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Response of grains yield and its components to several genotypes of rice (*Oryza sativa* L.) under the effect of deficient irrigation

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Abstract

A field experiment was carried out at the rice research station in Al-Mishkhab Najaf /Iraq affiliated to the Agricultural Research Department during the summer season 2022. the aim of the study was to investigate the performance of grains yield traits and its components for genotypes of rice, (Anber-33, Jasmine, Baraka, Furat, K1, K35, and K45) under the influence of levels of water stress, (daily flood irrigation, irrigation every 5 days, and irrigation every 10 days). The experiment was applied according to the RCBD Randomized Complete Block Design with three replicates according split-plot arrangement. The stress levels were occupied the main plot and the genotypes were placed in the secondary plot. The results of the statistical analysis showed that there were significant differences (LSD, $P<0.05$) for the genotypes, the genotypes (K1 and Furat) were significantly superior in the number of grains (142.2 seeds panicle^{-1}), the sterility rate, were 15.15%, the grains yield and biological yield (5,547 and 13,212 tons ha^{-1}) respectively. Sequentially, it was followed by the genotype (Furat), in characteristics the number of tillers.m^{-2} was 270.6, and the grains yield and biological yield were 4.306 and 11.448 tons.h^{-1} respectively. Beside, the results of the irrigation periods there was a highly significant on most of the characteristics of the grain yield and its yield components, as the irrigation level (every 10 days) was recorded the lowest average for most of the characteristics, including the number of tillers 197.3 tillers m^{-2}, the number of grains reached 70.8 seeds panicle^{-1}, the percentage of sterility 42.72%, in addition to grain yield and biological yield 2.645 and 9.483 tons.h^{-1} respectively. The results the interactions (genotypes X irrigation periods) showed that there is an significant effect on most of the traits, as the treatment (K1 X daily irrigation) recorded Significantly superiority in most of the traits such as the number of grains, the lowest percentage of sterility, the highest grains yield and the biological yield, and it gave 142.2 grain panicle^{-1}, 10.34%, 6,230 tons ha^{-1}

and 13,960 tons ha^{-1} respectively. Whereas, the Interaction (K45 X irrigation every 5 days) superiority in the weight of straw was 8,790 tons h^{-1}, the interaction (Baraka X irrigation every five 10 days) gave the highest number of tillers reached 298.3 tillers m^{-2}, the sterility rate reached 70.86%, the lowest grains yield was 0.432 tons ha^{-1}, and the lowest harvest index reached 6.77%.

Keywords: Rice, water stress, genotypes, sterility, yield.

Introduction

Rice is the third most important grains crop in Iraq after wheat and barley in terms of production and cultivated area. It is grown in 114 countries (Economic analysis of rice production) In Asia alone, nearly 90% of the global production of rice is produced and consumed, and they obtain 60-70% of energy needs depending on rice and its products (Vijayakumar *et al*., 2006).

Iraq was ranked among the top ten countries that consume the most rice (World Bank report, 2021). The importance of the rice crop comes from its role in achieving food security for a large number of countries and their peoples. Its nutritional importance comes from the fact that its grains contain a high percentage of easily digestible carbohydrates (70)-85%) and 2.2% fat and a percentage of fiber up to 1.1%, as well as a protein percentage of up to 9.78% with a balanced content of essential amino acids, especially lysine, compared to other grains crops (Shatti et al., 2011).

The percentage of sterility varies in different genotypes, which are also affected by environmental factors, including abiotic stresses, especially drought. In the booting stage, fertility is often sacrificed for growth and survival in rice under abiotic stress (Wen et al., 2021). The stage of reproductive development of rice is very sensitive to desiccation. A brief period of exposure to water stress during meiosis in the pollen cells of rice grown under water-stressed environmental conditions led to sterility of the pollen grains, as the mycotoxins containing sterilized pollen grains were smaller, thinner, and deformed. Often compared to the normal anthers of well-irrigated plants, only about 20% of the fully developed florets in the stressed plants produced grain, compared to 90% under normal irrigation conditions (Sheoran and Saini, 1996), in order to satisfy the need for rice from the growing world population. Total food production must be increased by 60% in the next 25 years, and to achieve this, several means and tools must be adopted, such as using high-yielding varieties or improving crop management and service, as well as adopting programs for breeding and genetic improvement of stocks. Breeding of genotypes and hybrids tolerant to abiotic stresses, including drought, and the use of

new biotechnology tools, it is one of the effective solutions to obtain selected genotypes with desirable productivity under water stress. (Al-Burki, 2020).

Materials and methods

The field experiment was carried out at the rice research station in Al-Mishkhab (located at latitude 31 north and longitude 44 east and at an altitude of 70 m above sea level in a loamy, alluvial soil) in Al-Najaf Governorate affiliated to the Agricultural Research Department - Rice Research Department/ Iraq during the summer agricultural season 2022. In order to know the response of the grain yield and its components to the seven genotypes under the influence of water stress.

Before planting, the soil of the field was chemically and physically analyzed after Nine samples were chosen at random for the analysis, and its characteristics are shown in Table (1).

Table (1) Some chemical and physical properties of field soil before planting

Adjective	Value	Measruing unit	Adjective	Value	Measruing unit
Sand	23.1	g Kg^{-1} Soil	Organic matter	1.5	Mg Kg^{-1} Soil
Silt	41.7	g Kg^{-1} Soil	Nitrogen	23.27	Mg Kg^{-1} Soil
Clay	35.2	g Kg^{-1} Soil	Phosphorous	15.30	Mg Kg^{-1} Soil
PH	7.42	_	Potassium	172.1	Mg Kg^{-1} Soil
EC (1:1)	4.00	dS m^{-1}	Soil texture	Clay admixture	Clay loam
CEC	5.98	Soil Cmol +Kg^{-1}			

The seedlings were planted in the field in hollows inside the plot, in each hollow one seedling was placed with a distance of (15 cm) between one hole and another, and the distance between one line and another (25 cm) in plot (6 m^2), With four lines inside plot, leaving a distance of two m between one experimental unit and another, 63 experimental units, three replications of the split plot design, and Randomized Complete Block Design (R.C.B.D.), while the agricultural operations of plowing, leveling and fertilization were carried out according to the approved recommendations for the rice crop. (Hassan, 2011). For the experiment's irrigation management, the method of

alternate immersion and drying was used for two weeks, after which the plant underwent experimental stress treatments until it reached the level of physiological maturity.

The experimental land was fertilized with the compound fertilizer NPK (18-18-0) by 400 kg ha^{-1} mixed with the soil, and urea fertilizer (46% N) at a rate of 140 kg ha^{-1} was added in two equal amounts, one batch after 10 days of seedling, and the second batch a month after the first, (Hassan, 2011). On 12/5/2022, when yellow plants, yellow flag leaves, and yellow panicles became visible, the harvest was carried out.

Experimental factors:

Water stress is the first factor (and the primary plot). Once two weeks had passed since the seedlings were moved to the permanent field, on the 1^{st} of August 2022,. Three **periods** of irrigation treatments included: first, continuous daily irrigation by immersion (Control), second, flood irrigation every 5 days, and third, flood irrigation every 10 days.

the second factor ,Seven genotypes made up the secondary plot, (Anber-33, Jasmine, Baraka, Furat, K1, K35, and K45). The mishkhab rice research at the Najaf Research Department/Station provided the seeds.

The studied traits: Number of fertile tillersm^{-2}, Number of grains.panicle^{-1}, the percentage of sterility (sterility percentage %)= (the number of empty grains / the number of total grains) x 100, weight of 1000 grains (g), Grain yield (**tons**.ha^{-1}), Straw yield (**tons**.ha^{-1}), Biological yield (tone.ha^{-1}), Harvest index. Harvest index= (grain y/biological y) x100 (%).

Data of phenotypic traits were analyzed statistically using the statistical program Genstat Discovery 4 to determine the sources of variation between the studied treatments. The means for each factor and their interaction were compared using the L.S.D 0.05 test at a significant level (5%) (Al-Rawi and Khalaf Allah, 2000).

Results

Number of fertile tillers m^{-2}

The results of Table (2) showed that the genotypes had a significant effect on the characteristic of the number of fertile tillers. (Furat) outperformed the rest of the genotypes and gave the highest average of 270.6 tillers.m^{-2}, while (Jasmine) gave the lowest average of (173.0 tillers.m^{-2}), that the reason for the variety of genotypes may be attributed to the difference in their genetic ability which is one of the determinants of tillering, which reflects the abundance of growth, the nature of the cultivar and its field characteristics, and this result agreed with (Sarhid and Ahmed, 2019).

the results of the same table indicated that there were significant differences between the irrigation periods, as the daily irrigation period gave the highest average of (221.9 tillers m^{-2}), while (10 day irrigation period)

gave the lowest average of (197.3 tillers m^{-2}), these results agreed with (Kashkoul et al., 2013), which showed the reason for the decrease in the number of fertile tillers, which is the increase in the number of days between one irrigation and another, and the growth of fertile tillers in rice plants was affected by the increase or lack of soil water.

As for the interaction, (Furat X irrigation every 10 days) showed the highest average of 283.7 tillers m^{-2}, while the interaction (Jasmine X irrigation every 10 days) gave the lowest average of 150.3 tillers m^{-2}.

The interaction results show that there is a distinct difference in how genotypes respond to various irrigation periods, but that they largely achieved their best responses with irrigation every ten days. This difference may be due to the level of genetic variation, which on the one hand caused a difference in the genotypes' ability to tillering. And for how it interacts with the environment and longer irrigation, and this result is consistent with (Hassan et al., 2016). When scheduling irrigation, which was significantly superior to daily flood irrigation treatments, which gave the lowest averages.

Table (2): The effect of genotypes and irrigation periods and their interaction on the characteristic of the number of fertile tillers

Genotypes	Irrigation periods			genotypes means
	Every day	5 days	10 days	
K1	188.3	202.7	183.7	191.6
K35	238.0	210.7	206.0	218.2
K45	192.7	211.7	173.7	192.7
Anber-33	193.3	177.0	188.3	186.2
Jasmine	199.3	169.3	150.3	173.0
Furat	274.3	253.7	283.7	270.6
Baraka	267.0	231.7	195.7	231.4
Irrigations means	221.9	208.1	197.3	
L.S.D 0.05	irrigation periods 34.32=	genotypes = 31.33		Interaction=56.14

Number of grains filled panicle^{-1}

The results showed (Table 3) that there were highly significant effects of the genotypes, irrigation periods, their interaction on the number of grains, as the K1 genotype achieved the highest average of 142.2 grains.panicle^{-1}, while Baraka genotype achieved the lowest number of grains with an average of 54.3. grain.anicle^{-1}, and the reason for the increase in the number of

grains in the panicle in the aforementioned genotypes maybe due to the increase in the length of the panicle, which may lead to an increase in the number of grains and then the possibility of increasing the its fertilization rate, in addition to increasing the leaf area and its role in the production and transformation of dry matter to the grain, and this result is consistent with what he found (Al-Burki, 2021).

The results showed that (daily irrigation period) was superior to the rest of the periods and gave 129.6 grains.panicle^{-1}, while (10 day irrigation period) recorded the least average of 70.8 grains.panicle^{-1}.

The results of the interaction in Table (3) indicated the superiority of (k1 X daily irrigation) and gave the highest number of grains, which amounted to 187.8 grains.panicle^{-1}, while the interference (Baraka X every 10 days) recorded the lowest average of 31.7 grains.panicle^{-1}

Table (3) The effect of genotypes and irrigation periods and their interactions on the number of grains (Panicle).

Genotypes	Every day	5 days	10 days	Genotypes means
K1	187.8	126.6	112.2	142.2
K35	100.5	71.1	56.5	76.0
K45	130.5	109.4	74.7	104.8
Anber-33	127.0	98.0	78.5	101.2
Jasmine	150.4	80.9	75.4	102.2
Al- Furat	131.0	95.7	66.9	97.9
Baraka	80.3	51.1	31.7	54.3
Irrigations means	129.6	90.4	70.8	
L.S.D 0.05	irrigation periods =15.87	genotypes = 9.29		Interaction=19.32

Sterility (%)

The results of Table (4) showed that there were significant differences in the characteristic of the sterility rate among the studied genotypes, as the genotype (K1) excelled by giving it the lowest sterility rate of 15.15%, which differed significantly from (Baraka), which gave the highest sterility rate of 49.02%. The explanation for the genotype-specific variation in the percentage of sterility is because it is a genetic trait that varies depending on the genotype, as well as on environmental factors including abiotic

stresses, particularly drought, and the planting date.

The results of the data of the table above regarding the irrigation periods showed that there were significant differences with regard to the irrigation periods, as the irrigation period excelled (every 10 days) and gave the highest average of (42.72%), while daily irrigation gave the lowest average (19.01%). In study by Wen et al., (2021) who reported that pollen sterility is caused by rice plants being exposed to water-stressful environmental circumstances during meiosis in pollen cells.

With regard to the interaction (genotypes X irrigation periods), showed high significant differences, as (K1 X daily irrigation) gave the lowest mean sterility rate of 10.34%, while the interaction (Baraka X irrigation every 10 days) gave the highest rate of 70.86%.

Table (4): Effect of genotypes and irrigation periods and their interaction on sterility%

Genotypes	Every day	5 days	10 days	Genotypes means
K1	10.34	19.80	15.31	15.15
K35	21.98	36.71	43.08	33.93
K45	21.11	27.74	42.57	30.47
Anber-33	24.46	29.00	42.87	32.11
Jasmine	14.99	31.37	40.84	29.07
Furat	14.83	29.04	43.53	29.13
Baraka	25.34	50.85	70.86	49.02
Irrigations means	19.01	32.07	42.72	
L.S.D 0.05	irrigation periods =2,977	genotypes = 3,762		Interaction= 6,391

Weight of 1000 grains (g)

The results of Table (5) indicated that the genotypes significantly affected the weight of 1000 grains, as Baraka genotype was significantly superior to the rest of the combinations, which averaged 25,560 g, while Jasmine genotype gave the lowest average of 17,117 g. Baraka genotype supremacy can be linked to a number of factors. When there are fewer filled grains, there is less competition for the materials generated, which raises the weight of the grain and lowers the number of filled grains. This result agreed with the results of (Al-Hassani and Al-Maadidi, 2017), who indicated the difference in the weight of 1000 grains according to the varieties and their genetic.

The results of the same table showed that daily irrigation period was superior and gave 21,419 g, which recorded a gradual decrease and was not significantly different from (irrigation period every 5 and 10 days), which recorded 20,447 and 19,990 gm, respectively.

With regard to the interaction between the factors, the results indicated a superiority of the interaction (Baraka X Irrigation every 5 days) and gave the highest average of 25,913 g, while the interference (Jasmine X Irrigation every 10 days) recorded the lowest average of 16,693 g.

Table (5) The effect of genotypes and irrigation periods and their interactions on the weight of 1000 grains (g).

Genotypes	Every day	5 days	10 days	Genotypes means
K1	21.630	20.053	20.307	20.663
K35	22.330	22.127	21.190	21.882
K45	20.843	19.587	19.283	19.904
Anber-33	20.387	18.523	18.233	19.048
Jasmine	17.683	16.973	16.693	17.117
Furat	21.227	19.953	19.290	20.157
Baraka	25.830	25.913	24.937	25.560
Irrigations means	21.419	20.447	19.990	
L.S.D 0.05	irrigation periods =0.7400	genotypes = 0.6993		1.2440=Interaction

Grain Yield (tons ha^{-1})

The results of Table (6) indicated that the genotypes had a significant effect on the grain yield characteristic, as the genotype (k1) outperformed the rest of the genotypes, which averaged 5,547 tons.ha^{-1}, while (Baraka) recorded the lowest grain yield amounted to 1,520 tons.ha^{-1}, Perhaps the superior number of full grains and weight of 1000 grains of the genotype (K1) account for its dominance in this feature, and this is compatible with (Al-Hassani and Al-Maadidi, 2017).

The results also showed that daily irrigation period was superior and gave the highest average of 4,304 tons.ha^{-1}, while irrigation period every 10 days recorded the lowest average, followed by irrigation every 5 days, which amounted to 2,645 tons.ha^{-1} and 3,029 tons.ha^{-1}, respectively, which is consistent With what he found (Kashkul et al., 2013), It linked the drop in grain yield to the length of time between irrigations, which

had a detrimental impact on all key plant processes, including vegetative and flowering growth, and consequently had an impact on the final grain yield.

As for the effect of the interaction between the factors, it was noted that the interaction (k1 X daily irrigation period) gave the highest average of 6,230 tons.ha^{-1}, while the interaction (Baraka X Irrigation every 10 days) gave the lowest average of 0.423 tons.ha^{-1}.

Table (6) The effect of genotypes and irrigation periods and their interaction on grain yield

Genotypes	Every day	5 days	10 days	Genotypes means
K1	6.230	5.293	5.117	5.547
K35	3.530	3.030	2.140	2.900
K45	3.907	2.657	2.320	2.961
Anber-33	3.213	2.940	2.663	2.939
Jasmine	4.977	2.127	2.227	3.110
Furat	5.240	4.050	3.627	4.306
Baraka	3.033	1.103	0.423	1.520
Irrigations means	4.304	3.029	2.645	
L.S.D 0.05	irrigation periods =0.6079	genotypes = 0.4527		Interaction= 0.8569

Straw Yield (Tons^{-1}.h)

Through the data of Table No. (7), the results showed that there were no significant differences in genotypes of straw weight. The genotype (K35) gave the highest average of 7,827 tons ha-1, followed by the genotype (K45)it gave 7.696 tons.ha^{-1}, while (Jasmine) recorded the lowest average of 6,400 tons.ha^{-1}.

The reason for the superiority of the genotypes (K35 and K45) in the straw weight characteristic maybe attributed to their superiority in the number of fertile tillers, which are among the main components of the straw yield.

The data of the same table also indicated that (irrigation period every 10 days) recorded the lowest average straw weight characteristic of 6,838 tons.ha^{-1}, which did not differ significantly from (irrigation period every 5days), while it was observed that (daily irrigation period) gave the highest average straw weight amounted to 7,763 tons.ha^{-1}.

As for the effect of the interaction on the weight of the straw, according to the results

of Table (7), the highest average of the interaction was (K45 X irrigation period every 5 days), which recorded the highest average of 8,177 tons.ha^{-1}, while the interaction (Baraka X Irrigation every 5 days) had a minimum value of 5,790 tons.ha^{-1}.

Table (7) Effect of genotypes and irrigation periods and their interaction on straw weight				
Genotypes	Every day	5 days	10 days	Genotypes means
K1	7.730	7.760	7.507	7.666
K35	8.023	8.123	7.333	7.827
K45	7.637	8.177	7.273	7.696
Anber-33	8.013	7.320	6.997	7.443
Jasmine	6.933	6.280	5.987	6.400
Al- Furat	8.140	6.360	6.927	7.142
Baraka	7.863	5.790	5.840	6.498
Irrigations means	7.763	7.116	6.838	
L.S.D 0.05	irrigation periods =1.0187	genotypes = 0.3855		Interaction = 1.0517

biological yield (tons.ha^{-1})

Through the data of Table (8), the results showed that there were significant differences in the biological yield. The genotype (k1) gave the highest average of 13,212 tons.ha^{-1}, while (Baraka) recorded the lowest average of 8,014 tons.ha^{-1} .

The reason for the superiority of the two genotypes (K1 and Furat) in the biological yield is due to their average increase in the number of fertile tillers, which is one of the main components of the straw yield , and it is one of the two components of the biological yield.

The data of the same table also indicated that irrigation period every 10 days recorded the lowest average for the biological yield, which amounted to 9,483 tons.ha^{-1}, while it was noted that (daily irrigation period) gave the highest average of 12,064 tons.ha^{-1}.

As for the effect of the interaction on the biological yield, through the results of the table it was shown that the highest average of the interaction was (K1 X daily irrigation period), which recorded the highest average of 13,960 tons ha^{-1}, while the interaction (Baraka X irrigation every 10days) showed The lowest value was 6,263 tons.ha^{-1}

Table No. (8): Effect of genotypes and irrigation periods and their interaction on the biological yield

Genotypes	Every day	5 days	10 days	Genotypes means
K1	13.960	13.053	12.623	13.212
K35	11.553	11.153	9.473	10.727
K45	11.543	10.833	9.593	10.657
Anber-33	11.227	10.260	9.660	10.382
Jasmine	11.910	8.407	8.213	9.510
Furat	13.380	10.410	10.553	11.448
Baraka	10.897	6.893	6.263	8.018
Irrigations means	12.067	10.144	9.483	
L.S.D 0.05	irrigation periods = 1.5403	genotypes = 0,6767		Interaction = 1,6578

Harvesting Index %

The data of Table (9) showed that there were significant differences, as (K1) achieved the highest value of the harvest index amounting to 41.88%, while Baraka genotype achieved the lowest value of the harvest index amounted to 16.87%.

The genotypes had a substantial impact on the harvest index's quality since it measures how effectively dry matter (grain + straw) or the byproducts of the carbon metabolism process are converted into an economic yield.

The results of Table (9) also showed that (daily irrigation period) recorded the lowest average of the harvest index, amounting to 35.12% compared to (irrigation period every 10 days), which gave the highest average of 26.14%, this is consistent with (Kashkoul et al., 2013), who attributed this increase to the fact that the interference gave the lowest dry matter weight and the lowest grain yield.

As for the interaction, the results of the interaction (K1 X daily irrigation) showed that it achieved the highest percentage for the harvest index, amounting to 44.62%, while the interaction (Baraka X irrigation every 10 days) recorded the lowest rate, amounting to 6.77%. In addition to the short time needed to reach flowering, which was a result of water stress, the reasons for the drop in the harvest index may also be related to the genotype and environmental conditions created by water stress (Al-Jana, 2021).

Table (9) Effect of genotypes and irrigation periods and their interaction on the harvest index				
Genotypes	Every day	5 days	10 days	Genotypes means
K1	44.62	40.49	40.54	41.88
K35	30.18	26.86	22.56	26.54
K45	33.79	24.37	24.22	27.46
Anber-33	28.55	28.63	27.52	28.23
Jasmine	41.80	24.87	27.21	31.29
Furat	39.12	38.61	34.19	37.31
Baraka	27.79	16.05	6.77	16.87
Irrigations means	35.12	28.55	26.14	
L.S.D 0.05	irrigation periods = 1.752	Genotypes =2.861		Interaction = 4,748

Conclusions

1- The (K1) genotype was significantly superior by giving the highest values for most of the studied traits, especially grain yield, biological yield and the number of grain filled under the influence of water stress, which indicates that it tolerates high **periods** of drought compared to the rest of the studied genotypes such as Anber-33 and Baraka. which showed poor indicators of tolerating water shortages.

2- The water stress negatively affected most of the yield components (the number of fertile tillers, the number of full grains and the biological yield).

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