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Effect of water quality, magnetization and spraying with jasmonic acid on biochemical content of potato plants and tubers

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ABSTRACT
A field experiment was conducted for two consecutive spring seasons 2023-2024 in a private field in Al-Mahawil District (45 km) north of Babil Governorate to study the response of the potato plant, Synergy variety, to irrigation water type (River or drainage) treated magnetically and sprayed with jasmonic acid, in terms of potato plant content of some biochemicals. The experiment was a Split-Split Plot Design, R.C.B.D, 24 treatments with three replicates and 72 experimental units. Irrigation water quality (river or drainage) took the main plot, magnetization levels (1500 Gauss with contact path 38.5 cm2 * 1, 2, or 3 K) in sub plot and spraying with jasmonic acid (0, 15, 30) mg.L^{-1} was in sub-sub plot. The results of the experiment showed that river water at a level of 1.47 ds m^{-1} was significantly higher than drainage water in all studied characteristics. The positive effect also increased in magnetized water with contact path 38.5 cm2 * 3. A similar effect was recorded with spraying with jasmonic acid especially at a concentration of 30 mg L^{-1} compared to treatments sprayed at a lower concentration or control. The results showed that the interaction of river water 1.47 ds m^{-1} magnetized with a contact path of 38.5*3 cm2 and spraying with jasmonic acid 30 mg L^{-1} recorded the highest values in the highest percentage of nitrogen, phosphorus and potassium in the leaves, the highest value of leaf total chlorophyll, and the highest percentage of tuber content of starch compared to plants irrigated with drainage water at a level of 5.7 ds m-1 that was not magnetized, regardless of presence or absence of spraying with jasmonic acid, which led to the lowest values.

Keywords: irrigation, fertilization, field crops, growth regulator, Solanum

INTRODUCTION

Potato Solanum tuberosum L. is a vegetable crop belonging to the Solanum family. Potato is widely cultivated in the world because it is a strategic vegetable crop with high economic value. The plant is relatively sensitive to stress, especially water stress, which may cause a 79% reduction in productivity in the absence of its water requirements [1]. China is the world's largest producer of potatoes with about 99.12 million tons per year, followed by India with 43.77 million tons per year [2]. Iraq's potato production is about 270,591 thousand tons per year [3].

Soil salinity is one of the main causes facing agriculture in arid and semi-arid lands [4]. Therefore, the optimal use of water resources is done through qualitative analysis of water and its evaluation to meet agricultural needs. In light of the severe shortage of water resources worldwide, and to reduce dependence on traditional water sources, attention has turned to non-traditional saline water sources such as sewage, groundwater and drainage water for use in various agricultural and industrial fields [5]. Therefore, water is often treated before being used for agricultural purposes, and one of these processes is water treatment by magnetization. The magnetization process is accompanied by a set of changes in the chemical and physical properties of water, including reducing surface tension and viscosity, increasing water polarity and the number of molecules making up a water droplet by breaking down the hydrogen bonds that connect the molecules.

On the other hand, Jasmonic acid C12H18O3 is one of the growth regulators that was first isolated from the fungus Lasiodipiodia obromae and increased interest in it as one of the derivatives of jasmonic MeJA MethyI Jasmonic due to its aromatic smell. It was extracted from the essential oils of white jasmine and rosemary plants, and Linolenic acid is considered the raw material for the production of jasmonic naturally in plastids and peroxisoma inside the plant [6]. Jasmonic acid is classified as a growth hormone that has a beneficial effect on plant growth and development [7]. Therefore, the study aimed to determine the effect of magnetically treated water with a flux of 1500 Kwh according to different water contact paths in the presence of vegetative spraying with jasmonic acid on the growth and characteristics of the potato crop, Synergy variety, and its role in reducing salt stress in the potato crop sensitive to salinity.

MATERIALS AND METHODS

The study was conducted as a field experiment for two consecutive spring seasons 2023-2024, starting in January in one of the fields of Al-Azzawiyah area/Al-Mahawil district, 45 km north of Babylon Governorate. The response of the potato plant, Synergy variety, to the quality of magnetically treated irrigation water and spraying with jasmonic acid was studied in some growth and productivity indicators. The experiment included 24 treatments distributed according to the Split Split Plot Design system according to (R.C.B.D) with three replicates, 72 experimental units. Irrigation water quality (River W1 and Drainage W2) in Main plot, magnetization treatments of sub plot (M) included irrigation with normal water M0 or magnetically treated water with a flux intensity of 1500Gauss with a contact path of 38.5 cm^2 once (M1) or twice (*2) M2 or tripled (*3) M3, while spraying with jasmonic acid was applied in sub plot using Jasmonic acid (S) at three concentrations 0, 15, or 30 mg L^{-1}, S0, S1, and S2, respectively.

Table 1: Some chemical and physical properties of the experimental soil before planting

Character/measurement		**2023 Season**	**2024 Season**	**Unit**
Ph		7.33	7.12	-----
EC		1.9	2.7	$ds.m^{-1}$
OM		0.63	0.69	%
N		35.0	31.7	mg Kg^{-1}
P		3.46	3.15	
K		30.0	33.9	
Bulk density		1.33	1.35	g cm^3
Soil texture	Sand	52	525	g Kg^{-1}
	Silt	388	380	
	Clay	92	95	

Table 2. The quality characteristics of irrigation water used in the study

Water Type	**EC $ds.m^{-1}$**	**pH**	**Dissolved ions**							
			Na^+ mg/L	K^+ mg/L	SO_4^- mg/L	Cl^- mg/L	CO_3^- mg/L	HCO_3^- mg/L	Mg^{++} mg/L	Ca^{++} mg/L
River	1.2ds/m	7.97	7.66	0.21	3.13	3.80	Nill	1.50	0.14	0.42
Drainage	4.5ds/m	7.78	25.79	0.31	6.27	19.00	Nill	2.30	0.41	1.25

Indicators under study

The study parameters included chemical indicators: the percentage nitrogen content of the leaves: which was estimated using the Kjeldahl apparatus described by Al-Sahaf, (1989) [8]. The percentage of phosphorus in the leaves using the ascorbic acid and ammonium molybdate method, where the light absorption was recorded by Spectrophotometer at a wavelength of 620 nm [8]. The percentage of potassium in the leaves was also estimated using Flame photometer [8]. The leaf content (five random leaves, fully exposed) of total chlorophyll (mg/100 g fresh material-1) was aided by Spectrophotometer to measure the light absorption of pigments at a wavelength of 645 and 663 nm [9]. In addition to the quality index of the product based on the percentage of starch in the tubers % according to A.O.A.C. (1980) [10].

RESULTS AND DISCUSSION

The results showed that there were significant differences in the quality of irrigation water with the superiority of river water at an EC level of 1.47 ds m-1 in all studied characteristics; percentage of nitrogen (Table3), phosphorus (Table4) and potassium(Table5) in leaves, total chlorophyll content in leaves (Table6), percentage of starch in tubers (Table7) which gave the highest values for both quarterly seasons respectively compared to drainage water at an EC level of 5.7 ds m-1 which gave the lowest values. Magnetically treated water recorded significantly higher values than that recorded by normal untreated water regardless of the water quality for both quarterly seasons respectively. Similarly, spraying with jasmonic acid had a significant effect in increasing the values of the indicators under study compared to the unsprayed treatments in the absence of other factors. The

W1M3S2 interaction treatment gave the highest values in all indicators, the percentage of nitrogen, phosphorus and potassium in leaves, the total chlorophyll content of leaves, the percentage of starch in tubers with values of 3.26 and 3.02%, 0.531 and 0.478%, 2.89 and 3.20%, 63.57 and 64.05 mg 100 g^{-1} FW and 15.32 and 16.96% for both spring seasons respectively compared to the untreated drainage water in the absence of jasmonic acid (W2M0S0) treatment which resulted in the lowest values that of 0.64 and 0.61%, 0.056 and 0.050%, 0.67 and 0.77%, 16.76 and 16.53 mg 100 g FW^{-1}) and 5.63 And 6.22% for both seasons, respectively.

Table 3. Response of potato leaf content of nitrogen (%) to water quality, water magnetizing, and foliar spray with Jasmonic acid for two growing seasons

Irrigation water quality	Irrigation with magnetically treated water	Growing season 2023					Growing season 2024				
		Jasmonic			W*M	Aver. W	Jasmonic			M × W	Aver. W
		S0	S1	S2			S0	S1	S2		
W1	M0	1.42	1.46	1.51	1.46	2.21	1.31	1.35	1.38	1.35	2.04
	M1	1.55	1.78	2.04	1.79		1.43	1.65	1.87	1.65	
	M2	2.19	2.43	2.77	2.46		2.01	2.23	2.53	2.26	
	M3	3.00	3.17	3.26	3.14		2.75	2.89	3.02	2.89	
W2	M0	0.64	0.69	0.74	0.69	1.05	0.61	0.65	0.69	0.65	0.98
	M1	0.77	0.83	0.90	0.83		0.72	0.78	0.85	0.78	
	M2	0.97	1.05	1.16	1.06		0.91	0.99	1.08	0.99	
	M3	1.23	1.57	2.04	1.61		1.15	1.46	1.89	1.50	
L.S.D 0.05		W*M*S =0.22			W*M=0.23	W= 0.29	W*M*S=0.20			W*M =0.20	W= 0.26
W*S	W1	2.04	2.21	2.39			1.88	2.03	2.20		
	W2	0.90	1.03	1.21			0.85	0.97	1.13		
L.S.D 0.05		L.S.D W* S=0.29					L.S.D W* S=0.26				
Aver. S		1.47	1.62	1.80			1.36	1.50	1.66		
L.S.D S=0.01					L.S.D S=0.01						

Table 4. Response of potato leaf content of phosphorus (%) to water quality, magnetizing, and foliar Jasmonic acid for two spring (2023-2024) growing seasons

Irrigation water quality	Irrigation with magnetically treated water	Growing season 2023					Growing season 2024				
		Jasmonic			W*M	Aver. W	Jasmonic			M × W	Aver. W
		S0	S1	S2			S0	S1	S2		
W1	M0	0.191	0.201	0.211	0.201	0.327	0.172	0.181	0.190	0.181	0.295
	M1	0.243	0.261	0.299	0.267		0.219	0.234	0.269	0.241	
	M2	0.321	0.348	0.395	0.355		0.289	0.314	0.355	0.319	
	M3	0.433	0.495	0.531	0.486		0.390	0.445	0.478	0.437	
W2	M0	0.056	0.068	0.082	0.068	0.131	0.050	0.061	0.074	0.062	0.118
	M1	0.107	0.124	0.134	0.122		0.096	0.112	0.121	0.110	
	M2	0.142	0.151	0.161	0.152		0.128	0.136	0.145	0.136	
	M3	0.168	0.181	0.199	0.183		0.151	0.163	0.179	0.164	
L.S.D 0.05		W*M*S = 0.038			W*M = 0.038	W= 0.049	W*M*S= 0.034			W*M =0.035	W= 0.044
W*S	W1	0.297	0.326	0.359			0.267	0.293	0.323		
	W2	0.118	0.131	0.144			0.107	0.118	0.130		
L.S.D 0.05		L.S.D W* S=0.048					L.S.D W* S=0.043				
Aver. S		0.208	0.229	0.251			0.187	0.206	0.226		

L.S.D S=0.002		L.S.D S=0.001		

Table 5. Response of potato leaf content of potassium (%) to water quality, magnetizing, and foliar Jasmonic acid for two spring (2023-2024) growing seasons

Irrigation water quality	Irrigation with magnetically treated water	Growing season 2023					Growing season 2024				
		Jasmonic			W*M	Aver. W	Jasmonic			M × W	Aver. W
		S0	S1	S2			S0	S1	S2		
W1	M0	1.11	1.19	1.25	1.18	1.81	1.23	1.33	1.40	1.32	2.01
	M1	1.32	1.45	1.61	1.46		1.49	1.61	1.78	1.62	
	M2	1.73	1.88	2.21	1.94		1.91	2.08	2.45	2.15	
	M3	2.43	2.68	2.89	2.67		2.70	2.94	3.20	2.94	
W2	M0	0.67	0.74	0.80	0.74	1.23	0.77	0.86	0.91	0.85	1.39
	M1	0.91	0.98	1.02	0.97		1.02	1.11	1.31	1.15	
	M2	1.18	1.29	1.45	1.31		1.33	1.45	1.63	1.47	
	M3	1.65	1.93	2.13	1.90		1.86	2.16	2.32	2.11	
L.S.D 0.05		W*M*S =0.12			W*M=0.12	W= 0.14	LSD W*M*S=0.13			W*M =0.13	W= 0.15
W*S	W1	1.65	1.80	1.99			1.83	1.99	2.21		
	W2	1.10	1.24	1.35			1.25	1.39	1.54		
L.S.D 0.05		L.S.D W* S=0.14					L.S.D W* S=0.15				
Aver. S		1.38	1.52	1.67			1.54	1.69	1.88		
L.S.D S=0.01					L.S.D S=0.01						

Table 6. Response of potato leaf content of total chloropgyll (mg $100g^{-1}$FW) to water quality, magnetizing, and foliar Jasmonic acid for two spring (2023-2024) growing seasons

Irrigation water quality	Irrigation with magnetically treated water	Growing season 2023					Growing season 2024				
		Jasmonic			W*M	Aver. W	Jasmonic			M × W	Aver. W
		S0	S1	S2			S0	S1	S2		
W1	M0	35.82	37.53	39.89	37.75	49.62	35.83	37.51	39.91	37.75	49.72
	M1	42.32	46.51	48.82	45.88		42.45	46.72	48.73	45.97	
	M2	51.52	53.73	55.61	53.62		51.46	53.76	55.83	53.68	
	M3	58.82	61.32	63.57	61.24		58.91	61.47	64.05	61.48	
W2	M0	16.76	19.45	22.72	19.64	34.05	16.53	19.61	22.66	19.60	34.66
	M1	27.01	29.23	33.54	29.93		27.15	30.07	34.35	30.52	
	M2	37.36	39.61	42.09	39.69		38.52	40.73	43.17	40.81	
	M3	44.18	46.75	49.87	46.93		45.35	47.67	50.09	47.70	
L.S.D 0.05		W*M*S =2.96			W*M = 2.96	W= 3.87	LSD W*M*S=2.88			*M= 2.88	W= 3.74
W*S	W1	47.12	49.77	51.97			47.16	49.87	52.13		
	W2	31.33	33.76	37.06			31.89	34.52	37.57		
L.S.D 0.05		L.S.D W* S=3.82					L.S.D W* S=3.69				
Aver. S		39.22	41.77	44.51			39.53	42.19	44.85		
L.S.D S=0.16					L.S.D S=0.16						

Table 7. Response of potato tuber content of starch (%) to water quality, water magnetizing, and foliar Jasmonic acid for two spring (2023-2024) growing seasons

Irrigation water	Irrigation with	Growing season 2023			Growing season 2024		
		Jasmonic	W*M	Aver.	Jasmonic	M ×	Aver.

quality	magnetically treated water	S0	S1	S2		W	S0	S1	S2	W	W
W1	M0	9.11	9.75	10.38	9.75	12.33	10.03	10.73	11.45	10.74	13.61
	M1	10.95	11.53	12.09	11.52		12.09	12.78	13.32	12.73	
	M2	12.72	13.21	13.82	13.25		13.98	14.70	15.28	14.65	
	M3	14.23	14.85	15.32	14.80		15.68	16.35	16.96	16.33	
W2	M0	5.63	6.07	6.75	6.15	8.48	6.22	6.72	7.47	6.80	9.41
	M1	7.12	7.63	8.08	7.61		7.88	8.45	8.97	8.43	
	M2	8.65	9.15	9.82	9.21		9.56	10.13	10.86	10.18	
	M3	10.45	10.97	11.41	10.94		11.56	12.12	12.94	12.21	
L.S.D 0.05		W*M*S =0.73			W*M= 0.74	W= 0.96	W*M*S=0.80			W*M =0.80	W= 1.04
W*S	W1	11.75	12.34	12.90			12.94	13.64	14.25		
	W2	7.96	8.46	9.02			8.80	9.36	10.06		
L.S.D 0.05		L.S.D W* S=0.95					L.S.D W* S=1.03				
Aver. S		9.86	10.40	10.96			10.87	11.50	12.16		
L.S.D S=0.03					L.S.D S=0.04						

The results of the study showed that there are differences in the quality of irrigation water in chemical indicators, as there was a decrease in the values of leaf chlorophyll content due to high salinity, which leads to the destruction of chlorophyll pigment due to the toxic effects of sodium and chloride ions in leaf tissues. These two elements replace magnesium in the chlorophyll component, which causes the decomposition of chlorophyll pigment [12]. The decrease in the total chlorophyll level is due to an imbalance in the ionic balance (Khan et al., 2013) or for other reasons, the most important of which is that salts increase the activity of the enzyme that destroys chlorophyll Chlorophylase [13], which leads to a decrease in chlorophyll pigment due to the lack of factors for building the compound. Also due to the increase in the plant hormone ABA (abscisic acid), which works to decompose chlorophyll, and salts cause. The results show a significant decrease in the percentage of nitrogen in the leaves. This is due to the negative effect of salinity of irrigation water and the inability of the plant to absorb nitrogen through direct competition between Cl and Na ions. This leads to displacement of nitrate absorption or through direct competition to change the permeability properties of plasma membranes [14, 15]. This is consistent with the results of previous studies on the effect of water salinity on plant performance [16]. The effect of salty water was also observed in reducing the percentage of phosphorus in the leaves, which is often due to the competition between Cl and H2PO4, in addition to the Cl ion reducing the absorption of H2PO4 by the plant [17]. The increase in sodium ions in the soil solution leads to an increase in the acidity of the soil, which leads to the deposition of phosphorus in the soil and a decrease in its availability to the plant. The increase in salt levels in the plant may lead to confusion in the plant's ability to maintain phosphorus, which leads to a reduction in the penetration between plant tissues and soil solutions and thus a reduction in the amount of absorbed elements [18, 19]. A significant decrease in the percentage of potassium in the leaves was recorded, which is due to the inverse relationship between potassium and sodium, because irrigating plants with salty water increases the level of sodium In the soil solution, which leads to the movement and exit of potassium from the root absorption zone, which causes an imbalance in the nutritional balance and a decrease in absorption [20]. This is consistent with Yildirim and Guvenic (2006) [21] in the decrease in the percentage of potassium in the leaves with the increase in the salinity of the drainage water due to the increase in the percentage of sodium in the leaves. It leads to the accumulation of sodium ions around the roots and inside the plant, which leads to an imbalance in the ionic balance inside the plant and works to hinder the absorption of potassium ions, which leads to weak plant growth. Thus, it reduces the amount of the crop due to competition for absorption with the roots, as they have the same absorption sites, including the root surface [22]. Salts work to decrease the water potential, which leads to a decrease in the plant's ability to absorb water and absorb potassium [6]. As for the water treated with magnetic contact, it had a clear significant effect on the chemical indicators of the potato plant. This may be attributed to the fact that when water passes through a magnetic field, its molecular shape changes and becomes more regular, which makes it more polarized, thus increasing the solubility of salts and heavy metals. This leads to the decomposition of the soil and an increase in the availability of nutrients for the plant, which increases the accumulation of nutrients in the vegetative system [23]. The accumulation of nutrients in the vegetative system is due to the adaptation of the magnetic field of the water, which makes it a better carrier of nutrients, and this is consistent with Martin (2003) [24] findings. Water treated magnetically in the contact path leads to a reduction in surface tension, which leads to the formation of small groups of bound water molecules resulting from the breaking of hydrogen bonds, thus facilitating the penetration of water into the cell membranes and increasing the efficiency of transporting nutrients. This facilitates the entry of a larger amount of water into the vegetative system, which causes the cells to fill up, the leaves to elongate and expand, and thus increasing the representation of carbohydrates, which positively affects most of the characteristics of vegetative growth. As for spraying with jasmonic acid, the results indicate a significant increase in total chlorophyll when spraying plants with jasmonic acid. The reason for this is due to the increased ability of the plant to absorb light, which in turn affects the greening of the leaves, in addition to increasing the process of photosynthesis [25].

CONCLUSION

Findings of this study showed that river water with its low EC level had better results than drainage water. The magnetized water positively affected all the study indicators comparing with the untreated water regardless of water source. A similar effect was recorded where spraying with jasmonic acid especially at a concentration of 30 mg L^{-1}. The highest values of all the parameters under study were recorded in combined interaction treatment of magnetized river water of low EC especially when interacted with foliar spray with jasmonic acid at 30 mg L^{-1}.

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