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Impact of Various Irrigation Water Types on Soil Quality, Grain Heavy Metals Concentration and Productivity of Some Rice Varieties

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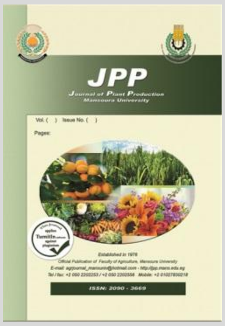

ABSTRACT

The lack of freshwater for rice cultivation has emerged as a significant issue, prompting rice farmers in Egypt's northern delta to use low-quality water for rice crops, which is deemed a disastrous situation. Two field trials were carried out during the summer seasons of 2022 and 2023 at the farm of Sakha Agriculture Research Station, Sakha, Kafr El-Sheikh, Egypt, to investigate the effect of using various ratios of freshwater to drainage water on soil quality and behaviours of some rice cultivars specifically; Giza 183, Giza 178, Sakha106 and Sakha108. A strip plot design featuring four replicates was employed in the experiments. The vertical plots focused on five types of water qualities as follows: Freshwater (FW), drainage water (DW),1FW: 1DW, 2FW: 1DW, and 1FW:2DW, rice varieties were put in horizontal plots. The results indicated that, highest level of heavy metals was found in drainage water which, diminished soil quality and raised heavy metals in rice grains, along with its harmful impact on rice growth, yield, and its components. The treatment of freshwater was the most effective, followed by 2FW: 1DW. The treatment of 2FW: 1DW is appropriate and cost-effective for watering rice plants, particularly during times of limited freshwater availability. Giza 183 and Giza178 cultivars are more resilient in drainage water compared to other varieties. It could conclude that poor quality water mixed with freshwater (2FW: 1DW) had profitability of rice, produced safely heavy metal level in soil and rice grains, along with cultivated both Giza178 and Giza183 rice varieties.

Keywords: Rice, Drainage water, grain quality, grain yield, Irrigation,

INTRODUCTION

The freshwater resources available globally remain unchanged while the population continues to grow. The amount of water accessible per person will keep rising diminishment leading to water shortages or pressure in certain regions (FAO, 2016). In Egypt, water is a vital resource for crop cultivation. Therefore, a technological option available to farmers to address water shortages is improving water use efficiency through crops, which can increase agricultural yields and alleviate the food deficit gap between consumption and production (Omar and Moussa,2016). Water impacts crop yields not only directly but also indirectly by influencing the availability of nutrients (Darwesh *et al.*,2016). Rice is regarded as one of the most vital strategic crops globally. Due to its importance, it comes after wheat in Egypt, as it contributes greatly to the national economy (USDA, 2022). Rice is considered one of the land reclamation crops, particularly in the northern region of the Nile Delta, where these areas are planted with rice to protect them from salinity that may arise due to groundwater from the Mediterranean Sea (Al-Waqaa, 2020). The total potential of water resources in any of the Middle East countries and other arid areas of the world is lower than what is needed to satisfy domestic, urban, and industrial demands (Hussein., 2012 and FAO/ WHO committee,2019). Many Middle Eastern nations will encounter serious water issues soon with inadequate water management booming population, and rising temperature as negative results of climate change have damaged the areas land and depleted its scarce water resources (CSIS, 2024). It is essential for development and the movement of nutrients from the soil to various parts of the plant, in rice paddies, the goal of water management is to maintain optimal growing conditions around the roots and enhance the utilization of soil nutrients (Darren *et al.*,2020). Due to constrained water resources, advancements in rice production in the future necessitate the creation of water-efficient technologies. (Gargouri *et al*., 2022). Recycled waste water or drainage water serves as the sole additional water source for agriculture, industry, and urban non-potable reuse that truly rises in volume as the population expands, while the urban and industrial sectors increasingly require more water (Soma *et al.*, 2023). Low-quality water and insufficient drainage systems significantly add to the salinity issue in rice fields (Mona *et al.*,2022). The inhibition of plant growth in saline environments may result from decreased osmotic pressure or the effects of specific ions (Yaron *et al*.,1973 and Zayed *et al.*,2024). The overall concentration of soluble salt in irrigation water is the key factor in assessing the quality of irrigation water after heavy metals because the salinity of soil solution is usually related to the salinity of irrigation water (Howida,2021). Agriculture land irrigated is the biggest user of developed water resources. Simultaneously, employing drainage water for irrigation is a significant factor contributing to waterlogging and soil contamination (Bhat *et al.*, 2019). The effective use of drainage water could improve the availability of water for irrigation. The primary health risks of significant concern, stemming from chemicals in waste water, result from heavy metal contamination of field crops such as rice (Mera *et al.*, 2016). These metals are absorbed from the soil and bio-accumulated within the crops themselves while inflicting harm on plants and lowering grain quality, when reaching elevated levels and under specific conditions, they can turn toxic to humans and animals

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consuming the metal-laden plants (Florence *et al.,* 2021) Generally, El Sharkawi and Zayed (2012) claimed that there is high potentiality to use poor quality water in rice paddy field without any side effect on soil or rice grain quality and yield with using some tolerant varieties and proper mechanism creating by specific cultural management such as relevant nitrogen sources, potassium application and mixture of fresh and drainage waters. The research intends to assess how irrigation water quality influences certain chemical characteristics of soil, rice yield and its components, along with the presence of heavy metals in the grain.

MATERALS AND METHODS

Filed trials were carried out at the Experimental farm of Sakha Agriculture Research Station, Sakha, KafrEl-Sheikh, Egypt during 2022 and 2023 seasons to explain the impacts of different water qualities on soil quality and some rice varieties i.e.; Sakha106 and Sakha108 (Japonica type-short grain), Giza178 and Giza183 (Japonica/ Indica type-short grain). Water qualities namely, freshwater (FW), drainage water (DW), IFW: IDW, 2FW: IDW, and IFW: 2DW. Irrigation water was distributed in equal amounts to all plots every four days. In accordance with IFW: IDW, freshwater was initially applied, and after four days, drainage water was introduced to the plots, continuing until the season's end. For the 2FW: IDW scenario, freshwater was used on two occasions, while drainage water was utilized during the third application. For IFW: 2DW, freshwater was used initially, followed by drainage water in the second and third applications, continuing this pattern until the season's end. A strip plot design incorporating four replications was implemented. The horizontal plots were allocated to the five treatments of irrigation water qualities, whereas the vertical plots were designated for the four rice cultivars. Every plot measured 36 m^2 and the prior crop for both seasons was clover. The nursery seedbed was well ploughed and dry levelled. Rice seeds at the rate of 150 $Kgha^{-1}$ were used as recommended, and phosphorus fertilizer (P_2O_5) at the rate of 36kg ha^{-1}, was added to all plots. Zinc sulphate (22% Zn) was applied at a rate of 50 Kg ha^{-1} after puddling and prior to sowing the nursery, while nitrogen fertilizer in the form of urea (46.5% N) was added at a rate of 150 Kg N ha^{-1}. After 25 days in the nursery, seedlings were uprooted and moved to the permanent field, where they were transplanted regularly in the plots with a spacing of 20 cm. The chemical and physical characteristics of soil and water irrigation were established based on (Black *et al*., 1965 and FAO 1976) and presented in (Tables1&2). The other agricultural cultural practices were carried out as advised. During the later stages of booting, measurements were taken for plant height(cm), flag leaf area(cm^2), leaf area index (LAI), relative growth rate (RGR) (g/g/week), light penetration, chlorophyll content (SPAD), and heading date. During harvest, we recorded plant height(cm), number of panicles, length of panicles(cm), filled grains per panicle, percentage of unfilled grains, and the weight of 1000 grains(g). A protected section of ten m2 was collected, air-dried, weighed for assessing biomass yield, and subsequently threshed; the grain yield was recorded in kg/plot, adjusted to a 14% moisture basis, and then transformed to t/ha. Grain samples were gathered for examination based on Chapman and Pratt (1961). RGR = (Loge W2-Loge W1)/ (T2-T1)(Hunt (1978).

Light penetration was measured at panicle initiation at 20 cm above the ground using Lux/meter Pu 150 (Lux). Chlorophyll content (SPAD) was assessed at maximum tillering with a chlorophyll meter (model SPAD= 502) in each plot. The total soluble cations, anions, and heavy metals in soil and grains were assessed using an Atomic Absorption Spectrophotometer.

Table 1. Mechanical and chemical analysis of the experimental soil (0-30cm).

Season	2022	2023
Mechanical analysis		
Sand %	11.5	11.5
Silt %	32.9	32.9
Clay %	55.4	54.5
Texture class%	Clay	Clay
chemical analysis		
Organic matter %	1.50	1.42
Ec ds/m	1.53	1.68
pH	8.16	8.20
Nitrogen ppm	45.0	61.0
Soluble P ppm	20.0	23.0
Cations meq/l		
Na^+	5.93	6.43
K^+	2.57	2.61
Ca^+	3.80	3.95
Mg^+	3.01	3.25
Anions meg/L		
CO_3	-	-
HCO_3	2.55	3.22
Cl	8.20	8.55
SO_4	4.71	5.12
Trance metal content (ppm)		
Available Zn	0.70	0.76
Available Fe	3.20	3.86
Available Mn	2.00	1.43
Available Cd	0.01	0.01
Available Ni	0.18	0.44
Available Pb	0.14	0.28

Table 2. Certain chemical properties and trace metals in the irrigation water utilized (Average of two seasons).

Seasons	2022		2023	
Water quality	FW	DW	FW	DW
pH	7.80	8.10	7.70	8.16
Ec	0.71	2.86	0.77	2.74
Cations meg/L				
Na+	3.44	22.8	3.10	21.2
K+	0.22	0.32	0.24	0.35
Ca+	2.20	3.00	2.40	3.11
Mg+	1.20	2.80	2.00	2.77
Anions meg/L				
CO3				
HCO3	3.00	6.80	4.00	6.90
Cl	1.40	2.40	1.70	2.60
SO4	1.06	19.8	2.04	17.62
Trance metal content (ppm)				
Zn	0.23	0.67	0.20	0.55
Fe	1.57	4.00	1.48	4.70
Mn	0.07	0.44	0.10	0.45
Cd	0.030	0.09	0.018	0.130
Ni	0.185	0.91	0.520	1.060
Pb	0.260	0.33	0.220	0.430

Data analysis: The data gathered for each character across both seasons were analysed using the standard analysis of variance, following the method described by Gomez and Gomez (1986), with the IRRISTAT Computer program. Treatment means were compared using the Revised L.S.D at a significance level of 5%.

RESULTS AND DISCUSSION

1: Effect of different types of irrigation water on soil chemical properties

Data in Tables3-5 indicated the effect of using different types of water on soil chemical properties. Using drainage water for irrigation caused significant increase in EC and soluble cations (Kand Na) in both seasons. The electrical conductivity of the soil after rice harvesting depends mainly on the chemical composition of the soil, ground water level, temperature, quality of water, and fertilizer during the growing season (Khasanov *et al*., 2023 and Zayed *et al*.,2024).

Table 3. ECe, Na, and K of experimental soil before cultivation and after harvesting as affected by different water quality in 2022 and 2023 season

Treatments	EC_e(dSm^{-1})		Na (maq l^{-1})		K (maq l^{-1})	
	before cultivation	After harvesting	before cultivation	After harvesting	before cultivation	After harvesting
			2022			
FW	1.2	1.00	4.33	5.07	2.17	3.45
DW	1.2	3.56	4.33	8.21	2.17	2.20
1FW:ID	1.2	1.65	4.33	5.31	2.17	2.69
2FW:1DW	1.2	1.12	4.33	5.28	2.17	2.80
1FW:2DW	1.2	2.58	4.33	5.87	2.17	3.90
LSD.5%	-	0.32	-	0.41	-	0.62
			2023			
FW	1.8	1.09	5.30	5.55	1.94	3.41
DW	1.8	3.95	5.30	8.90	1.94	1.94
1FW:ID	1.8	1.77	5.30	6.27	1.94	2.91
2FW:1DW	1.8	1.51	5.30	6.00	1.94	2. 58
1FW:2DW	1.8	2.93	5.30	7.33	1.94	2.21
LSD.5%	-	0.42	-	0.62	-	0.43

FW= Freshwater, DW= Drainage water, and = Mixed water

Table 4. Zn, Fe, and Mn of tested soil before cultivation and after harvest as affected by different water quality in 2022 and 2023 season

Treatments	Zn(ppm)		Fe(ppm)		Mn(ppm)	
	before cultivation	After harvesting	before cultivation	After harvesting	before cultivation	After harvesting
			2022			
FW	0.70	0.23	3.20	2.52	2.00	2.02
DW	0.70	0.67	3.20	4.15	2.00	5.10
1FW:ID	0.70	0.37	3.20	3.08	2.00	2.72
2FW:1DW	0.70	0.32	3.20	2.93	2.00	2.14
1FW:2DW	0.70	0.52	3.20	3.28	2.00	3.85
LSD0.05	-	0.12	-	0.32	-	0.32
			2023			
FW	0.76	0.20	3.85	3.61	1.43	1.74
DW	0.76	0.55	3.85	6.13	1.43	5.34
1FW:ID	0.76	0.34	3.85	4.14	1.43	2.74
2FW:1DW	0.76	0.31	3.85	4.09	1.43	2.21
1FW:2DW	0.76	0.43	3.85	4.47	1.43	3.63
LSD0.05	-	0.11	-	0.51	-	0.23

FW: Freshwater, DW= Drainage water

Table 5. Ni, Cd, and Pb of tested soil before cultivation and after harvest as affected by different water quality in 2022 and 2023 seasons

Treatments	Ni(ppm)		Cd(ppm)		Pb(ppm)	
	before cultivation	After harvesting	before cultivation	After harvesting	before cultivation	After harvesting
			2022			
FW	0.18	0.19	0.01	0.03	0.14	0.20
DW	0.18	0.91	0.01	0.09	0.14	0.53
1FW:ID	0.18	0.56	0.01	0.06	0.14	0.36
2FW:1DW	0.18	0.43	0.01	0.05	0.14	0.31
1FW:2DW	0.18	0.68	0.01	0.07	0.14	0.50
LSD0.05	-	0.21	-	0.02	-	0.11
			2023			
FW	0.440	0.52	0.01	0.02	0.28	0.30
DW	0.440	1.06	0.01	0.13	0.28	0.59
1FW:ID	0.440	0.78	0.01	0.07	0.28	0.38
2FW:1DW	0.440	0.69	0.01	0.05	0.28	0.36
1FW:2DW	0.440	0.86	0.01	0.09	0.28	0.52
LSD. 5%	-	0.18	-	0.01	-	0.12

FW= Freshwater, DW= Drainage water

It is widely recognized that inadequate water quality for irrigation is a major contributor to salinization and heavy metal pollution, primarily because of the concentration of salts and heavy metals in the irrigated topsoil combined with ongoing water evaporation. This rise was nearly proportional to the water's salt concentration. The rise in EC could be linked to the elevated evaporation rates during summer, which results in the buildup of salts in the root zone, especially with the ongoing use of drainage water (Ramadan, 1990 and Hwida,2021). The minimum salinity level (Na and K) concentration was obtained when freshwater was used, with no significant difference between freshwater, IFW: IDW and 2FW: IDW treatments.

The concentration of sodium in the soil was linked to the quality of the irrigation water. The availability of potassium, indicated as either soluble or exchangeable K, showed a minor rise with escalating salinity levels in both soil and water. Increasing of soluble potassium under DW may result from either NH^{+4} replacements for exchanged K or release of fixed potassium from soil secondary clay minerals. This explanation was correlated with (Baddesha *et al*, 1997, Zayed, 2002, Mahmoud, 2008 and Mona *et al.,* 2022). The amount of tested micro-elements (Zn, Fe, Mn, Ni, Pb and Cd) as affected by quality Tables (4 and 5), the highest concentration of micro-elements (Fe, Zn, Mn, Ni, Pb and Cd) have found when drainage water was applied.

The lowest concentrations were obtained when freshwater was used in both seasons. The amount of DTPA-extract Fe, Mn, Zn, Ni, Cd and Pb for the different types of waters were in the order of: DW> 1FW: 2DW>1FW:1DW>2FW: 1DW> Freshwater according to the toxic levels recommended by (Cottenie *et al*.,1984). it could beside that, the concentrations of Fe and Mn, under this study were within the normal range, while in case of the concentrations of Zn, Ni, Cd and Pb metals in soil under DW,1FW: 2DW were relatively high and more than the save limits in both seasons. High accumulation of Cd only in the soil paste after rice harvesting had occurred soil under DW and 1FW. 2DW compared with the concentration before planting, heavy metal concentrations would be expected to accumulate in the top layer of the paddy soil after the use of wastewater in irrigation. This may be attributed to capacity of soil sorption. Using drainage water in irrigation substantially increased total heavy metals in the soil than that of canal water. The salinity of water effects is due to a direct influence of ionic strength on solubility the competition of Na with Fe, Mn, Ni, Cd and Pb on the adsorption and sites of soil complex. Some of these elements had decreased compared to their values before planting due to their uptake by plant (Zeng *et al*.,2008, Mera *et al*., 2016 and Howida,2021). Iron concentration in the soil under poor water quality was more available than other elements under study. The high availability of iron is mainly attributed to the changes in the oxidation -reduction potential and reduction of ferric iron to ferrous iron. The same trends were obtained by El- Azab (1997) and Baddesha *et al*,. (1997).

2: Effect of different types of irrigation water on some growth criteria of rice

a: Effect of different types of water

Data of leaf area index, relative growth rate, chlorophyll content, and flag leaf area for certain rice cultivars influenced by water quality and their interactions during the 2022 and 2023 seasons are presented in Tables 6 and 7. Extremely notable impacts on LAI and flag leaf sizes in both seasons were observed, with the maximum values achieved when the rice plants were irrigated with freshwater during the entire season. Nevertheless, the application of drainage water demonstrated lower LAI and flag leaf areas when compared to all other treatments in both seasons. Poor water quality significantly impacted leaf growth, resulting in a decrease in the flag leaf area (Crooks and Prentice 2017).

Table 6. Leaf area index, relative growth rate, chlorophyll content, flag leaf area and light penetration of some rice cultivars as affected by irrigation water quality during 2022 and2023

Treatments	Leaf area index		RGR (g/g/week)		Chlorophyll content (SPAD)		Flag leaf area (cm)		Light penetration (Lux)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
FW	5.96	6.27	0.26	0.35	40.89	41.1	33.2	30.6	2277.6	2292.9
DW	4.23	4.08	0.40	0.49	43.55	43.9	23.1	23.7	3080.1	3294.6
1FW:ID	4.64	5.42	0.33	0.40	41.41	42.0	27.8	29.0	2815.0	2852.4
2FW:1DW	5.84	5.95	0.30	0.37	40.94	41.6	29.1	29.8	2285.5	2293.3
1FW:2DW	4.72	4.72	0.38	0.46	43.10	43.0	24.8	26.1	3019.5	3220.6
L.S.D.5%	0.57	0.62	0.01	0.02	1.28	1.78	2.80	3.90	506.7	477.4
					Rice cultivars (V)					
Giza 183	5.77	5.80	0.34	0.44	41.6	41.2	31.3	30.8	2155.3	2167.5
Giza 178	5.694	5.93	0.33	0.41	42.3	42.9	28.2	28.3	2627.1	2681.0
Sakha 106	3.872	4.10	0.37	0.47	40.6	41.3	23.8	24.9	3102.1	3016.5
Sakha 108	5.426	5.32	0.29	0.33	43.4	43.9	27.1	27.4	2709.1	2688.8
L.S.D.5%	0.13	0.24	0.02	0.02	1.18	0.7	1.50	1.60	574.8	471.8
Interaction	**	**	**	**	**	**	**	**	NS	NS

FW: Freshwater, DW= Drainage water, and = Mixed water

Table 7. Leaf area index, RGR, Chlorophy11 content and flag leaf area as affected by the interaction between water quality and some rice cultivar

Factors	Treatment	Leaf area index		RGR (g/g/week)		Chlorophyll content (SPAD)		Flag Leaf area cm^2	
		2022	2023	2022	2023	2022	2023	2022	2023
Giza 183	FW	6.83	7.18	0.29	0.39	43.08	40.43	42.30	33.54
	DW	4.80	4.35	0.37	0.49	42.13	42.35	23.79	25.22
	1FW:ID	5.68	5.68	0.36	0.43	41.05	41.03	31.12	32.67
	2FW:1DW	6.38	6.68	0.29	0.40	39.85	40.90	32.39	33.47
	1FW:2DW	5.15	5.10	0.37	0.47	41.70	41.20	27.07	29.24
Giza 178	FW	6.38	6.68	0.29	0.35	40.63	41.63	32.02	30.34
	DW	4.91	5.20	0.38	0.48	44.40	44.35	25.86	26.22
	1FW:ID	5.63	5.85	0.35	0.39	41.98	42.40	28.37	29.22
	2FW:1DW	6.35	6.30	0.30	0.38	41.55	41.70	29.42	29.47
	1FW:2DW	5.20	5.63	0.36	0.46	43.08	44.30	25.12	26.27
Sakha 106	FW	4.53	4.85	0.29	0.38	38.30	39.85	27.09	28.49
	DW	2.50	2.62	0.48	0.58	42.28	43.55	18.14	19.10
	1FW:ID	4.20	4.40	0.33	0.44	40.15	40.73	24.87	26.02
	2FW:1DW	4.53	4.68	0.34	0.42	39.23	40.40	26.49	27.02
	1FW:2DW	3.60	3.95	0.42	0.53	42.93	41.85	22.34	23.64
Sakha 108	FW	6.23	6.38	0.17	0.29	41.53	42.38	31.32	29.94
	DW	4.70	4.15	0.37	0.39	45.40	45.30	24.52	24.12
	1FW:ID	5.15	5.75	0.29	0.32	42.45	43.83	26.92	28.14
	2FW:1DW	6.10	6.15	0.26	0.29	43.13	43.28	28.28	29.42
	1FW:2DW	4.95	4.18	0.36	0.36	44.68	44.55	24.59	25.13
L.S.D. 5%	-	0.42	0.32	0.02	0.03	1.9	2.01	4.43	4.25

FW= Freshwater, DW= Drainage water, and = Mixed water

The greatest values of chlorophyll content and light penetration in both seasons were obtained with drainage water. The rise in RGR and chlorophyll content under poor water quality stress could be attributed to heightened physiological processes in rice plants (Bhat *et al.,* 2019). Increased chlorophyll levels in drainage water may be attributed to a deficiency of leaf area, similar findings were noted by (Gaballah *et al*., 2016). The rise of light penetration (Lux) under drainage water might be attributed to the decrease in plant height, number of tillers/m^2. These results concerning the impact of water quality on growth characteristics were reported by (Zeng-LingHe *et al.,* 2000, Abdel- Fattah, 2013, Abdel-Hafez *et al.,* 2017).

b: Performance of rice varieties:

Notable varietal variations were reported concerning leaf area index (Table 6). Giza 183 exhibited the greatest values for leaf area index and flag leaf area, showing no significant difference compared to Giza 178 on the other hand, Sakha 106 displayed the lowest values for LAI and flag leaf area in both seasons, respectively. The low LAI and flag leaf area of Sakha 106 could be attributed mainly to the significant effect of bad water quality on plant growth and leaf area because the fact that the variety has a low leave area compared with other cultivars (Howia.,2021). RGR increased in Giza183 without significant differences with sakha106 in both seasons concerning chlorophyll content it was greatly varied among the four rice cultivars (Giza 183 and 178, Sakha 106 and 108) in both seasons. Data revealed that Sakha 108 exhibited the highest chlorophyll content, with Giza 178 following closely behind. Conversely, Sakha 106 rice variety showed the least amounts of chlorophyll content. The data clearly indicate a negative correlation between chlorophyll levels and leaf size. A comparable trend was observed by Abd El-Wahab (1998), Abou Khalifa (2001), Zayed (2002), and Abdel-Fattah, (2013). Notable variations were observed among the rice cultivars concerning light penetration (Lux) across the two seasons. The minimum light penetration values were observed in Giza 183, followed by Giza 178, whereas Sakha 106 exhibited the highest light penetration values (Lux) during both seasons.

c: The interaction effects:

Interaction between water quality and rice varieties significantly affected leaf area index, relative growth rate, chlorophyll content, and flag leaf area (Table 7). The greatest LAI values were generated by Giza 178 under irrigation treatment 2FW: 1DW without significant difference with1FW: 1DW. The lowest LAI values were generated by Sakha 106 under poor water quality. These findings might be due to Sakha 106 lesser performance under drainage water stress compared to the other varieties examined. Giza 183 secured the second position behind Giza 178, likely due to its capacity to counteract the negative impacts of poor water quality. Concerning RGR, the greatest values under unfavorable water conditions were recorded by Sakha 106. The lowest RGR values were recorded by Sakha 108 under poor water quality, without statically differences with Giza 178 in both seasons. Data indicated that poor-quality water affects other cultivars more than Giza 183 and Giza 178, which may be encouraging since both cultivars show greater tolerance to salinity and other adverse effects compared to other varieties. The interaction of water quality and rice cultivars had notable effects on chlorophyll content across both seasons in (Table 7). Sakha 108 exhibited the highest chlorophyll content when exposed to poor water quality, followed by Giza 178. The lowest chlorophyll content was found in Giza 183 when it was irrigated with drainage water. This could be due to the poor quality of water characterized by elevated salt concentrations and a high SAR value, which impacts leaf area and has an adverse correlation with chlorophyll content.

These results agree with Gaballah *et al*. (2016). Regarding the relationship between water quality and rice cultivars on the flag leaf area, the greatest flag leaf area values were observed in Giza178 when exposed to poor water quality. Conversely, Sakha 106 exhibited the smallest flag leaf area when exposed to low water quality. The results gathered indicated that Giza183 and Giza 178 exhibited greater stability in poor quality water compared to the other cultivars examined.

3: Heading date, yield attributes and yield

a Effect of different types of water

Heading date, plant height(cm), and number of panicles/m² of some rice cultivars as affected by irrigation water quality as well as their interaction are presented in Tables (8-10). Number of days to heading was significantly affected by water quality, freshwater significantly increased days from sowing to heading followed by 2FW: 1DW, while DW decreased the heading date in both seasons. This is due to the fact that salt in drainage water depresses growth more strongly than freshwater. Plant height (cm) was affected by types of water in 2023 season only, poor water quality stress sharply decreased plant height (cm), and no significant difference was obtained between freshwater treatment, 1FW:1DW and 2 FW:1DW treatments.

The findings and the current discussion undoubtedly validate that drainage water has a greater impact on rice in terms of growth characteristics. Water quality had a clearly significant impact on the number of panicles per square meter during the 2022 and 2023 seasons. The greatest number of panicles was recorded when rice plants were irrigated with freshwater throughout the entire growing season, followed by a ratio of 2FW: 1DW. The smallest values were noted from drainage water treatment, with 1FW: 2DW following closely.

Data suggested that there was no notable difference between freshwater treatment and 2FW:1DW during both seasons. It seems that poor water quality affected plant growth and number of panicles as a first step for reducing yield. greatly raised the amount of unfilled grain as it was increasingly exposed to subpar water quality. The greatest percentages of unfilled grains were recorded in rice plants that were irrigated with drainage water during the entire growing season. In the meantime, freshwater resulted in the lowest amounts of unfilled grains, closely followed by the 2FW:1DW treatment during both seasons. This indicated the vulnerability of the pollination phase to stress caused by poor-quality water.

Table 8. Heading date, plant height(cm), number of panicles m^{-2} of some rice cultivars as affected by various irrigation water quality during 2022 and 2023 seasons.

Treatments	Heading date /day		Plant height (cm)		Number of Panicles/m²	
	2022	2023	2022	2023	2022	2023
Water quality (1)						
FW	98.75	100.75	102.95	102.24	435	464
DW	95.31	96.41	98.91	93.62	368	424
1FW:ID	97.96	100.19	102.30	101.29	406	451
2FW:1DW	98.28	100.56	101.82	99.88	429	451
1FW:2DW	95.81	97.75	99.46	98.79	376	438
L.S.D.5%	1.15	1.16	-	2.75	35.6	37.34
Rice cultivars (V)						
Giza 183	95.42	96.94	95.09	95.17	413	455
Giza 178	97.21	100.02	99.63	96.93	416	480
Sakha 106	91.33	91.92	114.49	110.83	373	381
Sakha 108	104.75	107.10	94.72	93.81	389	447
L.S.D.5%	1.00	1.29	1.65	2.16	15.2	15.77
Interaction	Ns	Ns	Ns	Ns	Ns	Ns

FW= Freshwater, DW= Drainage water, and = Mixed water

Table 9. Unfilled grain %, panicle weight and 1000-grain weight of some rice cultivars as affected by irrigation water quality during2022 and 2023 seasons

Treatments	Unfilled grain%		Panicle weight (g)		1000- grain weight (g)	
	2022	2023	2022	2023	2022	2023
Water quality (1)						
FW	6.05	6.03	3.51	3.49	24.64	24.59
DW	8.64	8.62	2.84	2.81	22.02	21.96
1FW:ID	7.03	7.01	3.49	3.47	24.57	24.32
2FW:1DW	5.74	5.72	3.63	3.61	24.39	24.10
1FW:2DW	8.14	8.10	2.95	2.92	22.45	22.55
L.S.D.5%	0.43	0.76	0.20	0.30	0.71	0.63
Rice cultivars (V)						
Giza 183	7.44	7.40	3.41	3.38	24.45	24.22
Giza 178	6.72	6.70	3.46	3.44	20.12	20.01
Sakha 106	5.57	5.54	2.57	2.55	24.86	24.81
Sakha 108	8.75	8.73	3.69	3.66	25.02	24.97
L.S.D.5%	0.66	1.39	0.19	0.23	1.18	1.02
Interaction	*	*	*	*	*	*

FW= Freshwater, DW= Drainage water,

Table 10. Panicle weight, unfilled grain and 1000-grain weight as affected by the interaction between water quality and some rice cultivar

Cultivars	Water quality	Panicle weight (g)		Unfilled grain (%)		1000-grain weight (g)	
		2022	2023	2022	2023	2022	2023
Giza 183	FW	3.09	3.07	6.12	6.10	25.51	25.45
	DW	2.91	2.88	8.17	8.15	22.71	22.65
	1FW:ID	3.92	3.89	7.00	6.97	25.01	24.50
	2FW:1DW	4.01	3.99	7.24	7.23	25.01	24.00
	1FW:2DW	3.11	3.07	8.67	8.56	24.01	24.50
Giza 178	FW	3.81	3.78	5.92	5.90	20.51	20.50
	DW	3.19	3.16	7.54	7.52	19.14	19.10
	1FW:ID	3.44	3.44	6.87	6.85	21.41	21.00
	2FW:1DW	3.61	3.61	5.00	4.97	20.26	20.22
	1FW:2DW	3.26	3.22	8.27	8.25	19.26	19.23
Sakha 106	FW	3.01	3.01	4.87	4.85	26.76	26.70
	DW	2.15	2.12	7.25	7.23	22.13	22.07
	1FW:ID	2.64	2.61	6.44	6.42	26.46	26.41
	2FW:1DW	2.86	2.83	4.57	4.55	26.51	26.45
	1FW:2DW	2.21	2.19	4.70	4.67	22.44	22.40
Sakha 108	FW	4.14	4.11	7.29	7.27	25.76	25.70
	DW	3.11	3.07	11.59	11.57	24.08	24.00
	1FW:ID	3.96	3.93	7.81	7.79	25.39	25.35
	2FW:1DW	4.03	4.00	6.14	6.12	25.76	25.74
	1FW:2DW	3.22	3.20	10.92	10.90	24.10	24.07
	L.S.D.5%	0.57	0.56	2.45	2.42	2.09	2.06

Data gathered on panicle weight indicates that poor water quality significantly reduced the panicle weight. The largest panicles were generated when rice plants were irrigated with freshwater, followed by the 2 FW: DW treatment. The lightest panicles were observed when rice plants received irrigation from drainage water in both seasons, respectively. The highest 1000-grain weight was observed when rice plants were supplied with freshwater. Decreasing 1000-grain weight under drainage water treatment could be attributed to elevated osmotic potential, reduced supply of assimilates to the sink, and heightened competition among spikelets, leading to lighter grains and partially filled grains. Various researchers, including several workers, have reported the negative impact of poor quality of irrigation water on yield attribute characters such as: Cabrera *et al.* (1988), Wang and Yan (1990), Sarkunan *et al.* (1991), Maria (1992), El Sayed (1998) Xu *et al.* (2001) and Abdel –Fattah, (2013).

b: Performance of rice varieties:

Days to heading were greatly varied among the four rice cultivars (Giza 183 and 178, and Sakha 106 and 108) and their performance during alternative seasons. It was clear that Sakha 106 was the earliest variety followed by Giza183. Meanwhile, Sakha 108 rice variety was the latest in heading followed by Giza 178. Notable variations were observed among the rice cultivars examined in terms of plant height (cm) across two seasons. Sakha 106 yielded the highest plants, whereas Sakha 108 yielded the lowest plants. Notable variations were found among the rice cultivars examined in terms of the number of panicles per m² across both seasons (Table 8). Giza 178 variety recorded the greatest number of panicles per square meter. followed by Giza183, Sakha180 occupied the third rank, while Sakha 106 gave the lowest number of panicles. Achieving maximum grain yield could be possible with increasing tillers, panicles with high spikelet's fertility. Sakha 106 recorded the lowest amounts of unfilled grain in both seasons, with Giza 178 following in both seasons. Sakha 108 variety produced the greatest percentages of unfilled grains. Giza 178 exhibited the heaviest panicles in the first and second study seasons, while Sakha 106 showed the lightest panicle. Likewise, the differences between varieties could be attributed to genetic composition. It is worth noting that stress significantly reduced the panicle weight of Sakha 106 due to its vulnerability in unfavorable conditions. Sakha 108 had the highest 1000-grain weight, while Giza 178 showed the lowest 1000-grain weight in both seasons. Typically, the differences in varieties could be attributed mainly to genetic composition and partly to environmental factors, with poor quality water being one of those. A comparable direction was discovered by Gorgy ,1998 and Gaballah *et al*.,2016).

c: The interaction effects:

The interaction between the two factors significantly influenced panicle weight, unfilled grain, and 1000-grain weight (Table 10). The earliest genotype was Sakha 106 under poor water conditions. Giza 183 secured the second position behind Sakha 106 during both seasons. Conversely, Sakha 108 was the most recent one to experience poor water quality. Sakha 108 generated the greatest amounts of unfilled grain despite poor water quality. Conversely, Sakha 106 produced the least unfilled grain when exposed to poor water quality. Giza 178 yielded the heaviest panicle when irrigated with drainage water. The same pattern was observed with 1FW: 2DW and Sakha 106 yielded the lightest panicle under equivalent water conditions. Sakha108 produced the heaviest 1000-grain weight under poor quality water. The same results were obtained under IFW: 2DW in both seasons. Giza 178 gave the lightest 1000-grain weight under the other water qualities used. from previous results Giza178 was the best under poor quality of irrigation water followed by Giza183 then Sakha108, meanwhile, Sakha106 came in the last order.

4: Yields and harvest index

a: Effect of different types of water

Information in Tables 11 and 12 indicated that water quality significantly influenced grain yield in both seasons.

The greatest grain yield was achieved when plants received freshwater, succeeded by the 2FW: 1 DW treatment. The lowest values were recorded when plants were given only drainage water throughout all seasons. Additionally, there were notable differences in grain yield across water qualities, except between the freshwater and 2 FW: 1 DW treatments in both seasons. The decrease in yield caused by utilizing various water qualities in each season to correspondingly (1 FW: 1DW, 2FW.1DW, 1FW:2DW, and DW) were (0.89-3.6), (5-8.9), (13.5-16.7), and (16.8-23.2%) relative to freshwater. It was noted that the decrease with using 1FW: 2DW, and DW was greater than that of IFW, IFW: 1DW, and 2FW: 1DW treatments. This could be attributed to poor-quality irrigation water that had various salt forms and elevated sodium levels, which hinder growth and disrupt the translocation of assimilates to the sink. Furthermore, the drainage water had elevated levels of heavy metals, oils, and various other chemicals, which impact growth development. The grain yield increased by using 2 FW: 1DW treatments due to the improvement in growth characteristics especially the number of panicles at maturity as well as, in most yield attributes such as the filled grain percentage,1000-grain weight and panicle grain weight. The study indicated that 2FW:1DW treatments It was noted that the decrease with using 1 FW: 2 DW and DW was greater than that of IFW, IFW: 1 DW, and 2 FW: 1 DW treatments. This could be attributed to poor-quality irrigation water that had various salt forms and elevated sodium levels, which hinder growth and impedes the translocation of assimilates to the sink. Moreover, the drainage water had elevated levels of heavy metals, oils, and various other chemicals, which impact growth development. The highest values of harvest index in both seasons respectively were obtained when freshwater was used throughout the season. Nonetheless, the application of drainage water treatment demonstrated lower effectiveness in harvest index compared to all other treatments, yielding the least value of harvest index. These data align well with those documented by Wang and Yan (1990), Sarkunan *et al.,* (1991), Maria,(1992), El Sayed, (1998) and Hossain *et al*., (2020).

Table 11. yields and harvest index of some rice cultivars as affected by irrigation water quality

Treatments	Grain yield t ha^{-}				Straw yield t ha^{-1}		Harvest index	
	2022	Reduction %	2023	Reduction %	2022	2023	2022	2023
Water quality (1)								
FW	9.74	-	10.72	-	12.50	12.58	0.44	0.45
DW	8.06	16.8	8.40	23.2	10.77	11.08	0.42	0.44
1FW:ID	9.24	5.00	9.83	8.90	12.21	12.88	0.43	0.44
2FW:1DW	9.66	0.89	10.37	3.53	12.39	12.73	0.44	0.45
1FW:2DW	8.39	13.57	9.05	16.7	11.61	11.71	0.43	0.44
L.S.D.5%	0.44		0.60	-	-	1.21	-	-
Rice cultivars (V)								
Giza 183	9.53		10.34		11.77	11.78	0.44	0.45
Giza 178	9.70		10.57		11.82	11.73	0.44	0.45
Sakha 106	7.77		7.83		10.91	10.36	0.41	0.42
Sakha 108	9.07		9.94		12.09	12.79	0.43	0.44
L.S.D.5%	0.32		0.52			0.86	0.02	0.01
Interaction	**		**		Ns	Ns	*	*

FW=Freshwater, DW =Drainage water

Table 12. Grain yield and Harvest index as affected by the interaction between water quality and rice cultivars

Cultivars	Water quality	Grain yield (t/ha)		Harvest index	
		2022	2023	2022	2023
Giza 183	FW	10.0	11.2	0.47	0.48
	DW	8.83	9.47	0.39	0.42
	1FW:ID	9.60	10.5	0.45	0.46
	2FW:1DW	10.2	10.8	0.46	0.46
	1FW:2DW	8.90	9.58	0.43	0.45
Giza 178	FW	10.2	11.2	0.45	0.46
	DW	8.97	9.87	0.44	0.45
	1FW:ID	9.86	10.7	0.44	0.45
	2FW:1DW	10.0	10.9	0.45	0.46
	1FW:2DW	9.38	10.1	0.44	0.45
Sakha 106	FW	8.56	8.83	0.39	0.42
	DW	6.93	6.55	0.42	0.44
	1FW:ID	7.81	7.55	0.40	0.41
	2FW:1DW	8.27	8.80	0.42	0.43
	1FW:2DW	7.28	7.43	0.41	0.42
Sakha 108	FW	10.1	11.5	0.44	0.45
	DW	7.50	7.70	0.42	0.43
	1FW:ID	9.70	10.5	0.43	0.44
	2FW:1DW	10.0	10.9	0.43	0.44
	1FW:2DW	7.98	9.08	0.42	0.44
L.S.D.5%		1.13	1.34	0.04	0.02

b: Performance of rice varieties

The data on grain yield in Table 11 indicated that notable differences existed among the rice cultivars examined during both seasons. Giza 178 produced the top grain yield in both seasons, showing no significant differences from Giza 183. Sakha 106 produced the lowest grain yield in both seasons. Varietal differences in grain yield t/ha could be mainly attributed to the genetic background and the differences in their response to bad quality of water. The submergence with poor quality of water (saline water) reduced the filled spikelets percentage, and decreased the number of panicles and 1000 grain weight. Yield reduction in rice may be revealed to some bad water characteristics such as increased SAR and osmotic pressure. The adverse effect of drainage water is mainly due to higher SAR and salts which effect on plant quality and disturb the physiological process and physiological availability of water to plant, and accumulation of toxic ions (Na, Cd, Ni and Pb) in the plant. The straw yield data indicated that there were notable differences among rice cultivars examined in the second season. Sakha108 rice variety yielded the most straw, followed by Giza 178, whereas Sakha 106 rice variety produced the least straw yield in both seasons. Additionally, the findings indicated that there was no notable difference between the 178 and Giza 183 varieties across both seasons. The poor straw yields of Sakha 106 result from its inferiority in these conditions. Giza 183 showed the highest harvest index values, whereas Sakha 106 produced the lowest harvest index values. There was no notable difference between Sakha 108 and Giza 178 during either season. These results were consistent with those documented by Wang and Yan (1990), Sarkunan *et al.,* (1991), Maria, (1992), Howida, (2021) and Mona,(2022).

c: The interaction effect

The interaction between water qualities and rice varieties had a notably significant impact on grain yield in both growing seasons (Table 12). Giza 178 achieved the top grain yield in both seasons with poor quality water, and a similar pattern was observed under 1FW; 2DW during both seasons. Sakha 106 generated the smallest grain yield compared to the other water qualities. Concerning the interaction between water qualities and rice cultivars on harvest index, Giza 178 yielded the highest harvest index despite poor water quality. Giza183 and Giza 178 exhibited more consistent performance under poor quality water compared to the other rice cultivars tested.

6.Mineral composition and heavy metal of rice plants in relation to water quality

a: Effect of different types of water

The information in Tables 13 and 14 indicated that water qualities significantly influenced K, Na, Zn, Fe, Mn, Ni, Cd, and Pb in rice grains during both the first and second seasons. The least amounts of potassium in grain were recorded with the use of drainage water, then with 1FW: 2DW, whereas the greatest levels of K were observed with the application of freshwater. Data also, indicated that there was no significant difference between freshwater and 2FW: 1DW. Potassium, an essential monovalent nutrient for plants, has important functions in membrane transport processes as well as in maintaining ionic and osmotic balance in cells, especially in saline environments. Raising the osmotic pressure and salinity of water results in noticeable decreases in K concentration (Atwa, 1999 Howida, 2021and Zayed *et al.*,2024).

The greatest sodium percentage in rice grain was achieved through the use of drainage water treatment and IFW: 2DW, whereas the lowest sodium % in grain resulted from using freshwater during the entire growing season. Additionally, data indicated that there was no significant difference between freshwater and 2FW. 1DW regarding Na content treatments during both seasons. The outcomes noted above are linked to the opposing interactions between K^+ and Na^+ in either the soil solution or in the plant tissues. The levels of K and Na in rice grains varied significantly based on the composition and type of water used (Zayed 2002, Mera et al., 2016). The earlier findings showed that the rise in drainage water (poor quality water) elevates the Na concentration in rice grains and enhances the salinization of the soil solution.

Table 13. K%, Na% Zn and Fe content in rice grains as affected by irrigation water quality during 2022 and 2023seasons

Treatments	K%		Na%		Zn ppm		Fe ppm	
	2022	2023	2022	2023	2022	2023	2022	2023
Water quality								
FW	0.47	0.47	0.10	0.11	94.55	96.73	88.5	83.5
DW	0.44	0.44	0.11	0.12	92.68	94.85	94.1	87.1
1FW:ID	0.37	0.38	0.11	0.12	76.05	78.88	111.5	109.4
2FW:1DW	0.32	0.32	0.12	0.16	69.51	75.47	124.0	124.5
1FW:2DW	0.28	0.27	0.13	0.16	68.93	72.56	131.8	128.8
L.S.D.5%	0.03	0.04	0.01	0.01	1.73	1.93	7.96	5.48
Rice cultivars								
Giza 183	0.38	0.38	0.12	0.13	80.20	84.92	105.39	103.17
Giza 178	0.41	0.41	0.11	0.13	85.19	86.06	113.00	111.94
Sakha 106	0.34	0.35	0.12	0.14	74.57	75.48	110.61	103.17
Sakha 108	0.45	0.44	0.11	0.13	85.57	90.31	109.94	108.39
L.S.D.5%	0.04	0.06	-	-	2.57	2.56	-	-
Interaction	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

FW= Freshwater, DW =Drainage water

Table 14. Mn, Ni, Cd and Pb content of rice grains as affected by irrigation water quality and rice cultivars during 2022 and 2023seasons

Treatments	Mn ppm		Ni ppm		Cd ppm		Pb ppm	
	2022	2023	2022	2023	2022	2023	2022	2023
Water quality (1)								
FW	92.75	63.2	0.97	1.05	0.13	0.17	0.60	0.45
DW	95.25	115.50	1.61	169	0.37	0.52	0.98	1.18
1FW:ID	69.33	68.17	1.13	1.25	0.17	0.22	0.67	0.51
2FW:1DW	64.33	64.25	1.09	1.17	0.16	0.21	0.64	0.49
1FW:2DW	88.67	101.25	1.55	1.63	0.29	0.43	0.92	1.09
L.S.D.5%	4.12	6.32	0.27	0.04	0.02	0.02	-	0.02
Rice cultivars (V)								
Giza 183	74.56	71.00	1.39	1.47	0.26	0.36	0.74	0.81
Giza 178	76.61	82.44	1.18	1.26	0.19	0.29	0.71	0.74
Sakha 106	74.99	73.17	1.62	1.70	0.25	0.35	0.82	0.86
Sakha 108	81.78	101.06	0.95	1.06	0.18	0.28	0.70	0.73
L.S.D.5%	2.11	3.26	0.11	0.06	0.03	0.03	-	-
Interaction(IxV)	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

FW= Freshwater, DW =Drainage water

Utilizing freshwater throughout the entire growing season leads to Na^+ leaching from the root zone, resulting in decreased Na^+ levels in both straw and grain. Naeem et al., (2012) indicated that the use of low-quality water raises sodium percentages in grains. The rise in Na^+ concentration in drainage water is due to elevated Na^+ levels in the soil solution when using drainage water treatment, which is regarded as a significant factor influencing Na content within the plant (Naeem et al.,2012 Zayed et al.,2024).

Data in Table (13) showed that there is a significant different between water quality on Zn and Mn concentration (ppm) in rice grain in both seasons. The highest concentration of Zn and Fe in grain were obtained when plants irrigated with freshwater overall the seasons. The lowest concentration of Zn and Fe in grain were found when plants were received drainage water overall seasons. Zn and Fe (ppm) concentration in grains followed this order FW > 2FW: IDW > IFW: IDW> IFW: 2DW>DW respectively. Data showed that the concentration of Zn and Fe differed according to the type and composition of applied water it's may attributed to that zinc under the high level of pH, was unavailable for rice roots. Also, inhibition of Zn absorption due to the competition by cations added with drainage water. Also, because the previous crop is clover (Legume), so the soil phosphorus enhances zinc adsorption by hydrous oxides of iron and aluminum. The prior findings suggested that with drainage water (bad water quality) processes increase soluble Fe in the soil solution and are absorbed by rice roots. El- Azab et al (1997), Atwa, (1999) and Naeem et al. (2012) stated that poor quality of irrigation water increased Zn and Fe (ppm) in the whole plant. With respect to Mn, Ni, Cd and Pb, the highest concentration of them in grain was associated with applied drainage water through the seasons, while the lowest concentration in grains was found where plants were irrigated with freshwater through the growth season. These results indicated that the concentration of Mn, Ni, Cd and Pb differed according to the type and composition of applied water, and followed this order DW > 1FW:2DW >>IFW: IDW> 2FW: IDW>FW respectively. The concentrations of Ni in rice plant growing in non-contaminated soil are generally in the range 0.1-5 ppm, the previous results indicated that drainage water increased soluble Cd in the soil solution and was absorbed by rice root. Applying freshwater, which contains less soluble heavy metals, reduced Cd concentration in the soil solution and decreased the Cd concentration in rice grains. While Cd toxicity can affect plants in various contaminated soils, its presence in food crops at non-phytotoxic levels raises more alarm because of the potential for higher dietary exposure in consumers. Even mildly increased Cd levels in foods can notably impact health over the long term. Fairly significant levels of Cd can build up in edible parts without the plant exhibiting signs of distress. Ultimately, the quantity of Cd absorbed by plants is influenced by a mix of soil and plant elements. These patterns were akin to those documented by (El-Sayed, 1998, Carlton-Smith, 1999, Glance, 2001, Zeng *et al.,*2008 and Florance *et al.,* 2021).

b: performance of different rice varieties:

The greatest Na content in grain was observed in Sakha 106, succeeded by Giza 183, whereas the least Na % in grain was found in Giza 178. The findings further indicated that Sakha 108 exhibited an intermediate position. This may clarify why Giza 178 is more resilient to poor conditions compared to Sakha 106, which is more responsive to unfavorable conditions. The greatest levels of Zn in grain were achieved by Sakha 108, with Giza 178 coming next. However, the lowest values of Zn (ppm) were obtained by Sakha 106.The highest concentrations of Mn in grain were obtained by Sakha 108 followed by Giza 178, while the lowest values of Mn (ppm) were obtained by Sakha 106. Ni in grain was with high concentration was found in Sakha 106 followed by Giza 183. The lowest values of Ni(ppm) were found in Giza178. The highest concentrations of Cd (ppm) were observed in Giza 183. Sakha 106 had the lowest Cd levels in the grain. Thus, it seems that the accumulation of Cd in plant tissue and grain strongly differs according to the concentration of the metal and rice cultivars itself in addition to soil parameters. No significant difference had been observed among tested rice varieties with respect to Pb content in rice grains the result is in harmony with those reported by Shehata (1995), Howida, (2021) and Mona *et al.,* (2022).

CONCLUSION

In conclusion, due to limited water resources and inadequate water for rice cultivation, the 2FW: 1DW treatment is both economical and suitable for irrigating rice. Additionally, Giza 183 and Giza 178 rice varieties exhibit greater stability under drainage water compared to other cultivars, along with their ability to decrease heavy metals in grains.

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تأثير نوعيات مختلفة من مياه الري على جودة التربة وتركيز العناصر الثقيلة فى الحبوب وانتاجية بعض اصناف الأرز

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الملخص

أقيمت تجربتان حقليتان خلال موسمي صيف 2022 و2023 فى مزرعة مركز البحوث والتدريب في الأرز بسخا كفر الشيخ مصر لدراسة سلوك بعض أصناف الأرز وتقييم إنتاجيتها تحت ظروف استخدام أنواع مختلفة من جودة مياه الري وخاصة مياه الصرف الزراعي كأحد الحلول الملحة لحل مشاكل المياة فى مصر واستخدم فى هذه التجربة تصميم الشرائح المتعامدة ذو أربع مكررات ووزعت أنواع مياة الري فى القطع الأفقية كالتالي:- 1-مياة نقية طوال موسم الزراعة. 2- مياه صرف زراعي طوال موسم الزراعة 3 - مياه مخلوطة (مياة نقية مع مياه صرف بنسبة1:1). 4 – رية واحدة مياة نقية: ريه واحدة مياة صرف زراعي5 - ريتين مياه نقية :ريه واحدة مياه صرف .-6- رية واحدة مياه نقية: ريتين مياه صرف زراعى .ووزعت ألأصناف (جيزة و183جيزة و178سخا106وسخا 108) على الشرائح الرأسية وكانت أهم النتائج المتحصل عليها كالتالي: وجد أن معاملات جودة مياه الري اظهرت تأثيرا معنويا على صفات النموو المحصول ومكوناته حيث وجد أن استخدام مياه الصرف فى الري طوال موسم الزراعة يقلل صفات النمو والمحصول ومكوناته وكانت أعلى القيم المتحصل عليها من تلك الصفات المذ كورة تحت ظروف الغمر المستمر بمياه نقيه، بينما أقلها كان تحت ظروف الغمر المستمر بمياة الصرف أورية واحده بمياه نقيه :ريتين مياه صرف .وكان الصنفين جيزه183وجيزة178 أعلى الأصناف فى القيم المتحصل عليها .وجد أن معاملات جودة مياه الري لها تأثير على تركيز البوتاسيوم والصوديوم ونسبة الصوديوم إلى البوتاسيوم فى الحبوب حيث أعطى الري بمياه الصرف أقل القيم لنسبة البوتاسيوم بينما أعطى قيما أعلى لكل من الصوديوم، ونسبة الصوديوم إلى البوتاسيوم فى الحبوب فى كلا الموسمين. أما فى حالة إستخدام المياه العذبة فقد أعطت أعلى قيم لنسبة البوتاسيوم فى الحبوب .ووجدت أقل نسبة للصوديوم وأعلى نسبة للبوتاسيوم لدى الصنف جيزة 183يليه الصنف جيزه178.وجد أن معاملات جودة مياه الري لها تأثيرعلى تركيز الحديد والمنجنيز والزنك والنيكل والكادميوم والرصاص فى الحبوب حيث أدى إستخدام مياه الصرف الي زيادة تركيز العناصر في الحبوب أكثر من النباتات المرويه بالمياه النقيه وقد كان الصنف جيزه 178 فى كلا الموسمين هو الأقل تركزا من هذه العناصر ويليه الصنف سخا 108 فى الحبوب . وبالنسبة لسلوك الأصناف فقد اختلفت فيما بينها فقد كان الصنف جيزه 183والصنف جيزة 178 أفضل الأصناف تحت الظروف الغير ملائمة ويليهما الصنف سخا 108 وأكدا مدى قدرتهما العالية على تحمل الظروف غير الملائمة بينما أظهر الصنف سخا 106 عدم قدرته على تحمل الظروف غير الملائمة .وعليه يمكن أن نعطى ريه من مياه الصرف وريتين من المياه العذبه دونما مخاطر وذ لك فى بعض الأماكن التي تعانى مشاكل فى نقص المياه الجيدة للزراعه أو فى نهايات الترع.