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Effect of Water Deficit on Some Agronomic Traits of Some Rice Genotypesat Reproductive Stage

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Abstract: Drought is one of the major abiotic stresses limiting plant production worldwide. The research work of the present study was carried out at the Experimental Farm of Sakha Agricultural Research Station, during seasons of 2018 and 2019, to study the effect of water deficit at reproductive stage on some rice genotypes. Thirty rice genotypes were used in this investigation; two of them are used as checks, NERICA 7 as tolerant to drought and IR64 as sensitive to drought. The results revealed that,all rice genotypes and their studied traits were affected significantly by drought stress at reproductive stage. The traits reduction % was varied among the genotypes depending on the genetic background and level of drought tolerance for each genotype. The best rice genotypes under water stress were NERICA 7, SK28-115-20-5-7-1, SK28-45-5-6-1-1, SK28-56-5-2-2-1, SK28-79-2-5-8-4 and SK28-61-1-2-5-3. The reduction in grain was 25.56, 27.03, 28.23, 30.18, 39.94 and 41.93%, respectively;they showed superioty, in terms of grain yield, under drought stress. This indicated that these genotypes can be used as donors in rice breeding program and direct selection based on yield should be used for screening.The results also revealed that the rice genotypes NERICA 7, SK28-45-5-6-1-1, SK28-115-20-5-7-1, SK28-61-1-2-5-3, Sk28-56-5-2-2-1 and ART16-13-13-2-2-B-1-B-1-Bachieved desirable means of root characteristics under water stress.The grain yield under water stress had positive correlation with panicle length, number of filled grains/panicle, panicle weight and plant height.

Key words: Rice · Water deficit · Reproductive stage

INTRODUCTION

The world population is expected to reach 9 billion by the middle of the twenty-first century. Given the projected population increase, a 40% improvement in crop yields in drought-prone areas is needed by 2025 [1]. In many crops, particularly cereals, the plants are more sensitive to drought stress during the reproductive phase than at any other stage, except early establishment while the root system is developing [2]. 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) [3].

Drought is one of the most important abiotic stresses causing drastic reductions in yield in rainfed rice ecosystem. 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 [4]. Drought is one of the major abiotic stresses limiting plant production in rainfed ecosystem [5]. 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$ by 3.6 billion at that time. Pantuwan *et al*. [6] reported that the rice plant is the most sensitive to water stress at reproductive stage.Reduction of grain yield occurs when water stress coincides with the irreversible reproductive processes making the genetic analysis of drought tolerance at reproductive stage crucially important. 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 [7]. Drought tolerance is the most important characteristic in upland 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 [8, 9].

The objective of this investigation wasto identify drought tolerant rice genotype and to evaluate the effect of water stress on some of rice genotypesat reproductive stage.

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MATERIAL AND METHODS

Plant Materials: A total of 30 rice genotypes were sown at the Experimental Farm of Sakha Agricultural Research Station, during seasons of 2018 and 2019, to study the effect of water deficit at reproductive stage on these rice genotypes. Two rice genotypes were used as checks; IR64 is sensitive to drought stress developed by International Rice Research Institute in the Philippines and NERICA 7 tolerant to drought developed by Africa Rice Center.

Methods: Seeds of the 30 rice genotypes were grown in the first week of May during 2018 and 2019 rice seasons and seedlings were transplanted individually after 30 days with a spacing of 20 x 20 cm among hills and rows. The experimental design was a randomized complete block design (RCBD), with three replications under well-watering and water stress. Each replication included seven rows for each genotype, the length of each row was 5 m and the harvested area was 5m^2. The irrigation continued in well-watered replications until the end of the experiment and always kept on moisture at saturated or above the field capacity. For water stress, two consecutive cycles of stress (15 days withholding then flash irrigation for oneday then withholding for 15 days) was applied after 45 days of transplanting.

The rate of NP 60: 15 Kg/fadwas applied as follows; 60 kg N/fad in the form of urea (46.5%N) was applied in two equal splits, the first half was added as basal applicationand 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, 15 kg P_2O_5/fad 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. The following data were recorded: days to 50% heading (day), flag leaf area cm^2, plant height at maturity (cm), number of panicles/plant, Panicle length (cm), number of filled grains / panicle, panicle weight (g), 1000 grain weight (g), grain yield (t/ha.) at 14% moisture content and root traits were measured at complete heading i.e., root length (cm); it was determined as the length of the root from the base of the plant to the tip of the main axis of primary root, root volume (cm^3) was determined in cubic centimeters using standard column and root thickness (mm) was measured by microscope with micrometer slide; it was measured as average diameter (mm) of the tip portion (about 1cm from the tip) of three random secondary roots at the middle position of the root/plant.For means comparison, least significant difference (L.S.D.) technique was used according to Gomez and Gomez [10]. Combined analysis of variance was used after performing homogeneity test.

$$\text{Reduction \%} = \frac{\text{Value of trait under well watered} - \text{value of trait under water stress}}{\text{Value of trait under well watered}} \times 100$$

RESULTS AND DISCUSSION

The Effect of Drought Stress on RiceGenotypes: For number of days to 50% flowering, the data in Table (1), showed that the water stress delayed the flowering for all rice genotypes under this investigation. Drought stress applied at the beginning of the reproductive stage usually results in a delay in flowering [11]. This is mainly due to slowed elongation of the panicle and supporting tissuesthese findings were in agreement with Lafitte *et al*. [12] and Ramakrishnayya and Murty [13] who 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 excretion. 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.

Regarding to flag leaf area, all genotypes were affected significantly by water stress during reproductive stage. The reduction % differs from one genotype to another according to the genetic background of genotype and its level of drought tolerance. The reduction ranged from6.19% for SK28-110-20-3-1-1 to 31.91% for SK28-115-22-1-2-2.

Plant height was lower under water stress than under well-watering for all rice genotypes in 2018 and 2019. The reductionof plant height under water stress ranged from7.92 to 32.69% according to the genotype and its level of drought tolerance as indicated in Table (1). The negative effect of drought on plant height may due to poor root development; decrease of leaf surface, increase of leaf senescence and inhibition of stem reserves. The same trend of results of drought effect on plant height was reported by Marie-Noelle *et al.*[14].

All rice genotypes were affected by waterstress; number of panicles/plant, panicle length and number of filled grains/panicle were affected significantly by water stress for all rice genotypes Table (2). The reduction in number of panicles/plant ranged from (7.26%) for SK28-23-6-7-2-4 to (72.94) for Giza 177. For panicle length

Table 1: Effect of water stress on number of days to 50% flowering (days), flag leaf area(cm^2) and plant height (cm) (data combined for 2018 and 2019 seasons).

Genotype	Number of Days to 50% Flowering (days)			Flag Leaf Area (cm^2)			Plant Height (cm)		
	Irrigated Mean	Drought Mean	Reduction %	Irrigated Mean	Drought Mean	Reduction %	Irrigated Mean	Drought Mean	Reduction %
SK28-45-5-6-1-1	79.00	86.60	-9.62	25.93	19.30	25.57	90.93	78.40	13.78
SK28-23-6-7-2-4	76.30	84.30	-10.48	33.14	24.79	25.20	95.20	79.06	16.95
SK28-56-5-2-2-1	81.30	86.30	-6.15	28.99	26.25	9.45	86.73	79.86	7.92
SK28-110-20-3-1-1	73.00	83.30	-14.11	29.39	27.57	6.19	92.20	62.06	32.69
ART3-6-L3P9-B-B-2	83.00	87.30	-5.18	29.01	24.46	15.68	87.86	77.13	12.21
ART3-7-L3P3-B-B-2	72.30	81.60	-12.86	25.22	22.60	10.39	90.80	73.20	19.38
C650-H-T-LigneeIP14-6-4	70.00	73.00	-4.29	17.62	14.64	16.91	72.53	54.86	24.36
SK28-34-5-4-2-3	77.60	91.30	-17.65	25.18	17.70	29.71	96.93	80.33	17.13
SK28-8-5-4-1-2	91.60	97.30	-6.22	27.02	21.91	18.91	89.13	79.00	11.37
Giza 177	95.00	102.00	-7.37	33.50	25.08	25.13	100.00	83.93	16.07
SK28-61-1-2-5-3	93.30	98.30	-5.36	31.49	28.30	10.13	96.73	79.33	17.99
SK28-79-2-5-8-4	76.60	82.30	-7.44	15.88	12.98	18.26	77.26	69.13	10.52
ART16-4-13-1-2-1-1-B-1-B	78.60	92.00	-17.05	27.63	20.37	26.28	90.40	68.00	24.78
ART16-5-4-3-3-2-1-B-1-B	81.00	87.30	-7.78	22.57	18.70	17.15	97.26	79.66	18.10
ART16-5-9-22-2-1-1-B-1-B	75.30	82.60	-9.69	27.42	20.00	27.06	86.73	71.73	17.30
SK28-15-3-2-1-1	77.30	86.30	-11.64	26.02	20.96	19.45	112.00	76.00	32.14
ART16-9-2-10-4-1-1-B-1-B	78.60	84.30	-7.25	24.02	21.20	11.74	85.73	70.60	17.65
SK28-115-22-1-2-2	79.60	86.00	-8.04	29.99	20.42	31.91	85.33	73.93	13.36
SK28-115-20-5-7-1	83.60	98.60	-17.94	29.98	22.46	25.08	97.33	80.00	17.81
ART16-9-8-32-3-3-1-B-1-B	79.00	85.30	-7.97	23.56	17.46	25.89	84.53	75.00	11.27
ART16-9-8-32-3-3-1-B-2-B	75.00	85.00	-13.33	26.49	21.24	19.82	102.00	81.26	20.33
ART16-9-10-15-4-B-2-B-3-B	73.60	82.00	-11.41	22.60	21.27	5.88	98.40	73.00	25.81
ART16-9-24-4-4-2-1-B-2-B	79.00	88.00	-11.39	20.20	18.62	7.82	86.06	72.26	16.04
ART16-9-26-21-3-2-1-B-2-B	79.00	89.30	-13.04	27.64	23.23	15.96	95.66	73.06	23.63
SK28-40-8-6-2-2	79.60	88.00	-10.55	28.52	22.29	21.84	98.26	76.06	22.59
ART16-13-12-23-5-1-1-B-3-B	79.30	85.30	-7.57	26.01	25.94	0.27	101.46	84.46	16.76
ART16-13-13-2-2-B-1-B-1-B	72.30	78.60	-8.71	28.54	20.96	26.56	88.00	69.93	20.53
ART16-13-14-1-1-1-1-B-1-B	77.00	84.30	-9.48	25.84	22.32	13.62	93.26	73.93	20.73
NERICA 7	75.30	87.30	-15.94	24.85	19.40	21.93	90.86	70.33	22.60
IR64	106.00	113.00	-6.60	14.12	11.69	17.21	66.66	58.13	12.80
SD	7.54	7.86		6.48	5.32		10.68	7.74	
LSD	3.26	6.86		10.08	9.78		11.76	8.88	
significant	< 0.001	< 0.001		< 0.001	< 0.011		< 0.001	< 0.001	

Irrigated = normal irrigation Drought = water stress

all rice genotypes were affected significantly by water stress and the lowest reduction 3.67% was recorded for the genotype SK28-79-2-5-8-4. The highest reduction value 21.31% was exhibited by SK28-40-8-6-2-2. While, the reduction for number of filled grains/panicle ranged from 8.18% for SK28-45-5-6-1-1 to 49.87% for SK28-110-20-3-1-1in that respect. Adam *et al*. [15] reported the increase in spikelet sterility under water deficit at reproductive stage is due to the reduction in metabolic functions and physiological processes in rice plant.

Panicle weight, 1000-grain weight and, grain yield,of all rice genotypes Table (3) and their traits were affected significantly by drought stress at reproductive stage. The reduction was varied among the genotypes depending on the genetic background and level of drought tolerance for each genotype. The reduction for panicle weight varied from 7.18% for SK28-8-5-4-1-2to 59.39% for SK28-15-3-2-1-1. Concerning to 1000-grain weight, the reduction was ranged between 2.69 to 18.92 Table (3). The reduction in grain yield varied from one genotype to another according to its level of drought tolerance. The reduction in grain yield due to drought stress compared with well-watered ranged from 25.56 and 73.44 %. The best rice genotypes under drought stress were NERICA 7, SK28-115-20-5-7-1, SK28-45-5-6-1-1, SK28-56-5-2-2-1, SK28-79-2-5-8-4 and SK28-61-1-2-5-3. The reductionpercentages were in grain yieldwas 25.56, 27.03, 28.23, 30.18, 39.94 and 41.93, respectively for the previous genotypes. In the context, Raumjit and Wichitparp [16] stated that when drought occurred during vegetative and reproductive stages, it decreased the yield of by up to 30%; that may be due to reduction of panicle number per unit area.

Table 2: Effect of water stress on number of panicles/plant, panicle length (cm) and number of filled grains/panicle (data combined for 2018 and 2019 seasons).

	Number of panicles /plant			Panicle length (cm)			Number of filled grains/panicle		
Genotype	Irrigated Mean	Drought Mean	Reduction (%)	Irrigated Mean	Drought Mean	Reduction (%)	Irrigated Mean	Drought Mean	Reduction (%)
SK28-45-5-6-1-1	11.07	8.53	22.89	22.60	18.93	16.22	110.00	101.00	8.18
SK28-23-6-7-2-4	8.27	7.67	7.26	21.97	20.08	8.60	113.33	59.67	47.35
SK28-56-5-2-2-1	8.47	5.60	33.86	22.12	19.39	12.33	131.00	98.67	24.68
SK28-110-20-3-1-1	12.33	9.00	27.03	22.23	18.22	18.04	102.00	51.13	49.87
ART3-6-L3P9-B-B-2	8.73	8.00	8.40	20.25	18.69	7.68	133.33	108.67	18.50
ART3-7-L3P3-B-B-2	6.53	4.73	27.55	23.90	20.07	16.04	111.33	74.13	33.41
C650-H-T-LigneeIP14-6-4	8.93	6.67	25.37	16.81	15.67	6.82	68.33	44.60	34.73
SK28-34-5-4-2-3	10.07	5.87	41.72	22.57	19.37	14.15	131.67	78.40	40.46
SK28-8-5-4-1-2	6.53	4.20	35.71	20.65	19.80	4.10	112.00	98.00	12.50
Giza 177	17.00	4.60	72.94	22.87	19.50	14.72	116.33	90.00	22.64
SK28-61-1-2-5-3	10.47	9.33	10.83	21.45	18.91	11.84	130.33	75.33	42.20
SK28-79-2-5-8-4	10.73	7.93	26.09	19.43	18.71	3.67	81.67	55.00	32.65
ART16-4-13-1-2-1-1-B-1-B	9.47	6.73	28.87	21.77	18.69	14.12	111.00	68.80	38.02
ART16-5-4-3-3-2-1-B-1-B	10.73	7.80	27.33	20.33	17.07	16.03	110.00	72.47	34.12
ART16-5-9-22-2-1-1-B-1-B	8.73	7.40	15.27	21.93	18.10	17.48	83.00	44.60	46.27
SK28-15-3-2-1-1	11.47	9.20	19.77	21.87	18.16	16.95	111.33	56.80	48.98
ART16-9-2-10-4-1-1-B-1-B	9.20	8.00	13.04	20.23	16.43	18.81	120.67	67.87	43.76
SK28-115-22-1-2-2	8.33	7.27	12.80	21.04	17.58	16.44	157.00	87.40	44.33
SK28-115-20-5-7-1	8.93	7.47	16.42	20.87	19.62	5.97	126.33	104.00	17.68
ART16-9-8-32-3-3-1-B-1-B	7.60	5.67	25.44	21.83	19.97	8.52	103.67	78.67	24.12
ART16-9-8-32-3-3-1-B-2-B	8.93	7.87	11.94	21.47	17.40	18.94	109.67	63.00	42.55
ART16-9-10-15-4-B-2-B-3-B	8.93	7.67	14.18	21.28	17.99	15.44	99.67	61.53	38.26
ART16-9-24-4-4-2-1-B-2-B	8.93	7.87	11.94	19.31	16.45	14.78	105.67	68.93	34.76
ART16-9-26-21-3-2-1-B-2-B	8.40	6.40	23.81	20.61	16.84	18.28	114.00	64.00	43.86
SK28-40-8-6-2-2	8.07	7.27	9.92	21.84	17.19	21.31	137.00	69.73	49.10
ART16-13-12-23-5-1-1-B-3-B	10.27	7.40	27.92	21.90	18.44	15.80	136.67	82.60	39.56
ART16-13-13-2-2-B-1-B-1-B	10.07	7.33	27.15	20.71	19.20	7.31	100.33	63.00	37.21
ART16-13-14-1-1-1-1-B-1-B	9.27	7.27	21.58	20.47	17.80	13.03	110.67	74.33	32.83
NERICA 7	10.80	8.67	19.75	20.73	17.98	13.25	99.33	90.33	9.06
IR64	20.40	17.00	16.67	19.20	17.51	8.78	51.00	35.00	31.37
SD	2.98	2.33		1.63	1.58		24.15	20.53	
LSD	4.60	3.12		2.43	2.50		31.74	25.08	
significant	< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	<0.001	

Irrigated = normal irrigation Drought = water stress

Table 3: Effect of water stress on panicle weight (g), 1000-grain weight (g) and grain yield (t/ha) (data combined for 2018 and 2019 seasons)

	Panicle weight (g)			1000-grain weight (g)			Grain yield (t/fad.)		
Genotype	Irrigated Mean	Drought Mean	Reduction (%)	Irrigated Mean	Drought Mean	Reduction (%)	Irrigated Mean	Drought Mean	Reduction (%)
SK28-45-5-6-1-1	3.39	2.35	30.71	28.60	26.20	8.39	4.18	3.00	28.23
SK28-23-6-7-2-4	3.69	2.05	44.58	29.00	26.40	8.97	2.80	1.33	52.50
SK28-56-5-2-2-1	3.90	3.47	10.94	26.60	25.80	3.01	3.38	2.36	30.18
SK28-110-20-3-1-1	3.42	1.72	49.71	30.00	29.00	3.33	4.78	1.65	65.48
ART3-6-L3P9-B-B-2	4.28	2.74	35.98	28.60	26.80	6.29	5.36	2.30	57.09
ART3-7-L3P3-B-B-2	4.29	2.35	45.34	34.30	30.00	12.54	3.56	1.46	58.99
C650-H-T-LigneeIP14-6-4	2.23	1.36	38.92	29.60	24.00	18.92	2.43	1.10	54.73
SK28-34-5-4-2-3	4.13	2.17	47.50	28.00	27.00	3.57	4.20	1.51	64.05
SK28-8-5-4-1-2	2.69	2.50	7.18	25.60	24.60	3.91	2.78	2.05	26.26
Giza 177	3.45	2.31	33.20	28.00	23.00	17.86	3.50	1.63	53.43
SK28-61-1-2-5-3	3.74	2.15	42.42	26.00	25.30	2.69	4.15	2.41	41.93
SK28-79-2-5-8-4	2.42	1.65	31.68	27.30	26.20	4.03	3.63	2.18	39.94
ART16-4-13-1-2-1-1-B-1-B	3.27	1.87	42.86	26.30	24.60	6.46	2.95	1.51	48.81
ART16-5-4-3-3-2-1-B-1-B	3.43	2.08	39.42	28.00	26.20	6.43	4.21	1.83	56.53

Table 3: Continued

Genotype	Panicle weight (g) Irrigated Mean	Drought Mean	Reduction (%)	1000-grain weight (g) Irrigated Mean	Drought Mean	Reduction (%)	Grain yield (t/fad.) Irrigated Mean	Drought Mean	Reduction (%)
ART16-5-9-22-2-1-1-B-1-B	2.77	1.24	55.18	29.30	25.10	14.33	2.83	1.11	60.78
SK28-15-3-2-1-1	3.48	1.41	59.39	26.60	22.60	15.04	4.81	1.56	67.57
ART16-9-2-10-4-1-1-B-1-B	3.72	1.83	50.72	27.30	25.90	5.13	3.81	1.90	50.13
SK28-115-22-1-2-2	4.34	2.11	51.31	26.00	23.70	8.85	3.81	2.18	42.78
SK28-115-20-5-7-1	3.73	2.44	34.64	26.30	25.00	4.94	3.70	2.70	27.03
ART16-9-8-32-3-3-1-B-1-B	2.87	1.98	31.09	25.30	23.30	7.91	3.00	1.71	43.00
ART16-9-8-32-3-3-1-B-2-B	3.50	1.67	52.38	28.60	25.70	10.14	3.20	0.85	73.44
ART16-9-10-15-4-B-2-B-3-B	3.19	1.73	45.61	29.00	26.50	8.62	3.73	1.60	57.10
ART16-9-24-4-4-2-1-B-2-B	3.31	1.89	42.86	28.00	25.50	8.93	3.80	1.78	53.16
ART16-9-26-21-3-2-1-B-2-B	3.55	1.71	51.78	28.30	25.50	9.89	3.55	1.23	65.35
SK28-40-8-6-2-2	4.08	1.83	55.07	26.00	23.20	10.77	3.33	0.96	71.17
ART16-13-12-23-5-1-1-B-3-B	4.04	2.02	50.00	27.00	24.80	8.15	4.53	1.45	67.99
ART16-13-13-2-2-B-1-B-1-B	3.29	2.05	37.73	29.00	26.00	10.34	4.35	2.15	50.57
ART16-13-14-1-1-1-1-B-1-B	3.73	1.89	49.20	29.00	25.00	13.79	4.31	2.20	48.96
NERICA7	3.13	1.93	38.17	28.60	24.60	13.99	4.03	3.00	25.56
IR64	1.28	0.90	29.69	23.60	22.40	5.08	3.01	1.15	61.79
SD	0.75	0.61		1.97	1.63		1.10	0.64	
LSD	1.01	1.10		3.02	2.52		2.06	1.19	
significant	< 0.001	< 0.003		< 0.001	< 0.001		< 0.021	< 0.001	

Irrigated = normal irrigation Drought = water stress

Table 4: Root characteristics of somegenotypesunder continuous flooding and water stress(data combined for 2018 and 2019 seasons)

Genotype	Continuous flooding Root length (cm)	Root volume	Root diameter (mm)	Water stress Root length (cm)	Root volume	Root diameter (mm)
SK28-45-5-6-1-1	27.33	36.70	0.97	28.67	35.00	0.95
SK28-56-2-2-1	24.50	29.30	1.14	25.83	29.00	0.92
ART16-13-13-2-2-B-1-B-1-B	25.83	37.30	0.97	27.17	36.70	1.00
SK28-61-1-2-5-3	27.33	36.70	1.09	26.33	32.30	1.00
SK28-115-20-5-7-1	28.67	36.30	1.16	25.00	28.70	0.99
NERICA 7	22.83	37.00	1.04	24.17	30.00	1.06
IR 64	18.83	20.00	0.79	18.00	23.30	0.78
LSD 0.05	4.70	11.72	0.091	2.15	9.35	0.168

Irrigated = normal irrigation Drought = water stress

Root Traits

Root Traits underContinuous Flooding: Data in Table (4) indicated that SK28-115-20-5-7-1 recorded the longest roots without any significant difference with the genotypesSK28-45-5-6-1-1 and SK28-61-1-2-5-3 under continuous flooding.Meanwhile, IR 64 and NERICA 7 exhibited the lowest values of root length under the same conditions.

Concerning root volume ART16-13-13-2-2-B-1-B-1-B showed the highest values without any significant differences with the genotypes NERICA 7, SK28-61-1-2-5-3, SK28-115-20-5-7-1 and SK28-56-2-2-1while, IR 64 recorded the lowest value under continuous flooding Table (4). For root diameter, the rice genotypesSK28-115-20-5-7-1, SK28-56-2-2-1, SK28-61-1-2-5-3 and NERICA 7 gave thickest roots (1.16, 1.14, 1.09 and 1.04 mm), respectivelywhile, IR 64 gave the lowest value (0.79mm) for this trait.

From the above mentioned results it could be concluded that the rice genotypesSK28-115-20-5-7-1, NERICA 7and SK28-45-5-6-1-1 showed the desirable means of root characteristics under flooding conditions.

Root Traits underWater Stress: Data in Table (4) showedthatSK28-45-5-6-1-1andART16-13-13-2-2-B-1-B-1-B gave the longest roots while, IR 64showed the shortest roots under water deficit.

Concerning root volume, ART16-13-13-2-2-B-1-B-1-B, SK28-45-5-6-1-1 and SK28-61-1-2-5-3 showed the highest values. In contrast, IR 64 recorded the lowest value under water stress Table (5). For nodal root number, IR 64 gave the highest value while, SK 28-115-20-5-7-1 gave

Table 5: Correlation coefficients among studied traits under water stress.

Trait	Days to flowering	Flag leaf area	Plant height	Number of panicles	Panicle length	Number of filled grains	Panicle weight	1000-grain weight	Grain yield
Days to flowering	1								
Flag leaf area	-0.01	1							
Plant height	0.17*	0.52**	1						
Number of panicles	0.40**	-0.35**	-0.45**	1					
Panicle length	0.21**	0.31**	0.47**	-0.33**	1				
Number of filled grains	0.18*	0.40**	0.65**	-0.45**	0.44**	1			
Panicle weight	0.02	0.53**	0.60**	-0.55**	0.54**	0.85**	1		
1000-grain weight	-0.40**	0.30**	0.03	-0.24**	0.22**	0.06	0.31**	1	
Grain yield	0.07	0.13	0.20*	-0.04	0.30**	0.68**	0.55**	0.11	1

the lowest value. For root diameter, the rice genotypes i.e., NERICA 7, ART16-13-13-2-2-B-1-B-1-B and SK28-61-1-2-5-3 exhibited the thickest roots mm respectively. On the other hand, IR 64gave the lowest value under water stress.

From the above mentioned results it could be concluded that the rice genotypes SK28-45-5-6-1-1, ART16-13-13-2-2-B-1-B-1-B,SK28-61-1-2-5-3andNERICA 7showed the desirable means of root characteristics under water stress. So, these rice genotypes could be considered tolerant to water stress through absorbing more water from deep soil layers. Champoux *et al*. [17] and Thanh *et al*. [18] they reported that maximum root length, root volume and root thickness played a vital role in drought resistance mechanism (avoidance method) by absorbing more water from lower soil layers.

Correlation Coefficient: Data in Table (5) showed that significant and highly significant and positive correlation was observed between days to complete heading and each of number of panicles/plant, panicle length, plant height and number of filled grain /panicle. While, highly significant and negative correlation between days to complete heading and 1000-grain weight was observed. Highly significant and positive correlation was also obtained between flag leaf area and plant height, panicle length, number of filled grains/panicle, panicle weight and 1000-grain weight. On the other hand a negative and highly significant correlation was found between flag leaf area and number of panicles/plant.Regarding to plant height, data in Table (5) exhibited significant and highly significant and positive correlationswas found between plant height and each of panicle length, number of filled grains/panicle, panicle weight and grain yield. In contrast, highly significant and negative correlation was recorded between plant height and number of panicles/plant.

Highly significant and negative correlation was recorded between number of panicles/plant and each of 1000-grain weight, panicle weight, number of filled grains/panicle and panicle length. Data in Table (5) revealed highly significant and positive correlation was found between panicle length and each of number of filled grains/panicle, panicle weight, 1000-grain weight and grain yield. The same trend of correlation was observed between number of filled grains/panicle and each of panicle weight and grain yieldand between panicle weight and each of 1000-grain weight and grain yield.

From the above mentioned results it could be concluded that grain yield under water stress had a positive correlation with each of panicle length, number of filled grains/panicle, panicle weight and plant height. This is in accordance with the findings of Masakata *et al*. [19]; Marie-Noelle *et al*. [14] and Sedeek *et al*. [20].

CONCLUSION

The present investigation revealed high variation among the rice genotypes for all studied traits under water stress at reproductive stage. The rice genotypes, NERICA 7, SK28-115-20-5-7-1, SK28-45-5-6-1-1, SK28-56-5-2-2-1, SK28-79-2-5-8-4 and SK 28-61-1-2-5-3, that had reductions in grain of 25.56, 27.03, 28.23, 30.18, 39.94 and 41.93%, respectively, they achieved the lowest decrease in grain yield under water stress.The grain yield under water stress had a positive correlation with each of panicle length, number of filled grains/panicle, panicle weight and plant height.

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