Effect of irrigation regimes and potassium foliar spraying on some quinoa cultivars in sandy soils.

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ABSTRACT:

Field trials were conducted in the Al-Husein Society, a 64km stretch along the Cairo-Alexandria desert road in Giza Governorate, Egypt, during the 2021/2022 and 2022/2023 seasons. These experiments aimed to evaluate the impact of irrigation regimes (800, 1000, and 1200m^3/fed) and potassium foliar spraying (control, 0.5 and 1g/L) on two quinoa cultivars (*Chenopodium quinoa* willd.) grown in sandy soils. Results indicated that there were significant differences among irrigation regimes, potassium foliar spraying, and quinoa cultivars for various plant traits, including branch count, spike length, spike count, thousand-grain weight, grain yield, harvest index, and protein content. Quinoa plants irrigated with 1200m^3/fed and treated with 1g/L potassium foliar spray, exhibited consistently the most favorable outcomes for all studied traits with chipaya cultivar in both seasons. While, interactions between the studied parameters were not significant for branch count, thousand-grain weight, and harvest index in either season, as well as for spike length in the second season only. In contrast, grain yield, spike count, and protein content were significantly influenced by the interactions between these parameters in both seasons. In general, the results recommended that the appropriate amount of water for irrigation quinoa plants should be 1200m^3/fed. They also recommended the importance of foliar spraying with potassium, in addition to the superiority of the chipaya cultivar in grain productivity and quality under the sandy soil conditions prevailing in Egypt.

Keywords: *chenopodium quinoa*; foliar application of potassium; water amounts; productivity; protein.

INTRODUCTION

Quinoa, a nutritional powerhouse, offers a promising solution for sustainable agriculture in arid regions. Its high protein content (14-22%) surpasses that of traditional cereals (7-14%), and its optimal balance of essential amino acids and minerals like iron (19.8mg/100g) make it a valuable dietary addition. To address the challenge of water scarcity in agriculture, quinoa's ability to thrive under deficit irrigation conditions is particularly noteworthy. Potassium plays a crucial role in enhancing water use efficiency by regulating over 80 enzymes within the plant. Cultivar selection and its interaction with environmental factors significantly impact quinoa's performance. Studies have consistently demonstrated variations in yield components among different genotypes. For instance, the Regalona cultivar exhibited superior growth, productivity, and water stress tolerance in Mediterranean environments (Pulvento *et al*., 2010). In Egypt, the CICA-17 variety outperformed others in terms of yield, while Ollague struggled under severe water stress (Al-Naggar *et al*., 2017). Similarly, the Q-37 cultivar demonstrated exceptional traits in the Ras Sudr region (El-sayed *et al*., 2018). Quinoa cultivation environments in Egypt are characterized by great variability. Therefore, evaluation of yield reliability conducted depending on drought tolerance indices and stability of tested genotypes as estimated by grain yield and the data showed that line 14 of the tested genotypes excel in the grain yield and stability parameters, whereas chipaya genotype showed the best performance under high drought stress conditions (Badran 2022). Regarding irrigation practices, quinoa's water requirements during the main growing season (September-April) in Bolivia average 4-6.2mm/day (Geerts *et al*., 2008). Research indicates that quinoa is tolerant to soil drying during seed filling, allowing for flexible irrigation strategies. Studies have shown that quinoa can yield satisfactorily with varying irrigation amounts, ranging from 166mm/ha to 279.2mm/ha, depending on soil type and irrigation timing (Razzaghi *et al*., 2012).

Sezen *et al*. (2016) reported that irrigation rates ranged from 320 to 514 millimeters per hectare in 2014 and from 228 to 49 millimeters per hectare in 2015. In the Mediterranean region of Turkey, fully irrigated quinoa crops, particularly those using sprinkler irrigation, exhibited significant improvements in yield and yield components. The amount of water requirements of quinoa crop less than that of wheat crop where, the calculation of water requirements of quinoa plant (ET) during the period from 30 December to 17 March was 3029.25 m^3/ha (Algosaibi *et al.,* 2017)

Cea *et al*. (2021) found that the Cahuil quinoa genotype, when irrigated with 100% of available water, consistently outperformed those receiving 70%, 40%, and 20% irrigation in both growing seasons in Chile. Additionally, AL-Tamimi *et al*. (2024) reported that irrigation rates between 600 and 700 millimeters per hectare yielded the most favorable results for various traits in quinoa grown in the United Arab Emirates. Beltran *et al*. (2021) determined that quinoa requires 12.5 to 25 kilograms of potassium oxide (K_2O) per ton of total biomass produced, especially when irrigated at 100% of crop evapotranspiration (ETC). Minh *et al*. (2022) further emphasized the positive impact of potassium on quinoa yield, yield components, and quality attributes. In Vietnam, applying 105 kilograms of K_2O per hectare resulted in optimal quinoa production. Therefore, this study aimed to explore the effects of various irrigation practices and foliar potassium applications on yield, yield components, and protein content in quinoa grains grown on sandy soils in Egypt.

MATERIALS AND METHODS

Field experiments were conducted during the 2021-2022 and 2022-2023 seasons to evaluate the impact of irrigation regimes and potassium foliar sprays on two quinoa cultivars (*Chenopodium quinoa* willd.). The trials were carried out at the AL-Husin Society for Reclaiming and Cultivating Land, located 64 km from Cairo on the Alexandria Desert Road. A split-split plot design with three replications was employed. The experiment involved three irrigation regimes (800, 1000, and 1200 cubic meters per feddan.), three potassium foliar spraying concentrations (control, 0.5, and 1gram per liter), and two quinoa cultivars (Chipaya and Q5). Irrigation regimes were assigned to main plots, while potassium concentrations and cultivars were allocated to sub-plots and sub-sub-plots, respectively. Quinoa seeds were sown by hand at a depth of 2-3 cm in 60-meter-long rows with 60 cm row spacing and 30 cm hill spacing. After 30 days, thinning reduced the plant population to three per hill. Each experimental plot measured 3 meters by 3.5 meters. Phosphorus fertilizer (31 kg P_2O_5/fed. as calcium super phosphate) was applied during soil preparation, and nitrogen fertilizer (75 kg N/fed. as ammonium sulfate) was added in four equal portions: 20% during soil preparation and 30% at 30 and 50 days after sowing, with the final 20% added 65 days after sowing. Standard quinoa cultivation practices were followed throughout the experiments.

Soil analysis for two seasons were carried out according to Jackson (1973). The results of analysis are showed in table (1).

Studied factors:

Factor A : Irrigation water amounts.

800m^3/fed. application.

1000m^3/fed. application.

1200m^3/fed. Application. water applied every one week from after planted and until 70 days from sowing then each 5 days until harvesting, (2/3+1/3 water amount) in all treatments.

Factor B : Potassium foliar spraying:

Control, without potassium application.

Foliar spraying with1/2gm/L, concentrate.

Foliar spraying with 1gm/L, concentrate, that at 35, 50 and 65 days from sowing as potassium sulfate (48% K_2O)., the rate of foliar spraying was 200L/fed.

Factor C : Cultivars of quinoa, two cultivars were tested:

Chipaya, and Q5 cultivars. Sowing date for these cultivars were in 10 November in the two seasons.

Studied traits:

At harvest (120 days after planting) individual plants were chosen at random from plot to record the experimental data. While, grain yield/fed. was taken from whole plot.

Number of branches per plant, was taken at 70 days from sowing.

Spike length in cm.

Number of spike per plant.

1000grains weight, in g.

Grain yield per fed, in kg, was taken from whole plot.

Harvest index (HI) computed as :

Harvest index (HI) = Grain yield (kg/fed.)/Biological yield(kg/fed.x100)

Protein content in grains as % , by multiplying the total nitrogen percent x 6.25 ,(Anon1990)

Statistical analysis:

The obtained data were statistically analyzed according to the methods suggested by Gomez and Gomez (1984). Means were compared by using the L.S.D values at 5% level of significance.

RESULTS AND DISCUSSTION

The impact of irrigation regimes and foliar potassium application on quinoa yield, its components, and protein content was assessed across two growing seasons (2021-2022 and 2022-2023). The results, presented in Tables 3-9, reveal significant differences between irrigation treatments for various agronomic traits, including branch count, spike length, spike number, thousand-grain weight, grain yield, harvest index, and protein content. Quinoa plants irrigated with 1200 m^3/fed demonstrated superior performance across all studied characteristics, while those receiving 800 m^3/fed exhibited the lowest values. The positive influence of higher irrigation amounts can be attributed to enhanced ion transport from soil to roots, improved nutrient distribution within the plant, increased amino acid synthesis, and consequently, accelerated protein formation. The correlation between protein content and moisture levels, along with elevated enzyme activity, promotes cell division, leaf area index, net assimilation rate, and dry matter accumulation, ultimately leading to higher yield, its components, and protein content. These findings align with previous research by Geerts *et al*. (2008), Cea *et al*. (2021), and AL-Tamimi *et al*. (2024), which consistently demonstrate a positive relationship between increased irrigation and enhanced quinoa performance. Regarding foliar potassium application, the results indicate significant effects on all studied traits in both seasons. A potassium concentration of 1 g/L yielded the maximum values, while the control treatment (without potassium) produced the lowest. The positive impact of higher potassium concentrations can be attributed to their role in improving quinoa's water use efficiency, particularly under deficit irrigation conditions. Additionally, potassium is involved in regulating over 80 enzymes within plant cells, thereby promoting leaf area index, net assimilation rate, dry matter accumulation, yield components, and protein content.

Our results align with previous studies by Beltran *et al*. (2021) and Minh *et al*. (2022), confirming the positive influence of potassium on quinoa yield, composition, and quality traits. Among the quinoa cultivars tested, Chipaya consistently outperformed Q5 across both seasons, exhibiting superior values for all studied traits. The interaction between irrigation amount and potassium treatments significantly impacted all traits. Quinoa plants irrigated at 1200m^3/fed and treated with 1g/L potassium foliar spray yielded the best results, surpassing those under lower irrigation and control conditions. The interaction between irrigation treatments and quinoa cultivars also proved significant, with 1200m^3/fed irrigation and Chipaya cultivar producing the highest values (Badran 2022).

Regarding the interaction between potassium treatments and quinoa cultivars, significant effects were observed for spike number, grain yield, and protein content. However, branch number, spike length, and 1000-grain weight were not significantly influenced. The combination of 1g/L potassium foliar spray and Chipaya cultivar consistently yielded the best results, while the control treatment and Q5 cultivar generally produced the lowest values. In conclusion, our findings demonstrate that quinoa plants irrigated at 1200m^3/fed and treated with 1g/L potassium foliar spray, particularly when planted with the Chipaya cultivar, exhibit enhanced grain yield, composition, and protein content under the experimental soil conditions and it is consistent with what was reached by Minh *et al.* (2022). This may be due to the role potassium plays in enhancing water use efficiency by regulating a large number of enzymes within the plant (Pulvento *et al.*, 2010)

CONCLUSION

The results of the field experiments of the present study can be summarized as follows: Quinoa grown in sandy soils can rely on limited irrigation water to a great extent and is characterized by its response to potassium foliar spray. The treatments are significantly shown when applied with a superior cultivar such as chipaya, especially in grain yield and protein content. However, the interactions between irrigation systems, potassium foliar spray and quinoa cultivars were not significant for all traits. Therefore, the optimum combination to maximize quinoa yield and quality under the studied conditions is irrigation at a rate of 1200m^3/fed., and potassium foliar spray at a rate of 1 g/L., for chipaya cultivar. These results provide valuable insights for quinoa for quinoa cultivation in Egypt and similar arid regions with sandy soils.

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Table 1 : Mechanical and Chemical properties of the experimental soil in 2021/2022 and 2022/ 2023 seasons.

Mechanical analysis				
Season	Sand%	Silt%	Clay%	Soil texture
2021/2022	91.50	6.50	2.00	Sandy loam
2022/2023	94.00	4.30	1.70	Sandy loam

Chemical analysis															
Season	PH	E.C (ds/m)	Saturation soluble extract(mg/kg)								AHM*				
			Cations				Anions								
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	Cu	Mn	Zn	Ni	Fe
2021/2022	8.00	0.51	1.60	0.50	2.85	0.13	0.00	0.50	3.50	1.08	<0.05	0.34	<0.05	<0.05	7.12
2022/2023	8.15	0.33	1.10	0.50	1.60	0.08	0.00	0.50	2.00	0.78	0.00	0.36	0.00	0.00	10.81

Table 2: Chemical analysis of irrigation water in 2021/2022 and 2022/2023 seasons.

Season	PH	Total alkalinity	E.C (ds/m)	Total soluble salts(ppm)	Soluble Cations (mg/L)				Soluble Anions(mg/L)			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
2021/2022	7.95	225.00	7.91	5060.00	355.00	226.00	966.00	24.00	-	225.00	1688.00	1219.00
2022/2023	7.70	175.00	7.53	4820.00	393.30	204.70	1150.00	20.00	-	175.00	1600.00	1277.00

Table 3 : Effect of irrigation regimes, Potassium foliar spraying and their interactions on Number of branches /plant of some quinoa cultivars in 2021/2022 and 2022/2023 seasons.

Treatments		Number of branches /plant					
		2021/2022 season			2022/2023 season		
Irrigation levels (A)	Potassium foliar spraying (B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C_1)	Q5(C_2)		Chipaya(C_1)	Q5(C_2)	
800 m^3/fed.(A_1)	Control. (B_1)	8.00	7.40	7.70	8.20	7.20	7.70
	1/2gm/L. (B_2)	8.80	8.00	8.40	9.00	8.00	8.50
	1gm/L. (B_3)	9.80	9.00	9.40	10.20	8.80	9.50
Mean		8.87	8.13	8.50	9.13	8.00	8.57
1000m^3/fed.(A_2)	Control. (B_1)	12.20	9.40	10.80	12.40	9.60	11.00
	1/2gm/L. (B_2)	13.20	10.60	11.90	13.80	10.80	12.30
	1gm/L. (B_3)	15.20	12.00	13.60	15.40	12.40	13.90
Mean		13.53	10.67	12.10	13.87	10.93	12.40
1200m^3/fed.(A_3)	Control. (B_1)	17.60	14.20	15.90	17.80	14.60	16.20
	1/2gm/L. (B_2)	19.20	16.00	17.60	19.60	16.40	18.00
	1gm/L. (B_3)	21.00	17.80	19.40	21.53	18.00	19.77
Mean		19.27	16.00	17.63	19.64	16.33	17.99
Potassium foliar spraying (B)	Control. (B_1)	12.60	10.33	11.47	12.80	10.47	11.63
	1/2gm/L. (B_2)	13.73	11.53	12.63	14.13	11.73	12.93
	1gm/L. (B_3)	15.33	12.93	14.13	15.71	13.07	14.39
Cultivars (C)		13.89	11.60		14.21	11.76	
LSD at 0.05 for							
A		0.28			0.18		
B		0.14			0.19		
AB		0.24			0.32		
C		0.10			0.11		
AC		0.17			0.18		
BC		NS			NS		
ABC		NS			NS		

Table 4: Effect of irrigation regimes, Potassium foliar spraying and their interactions on spike Length (cm) of some quinoa cultivars in 2021/2022 and 2022/2023 seasons.

Treatments		Spike length(cm)					
		2021-2022 season			2022-2023 season		
Irrigation levels (A)	Potassium foliar spraying (B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C_1)	Q5(C_2)		Chipaya(C_1)	Q5(C_2)	
800 m^3/fed. (A_1)	Control. (B_1)	6.12	5.50	5.81	6.54	5.62	6.08
	1/2gm/L. (B_2)	6.96	6.34	6.65	7.42	6.48	6.95
	1gm/L. (B_3)	7.76	7.14	7.45	8.22	7.30	7.76
Mean		6.95	6.33	6.64	7.39	6.47	6.93
1000m^3/fed. (A_2)	Control. (B_1)	9.12	8.44	8.78	9.62	8.64	9.13
	1/2gm/L. (B_2)	10.08	9.40	9.74	10.60	9.58	10.09
	1gm/L. (B_3)	11.04	10.32	10.68	11.54	10.52	11.03
Mean		10.08	9.39	9.73	10.59	9.58	10.08
1200m^3/fed. (A_3)	Control. (B_1)	12.44	11.70	12.07	12.98	11.88	12.43
	1/2gm/L. (B_2)	13.64	12.48	13.06	14.08	12.78	13.43
	1 gm/L. (B_3)	14.62	13.42	14.02	15.06	13.74	14.40
Mean		13.57	12.53	13.05	14.04	12.80	13.42
Potassium foliar spraying (B)	Control. (B_1)	9.23	8.55	8.89	9.71	8.71	9.21
	1/2gm/L. (B_2)	10.23	9.41	9.82	10.70	9.61	10.16
	1gm/L. (B_3)	11.14	10.29	10.72	11.61	10.52	11.06
Cultivars (C)		10.20	9.42		10.67	9.62	
LSD at 0.05 for							
A		0.09			0.08		
B		0.05			0.06		
AB		0.09			0.11		
C		0.06			0.05		
AC		0.10			0.08		
BC		NS			NS		
ABC		0.18			NS		

Table 5: Effect of irrigation regimes, Potassium foliar spraying and their interactions on Number of spikes/plant of some quinoa cultivars in 2021/2022 and 2022/2023seasons.

Treatments		Number of spikes/plant					
		2021-2022 season			2022-2023 season		
Irrigation levels (A)	Potassium foliar spraying (B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C_1)	Q5(C_2)		Chipaya(C_1)	Q5(C_2)	
800 m^3 /fed.(A_1)	Control. (B_1)	7.80	6.47	7.13	7.93	6.60	7.27
	1/2gm/L. (B_2)	8.73	7.47	8.30	9.00	8.00	8.50
	1gm/L. (B_3)	9.67	8.80	9.23	9.80	8.93	9.37
Mean		8.73	7.71	8.22	8.91	7.84	8.38
1000m^3/fed.(A_2)	Control. (B_1)	9.67	9.00	9.33	9.87	9.20	9.53
	1/2gm/L. (B_2)	11.00	10.27	10.63	11.13	10.33	10.73
	1gm/L. (B_3)	12.07	11.20	11.63	12.40	11.47	11.93
Mean		10.91	10.16	10.53	11.13	10.33	10.73
1200m^3/fed.(A_3)	Control. (B_1)	12.67	12.00	12.33	12.87	12.20	12.53
	1/2gm/L. (B_2)	13.73	13.07	13.40	14.00	13.13	13.57
	1gm/L. (B_3)	15.00	13.87	14.43	15.20	13.93	14.57
Mean		13.80	12.98	13.39	14.02	13.09	13.56
Potassiumfoliar spraying (B)	Control. (B_1)	10.04	9.16	9.60	10.22	9.33	9.78
	1/2gm/L. (B_2)	11.16	10.40	10.78	11.38	10.49	10.93
	1gm/L . (B_3)	12.24	11.29	11.77	12.47	11.44	11.96
Cultivars (C)		11.15	10.28		11.36	10.42	
LSD at 0.05 for							
A		0.17			0.12		
B		0.13			0.08		
AB		NS			0.13		
C		0.06			0.08		
AC		0.10			0.14		
BC		0.10			NS		
ABC		0.18			0.25		

Table 6: Effect of irrigation regimes, potassium foliar spraying and their interactions on 1000- Grain weight (g) of some quinoa cultivars in 2021/2022 and 2022/2023 seasons.

Treatments		1000 grain weight (g)					
		2021-2022 season			2022-2023 season		
Irrigation levels (A)	Potassium foliar spraying (B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C_1)	Q5(C_2)		Chipaya(C_1)	Q5(C_2)	
800 m^3/fed.(A_1)	Control. (B_1)	1.80	2.05	1.92	1.88	2.12	2.00
	1/2g m/L. (B_2)	2.07	2.33	2.20	2.16	2.41	2.28
	1gm/L. (B_3)	2.36	2.60	2.48	2.44	2.71	2.57
Mean		2.08	2.33	2.20	2.16	2.41	2.29
1000m^3/fed.(A_2)	Control. (B_1)	2.42	2.69	2.56	2.51	2.81	2.66
	1/2gm/L. (B_2)	2.74	3.03	2.88	2.84	3.20	3.02
	1gm/L. (B_3)	3.04	3.34	3.19	3.15	3.57	3.36
Mean		2.73	3.02	2.88	2.84	3.19	3.01
1200m^3/fed.(A_3)	Control. (B_1)	3.17	3.47	3.32	3.32	3.79	3.55
	1/2gm/L. (B_2)	3.47	3.80	3.64	3.65	4.14	3.89
	1gm/L. (B_3)	3.83	4.16	3.99	4.00	4.34	4.17
Mean		3.49	3.81	3.65	3.65	4.09	3.87
Potassium foliar spraying (B)	Control. (B_1)	2.46	2.73	2.60	2.57	2.91	2.74
	1/2gm/L. (B_2)	2.76	3.05	2.91	2.88	3.25	3.07
	1gm/L. (B_3)	3.07	3.37	3.22	3.20	3.54	3.37
Cultivars (C)		2.77	3.05		2.88	3.23	
LSD at 0.05 for							
A		0.03			0.09		
B		0.02			0.03		
AB		0.03			0.05		
C		0.02			0.03		
AC		0.03			0.06		
BC		NS			NS		
ABC		NS			NS		

Table 7 : Effect of irrigation regimes, potassium foliar spraying and their interactions on grai yield / fed. (kg) of some quinoa cultivars in 2021/2022 and 2022/2023 seasons.

Treatments		Grain yield/fed.(Kg)					
		2021-2022 season			2022-2023 season		
Irrigation levels (A)	Potassium foliar spraying (B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C_1)	Q5(C_2)		Chipaya(C_1)	Q5(C_2)	
800 m^3/fed.(A_1)	Control. (B_1)	325.49	279.94	302.72	333.82	294.94	314.38
	1/2gm/L. (B_2)	423.80	381.59	402.70	433.58	398.25	415.92
	1gm/L. (B_3)	542.67	494.35	518.51	543.78	513.23	528.51
Mean		430.65	385.29	407.97	437.06	402.14	419.60
1000m^3/fed.(A_2)	Control. (B_1)	531.01	509.90	520.45	563.78	533.67	548.73
	1/2gm/L. (B_2)	652.65	635.43	644.04	691.86	658.76	675.31
	1gm/L. (B_3)	773.52	750.96	762.24	822.61	779.29	800.95
Mean		652.39	632.10	642.24	692.75	657.24	675.00
1200m^3/fed.(A_3)	Control. (B_1)	824.28	771.51	807.89	875.71	820.95	848.33
	1/2gm/L. (B_2)	948.70	916.48	932.59	1014.80	948.70	981.75
	1gm/L. (B_3)	1086.45	1044.24	1065.34	1168.66	1079.79	1124.22
Mean		953.14	917.41	935.28	1019.72	949.81	984.77
Potassium foliar spraying (B)	Control. (B_1)	560.26	527.12	543.69	591.10	549.85	570.48
	1/2gm/L. (B_2)	675.05	644.50	659.78	713.41	668.57	690.99
	1gm/L. (B_3)	800.88	763.18	782.03	845.02	790.77	817.89
Cultivars (C)		678.73	644.93		716.51	669.73	
LSD at 0.05 for							
A		16.48			11.23		
B		10.31			11.80		
AB		17.86			20.43		
C		1.80			2.37		
AC		3.11			4.10		
BC		3.11			4.10		
ABC		NS			7.10		

Table 8: Effect of irrigation regimes, Potassium foliar spraying and their interactions on Harvest index of some quinoa cultivars in 2021/2022 and 2022/2023 seasons.

Treatments		Harvest index(%)					
		2021-2022 season			2022-2023 season		
Irrigation levels (A)	Potassium foliar spraying (B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C$_1$)	Q5(C$_2$)		Chipaya(C$_1$)	Q5(C$_2$)	
800 m^3/fed.(A$_1$)	Control. (B$_1$)	30.39	30.92	30.66	31.28	31.81	31.55
	1/2gm/L. (B$_2$)	31.78	32.37	32.08	32.75	33.35	33.05
	1gm/L. (B$_3$)	33.24	33.78	33.51	34.11	34.66	34.38
Mean		31.81	32.36	32.08	32.71	33.27	32.99
1000m^3/fed.(A$_2$)	Control. (B$_1$)	33.99	34.74	34.36	34.90	35.69	35.29
	1/2gm/L. (B$_2$)	35.60	36.33	35.97	36.58	37.32	36.95
	1gm/L. (B$_3$)	37.12	37.87	37.49	38.20	38.95	38.58
Mean		35.57	36.31	35.94	36.56	37.32	36.94
1200m^3/fed.(A$_3$)	Control. (B$_1$)	38.00	38.84	38.42	39.00	39.83	39.41
	1/2gm/L. (B$_2$)	39.87	40.81	40.34	40.93	41.86	41.39
	1gm/L. (B$_3$)	41.59	42.56	42.08	42.73	43.74	43.24
Mean		39.82	40.74	40.28	40.89	41.81	41.35
Potassium foliar spraying(B)	Control. (B$_1$)	34.13	34.83	34.48	35.06	35.77	35.42
	1/2gm/L. (B$_2$)	35.75	36.50	36.13	36.75	37.51	37.13
	1gm/L. (B$_3$)	37.32	38.07	37.69	38.35	39.12	38.73
Cultivars (C)		35.73	36.47		36.72	37.47	
LSD at 0.05 for							
A		0.09			0.08		
B		0.10			0.09		
AB		0.17			0.16		
C		0.07			0.06		
AC		0.12			0.10		
BC		NS			NS		
ABC		NS			NS		

Table 9: Effect of irrigation regimes, Potassium foliar spraying and their interactions on Protein content in grain (%) of some quinoa cultivars in 2021/2022 and 2022/2023 Seasons.

Treatments		Protein content in grain (%)					
		2021-2022 season			2022-2023 season		
Irrigation levels (A)	potassium foliar spraying(B)	Cultivars (C)		Mean	Cultivars (C)		Mean
		Chipaya(C$_1$)	Q5(C$_2$)		Chipaya(C$_1$)	Q5(C$_2$)	
800 m^3/fed.(A$_1$)	Control. (B$_1$)	16.39	16.47	16.43	11.80	5.21	8.51
	1/2gm/L. (B$_2$)	15.51	16.09	15.80	14.48	6.91	10.70
	1gm/L. (B$_3$)	15.14	15.99	15.57	10.65	8.49	9.57
Mean		15.68	16.18	15.93	12.31	6.87	9.59
1000m^3/fed.(A$_2$)	Control. (B$_1$)	17.04	10.98	14.01	10.35	11.03	10.69
	1/2gm/L. (B$_2$)	18.16	12.96	15.56	9.30	8.66	8.98
	1gm/L. (B$_3$)	14.01	16.25	15.13	10.65	6.88	8.77
Mean		16.40	13.40	14.90	10.10	8.86	9.48
1200m^3/fed.(A$_3$)	Control. (B$_1$)	11.40	10.97	11.25	7.50	12.04	9.77
	1/2gm/L. (B$_2$)	12.07	10.14	11.11	9.48	11.50	10.49
	1gm/L. (B$_3$)	13.04	9.47	11.26	10.13	9.84	9.99
Mean		12.21	10.19	11.20	9.04	11.13	10.08
Potassium foliar spraying(B)	Control. (B$_1$)	14.98	12.81	13.90	9.88	9.43	9.66
	1/2gm/L. (B$_2$)	15.25	13.06	14.16	11.09	9.02	10.06
	1gm/L. (B$_3$)	14.06	13.90	13.98	10.48	8.40	9.44
Cultivars (C)		14.76	13.26		10.48	8.95	
LSD at 0.05 for							
A		0.02			0.05		
B		0.02			0.04		
AB		0.03			0.07		
C		0.02			0.03		
AC		0.03			0.06		
BC		0.03			0.06		
ABC		0.05			0.10		

تأثير نظم الري والرش بالبوتاسيوم علي بعض أصناف الكينوا في الأراضي الرملية

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الملخص العربي:

أجريت تجربتان حقليتان بجمعية الحسين لاستصلاح واستزراع الأراضي الكيلو64– طريق مصراسكندرية الصحراوي–الجيزة – مصر- وذلك لدراسة تأثيرنظم الري (800،1000و1200م3/فدان) والرش الورقي بالبوتاسيوم بتركيزات{صفر(كنترول)،1/2و1جرام/لتر} علي بعض أصناف الكينوا (صنف Chipaya وصنف Q5) وذلك في الأراضي الرملية. تم تصميم التجربة وفقاً لتصميم القطع المنشقة مرتين في ثلاث مكررات. حيث وضعت كميات المياه في القطع الرئيسية والرش بالبوتاسيوم في القطع الشقية الأولي والأصناف في القطع الشقية الثانية. حيث أظهرت النتائج تأثيراً معنويًا لمعاملات الري علي عددالأفرع/نبات، طول النورة/نبات، عدد النورات/نبات، وزن ال1000حبة، محصول الحبوب/فدان، دليل الحصاد ومحتوي البروتين في الحبوب في موسمي الدراسة. كماأظهرت النتائج أن ري نباتات الكينوا بـ1200م3/فدان قد أعطي أحسن القيم لكل الصفات المدروسة، بينما أقل القيم كانت موضحة من ري النباتات بـ800م3/فدان في كلاالموسمين. كماأظهرت النتائج تأثيراً معنوياً موجباً للرش بالبوتاسيوم علي كل الصفات المدروسة. كما أوضحت النتائج أن رش نباتات الكينوا بتركيز1جرام/لتر من البوتاسيوم أعطي أعلي القيم لكل الصفات المدروسة في موسمي النمو، بينما كانت أقل القيم لكل الصفات المدروسة موضحة من الكنترول (بدون رش بالبوتاسيوم) وذلك في موسمي الدراسة. كما أوضحت النتائج أن المحصول ومكوناته ومحتوي البروتين في الحبوب تأثر معنوياً بأصناف الكينوا في الموسمين. أعلي القيم لكل الصفات المدروسة كانت موضحة من زراعة الصنف Chipaya، بينما أقل القيم كانت موضحة من زراعة الصنف Q5 في موسمي الدراسة. كماكان للتفاعل بين كميات مياة الري والرش بالبوتاسيوم تأثيراً معنوياً علي كل الصفات المدروسة في كلا الموسمين. كما أكدت النتائج أن ري نباتات الكينوا بـ1200م3/فدان والرش بتركيز1جرام/لتر من البوتاسيوم قد أعطي أعلي القيم لكل الصفات المدروسة، بينما أقل القيم بالنسبة لتلك الصفات كانت موضحة من الري بـ800م3/فدان مع الكنترول (بدون رش بالبوتاسيوم) في موسمي الدراسة. كماكان للتفاعل بين كميات مياة الري وأصناف الكينوا تأثيراً معنوياً موجباً لكل الصفات المدروسة في موسمي النمو. كما أكدت النتائج أن ري نباتات الكينوا بـ1200م3/فدان مع زراعة الصنف Chipaya قد أعطي أعلي القيم لكل الصفات المدروسة، بينما أكدت النتائج أيضاً أن ري نبات الكينوا بـ800م3/فدان مع زراعة الصنف Q5 قد أعطي أقل القيم لكل الصفات المدروسة في موسمي الدراسة. كماكان للتفاعل بين نظم الري،الرش بالبوتاسيوم وأصناف الكينوا تأثيراً معنوياً موجباً لصفات عددالنورات/نبات، محصول الحبوب/فدان ومحتوي البروتين في الحبوب في موسمي الدراسة. أحسن القيم لتلك الصفات كانت موضحة من ري نباتات الكينوا بـ1200م3/فدان والرش بـ1جرام بوتاسيوم/لتر مع زراعة الصنف Chipaya في موسمي الدراسة. ومن النتائج يتضح أن ري نباتات الكينوا بـ1200م3/فدان ورش النباتات بتركيز1جرام/لتر مع زراعة الصنف Chipaya قد أدي الي زيادة ناتج حبوب الفدان ومكوناتة ومحتوي البروتين في الحبوب تحت ظروف أرض التجربة.

الكلمات الاسترشادية : شينوبوديوم كينوا،الرش الورقي بالبوتاسيوم،كميات المياة للكينوا،الانتاجية،البروتين.