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Effect of Water Deficiency as Abiotic Stress on the Reproductive and Ripening Stage of Rice Genotypes

Research Article

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Abstract

Drought is one of the major a biotic stress limiting plant production in worldwide. The research work of the present study was carried out at the Experimental Farm of Sakha agricultural Research Station, Kafrelsheikh, Egypt during season of 2017 and 2018, to study the effect of water deficit at reproductive stage and ripening stage on 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 investigation revealed that all rice genotypes and their traits were affected significantly by drought stress at reproductive stage and ripening stage. The drought stress at reproductive stage reduced significantly plant height, number days to complete heading, flag leaf area, chlorophyll content and number of panicles hill. while, the drought stress at ripening stage decline significantly the number of filled grains panicle-1 and 100-grain weight and grain yield t/ha. The reduction in grain yield due to drought at ripening stage is 52 and 55 % compared with well-watered in 2017 and 2018.While, the reduction in grain yield attributed to water stress at reproductive stage is 42 and 42.9% in both seasons of research. All rice varieties were affected significant by drought stress at ripening stage followed by the drought stress at reproductive stage. The reduction in grain yield its differed among the rice varieties according to their level of tolerance, the reduction in grain yield due to drought stress at both ripening and reproductive stage for the sensitive variety Giza 177 was about 80.7 and 55% compared with well-watered. While, the lowest reduction percentage in grain yield under the same conditions were recorded for NERICA 7 and NERICA 8. Grain yield was positively correlated with chlorophyll content, number of panicles per hill, number of filled grains per panicle under well-watered and water stress at reproductive stage. Also, highly significant and positive correlation between grain yield and each of number of panicles and 1000-grain weight under water stress at ripening stage.

Keywords: Rice; Drought Effects; Reproductive and Ripening Stages.

Introduction

Egypt is facing two major challenges i.e. food security and water shortage, particularly in the terminal areas. Water shortage is one of the most limiting factors in more than 30% of paddy fields in Egypt, where the developed varieties cannot perform well under water shortage [1]. The world population is expected to reach 9 billion by the middle of the twenty-first century. In many crops, particularly cereals, the plants are more sensitive to drought stress during the reproductive phase than at any other time, except early establishment while the root system is developing [18]. Water deficit is a major problem for crop production worldwide, limiting the growth and productivity of many crop species, especially in rain-fed agricultural areas (>1.2 billion hectares) (2; 15). Drought is one of the most important abiotic stresses causing drastic reductions in yield in rainfed rice environments. Large areas of rice are grown under lowland and upland rainfed conditions, these areas respectively occupy 31 and 11% of the global rice growing area [7]. Drought is one of the major a biotic stress limiting plant production in rainfed ecosystem. (Evensonet al., 1996) [3] estimated global rice grain yield lost due to drought to be 18 million tons annually or 4% of total rice production, which was valued conservatively at US$ 3.6 billion at that time. Selection for lines that maintain high spikelet fertility under drought stress and/or a low rate of leaf drying under drought stress is also common [9]. Drought tolerance is the most important characteristic in upland

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rice breeding. Various evaluation 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 [4, 10]. The objectives of this investigation to identify drought tolerant rice variety and to evaluate the effect of water stress on some of rice genotypes at reproductive stage and ripening stages.

Materials and Methods

The research work of the present study was carried out at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr EL-Sheikh, Egypt, during the two successive rice seasons 2017 and 2018 to study the effect of water stress on yield and its components for some rice genotypes at different reproductive and ripening growth stages of rice. 14 genotypes, 11 upland rice varieties were introduced from Africa Rice and 3 Egyptian commercial varieties were chosen for this study. These genotypes have a wide range of variation due to their different genetic background. The pedigree, group type and main characters of these varieties are illustrated in Table (1). The 14 rice genotypes utilized in this study were grown in two successive seasons in 2017 and 2018. Seeds of the 14 rice genotypes were grown in the first week of May during 2017 and 2018 rice seasons and seedlings were transplanted individually after 30 days with a spacing of 20 x 20 cm.

Statistical design of the experiment was split plot design. Rice varieties were applied in the sub plots and water treatments were allocated in the main plots under the well-watering and water stresses. Each replication included seven rows for each genotype, the length of each row were 5m, and harvested 5m^2. The irrigation continue in well-watered replications until the end of the experiment and always keep on moisture at saturated or above the field capacity. For water stress, two consecutive cycles of stress was applied at reproductive stage (after 45 days of transplanting) for 15 days with holding till appear the drought susceptibility traits (leaf rolling and leaf drying score) on the tolerant variety and irrigated after water stress up to harvest. While, the second water stress was applied at ripening stage (after complete heading) for 15 days then irrigated up to harvest. The rate of NP 60: 30 Kg/ha 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 P2O5/ha in the form of single super phosphate (15% P2O5) 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., Plant height (cm), Number of Days to heading (days), Flag leaf area (cm^2), Chlorophyll content, Number of panicles/plant, Number of filled grains/panicle, 1000-grain weight (g) and Grain yield t/ha was measured according to IRRI, 1996. The relationships among the studied characters were assessed statistically through simple correlation, following (Gomez and Gomez, 1983) [5] using SPSS version 16 for windows.

Results and Discussion

Plant Height

The plant height reduced significantly with drought stresses at reproductive and ripening stages compared with well-watering Table 2. The lowest values of plant height were recorded with water stress at reproductive stage. All rice varieties differed among them in their response to water stress according to their level of tolerance and their genetic background. NERICA 7 showed the tallest plants while, the Egyptian rice varieties Giza 177, Giza 179 and Giza 178 exhibited the shortest plants in both seasons of investigation Table 3. The negative effect of drought on plant height may due to poor root development; reduce leaf surface, increase leaf senescence and inhibition of stem reserves. The same trend of results of drought effect on plant height was reported by (Marie-Noelle etal,. 2010) [12].

Days to Complete Heading

The number of days to complete heading was increased under

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	Giza 179	GZ 1368-S-5-4/ GZ6296-12-1-2-1-1	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

water stresses at reproductive stage and ripening stage compared with well-watering Table 2. (Hong and Serraj, 2012) [6] found that the peduncle elongation rate was significantly inhibited by drought, simultaneously with the decrease of plant water status parameters.

The data in Table 3 indicated that the number of days to complete heading was increased due to drought stress. Drought stress applied at the beginning of the reproductive stage usually results in a delay in flowering, [17]. This is mainly due to slowed elongation of the panicle and supporting tissues [11, 14] reported that the delay in flowering under drought is a consequence of a reduction in plant dry-matter production and of a delay in panicle exsertion. The delays in flowering and maturity could be considered as good indicators in drought screening tests since the effect of drought on the trait was consistent. All rice varieties were affected by drought stress and the affected was differed based on the nature of genetic of each variety and its tolerance. All rice varieties were delay in flowering under water stress compared with well-watered.

Flag Leaf Area

The water stress affected significantly on the flag leaf area for all rice varieties under study it recorded 26.63 cm^2 at reproductive stage followed by the drought stress at ripening stage while the highest values of flag leaf area was recorded under well-watered 44.56 cm^2. The reduction in the flag leaf area due to drought stress mainly attributed to .the rice genotypes differed in their flag leaf area according to the nature of each variety Table 2.

The flag leaf area for all rice varieties were affected significantly by water stresses at reproductive and ripening stage. The reduction in the flag leaf area differed among the rice varieties according to their levels of tolerance; the reduction in the flag leaf area was high under reproductive stage compared with ripening stage and well-watered Table 4. Giza 177 showed the lowest value of flag leaf area under reproductive stage 15.7 cm^2 compared with the area under ripening and well-watered 33.53 and 38.1 cm^2.

Chlorophyll Content

The degradation in the chlorophyll content was higher at reproductive stage than at ripening and well-watered treatments as shown in Table 2. The lowest value was obtained with water stress at reproductive stage 31.55 and 28.39 SPAD in 2017 and 2018 while the highest values were observed with well-watered treatment in both seasons Table. The reduction in chlorophyll content due drought stress at reproductive stage was high for all rice varieties followed by the stress at ripening stage and well-watered Table 4. Drought affected chlorophyll content. Such a stress influence plant growth by suppressing cell enlargement and cell division, by reducing cell turgor, photosynthesis rate, metabolic and assimilate processes, pigment formation, and water and nutrients uptake as well as the transportation of organic

Table 2. Plant height (cm), days to 50% heading (days), flag leaf area (cm^2) and chlorophyll content(SPAD) as affected by water treatments of some rice genotypes during 2017 and 2018.

Factor	Plant height (cm)		Days to 50 heading (days)		Flag leaf area (cm^2)		Chlorophyll content (SPAD)	
	2017	2018	2017	2018	2017	2018	2017	2018
Well-watered	124.77	121.73	93.35	92.3	44.56	48.28	45.75	46.49
Reproductive	105.3	105.05	99.9	98.8	26.63	26.76	31.55	28.39
Ripening	115.87	111.37	94.8	93.7	38.61	39.64	43.27	43.07
L.S.D 0.05	2.51	0.45	0.76	0.69	0.88	1.1	1.13	0.88
Variety								
Giza177	87.96	86.93	93	91.8	29.11	30.94	36.78	39.97
Giza178	99.44	100	104	102.7	35.47	34.37	43.52	37.68
Giza179	91.76	83.93	88.7	88	27.2	27.48	40.52	40.99
Nerica1	120.03	116.44	94.3	92.6	43.42	44.79	43.97	38.63
Nerica2	107.22	103.06	95.7	94.5	43.17	42.49	40.61	39.6
Nerica3	113.01	104.47	90.3	89.6	33.87	37.37	41.93	39.16
Nerica4	114.07	113.87	93	92.1	33.64	38.99	38.62	38.77
Nerica6	115.21	113.98	94.4	93.4	40.42	45.69	38.66	38.6
Nerica7	146.91	143.94	95.3	93.6	39.29	40.59	40.54	39.84
Nerica8	122.62	126.1	101	103	42.84	44.22	37.26	37.8
Nerica9	129.11	126.68	102.6	101.6	36.67	38.04	44.98	43.1
Nerica12	113.74	107.93	96.9	96.2	36.39	37.58	43.78	45.97
Nerica13	123.37	124.5	98.8	98	34.18	32.66	36.19	35.03
Nerica14	129.9	126.39	96	94.8	36.74	39.98	35.31	35.29
L.S.D 0.05	2.64	0.98	1.22	0.97	1.37	1.84	2.33	0.82
	**	**	**	**	**	**	**	**

Table 3. Plant height (cm) and number of days to 50% heading (days) as affected by the interaction between some rice genotypes and water treatments in 2017 and 2018 studied seasons.

Variety	Plant height (cm)						Days to 50% heading (day)					
	2017			2018			2017			2018		
	Well	Rep	Ripening	Well	Rep	Ripening	Well	Rep	Ripening	Well	Rep	Ripening
Giza177	100	77.07	91.6	98	79.06	89.67	90	97	92	89	96.33	90.33
Giza178	101	80.33	96	103	76.2	84.4	101	109	102	100.33	107	101
Giza179	96	90.73	93	101	94.67	100.33	90.33	97.33	95.33	88.33	96	93.67
Nerica1	126.07	111.57	122.47	128.1	108.33	112.3	91.33	99	97	90.33	98	95.33
Nerica2	112.2	100.07	109.4	113.67	95.97	99.53	88.33	93.67	89	88.33	93	87.67
Nerica3	124.3	101.23	113.5	114.33	96.87	102.2	91	96	92	89.33	95.67	91.33
Nerica4	120.23	109	113	120.87	108.2	112.53	91.67	98.67	93	90.67	97.67	92
Nerica6	119.1	111.43	115.1	119.53	107.53	114.87	93	99	94	91	98.67	91.33
Nerica7	166.8	114.13	159.8	157.63	134.4	139.8	99	105	99	98	104	98.66
Nerica8	135.47	114.07	118.33	137.77	117.2	123.33	101	107	100	99.33	106	99.67
Nerica9	134.87	127.13	125.33	136.4	116.53	127.1	95	99.67	96	94.33	98.67	95.67
Nerica12	123.9	104.67	112.67	115.97	101.43	106.4	96	103.33	97.33	95.33	102	96.67
Nerica13	133.23	114.2	122.67	136.1	113.4	124	93	101	94	91.36	99.67	93.33
Nerica14	151.83	115.33	122.33	135.53	113.63	130	90	97	92	89	96.33	90.33
LSD 0.05	4.57	4.57	4.57	1.7	1.7	1.7	2.12	2.12	2.12	1.68	1.68	1.68

Table 4. Flag leaf area (cm^2) and chlorophyll content(SPAD) as affected by the interaction between some rice genotypes and water treatments in 2017 and 2018 studied seasons.

Variety	Flag leaf area (cm^2)						Chlorophyll content (SPAD)					
	2017			2018			2017			2018		
	Well	Rep	Ripening	Well	Rep	Ripening	Well	Rep	Ripening	Well	Rep	Ripening
Giza177	38.1	15.7	33.53	43.87	18.77	30.2	45.03	23.1	42.2	47.3	30.83	41.77
Giza178	44.17	21.2	41.03	41.17	21.75	40.2	46.56	40.27	43.72	47.73	22.07	43.23
Giza179	33.03	18.93	29.63	34.23	17.37	30.83	43.97	37.3	40.3	43.7	38.87	40.4
Nerica1	50.7	38.57	41	57.8	33.8	42.76	46.83	40	45.06	46	26.5	43.4
Nerica2	50	36.83	42.67	49.7	34.9	42.87	47.37	29.1	45.36	47.9	26.2	44.7
Nerica3	38.93	27.33	35.33	47.6	27.5	37	47.3	33	45.5	47.47	25.83	44.17
Nerica4	39.77	25.17	36	51.7	25.27	40	39.87	29.27	46.73	45.13	27.97	43.2
Nerica6	46.47	33.3	41.5	56.1	37.77	43.2	44.07	30.3	41.6	44.5	30.77	40.53
Nerica7	50.4	25.27	42.2	56.27	22.53	42.97	45.63	34.67	41.33	43.7	33.77	42.06
Nerica8	52.13	32.87	43.53	53.43	35.53	43.7	44.43	24.67	42.67	44.67	24.23	44.5
Nerica9	43.1	28.9	38	48.6	22.8	42.73	51.33	36.63	46.97	53.1	28.9	47.3
Nerica12	48.5	23.3	37.37	48.6	28.07	36.07	51.53	33.4	46.4	53	35.5	49.4
Nerica13	42.9	21.9	37.73	35.37	23.93	38.67	43.63	25.73	39.2	41.87	23.73	39.5
Nerica14	45.63	23.6	41	51.53	24.63	43.77	42.79	24.23	38.73	44.8	22.3	38.77
L.S.D 0.05	2.37	2.37	2.37	3.18	3.18	3.18	4.05	4.05	4.05	1.42	1.42	1.42

solutes from one organ to another in the rice plant.

Number of Panicles Plant-1

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

The sensitive Giza 177 recorded the lowest value of number of panicles under water stress at reproductive stage in the both season of study. While Giza 179 gave the highest value under the same conditions Table 6.

Number of filled Grains Panicle-1

The lowest values of number of filled grains panicle-1 was recorded under ripening stage in both seasons followed by water stress at reproductive stage compared with well-watered gave the

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 2017 and 2018.

Factor	No.of panicles/plant		No.of filled grains/panicle		1000-grain weight (g)		Grain yield (t/ha)	
	2017	2018	2017	2018	2017	2018	2017	2018
well	18.8	20.04	165.26	163.64	28.98	29.86	7.28	7.91
reproductive	13.69	14.19	121.5	110.02	25.78	26.54	4.22	4.51
ripening	16.9	17.02	104.5	87.78	22.7	23.47	3.49	3.53
L.S.D 0.05	0.9	0.4	1.24	1.17	0.96	0.2	0.07	0.23
Variety								
Giza177	20.67	20	97.98	103.56	25.32	25.57	5.06	4.07
Giza178	21.89	22.11	131.33	123.67	23.86	23.96	6.73	8.11
Giza179	20.33	21	121.11	117.11	23.49	24.12	5.4	5.75
Nerica1	15	15.67	131.56	119.11	29.8	30.63	4.09	4.77
Nerica2	15.67	17.22	134.44	126.33	23.79	25.37	3.69	4.41
Nerica3	16.33	16	142.56	122.22	24.79	24.93	4.85	4.8
Nerica4	16.11	15.44	128.67	112.56	25.01	25.72	4.8	5.37
Nerica6	17.33	15.78	160	123.11	27	27.79	4.87	5.17
Nerica7	14.33	14.22	149.33	134.89	26.63	26.42	8.9	4.76
Nerica8	14.33	10.67	124.44	121	26.27	27.23	4.67	4.68
Nerica9	13.56	15	129.67	125.33	31.04	32.13	5.9	5.37
Nerica12	15	17.11	119.33	107.33	25.97	28.37	5.09	5.48
Nerica13	14.67	17.22	127.56	118.11	24.42	24.51	4.7	5.53
Nerica14	15.33	17.78	128.11	132.44	24.14	25.98	5.22	6.17
L.S.D 0.05	1.05	0.82	1.3	1.68	1.17	0.97	0.12	0.35
	**	**	**	**	**	**	**	**

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 2017 and 2018 studied seasons.

Variety	No.of panicles/plant						No.of filled grains/panicle					
	2017			2018			2017			2018		
	well	rep	ripening	well	rep	ripening	well	rep	ripening	well	rep	ripening
Giza177	22	10	18	22.67	9	19	161.67	70	61.67	165.67	89.33	55.67
Giza178	24.67	19	22	24.33	19.67	22.33	150	125.33	118.67	146	124	101
Giza179	21.67	20.67	18.67	23.33	18.67	21	163.33	123.67	76.33	150.33	110	91
Nerica1	17.67	11.67	1567	18	12.67	16.33	154	123.67	117	144	125.67	87.67
Nerica2	17.33	13	16.67	19.33	14.67	17.67	165	128.33	110	182.33	119.67	77
Nerica3	19	13	17	18.67	13.67	15.67	191.33	124	112.33	195.33	96	75.33
Nerica4	18	15	17.33	17	14	15.67	170.33	114	101.67	129.67	109.33	98.67
Nerica6	19.67	14	18.33	18.33	13	16	184.33	156.67	113	180.33	100	89
Nerica7	17	15	15.33	17.67	16	14	180	155	139	181.67	130	105.67
Nerica8	16.67	12	14.33	20	10.33	13.67	154	116.33	103	180.33	99	83.67
Nerica9	15.67	11.67	13.33	17.67	12.33	15	174.67	111.33	103	175.33	112.67	88
Nerica12	17.67	11	16.33	22	13.33	16	145	112.67	100.33	145	94	83
Nerica13	17	12	15	21.33	13.67	16.67	155.67	124	103	154	123	77.33
Nerica14	17	15	16.33	20.33	14.67	18.33	164.33	116	104	161	120.33	100
L.S.D 0.05	1.81	1.81	1.81	1.42	1.42	1.42	2.26	2.26	2.26	2.21	2.21	2.21

highest values Table 5. NERICA 7 gave the highest values of number of filled grains panicle-1 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

The water stress at ripening stage gave the light grains in both seasons 2017 and 2018 then the water stress at reproductive stage. While well-watered treatment gave the highest values. The rice varieties were affected significantly due to water stress at 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.

Grain Yield (t/ha)

The data in Table 5 shows that the highest grain yield t/ha was obtained with well watered while the lowest values of grain yield was recorded under ripening and reproductive stage respectively Table 5. The reduction in grain yield due to drought at ripening stage is 52 and 55 % compared with well-watered in 2017 and 2018 while, the reduction in grain yield attributed to water stress at reproductive stage is 42 and 42.9% in both seasons of research Table 7. Hong and Serraj 2012 reported that the reduction in grain yield due drought stress at reproductive stage about 20% of that of the control.

All rice varieties were affected significant by drought stress at ripening stage followed by the drought stress at reproductive stage. The reduction in grain yield its differed among the rice varieties according to their level of tolerance, the reduction in grain yield due to drought stress at both ripening and reproductive stage for the sensitive variety Giza 177 was about 80.7 and 55% compared with well-watered. While, the lowest reduction percentage in grain yield under the same conditions were recorded for NERICA 7 and NERICA 8 Table 7. Raumjit and Teerayut (2014) state that when drought condition occurred during vegetative and reproductive stages, it decreased in yield of up to 30% was due to reduced panicle number per unit area.

Table 7. 1000-grain weight (g) and grain yield (t/ha) as affected by the interaction between some rice genotypes and water treatments in 2017 and 2018 studied seasons.

Variety	1000-grain weight (g)						Grain yield (t/ha)					
	2017			2018			2017			2018		
	well	rep	ripening	well	rep	ripening	well	rep	ripening	well	rep	ripening
Giza177	27.67	25.93	22.37	28.6	26	22.1	9.29	4.12	1.79	8.04	2.5	1.66
Giza178	26.5	24.03	21.03	25.33	24.2	22.33	10.88	4.82	4.49	11.88	7.52	4.93
Giza179	25.5	24	20.97	26.33	24.7	21.33	8.97	4.28	2.95	9.03	4.97	3.25
Nerica1	33.33	29.63	26.43	33.5	30.9	27.5	6.37	3.69	2.22	6.86	4.18	3.26
Nerica2	27.23	24.2	19.93	28.37	24.93	22.8	5.15	3.6	2.32	5.36	4.6	3.26
Nerica3	28.07	23.77	22.53	29.2	23.7	21.9	6.5	4.45	3.61	7.7	3.5	3.19
Nerica4	27.37	25.1	22.57	28.6	26.23	22.33	6.53	4.4	3.49	7.72	4.38	4.02
Nerica6	31.1	27.63	22.27	32.2	28.2	22.97	7.5	4.09	3.03	6.64	4.78	4.1
Nerica7	29.4	26.73	23.77	28.53	26.73	24	6.24	4.93	3.53	6.55	4.17	3.56
Nerica8	28.93	26.33	23.53	31	27.33	23.37	5.87	4.52	3.62	6.5	4.52	3.02
Nerica9	34.1	31.03	28	35.67	32.07	28.67	7.56	5.31	4.83	8.56	4.29	3.26
Nerica12	28.57	26	23.33	31.47	27.8	25.83	7.41	4.43	3.43	8.5	4.46	3.48
Nerica13	28.73	23.5	21.03	29.13	23.3	21.1	6.24	4.25	3.62	7.44	4.72	4.44
Nerica14	29.3	23.1	20.03	30.07	25.5	22.37	7.42	4.35	3.9	9.98	4.51	4.02
L.S.D 0.05	2.03	2.03	2.03	1.69	1.69	1.69	0.21	0.21	0.21	0.61	0.61	0.61

Table 8: Correlation coefficient among the studied traits under well-watered condition.

Traits	plant height	Days to 50% heading	flag leaf area	chlorophyll content	number of panicles	number of filled grains	1000-grain yield
Days to 50% heading	0.253	1					
flag leaf area	0.585**	0.160	1				
chlorophyll content	-0.111	0.373**	0.123	1			
number of panicles	-0.735**	0.016	-0.620**	-0.038	1		
number of filled	0.156	0.457**	0.209	0.046	0.086	1	
1000-grain yield	-0.246	0.332**	-0.224	-0.113	0.550**	0.600**	1
Grain yield	-0.379**	0.358**	-0.363**	0.309**	0.588**	0.369**	0.648**

Table 9. Correlation coefficient among the studied traits under reproductive stage.

Traits	plant height	Days to 50% heading	flag leaf area	chlorophyll content	number of panicles	number of filled grains	1000-grain yield
Days to 50% heading	0.259*	1					
flag leaf area	0.393**	0.083	1				
chlorophyll content	-0.081	-0.314**	-0.149	1			
number of panicles	0.211	0.547**	-0.090	0.196	1		
number of filled	0.467**	0.118	0.334**	0.231	0.494**	1	
1000-grain yield	0.640**	0.374**	0.466**	0.305**	0.281*	0.249	1
Grain yield	-0.074	0.524**	-0.044	0.349**	0.680**	0.478**	0.197

Table 10. Correlation coefficient among the studied traits under ripening stage.

Traits	plant height	Days to 50% heading	flag leaf area	chlorophyll content	number of panicles	number of filled grains	1000-grain yield
Days to 50% heading	0.121	1					
flag leaf area	0.579**	0.593**	1				
chlorophyll content	-0.136	0.304**	0.036	1			
number of panicles	0.227	0.007	0.282*	-0.373**	1		
number of filled	0.609**	0.284*	0.705**	-0.002	0.433**	1	
1000-grain yield	-0.027	0.360**	0.425**	-0.178	0.596**	0.494**	1
Grain yield	-0.028	0.302*	0.123	-0.279*	0.489**	0.102	0.425**

Correlation Coefficients Analysis

The data in Tables 8, 9 and 10 showed the correlations among the plant characteristics under control and drought stress at reproductive and ripening stages of rice. Grain yield was positively correlated with chlorophyll content, number of panicles per hill, number of filled grains per panicle under well-watered and water stress at reproductive stage. Also, highly significant and positive correlation between grain yield and each of number of panicles and 1000-grain weight under water stress at ripening stage. Whereas it was negatively correlated with plant height and flag leaf area under well-watered. This is in accordance with findings of Masakata et al., (2006), Marie-Noelle et al., (2010) [12] and Sedeek et al., 2017 [19].

Conclusion

The results of this investigation revealed that all rice genotypes and their traits were affected significantly by drought stress at reproductive stage and ripening stage. The drought stress at reproductive stage reduced significantly plant height, number days to complete heading, flag leaf area, chlorophyll content and number of panicles hill. while, the drought stress at ripening stage decline significantly the number of filled grains panicle-1 and 1000-grain weight and grain yield t/ha. The reduction in grain yield its differed among the rice varieties according to their level of tolerance.

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