Kirkuk University Journal for Agricultural Sciences
ISSN:2958-6585
https://kujas.uokirkuk.edu.iq

RESEARCH ARTICLE https://doi.org. 10.58928/ku25.16405

Effect Of Ionic Strength Of Irrigation Water On Nitrate Concentration Of Cucumber (Cucumis Sativus L.) In Erbil Plain

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Received:25/05/2025 **Revised: 13/07/2025** **Accepted: 17/09/2025** **Published: 02/12/2025**

ABSTRACT

The study was conducted during the growing season of 2024 at 28 locations in Erbil plain, Iraq, Iraqi Kurdistan Region, to test the influence of the ionic strength of irrigation water on nitrate (NO3-) concentration of the cucumber plant. The green test and the spectrophotometric method were used for nitrate determination. The selected locations were similar in soil properties, type, and amount of chemical and organic fertilizers applied by farmers. The results indicated the permissible nitrate concentration (NO3-) in the studied cucumber samples was less than the maximum allowable concentration of 400 µg g-1. The highest soil calcium carbonate, active lime, and soil pH were ranged between (20.76 - 29.31%), (2.09 - 4.39%), and (7.70 - 8.30), respectively. The nitrate concentration of cucumber in the study ranged between 189.67 to 324.11 and 182.16 to 316.12 (µg g-1 for both analysis methods, respectively. A significant correlation was recorded between the green analyzer and the spectrophotometric method, with a correlation coefficient value of (r =0.97**) was recorded between both methods in determining nitrate concentration. This means that both methods of nitrate analysis are accurate and dependable for scientific studies. The negative correlation was recorded between cucumber nitrate concentration and the total and active calcium carbonate, with the correlation coefficient values (r = -0.57* and -0.83 **), respectively. The statistical analysis results indicated to a significant correlation between nitrate concentration and ionic strength of irrigation water, with the correlation coefficient values of (r=0.63* and 0.73*) between nitrate concentration in cucumber and irrigation water ionic strength for green analyzer and spectrophotometric methods, respectively. Finally, the nitrate concentration of the cucumber plant had no risk on human health due to its low concentration.

***Keywords*:** Water Ionic strength, Calcareous soil, Cucumber plant, Nitrate risk, Methods of analysis.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is the largest cultivated vegetable in the world. It has become one of the main vegetable crops in recent years as a result of the reduction of fertile land and the increase of soil and water salinity [1][2]. Cucumber is an important vegetable crop belonging to the Cucurbitaceae family and has a chromosome number of 2n=14 [3]. Cucumber is grown in large quantities in South Asia, especially in the hot and humid climate of the Himalayas in Northwest India, and in countries located in North Africa. The climatic conditions of these countries correspond to the productivity requirements of cultivation with high temperature, humidity, and light intensity, with a sufficient amount of water and nutrients. Cucumber cultivation in India dates back to 3000 B.C. (Before Christ), and in China, 100 B.C. [4] . Cucumber is considered the most indoor and outdoor cultivated plant in the world [5][6], the growth and development of cucumber in the process of cultivation in greenhouses, its physiology, It is characterized by the fact that a lot of scientific researches has been carried out on the biochemistry and factors affecting productivity [5][7]. However, in scientific sources, there are insufficient research studies on the effect of bio humus on the migration of heavy metals during the cultivation of cucumbers in greenhouses and the mobility of nitrates in cucumber fruits [8]. Therefore, this study focused on the influences of water quality and soil calcium carbonate on Nitrate concentration in cucumber plants. The widely distributed nutrient in nature is nitrate (NO_3^-), which exists in soil, irrigation water, and food. Cucumbers can accumulate large amounts of NO_3^-, which had a negative effect on human health. There are numerous factors affecting the amount of consumed nitrate per capita from cucumber or other vegetables, which include the type of vegetables, varieties, environmental conditions, soil properties, and dietary

habits of humans.

Cucumber plants may accumulate large amounts of NO_3^-, which depends on irrigation water quality, plant cultivar, and type of applied nitrogen fertilizer [9].

The toxic influence of NO_2^- and NO_3^- was mentioned by the Scientific Food Committee. They indicated the allowable daily nitrate intake, which was 0.222 g per kilogram human weight [10].

More than 97 percent of nitrate intake was from eating vegetables. The consuming or eating 0.40 kg of different vegetables could exceed the nitrate intake per day per adult. The bad growing conditions may cause the nitrate intake per day per adult to be twice as recorded by [11]. The increase in high gastric cancer incidence in the Far East could be due to the eating of vegetables and foods that contain high nitrate concentration. Epidemiologic investigations indicated an increase in gastric cancer risk for those eating diets with high nitrite or nitrate content [12]. The main sources of nitrate are vegetables, water, soil, and nitrogen fertilizers. The vegetables' nitrate concentration ranged between 1 to 4800 mg per kilogram. Five to twenty percent of nitrate ions can be converted to toxic nitrite by anaerobic bacteria in the oral cavity and gastrointestinal tract, respectively [13].

Since there are little or no studies about the influence of irrigation water ionic strength on nitrate accumulation in cucumber and great influences of nitrate on human health, for this reason, the objectives of this investigation are:

1-Determination of nitrate concentration of cucumber and its relation with ionic strength of irrigation water.

2- Limiting the suitability of cucumbers in different fields in Erbil for human consumption or limiting the risk of the nitrate content of cucumbers on human health.

Materials and Methods

The survey was done for the fields cultivated with the cucumber plant, variety Sonia, in Erbil plain, which included the fields of 100 farmers. The 28 fields were selected depending on the similarity of soil textures, sowing date, amount, and types of organic, chemical fertilizers applied by farmers, and cucumber variety. Table 1 and Figure 1 show the GPS reading and map of the studied location.

Table 1. Locations of the studied samples

Locations	Latitude	Longitude
Kawraban 1	36°13'35.6"N	43°46'36.1"E
Kawraban 2	36°13'47.4"N	43°46'48.6"E
Chalwk	36°15'22.2"N	43°42'35.9"E
Chalwk gawra	36°14'22.5"N	43°45'01.1"E
Agholan 1	36°19'48.4"N	43°46'13.5"E
Jdeda zab 1	36°17'33.0"N	43°47'01.1"E
Mala Omer kalak	36°13'02.9"N	43°36'35.4"E
Kawrgusk	36°20'43.9"N	43°47'07.7"E
Jdeda zab 2	36°17'53.2"N	43°47'07.6"E
Agholan 2	36°19'29.6"N	43°45'54.7"E
Chamadubz	36°13'48.4"N	43°37'41.1"E
Khabat	36°16'25.6"N	43°39'14.3"E
Murtakae gawra	36°02'43.7"N	44°03'51.4"E
Tarjan	36°07'01.9"N	43°45'21.8"E
Dugrdkan	35°58'39.9"N	43°56'53.2"E
Shamshwla	36°07'35.7"N	43°38'36.3"E
Grdarash	36°18'03.1"N	43°42'06.1"E
Zaga	36°06'51.1"N	43°38'11.3"E
Murtakae Shhab	36°03'33.3"N	44°03'40.2"E
Quchablbas 1	36°03'15.1"N	43°59'24.2"E

Qoritan 1	36°04'32.5"N	43°56'33.7"E
Pemarabr	36°06'55.3"N	43°34'21.1"E
Quchablbas 2	36°03'17.2"N	43°59'04.2"E
Sebardan	36°07'35.6"N	43°38'16.7"E
Lajan	36°07'29.2"N	43°47'34.4"E
Qadiriya	36°07'25.0"N	43°39'56.9"E
Qoritan 2	36°04'55.9"N	43°56'38.7"E
Qushtapa	36°00'23.7"N	44°00'51.5"E

The texture of the studied soil ranged between silty clay and silty clay loam (similar in texture). The soils are extensively calcareous (more than 10% calcium carbonate). The poultry manure was added by farmers 45 days before sowing. The seeds were sown under tunnels of nylon from 1 to 5 March on 5th of April 2024 (± 2 days); the nylons were removed. The irrigation was done using drip irrigation, and the fertilizers were added using the fertigation method. The chemical fertilizers applied by farmers were powder DAP (18%N and 44%P_2O_5) and NPK (20%N,20% P_2O_5, and 20 K_2O) as follow:

The first, second, and third doses of 10,20, and 30 kg powder DAP donum^{-1} were added on the 10th, 20th, and 30th of April, 2024, then 35 kg NPK donum^{-1} was applied twice on the 10th and 20th of May 2024.

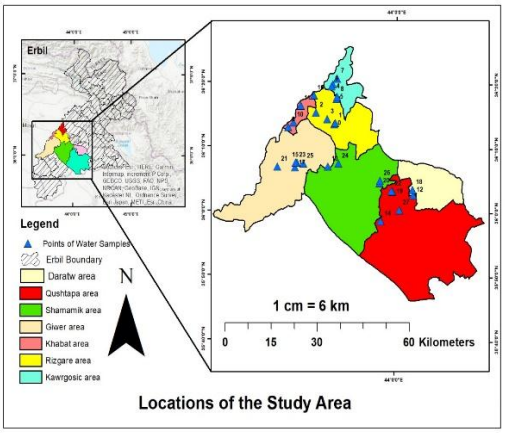

Fig 1. Map for Locations of the study area

The cucumber samples were taken on the 3rd of June 2024 from the mentioned fields, then the nitrate concentration was determined using the following methods:

1- Green test method. In this method, the nitrate measurement was conducted directly from the fruit using the device's special needle.
2- Spectrophotometric method. It is used after extracting the cucumber samples, then recording the data at wavelength, 538 nm, for the samples then determining NO_3^- concentration.

Fig. 2. Green analyzer .

Fig 3. spectrophotometer

The electrical conductivity and NO_3^- concentration of the irrigation waters or water of wells used for irrigation were determined according to [14][15].

The ionic strength was calculated according to the Rajab and Esmail model [16] as follows:

Ionic strength (I) mole L^{-1} = 0.0157 *EC (dS m^{-1}).

The total, active lime, and soil particle size distribution were determined according to Jackson [17], as shown in Table 2.

The statistical analysis was conducted using the SPSS program version 27, recording the correlation coefficient (r) values between nitrate concentration with total and active $CaCO_3$, and nitrate concentration in both methods with ionic strength in irrigation water.

Table 2. Some physical and chemical properties of the soil and irrigation water samples.

Locations	Soil texture	Soil properties					Irrigation water properties		
		Sand	Silt	Clay	$CaCO_3$ %		pH	ECiw (dS m^{-1})	I (mole L^{-1})
		mg Kg^{-1}			Total	Active			
Kawraban 1	Silty Clay Loam	143.10	511.30	345.60	22.23	2.22	7.90	0.71	0.011
Kawraban 2	Silty Clay Loam	152.20	513.50	334.30	23.04	2.76	8.00	0.72	0.011
Chalwk	Silty Loam	248.00	564.20	187.80	25.11	3.77	8.10	0.57	0.009
Chalwk gawra	Silty Loam	249.00	563.00	188.00	27.12	4.07	8.20	0.73	0.011
Agholan 1	Silty Clay Loam	100.20	516.30	383.50	24.22	2.90	8.00	1.23	0.019
Jdeda zab 1	Silty Loam	258.00	557.00	185.00	25.09	3.76	8.10	0.79	0.012
Mala Omer kalak	Silty Clay Loam	109.00	515.00	376.00	23.61	3.54	8.00	0.78	0.012
Kawrgusk	Silty Clay Loam	167.30	526.50	306.20	24.89	2.98	7.95	0.71	0.011
Jdeda zab 2	Silty Clay Loam	127.30	550.40	322.30	27.31	4.09	8.20	0.42	0.007
Agholan 2	Silty Clay Loam	114.70	590.10	295.20	20.76	3.11	7.70	1.23	0.019
Chamadubz	Silty Clay	178.50	468.80	352.70	22.18	2.22	7.80	0.34	0.005
Khabat	Silty Clay Loam	126.60	516.60	356.80	23.91	2.39	7.90	0.78	0.012
Murtakae gawra	Silty Clay Loam	102.20	565.30	332.50	25.31	3.79	8.02	0.35	0.002
Tarjan	Silty Clay Loam	190.20	443.50	366.30	26.21	2.62	8.12	2.63	0.041
Dugrdkan	Silty Clay Loam	163.30	465.40	371.30	22.13	3.31	8.11	0.48	0.008
Shamshwla	Silty Clay Loam	155.30	474.50	370.20	20.98	2.09	7.70	1.35	0.021
Grdarash	Silty Clay Loam	110.30	512.50	377.20	28.17	4.23	8.25	0.33	0.005
Zaga	Silty Clay Loam	124.50	517.70	357.80	24.11	2.89	8.00	0.21	0.003
Murtakae Shhab	Silty Clay Loam	101.30	568.10	330.60	22.65	3.39	7.90	0.46	0.007
Quchablbas 1	Silty Clay Loam	169.00	524.00	307.00	27.71	4.15	8.20	0.42	0.007
Qoritan 1	Silty Clay Loam	163.30	495.40	341.30	26.01	3.90	8.02	0.32	0.005
Pemarabr	Silty Clay Loam	183.30	465.40	351.30	21.32	2.13	7.90	1.49	0.023
Quchablbas 2	Silty Clay Loam	151.90	478.80	369.30	23.12	3.46	7.80	0.39	0.006
Sebardan	Silty Clay Loam	135.40	554.30	310.30	21.17	3.17	7.80	0.34	0.005
Lajan	Silty Clay Loam	141.00	515.00	344.00	29.31	4.39	8.30	0.97	0.015
Qadiriya	Silty Clay Loam	129.80	534.80	335.40	22.26	2.67	7.75	0.35	0.005
Qoritan 2	Silty Clay Loam	154.20	511.30	334.50	28.51	4.27	8.06	0.46	0.007
Qushtapa	Silty Clay Loam	116.00	587.00	297.00	24.37	3.65	8.03	0.44	0.007
Mean	-	152.32	521.63	326.05	24.39	3.28	7.99	0.71	0.01
SD	-	42.59	37.98	53.89	2.45	0.71	0.16	0.51	0.01

Results and Discussion

Table 3 refers to the nitrate concentration in cucumber samples depending on two different methods. The results indicated to the safety of the cucumbers from the studied fields in Erbil plain, as the NO_3^-concentration was below the maximum available concentration (400 µg g-1) for human consumption [18]. This may be due to high soil calcium carbonate, active lime, and slightly alkaline soil pH, which were ranged between (20.76 - 29.31%), (2.09 - 4.39%), and (7.70 - 8.30), respectively, which caused the increase in nitrogen volatilization and then the decrease in nitrates concentration in cucumber [18].On the other hand, high temperatures (more than 10 C°) also caused an increase in nitrogen volatilization, followed by a decrease in NO_3^- concentration [19][20].

Figure 4 refers to the negative correlation between nitrate concentration (measured by spectrophotometer) in cucumber and each of the total and active calcium carbonate, with the correlation coefficient value (r =- 0.57* and -0.83 **), respectively. This explains the role of soil calcium carbonate in decreasing nitrate concentration in cucumber due to an increase in nitrogen volatilization with increasing concentration of calcium carbonate in the soil [18]

Table 3. The mean of the NO_3^- concentration in cucumber using two methods

Location	NO_3^- green analyzer	NO_3^- Spectrophotometer
	µg g^{-1}	
Kawraban 1	254.44	240.21
Kawraban 2	242.67	235.89
Chalwk	201.67	202.17
Chalwk gawra	235.11	219.43
Agholan 1	255.44	234.23
Jdeda zab 1	210.10	215.21
Mala Omer kalak	245.00	228.45
Kawrgusk	235.56	231.12
Jdeda zab 2	216.67	211.08
Agholan 2	201.78	209.25
Chamadubz	252.22	251.78
Khabat	266.11	249.78
Murtakae gawra	203.11	198.22
Tarjan	324.11	316.12
Dugrdkan	213.22	201.18
Shamshwla	286.44	269.39
Grdarash	195.67	183.89
Zaga	235.33	224.67
Murtakae Shhab	235.89	213.91
Quchablbas 1	234.78	211.98
Qoritan 1	204.67	202.23
Pemarabr	273.33	261.18
Quchablbas 2	236.67	212.98
Sebardan	204.67	201.35
Lajan	189.67	182.16
Qadiriya	245.89	237.28
Qoritan 2	222.22	209.61
Qushtapa	214.56	211.78

Mean	233.46	223.80
SD	30.44	28.11

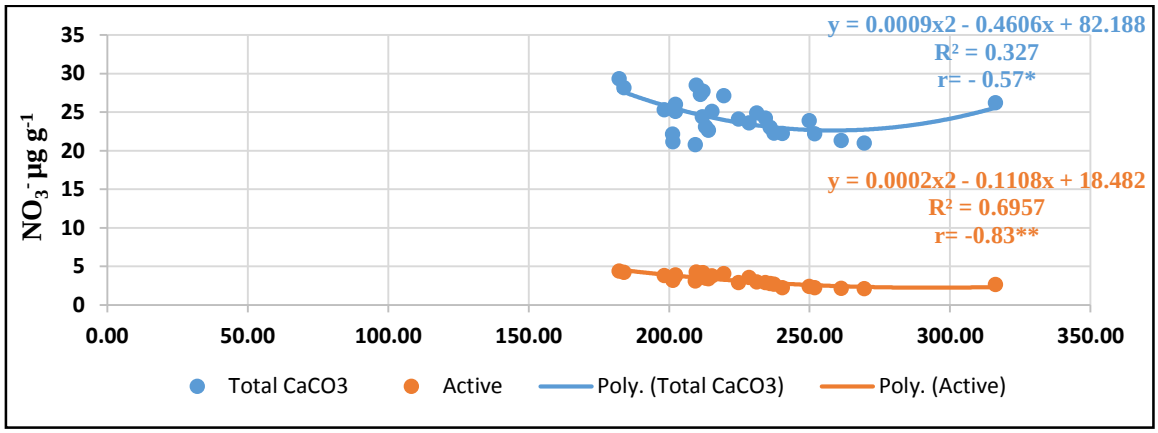

Fig.4 Relationship between NO_3^- with total and active $CaCO_3$

Figures 5 and 6 show that the concentration of NO_3^- in cucumber samples is below the maximum allowable concentration using both green analyzer and spectrophotometer (chemical) methods. It means the cucumbers of the studied 28 fields are healthy for human use because the NO_3^- concentration of them is less than 400 µg g^{-1}. This may be due to the reasons mentioned before, which led to a decrease in NO_3^- concentration and didn't reach a toxic level due to the application of nitrogen fertilizers.

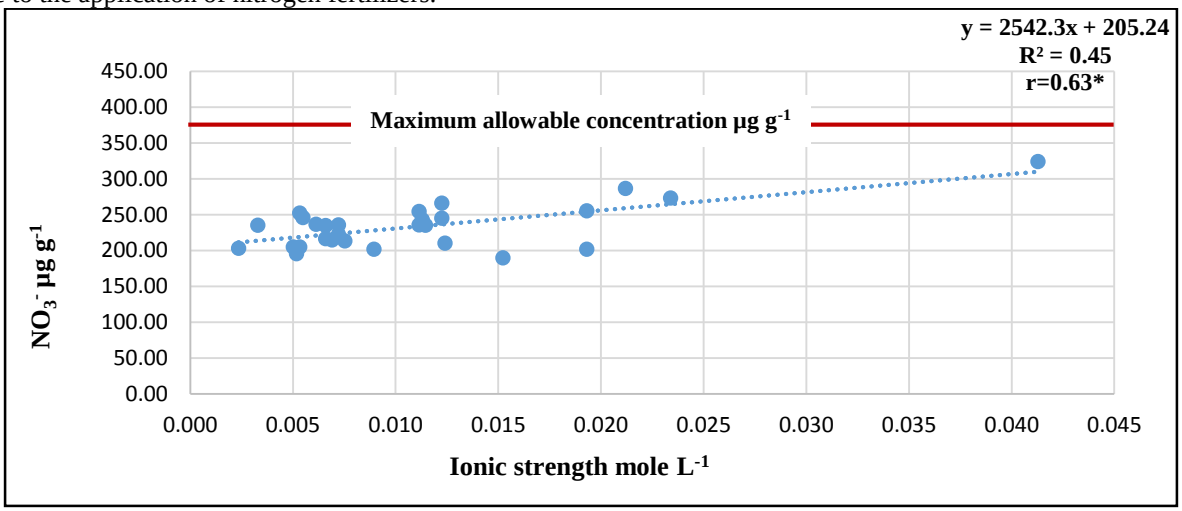

Fig. 5 Relationship between NO_3^- concentration by green analyzer method and ionic strength of irrigation water.

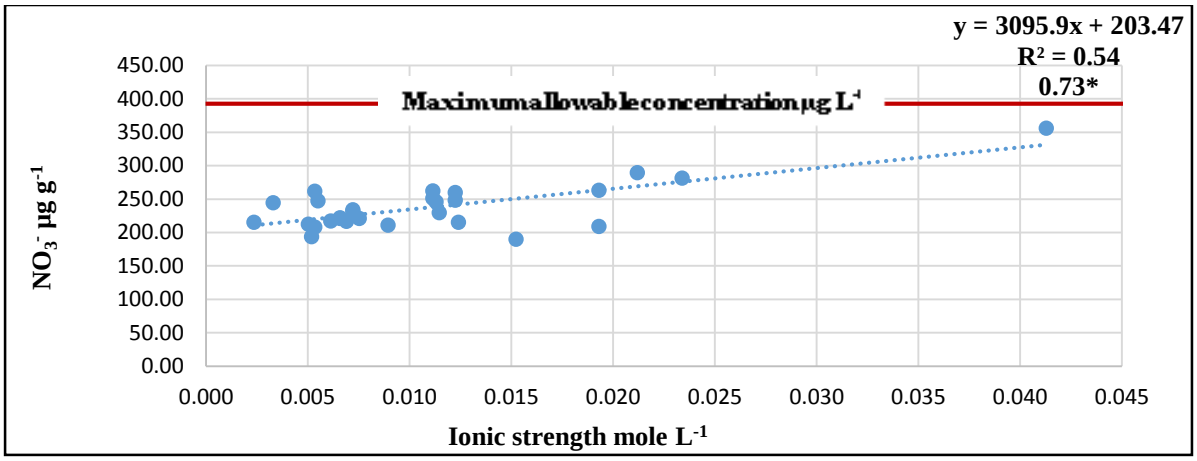

Fig.6 Relationship between NO_3^- concentration by Spectrophotometer method and ionic strength of irrigation water.

Figure 7 explains the significant correlation coefficient value r=0.97** between the green analyzer and spectrophotometer. It means the researchers can depend on the simple method of the green analyzer instead of the expensive chemical method.

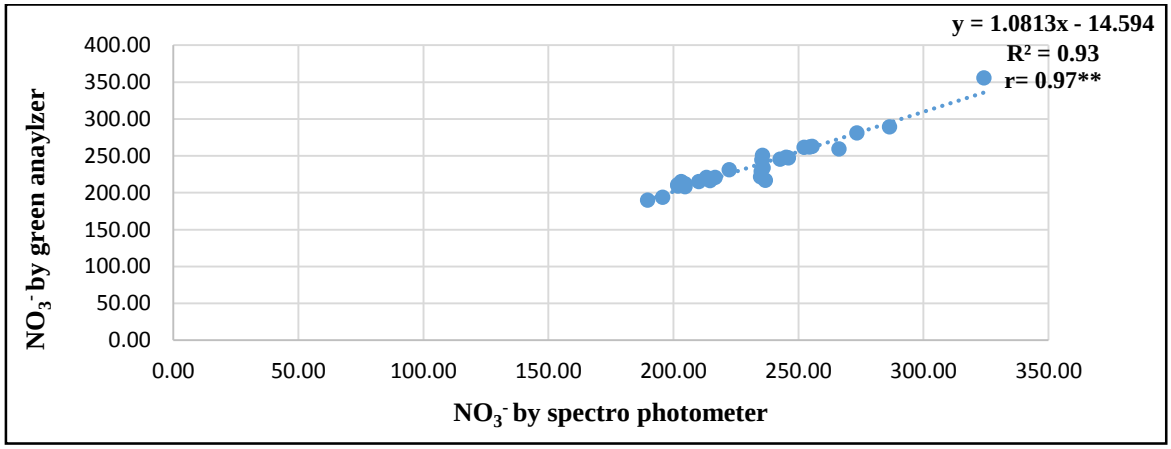

Fig. 7 Relationship between two methods of NO_3^- determination.

Conclusions

Based on the investigation's results, we conclude that the concentration of nitrate in the studied cucumber was within the allowable concentration for human use and did not risk to human health. The ionic strength of irrigation water has no negative influence on the nitrate concentration of cucumber due to its suitability for irrigation.

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تأثير القوة الايونية لمياه الري على تركيز النترات في الخيار (Cucumis sativus L.) في سهل أربيل

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قسم التربة و المياه ، كلية علوم و هندسة الزراعية، جامعة الصلاح الدين، أربيل، العراق[1].

الخلاصة

أجريت الدراسة خلال موسم النمو لعام 2024 في 28 موقعًا في سهل أربيل، العراق، إقليم كردستان العراق، لاختبار تأثير القوة الأيونية لمياه الري على تركيز النترات (***NO3***-) في المحصول الخيار. تم استخدام طريقتين لتحديد النترات، وهما الاختبار الأخضر والطريقة الطيفية الضوئية. كانت المواقع المختارة متشابهة في خصائص التربة ونوع وكمية الأسمدة الكيميائية والعضوية المستخدمة من قبل المزارعين. أشارت النتائج إلى التركيز المسموح به للنترات (***NO3***-) في عينات الخيار المدروسة، والذي كان أقل من الحد الأقصى المسموح به 400 ميكروغرام لكل غرام.تراوحت تركيز كاربونات الكاسيوم الكلية و النشطة و درجة تفاعل للترب المدروسة بين بين (20.76 - 29.31%) و(2.09 - 4.39%) و(7.70 - 8.30) على التوالي .تراوح مدى تركيز النترات في الدراسة بين (189.67 إلى 324.11) و (182.16 إلى 316.12) ميكروغرام لكل غرام لكلا طريقتي التحليل على التوالي. تم تسجيل ارتباط معنوي بين محلل الأخضر والطريقة الطيفية الضوئية بقيمة معامل الارتباط (***r = 0.97*****). هذا يعني أن كلا طريقتي تحليل النترات دقيقتة وموثوقة للدراسات العلمية. تم تسجيل ارتباط سلبي بين تركيز نترات في الخيار وكل من كربونات الكالسيوم الكلية والنشطة، بقيم معامل الارتباط (***r = - 0.57**** و -0.83 **) على التوالي. أشارت نتائج التحليل الإحصائي إلى وجود ارتباط معنوي بين تركيز النترات والقوة الأيونية لمياه الري، حيث بلغت قيم معامل الارتباط) (***r=0.63* , 0.73**** لطريقة التحليل الأخضر والقياس الطيفي الضوئي، على التوالي. وأخيرًا، لم يُشكل تركيز النترات في الخيار أي خطر على صحة الإنسان نظرًا لانخفاض تركيزه.

الكلمات المفتاحية: القوة الأيونية للماء، تربة كلسية، نبات الخيار، خطر النترات ، طرق التحليل.