.00	82.00	130.00	95.00	115.00
Nerica6	24.43	30.23	27.43	25.70	29.70	27.40	139.00	73.43	70.50	143.00	73.30	107.33
Nerica7	31.70	35.17	34.00	32.00	35.37	34.33	211.17	130.00	172.67	214.50	115.00	163.33
Nerica8	24.83	27.90	26.33	24.80	27.63	25.90	125.00	54.67	115.00	130.00	55.00	102.33
Nerica9	28.40	31.30	32.40	26.00	31.00	29.27	115.00	73.87	101.67	115.00	72.60	101.67
Nerica12	24.50	29.50	26.70	25.43	28.53	27.47	90.00	70.77	75.00	93.20	74.77	85.00
Nerica13	25.07	27.77	26.43	25.70	28.80	27.20	70.17	64.87	62.00	86.60	65.67	76.53
Nerica14	28.50	32.77	31.40	26.70	33.53	30.77	86.33	71.70	73.33	82.83	72.00	73.00
L.S.D 0.05	1.12			1.44			5.99			3.15		

well, well-watered,
rep, water stress at reproductive stage
ripening, water stress at ripening stage

Table (4): Root thickness (mm) and root dry weight (g) as affected by the interaction between some rice genotypes and water treatments in 2019 and 2020 studied seasons

Variety	Root thickness (mm)						Root dry weight (g)					
	2019			2020			2019			2020		
	well	rep	ripening	well	rep	ripening	well	rep	ripening	well	rep	ripening
Giza177	1.16	1.26	1.26	1.14	1.30	1.30	61.10	11.50	50.00	61.30	10.50	53.00
Giza178	1.36	1.60	1.63	1.40	1.61	1.62	32.43	46.83	49.33	32.50	50.00	48.67
GZ 10590-1-3-3	1.36	1.40	1.53	1.37	1.41	1.50	34.87	41.90	33.33	36.00	44.00	35.00
Nerica1	1.30	1.43	1.40	1.33	1.45	1.41	24.67	19.60	27.00	26.00	19.33	30.33
Nerica2	1.30	1.33	1.36	1.31	1.38	1.34	24.63	16.67	25.00	24.30	15.00	18.33
Nerica3	1.36	1.43	1.46	1.38	1.45	1.48	32.83	25.10	25.33	31.50	24.30	21.67
Nerica4	1.63	1.80	1.80	1.65	1.82	1.79	21.33	17.33	23.00	21.00	16.50	21.00
Nerica6	1.36	1.46	1.53	1.35	1.48	1.52	43.67	17.20	35.00	46.00	15.60	32.67
Nerica7	1.63	1.96	2.00	1.65	2.00	1.93	29.20	28.33	27.33	28.60	29.00	29.33
Nerica8	1.53	1.66	1.80	1.50	1.67	1.75	26.43	14.67	25.33	26.30	13.00	23.67
Nerica9	1.43	1.43	1.53	1.41	1.44	1.50	44.67	18.33	35.00	45.00	17.00	28.67
Nerica12	1.26	1.46	1.43	1.30	1.48	1.42	15.43	27.10	16.67	19.97	27.33	17.66
Nerica13	1.33	1.33	1.43	1.30	1.36	1.40	28.10	24.00	30.00	28.30	23.00	25.00
Nerica14	1.26	1.36	1.53	1.27	1.45	1.41	26.33	31.20	28.33	26.00	30.60	21.33
L.S.D 0.05	0.0751			0.0305			3.78			3.87		

Well, Well-watered,
rep, water stress at reproductive stage
ripening, water stress at ripening stage

Yield and its components

Number of panicles plant^{-1}

The data in (Table 5) revealed that the number of panicles was significantly affected by water stress at the reproductive stage followed by the ripening stage compared with well-watered.

The sensitive Giza 177 recorded the lowest value for number of panicles under water stress at the reproductive stage in both seasons of study; however GZ 10590-1-3-3-2 which gave the highest value under the same conditions (Table 6). Results indicated that the number of panicles plant^{-1} of the tolerant varieties was found to be higher than those of the susceptible parent under aerobic conditions. These results are agreed with (Sandhu *et al.,* 2013), (Maisura *et al.,* 2014) and (Abade *et al,* 2016).

Table (5): No. of panicles/plant, no. of filled grains/panicle, 1000-grain weight (g) and grain yield (t/ha.) as affected by water treatments of some rice genotypes during 2019 and 2020.

Factor	Number panicles/plant		No. of filled grains/panicle		1000-grain weight (g)		Grain yield (t/ha.)	
	2019	2020	2019	2020	2019	2020	2019	2020
Well-Watered	18.80	20.25	165.46	164.64	28.84	29.73	7.47	8.00
Reproductive	14.06	14.10	122.05	112.01	25.78	26.49	4.59	4.52
Ripening	17.01	17.12	105.60	87.73	22.71	23.49	3.50	3.68
L.S.D 0.05	0.93	0.50	1.40	1.20	0.98	0.22	0.07	0.23
Variety								
Giza177	17.43	17.18	98.01	104.18	25.46	25.67	5.19	4.13
Giza178	21.90	22.23	131.64	124.54	22.33	22.83	8.33	8.67
GZ 10590-1-3-3-2	20.57	21.21	121.27	117.99	23.69	24.21	6.02	6.02
Nerica1	15.20	15.75	131.96	119.88	29.55	30.54	4.11	4.79
Nerica2	15.90	17.37	135.03	127.58	23.91	25.39	3.72	4.44
Nerica3	16.84	16.10	142.96	123.25	24.91	24.88	4.88	4.81
Nerica4	16.97	15.77	129.11	113.07	25.03	25.79	4.82	5.39
Nerica6	17.54	16.01	151.95	124.40	27.07	27.78	4.91	5.18
Nerica7	15.93	16.08	158.68	139.88	26.73	26.48	4.93	4.79
Nerica8	14.47	14.78	124.84	121.68	26.31	27.28	4.67	4.70
Nerica9	13.67	15.21	131.23	126.32	30.90	32.17	5.93	5.40
Nerica12	15.38	17.28	120.01	108.51	26.18	28.39	5.11	5.52
Nerica13	14.93	17.32	128.71	119.38	24.51	24.55	4.74	5.54
Nerica14	16.37	17.90	129.06	128.77	24.28	26.01	5.26	6.20
L.S.D 0.05	1.06	0.85	1.50	1.70	1.20	0.99	0.12	0.35
Interaction	**	**	**	**	**	**	**	**

Well-watered,
Water stress at reproductive stage
water stress at ripening stage

Table 6: No. of panicles/plant and no. of filled grains/panicle as affected by the interaction between some rice genotypes and water treatments in 2019 and 2020 studied seasons

Variety	No. of panicles/plant						No. of filled grains/panicle					
	2019			2020			2019			2020		
	well	rep	ripening	well	rep	ripening	well	rep	ripening	well	rep	ripening
Giza177	23.00	11.00	18.30	23.00	9.20	19.33	161.70	71.00	61.33	166.20	90.00	56.33
Giza178	24.50	19.10	22.10	24.60	19.70	22.40	150.33	126.10	118.50	148.20	126.10	102.33
GZ 10590-1-3-3-2	22.00	20.70	19.00	23.50	18.80	21.33	163.40	124.00	76.40	150.33	111.20	92.44
Nerica1	17.70	11.80	16.10	18.10	12.70	16.44	154.33	124.10	117.44	145.21	126.23	88.20
Nerica2	17.40	13.30	17.00	19.60	14.80	17.70	165.10	128.50	111.50	184.55	120.10	78.10
Nerica3	18.9	13.33	17.20	19.00	13.70	15.60	191.44	124.33	113.10	196.33	97.33	76.10
Nerica4	18.20	15.20	17.50	17.33	14.20	15.77	170.20	114.80	102.33	130.00	110.00	99.20
Nerica6	19.70	14.33	18.60	18.50	13.33	16.20	184.42	157.10	114.33	181.00	102.10	90.10
Nerica7	17.10	15.00	15.70	17.70	16.20	14.33	180.10	155.50	140.44	182.33	130.55	106.77
Nerica8	16.70	12.20	14.50	20.20	10.44	13.70	154.77	116.20	103.55	180.60	100.10	84.33
Nerica9	15.72	11.70	13.60	17.80	12.40	15.44	174.80	112.10	106.78	175.66	114.10	89.20
Nerica12	18.00	11.44	16.70	22.10	13.40	16.33	145.44	113.20	101.40	146.10	95.10	84.33
Nerica13	17.10	12.40	15.30	21.50	13.70	16.77	155.88	124.60	105.66	155.33	124.10	78.70
Nerica14	17.20	15.30	16.60	20.50	14.80	18.40	164.50	117.10	105.57	163.10	121.10	102.10
L.S.D 0.05		1.85			1.46			2.44			2.46	

well, well-watered,

rep, water stress at reproductive stage

ripening, water stress at ripening stage

Number of filled grains panicle^{-1}

The water withholding treatments significantly influenced number of filled grains panicle^{-1} at both seasons. Backing to (Table 5), water stress induced at the ripening stage was significantly more severe than that happened at reproductive stage. The elevated hazardous effect of water stress at the ripening stage is mainly attributed to its effect on current photosynthesis, net assimilation, assimilation translocation of pre-heading photosynthesis and restricting filling rate of grain resulted in reducing filled grain number in the terms of raising sterility. The interaction between rice genotypes and water treatments had significant effect on filled grains panicle^{-1} in both study seasons. The interaction results fixed the high affinity of NERICA 7 rice variety to water stress tolerance since it gave the maximum values of filled grains panicle^{-1} under the two water withholding stresses at reproductive and ripening stages. Also, Giza 177 rice variety was inferior one under water stresses. These results are similar with data observed by (Zubaer *et al.,* 2007) and (Abd Allah *et al.,* 2010), who found that number of filled grains panicle^{-1}, was decreased with increasing water stress levels.

NERICA 7 gave the highest values of number of filled grains per panicle under water stresses at ripening and reproductive stage of rice, respectively. On the other hand, the Egyptian rice variety Giza 177 recorded the lowest values under the same conditions (Table 6).

1000-grain weight (g)

The water stress at the ripening stage gave the light grains in both seasons followed by water stress at the reproductive stage. Well-watered treatment gave the highest values (Table 5). The rice varieties were affected significantly due to water stress at the ripening and reproductive stage and the reduction in 1000-grain weight differed according to the nature of each variety and its level of tolerance (Table 7). (Abbasi and Sepaskhah 2011) and (Bozorgi *et al.*, 2011) showed that all the varieties produced better 1000-grain weight under continuous flooding, while this trait was reduced significantly under water stress conditions.

Grain yield t/ha^{-1}

The data in Table 5 shows that the highest grain yield tha^{-1} was obtained with well watered while the lowest values of grain yield were recorded under the ripening followed by reproductive stage (Table 5). The reduction in grain yield due to drought at the ripening stage is 53.14 and 54.00 % compared with well-watered in 2019 and 2020 seasons; respectively. The reduction in grain yield attributed to water stress at the reproductive stage is 38.55 and 43.50 % in both grown seasons of research (Table 7). (Hong and Serraj 2012) reported that the reduction in grain yield due to drought stress at reproductive stage was about 20% of that of the control. The interaction effect was significant regarding grain yield in both seasons.

All rice varieties were significant affected by drought stress at the ripening stage followed by the drought stress at the reproductive stage. The grain yield reduction differed among the rice varieties according to their level of tolerance. The reduction in grain yield due to drought stress at both the ripening and reproductive stage for the sensitive variety Giza 177 was about 79.63 and 69.26% compared with well-watered. While the lowest reduction percentage in grain yield under the same conditions was recorded for NERICA 7, NERICA 8 and Giza 178 (Table 7).

Table 7: 1000-grain weight (g) and grain yield (t/ha.) as affected by the interaction between some rice genotypes and water treatments in 2019 and 2020 studied seasons

Variety	1000-grain weight (g)						Grain yield (t/ha.)					
	2019			2020			2019			2020		
	well	rep	ripening	well	rep	ripening	well	rep	ripening	well	rep	ripening
Giza177	28.00	25.98	22.40	28.80	26.10	22.12	9.50	4.30	1.78	8.20	2.52	1.67
Giza178	23.50	23.00	20.50	23.40	23.00	22.10	11.20	7.30	6.50	11.89	7.53	6.60
GZ 10590-1-3-3-2	26.10	24.00	20.98	26.50	24.80	21.34	10.80	4.30	2.96	9.80	4.96	3.30
Nerica1	32.50	29.70	26.44	33.20	30.91	27.52	6.40	3.70	2.24	6.87	4.20	3.30
Nerica2	27.60	24.20	19.94	28.40	24.92	22.84	5.20	3.63	2.33	5.40	4.63	3.30
Nerica3	28.20	24.00	22.54	29.00	23.71	21.92	6.51	4.50	3.63	7.71	3.51	3.20
Nerica4	27.40	25.10	22.60	28.60	26.33	22.44	6.52	4.43	3.50	7.74	4.40	4.03
Nerica6	31.20	27.70	22.30	32.20	28.21	22.93	7.53	4.10	3.10	6.65	4.77	4.13
Nerica7	29.60	26.80	23.78	28.51	26.72	24.20	6.30	4.94	3.54	6.56	4.20	3.60
Nerica8	29.00	26.40	23.54	31.10	27.34	23.40	5.84	4.53	3.63	6.54	4.53	3.04
Nerica9	33.40	31.30	28.00	35.70	32.10	28.70	7.60	5.35	4.84	8.60	4.30	3.30
Nerica12	29.00	26.10	23.44	31.50	27.82	25.84	7.44	4.44	3.46	8.55	4.50	3.50
Nerica13	28.90	23.52	21.10	29.20	23.33	21.13	6.30	4.30	3.63	7.45	4.73	4.45
Nerica14	29.40	23.11	20.33	30.10	25.52	22.40	7.46	4.40	3.91	9.97	4.52	4.10
L.S.D 0.05		2.04			1.70			0.34			0.63	

well, well-watered,

rep, water stress at reproductive stage

ripening, water stress at ripening stage

(Raumjit and Teerayut 2014) stated that when drought condition occurred during vegetative and reproductive stages, it decreased in yield of up to 30% was due to reduced panicle number unit area^{-1}. (Hong and Serraj 2012) reported that the reduction in grain yield due to drought stress at the reproductive stage was about 20% of that of the control.

Correlation coefficient:

Data in (Table 8) indicated that root length was positive and significantly correlated with root dry weight and grain yield. Also, root length positive and highly significant with number of panicles plant^{-1}. Root dry weight was significant and highly significant correlated with number of panicles plant^{-1}, 1000-grain weight and grain yield. Each of number of panicles plant^{-1} and 1000-grain weight correlated positively with grain yield under water stress at reproductive stage. The results are in agreement with (Mohamed *et al*., 2019).

The results in (Table 9) showed the correlation among the studied traits under water stress at ripening stage. Root length was positively correlated with root thickness, also root thickness correlated significantly and positive with number of filled grains panicle^{-1}, 1000-grain weight and grain yield respectively. Root dry weight positive correlated with number of panicles plant^{-1}. Grain yield was positive correlated with each of number of filled grains panicle^{-1} and 1000-grain weight. The results obtained are similar with those reported by (Abd Allah *et al.,* 2010).

Anatomical Studies*:*

For rice root transverse section observations under water deficit stress, there is a significant variation in root anatomical response of rice varieties, NERICA 7, Giza 178 expressed the highest tolerance to drought condition., while Giza 177 showed a significant reduction in all anatomical traits compared with cultivars under same conditions Fig. 1 and (Table 10).

Table 8: Correlation coefficient among the studied traits under water stress at reproductive stage

	Root length	Root volume	Root thickness	Root dry weight	Number of panicles	Number of filled grains	1000-grain weight	Grain yield
Root length	1	-0.202	0.500	0.64*	0.705**	0.198	0.376	0.559*
Root volume		1	-0.27	-0.438	-0.401	0.056	-0.256	-0.231
Root thickness			1	0.345	0.404	0.301	0.468	0.511
Root dry weight				1	0.819**	0.235	0.636*	0.728**
Number of panicles					1	0.126	0.742**	0.781**
Number of filled grains						1	0.280	0.436
1000-grain weight							1	0.820**
Grain yield								1

Table (9): Correlation coefficient among the studied traits under water stress at ripening stage.

	Root length	Root volume	Root thickness	Root dry weight	Number of panicles	Number of filled grains	1000-grain weight	Grain yield
Root length	1	-0.173	0.706**	0.158	-0.191	0.281	0.449	0.484
Root volume		1	0.113	-0.416	-0.166	-0.01	-0.062	-0.001
Root thickness			1	0.004	-0.188	0.649*	0.870**	0.719**
Root dry weight				1	0.613*	-0.386	-0.014	0.274
Number of panicles					1	-0.085	-0.076	0.190
Number of filled grains						1	0.664**	0.422
1000-grain weight							1	0.799**
Grain yield								1

Nerica 7 Giza 178 Giza 177

Fig 1: Root anatomical traits of rice varieties under water stress condition

Table 10: Root anatomical structure of some rice varieties under water stress conditions

	Epidermis (μm)	Cortex(μm)		Vascular band Vb (μm)		No. M. xylem vessels	Vb/root diameter %	xylem(μm)	
		Length	Width	Length	Width			Length	Width
NERICA 7	60	400	390	350	350	8	20.59	50	50
Giza 178	40	390	380	240	230	6	14.51	40	40
Giza 177	30	340	350	180	180	4	12.50	30	30
L.S.D. 5%	18.97	39.93	25.86	107.09	108.52	2.48		12.42	12.42

Concerning epidermis thickness, and the epidermal layer thickness one considered as an indication to of drought tolerant rice varieties. Therefore the tolerant variety exposure to water stress can develop of thick root epidermis as an adaptive mechanism to drought. NERICA 7 rice reflected a double thickness of epidermis compared with Giza 177. Therefore, epidermis cells thick in a tolerant variety can maintain more water content and preserved a fixed turgor pressure. These results clearly indicate that epidermis thickness is highly associated with drought tolerance therefore, it can be used as a phenotypic marker- trait for selection to drought in breeding program. Cortex thickness reflected the same trend and behavior of the epidermis whereas, NERICA 7 recorded the most thickness of cells compared with the rest of the varieties.

For the length and width of both vascular bands associated with water and nutrients uptake in roots, anatomical analysis shows a significant increase in both NERICA 7 and Giza 178 that recorded the highest vascular bundle diameter in highly significant differences compared with the sensitive variety Giza 177. The vascular bundle is the central part of the root system that contains vascular tissue Therefore, the reduction in diameter of vascular band may be reflect any disturbance in water and nutrients uptake and translocation, Vascular bundle diameter was highly responsive trait in tolerant varieties to water deficit stress in compared with sensitive ones which came in accordance with the results presented by (Kadam *et al.* 2015). Vascular bundle diameter could play a maintaining and supportive role in water uptake and transport, (Kadam *et al.,* 2015).

Vascular bundle areas were compared to root areas, as much important proportion of the total cross-sectional of root area. The mean proportion of cross-sectional area as vascular bundle to root diameter was 20.59% and 14.51% for NERICA 7 and Giza 178 respectively as drought stressed tolerant varieties, and 12.50% for Giza 177 drought stressed sensitive variety. Therefore, the proportion of vascular bundle diameter to root diameter showed significant differences among all tested varieties and importance of this traits in selection to drought tolerance, which came in accordance with the results presented by (Kadam *et al.,* 2015).

The number of metaxylem vessels in drought tolerant variety NERICA 7 was significantly differed than more sensitive variety Giza 177, whereas it displays doubled number, 8 vessel to 4. In addition, metaxylem diameter has the same trend of xylem number. Therefore, xylem diameter and xylem number along the root length in tolerant rice varieties accelerate more water use efficiency under water deficit stress (Kadam *et al.,* 2015). Root metaxylem is phenotypic varied structures and their function is associated with their anatomy, mainly under drought stress (Kadam *et al.,* 2015).

Out of current results, the decrement in thickness of root tissues in sensitive variety showed fixed direction, from epidermal layer throughout the xylem vessels, indicating that the reduction caused a sort of stress and blocking due to narrow space of xylem vessels, consequently, reduction in xylem diameter associated with deficit of water uptake. The cultivar with the highest values of anatomical traits is considered as drought tolerant as NERICA 7 and Giza 178.

These results clearly indicated that root anatomical traits play an important role in tolerance of drought stress and could be associated with the rest of the traits such as agronomic and physiological ones.

Conclusion

The results of this investigation revealed that all rice genotypes and their traits were affected significantly by water stress at the reproductive stage and the ripening stage. It could be concluded that water withholding is more sever at the ripening stage then the reproductive stage based on grain yield. Giza 178 rice variety was more tolerant for water stress during both studied stages followed by NERICA 13 and NERICA 7. Large root and epidemic thickness as well as xylem diameter, vascular band and high number of meta xylem one certain indications for rice variety water stress tolerance.

REFERENCES

Abade, H., J.M. Bokosi, A.M. Mwangwela, T.R. Mzengeza and A.J. Abdala. (2016). Characterization and evaluation of twenty rice (*Oryza sativa*, L.) genotypes under irrigated ecosystems in Malawi and Mozambique. Afr. J. Agric. Res., 11(17): 1559-1568.

Abbasi, M.R. and A.R. Sepaskhah (2011). Effects of water-saving irrigations on different rice cultivars (*Oryza sativa*, L.) in field conditions. Intern. J. Plant Prod., 5(2): 153-166.

Abd Allah, A.A. (2010). Development of some high yielding rice lines tolerant to drought stress conditions. J. Medi. Plants Res., 4(7): 528-535.

Abd Allah, A.A., Shimaa A. Badawy, B.A. Zayed and A.A. El. Gohary (2010). The role of root system traits in the drought tolerance of rice (*Oryza sativa* L.). International Journal of Agriculture and Biological Science 1(2):83-87.

Bozorgi, H.R., F. Tarighi, M. Moradi and E. Azarpour (2011). The study effect of drought stress on four native rice varieties in Iran. World Appl. Sci. J., 13(3): 410-414.

Chaves, M.M. and M.M. Oliveira (2004). Mechanisms underlying plant resilience to water deficits: prospects for water-saving agriculture. J. Exp. Bot., 55: 2365–2384.

Evenson, R., R.W. Herdt and M. Hossain (1996). Rice Research in Asia: Progress and priorities CAB International, Wallingferd,UK 210-220.

Fujii, Y. (1974). The morphology and physiology of rice roots". ASPASC

Gerlach, D. (1977). Botanshe Microtechnik. Eine einfuhrung Theime Verlag, Stuttgart, BRO, Germany.

Ghazy, M.I. (2012). Response of rice growth and productivity to drought and heat stress conditions. M.Sc. Thesis, Agron., Dept., Fac. Agric. Kafrelsheikh Univ., Egypt. pp. 185.

Gomez, K. A. and A A. Gomez (1983). Statistical procedures for agricultural research. Second Edition. 680P

Gupta, P.C. and J.C.O. Toole (1986). Drought resistance in upland rice, Aglobal prospective International Rice Research Institute, Phillippines.P. 148-174.

Hong, H. and R. Serraj (2012). Involvement of peduncle elongation, anther dehiscence and spikelet sterility in upland rice response to reproductive stage drought stress. Environmental and Experimental Botany 75: 120-127.

IRRI (2001). Rice ecosystem Table 30. Distribution of rice crop area (000 ha), by environment, 2001.http://www.irri.org/science/ricestat/pdf.

IRRI (1996). International Rice Research Institute Descriptors for Rice. Los Banos, Laguna, Philippines.52p.

Jongdee, B., G. Pantuwan, S. Fukai and K. Fischer (2006). Improving drought tolerance in rainfed lowland rice: An example from Thailand. Agricultural Water Management 80:225-240.

Kadam, N. N., X. Yin, S. Prem, B. Paul, C. Struik and S.V. Krishna (2015). Does Morphological and Anatomical Plasticity during the Vegetative Stage Make Wheat More Tolerant of Water Deficit Stress Than Rice?. Plant Physiology_, April 2015, Vol. 167, pp. 1389–1401. http://www.plantphysiol.org/cgi/doi/10.1104/pp.114.253328

Kandil, A.A., M.S. Sultan, M.A. Badawi, A.A. Abd El-Rahman and B.A. Zayed (2010). Performance of rice cultivars as affected by irrigation and potassium fertilizer under saline soil conditions. 1-Physiological and chemical characteristics. Crop Environ., 1(1): 35-38.

Kon, T. (1990). Drought tolerane. Nogyogijutsu 45: 422-427(in Japanese).

Maisura, M. A. C., I. Lubis, A. Junaedi and H. Ehara (2014). SOME PHYSIOLOGICAL CHARACTER RESPONSES OF RICE UNDER DROUGHT CONDITIONS IN A PADDY SYSTEM. J. ISSAAS Vol. 20, No. 1:104-114.

Mohamed, A., S. Sedeek, A. Galal and M. Alsakka (2019). Effect of water deficiency as abiotic stress on the reproductive and ripening stage of rice genotypes. International Journal of Plant Science and Agriculture. 13-19.

Passioura, J. (2007). The drought environment: physical, biological and agricultural perspectives. J. Exp. Bot., 58: 113-117.

Raumjit, N. and T. Wichitparp (2014). Effect of drought condition on growth, yield and grain quality of upland rice. American Journal of Agric. and Bio. Sci., 9(3): 439-444.

Salter, P.L. and J.E. Goode (1967). Crop response to water at different stages of growth. Commonwealth Agricultural Bureaux, Farnham Royal.

Sandhu, N., S. Jain, A. Kumar, B.S. Mehla and R. Jain (2013). Genetic variation, linkage mapping of QTL and correlation studies for yield, root and agronomic traits for aerobic adaptation. BMC Genetics, 14(104): 1-16.

Zubaer, M.A., A.K.M.M.B. Chowdhury, M.Z. Islam, T. Ahmed and M.A. Hasan (2007). Effect of water stress on growth and yield attributes of aman rice genotypes. Int. J. Sustain. Crop Prod. 2(6): 25-30.

تأثير الاجهاد المائى على سلوك بعض اصناف ارز النريكا تحت الظروف المصرية

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الملخص العربى

يعد الجفاف واحد من اهم الاجهادات غير الحيوية والتى تؤثر على انتاجية الارز. اجريت هذه الدراسة بالمزرعة البحثية بمحطة البحوث الزراعية بسخا موسمى 2019 و 2020 لدراسة تاثير الاجهاد المائى فى مرحلتى التفريع وامتلاء الحبوب على بعض اصناف ارز النريكا تحت الظروف المصرية. اظهرت النتائج ان كل الاصناف المختبرة تاثرت معنويا بمعاملات الاجهاد المائى . ادى تعرض الاصناف المختبرة للاجهاد المائى عند مرحلة التفريع الى نقص عدد الداليات بالجورة بينما ادى الاجهاد المائى عند مرحلة امتلاء الحبوب الى نقص معنوى فى عدد الحبوب الممتلئة بالدالية ووزن الالف حبة ومحصول الحبوب للهكتار هذا وقد بلغ مقدار النقص فى محصول الحبوب حوالى 52.07 و 55.38% نتيجة تعرض النباتات للاجهاد المائى فى مرحلة امتلاء الحبوب بينما كان الانخفاض فى المحصول 42.04 و 42.99% والراجع للاجهاد المائى عند مرحلة التفريع خلال موسمى الزراعة . اختلف الانخفاض فى محصول الحبوب بين الاصناف المختبرة طبقا لدرجة الحساسية والمقاومة لنقص الماء حيث انخفض محصول الحبوب للصنف جيزة 177 81.3 و 54.8% نتيجة الاجهاد المائى مقارنة بالري المستمر. اظهر التركيب التشريحى للجذور تفوق جيزة 178 ونريكا 7 فى كل صفات الجذور مقارنة بالصنف الحساس جيزة 177.

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