Nitrate in irrigation water and its impact on growth of wheat and lettuce

E. M. Tawfiek *, A. M. Mashhour, and E. S. E. Abd El-Hady.

Department of Soils and Water, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

* Corresponding author E-mail: esamtawfiek@azhar.edu.eg (E. Tawfiek)

ABSTRACT:

A pot experiment was carried out to evaluate the impact of nitrate concentration in irrigation water as one of the miscellaneous or accidental effects on irrigation water on the growth of wheat and lettuce plants. The pots are filled with sandy soil, irrigated at field capacity with different concentration of nitrate; 0, 10, 20, and 50 mg L-1 from planting to harvest. The results indicated that all growth parameters of wheat and lettuce was rising by rising nitrate levels to 50 mg L-1, but grain yield of wheat was non-significantly decreased at 50 mg L-1 with 3.52% decline comparison control. Furthermore, nitrate in lettuce wasn't harmful to human because nitrate didn't exceed the permissible limits. We concluded that wheat might be irrigated with water containing up to 20 mg L-1 NO3- without any decline in the grain yield, while in the lettuce plants, water could be used containing up to 50 mg L-1 nitrate concentration without any harmful effect on consumers from nitrate accumulation in lettuce leaves, as nitrate contents didn't exceed the permissible limits. This water is used with the recommended fertilization for both crops.

Keywords: water quality; nitrate; wheat; lettuce.

INTRODUCTION:

Nitrogen in the applied irrigation water is generally beneficial for most crops but may cause problems for some. Nitrate loss from soil profile by leaching to drainage and ground water, explains its presence in irrigation water with markedly quantity (Hansen et al., 2019; Hosono et al., 2023; Jahangir et al., 2012; Nolan et al., 2012; Vinod et al., 2015). One of the miscellaneous problems that effect irrigation water quality is excessive nitrogen, which causes excessive and strong growth, lodging, delayed and irregular ripening, and decline yield quantity, quality, and marketability. Wheat and corn are examples of tolerate crops that can withstand up to 30 mg L^{-1}, while grapes, apricots, and cotton sensitive crops cannot tolerate more than 5 mg L^{-1} nitrate (Ayers and Westcot, 1985). Many researchers focused on studying nitrate in irrigation water and its impact on plants especially leafy vegetables. In leafy vegetables as lettuce fresh, nitrate accumulated with significant amounts, that lead to harmful effects on costumers health (Bondonno et al., 2018; Chetty et al., 2019; Colonna et al., 2016; Kiani et al., 2022; Uddin et al., 2021; Zendehbad et al., 2022). Nitrate metabolites possess significant physiological and pharmaceutical characteristics such as those related to tissue protection and vasoregulation (European Food Safety, 2008). There is no evidence that nitrates in water, meat, and vegetables are carcinogenic (Bondonno et al., 2018). There are regulatory limitations on the production and marketing of specific vegetables, despite the fact that there is disagreement between theories that confirm harm effects of nitrates to human health and those that reject this effect (Cavaiuolo and Ferrante, 2014). Nitrate accumulation in vegetables has drawn increasing attention due to its harmful effects on human health. After entering the body nitrate NO_3 can be converted to nitrite NO_2 by bacteria and certain enzymes found in the human digestive system. Next, nitrite enters bloodstream, combining with hemoglobin converting Fe^{+2} to Fe^{+3} by oxidation. This inhibits the bloodstream system's ability to transmit oxygen and causes methaemoglobinemia, which is more dangerous for children. More seriously, when nitrite reacts with amines and amides, it can produce the well-known cancer-causing chemicals nitrosamine and nitrosamide (Choi, 1985) and (Walker, 1990). Nitrate from vegetables is now recognized as an essential bioactive phytochemical with cardioprotective qualities, reduced blood pressure, and improvements in other vascular health indicators. Besides that, studies show that 85% of the dietary nitrate consumption across many communities comes from fruits and vegetables, which have a high nitrate concentration. (Bondonno et al., 2018). In canola the number of seeds per pod, seed production, and oil content all declined as nitrogen fertilizer application levels are rising (Cheema et al., 2001). Also, Rathke et al. (2005) found that the oil content of canola reduced as a consequence of high N rates, while seed yield and crude protein content raised. Generally, the most suitable amount of N to use depends on whether producing a high oil content or high seed yield. Oil yield is often, the major management. Nitrate fertilizer supply significantly enhanced nitrate accumulation in vegetables compared to ammonium N fertilizer supply. An excessive nitrogen fertilizer dose resulted in a decrease in yield. However, nitrate levels in vegetables as a whole showed a positive correlation with N rates. (Wang and Li, 2004). Leaf area of rice increased as the amount of N in the growth media increased. Nevertheless, higher levels of N in the growth media had a negative impact on grain production and Fe content in the leaves and grains (Panda et al., 2012). Geren (2015) found that the quinoa plant height, grain yield, harvest index, thousand grain weight, grain yield and crude protein content of seed were increased by levels N fertilizer up to 150 kg ha^{-1}, while rise dose until 175 kg ha^{-1} led to reduce all parameters except plant height and crude protein content of seed. The excessive nitrogen supply had a negative impact on sesame seed quality. In fact, N fertilizer enhanced the accumulation of proteins until 57.16%, in detriment of oil and sugars that reduced by 49.43% and 16.27%, respectively. Moreover, there was a considerable decrease in the quantity of flavonoids, total phenolics, and antioxidant activity (Elhanafi et al., 2019). The purpose of this study was evaluated of the impact of nitrate in irrigation water on growth of wheat and lettuce plants.

MATERIALS AND METHODS

A pot experiment was conducted in winter season of 2019/2020 at the farm of Soils & Water Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. The plastic pots packed with 12 kg of sandy soil, some physical and chemical analysis of soil are were recent in Tables (1 and 2). 15 grains of wheat were sown in each pot on 25 November 2019. After complete germination, wheat was thinned to 10 plants pot-1. The plants were harvested on 28 April 2020 after 155 days. Then some growth parameters (straw dry weight, grains yield) were estimated as well as NPK content and uptake. Also, lettuce plant cultivated in winter season of 2020/2021 in plastic pots packed with 20 kg sandy soil. Lettuce seeds were sown in arboretum trays on 25 October 2020. After one month, one lettuce plant was transplanting in each pot. The plants were harvested on 14 January 2021. Then some growth parameters (head fresh weight, head dry weight) were estimated as well as NO_3, P, and K content and uptake. Wheat and lettuce were irrigated at field capacity from planting until harvest with tap water (table 3) contain 0, 10, 20, and 50 mg L^{-1} NO_3^-, which prepared from $Ca(NO_3)_2$ and KNO_3 salts. The fertilizers were added to wheat and lettuce as recommended doses by Ministry of Agriculture in Egypt. Where the organic fertilizer was farmyard manure. The used mineral fertilizers were ammonium nitrate (33.5% N-NH_4 - NO_3 as a source of nitrogen), super phosphate (12.5% P_2O_5 as a source of phosphorus) and potassium sulphate (50% K_2O as a source of potassium).

The plant samples were air dried then oven at 70 ◦C until constant of dry weight. The dry samples were then ground in a stainless steel mill to prepare them for digestion. Wet digestion for straw, grains for wheat and head lettuce. 0.2 gram of powder plant tissues its digested using a mixture of H_2O_2 and H_2SO_4 conc. according to the procedure of Parkinson and Allen (1975). Total nitrogen was determined following the micro-kjeldahl method as described by Baker and Thompson (1992). Nitrate was determined rapid colorimetric determination by nitration of salicylic acid with a spectrophotometer according to Cataldo et al. (1975), Phosphorus was determined by colorimetric method by an acidified solution of ammonium molybdate and antimony potassium tartrate , containing ascorbic acid, measured absorbed light (blue solution at 660 nm) with a spectrophotometer, obtained by Moore (1992) and potassium were measured in the digested extract using the flame photometer, according to Page et al. (1982).

Soil analysis

Particles size distribution according to the international pipette (Gee and Bauder, 1986). Moisture content and porosity by (Estefan, 2013). EC, pH, total $CaCO_3$, Ca, Mg, Cl, K, and Na by (Jackson, 1973). CO3-2 and HCO_3- by (Bower and Wilcox, 1965). The experiments were designed as a single factor of complete randomized design with three replicates for each treatment. Significantly different according to Duncan's multiple range test at the 0.05 level (DMRTs) by SPSS 20 program.

RESULTS AND DISCUSSION

Effect of nitrate in irrigation water on NPK content, uptake and productivity of wheat yield.

Data found in Table 4 and illustrated by Fig. 1 show that the impact of nitrate in irrigation water on wheat crop. Where that all growth parameters of wheat increased with increasing of NO_3^- at 50 mg L^{-1}. The increasing in N and K content% and uptake mg pot^{-1} in straw and grains are significantly increased, while phosphorus content% and uptake mg pot^{-1} in straw were significantly decreased with increasing NO_3^-. The highest straw yields were 44.93 obtained with 50 mg L^{-1} NO_3^- and decreased 42.68 g pot^{-1} obtained with control 0.0 NO_3, while the lowest grain yields were 82.75 obtained with 50 mg L^{-1} NO_3^- and increased 88.33 g pot^{-1} obtained with 10 mg L^{-1} NO_3^-. The excess percentage in straw at NO_3 levels 10, 20, and 50 mg L^{-1} compare to control were 2.82, 3.21, and 5.53% respectively, while in grains, the increase is at 10, 20 mg L^{-1} NO_3 only, were 3.04, 1.28% respectively, on the other hand, the grain yields decline at 50 mg L^{-1} NO_3 compared to control by 3.52%. Nitrogen content% and uptake mg pot^{-1} were 1.56, 665.45 for straw and 2.37, 2032.38 for grains and increased by 1.89, 850.37 and 2.58, 2166.63 with increasing NO_3^-. The highest values of phosphorus content % and uptake mg pot^{-1} were 0.35, 151.82 for straw obtained at 10 mg L^{-1} NO_3^- and 0.55, 471.90 for grains and the lowest values were 0.23, 104.84 and 0.38, 311.92 obtained at 50 mg L^{-1} NO_3^-. Potassium content% and uptake mg pot^{-1} were 1.95, 831.30 for straw and 2.20, 1888.98 for grains and increased by 2.21, 994.08 and 2.67, 2209.86 with increasing of NO_3 concentration from 0.0 to 50 mg L^{-1}. The increase in all estimated straw, grains, nitrogen, phosphorus and potassium, content % and uptake mg pot^{-1} in straw and grains, due to increasing of nitrate in irrigation water, which led to increasing of vegetative growth for wheat crop. The results are compatible with those of Crook and Ennos (1995), they showed that plant morphological features, stalk physical strength, and lodging resistance in wheat were affected by increased N rates. Pramanik and Bera (2013) found that in rice crop, grain production raised continuously with nitrogen level rise up to 150 kg ha^{-1} and reduced with additional N fertilizer application 200 kg N ha^{-1}, despite of the plant height, yields of straw, and total chlorophyll increased as nitrogen levels increased. Imdad Ullah et al. (2018) found that the rising nitrogen rates led to enhanced vegetative growth, nevertheless grain yield of wheat crop was decreased. Furthermore, Guo et al. (2019) indicated that nitrate treatment of wheat plants, boosted biomass, photosynthetic productivity, root development, and N absorption. After that, N and K were shown to interact synergistically to produce a combined effect greater than the sum of their separate effects.

Effect of nitrate in irrigation water on NO_3, P and K content, uptake and productivity of lettuce plant

The growth of lettuce plant significantly boosted when irrigated by high levels of nitrate in comparison with the control, as shown in Table 5 and Fig. 2. Fresh and dry weights and the content of NO_3,PK have been positively impacted, respectively, the plant content of several elements reflected in NO_3 and K grew dramatically, but P content significantly decreased. The data are strongly support the effectiveness of nitrate high levels in irrigation water under critical levels in enhancing plant growth. Therefore, the range of mean values of fresh and dry weight from 666.13 to 859.17 and 42.62 to 45.07 g pot^{-1}, respectively. Where, the excess percentages 6.07, 20.08, and 29.18% for fresh weight and 2.43, 4.85, and 5.96% for dry weight at levels of nitrate 10, 20, and 50 mg L^{-1}, respectively, in comparison with control. Where excess% was significant in fresh weight while non-significant in dry weight. As a result of this, the range of nitrate content mg kg^{-1} fresh weight in head lettuce ranged between 39.67 to 544.67 mg kg^{-1} fresh weights. Thus, the range of uptake was from 26.45 to 468.02 mg pot^{-1} when rise nitrate up to 50 mg L^{-1}. The concentration of nitrate in lettuce plant under conditions of our experiment wasn't harmful to human because nitrate didn't exceed the permissible limits European (2006) reported that the maximum levels of nitrate in fresh lettuce ranged by 2500 to 4500 mg kg^{-1} fresh weight. Furthermore, Guffanti et al. (2022) mentioned that the green leafy plants like lettuce can accumulate elevated levels of nitrate, which is a critical risk for humans. Based on this principle, lettuce plants can be irrigated with irrigation water with a nitrate concentration of up to 50 mg L^{-1}. Moreover, the range of phosphorus and potassium as content and uptake were from 0.75 to 0.70%, 338.02 to 316.75 mg pot^{-1} and 3.34 to 3.51%, 1422.36 to 1580.63 mg pot^{-1}, respectively, at levels of nitrate in irrigation water. These findings are in harmony with those of Kučerová et al. (2021), they indicated that the nitrate was primarily responsible for an enhancement in dry weight, photosynthetic pigment content, photosynthetic rate, and overall improvement in morphology of lettuce plants.

CONCLUSION:

we concluded from this study, that different sources of water can be used to irrigate wheat crop, which containing up to 20 mg L^{-1} NO_{3^-} without affecting the grain yield or delaying the maturity of the crop. While for the lettuce plants, it can utilization water contain up to 50 mg L^{-1} NO_{3^-} without any harmful for consumers from nitrate accumulation in the leaf of lettuce. Whereas the nitrate concentration in plant leaves didn't exceed the permissible limits. This study recommend to use other plants and irrigating them with water that contains higher concentration of nitrate, in order to know the permissible limits for irrigation of these plants.

REFERENCES

Ayers, R.S., Westcot, D.W. 1985: Water quality for irrigation. *FAO irrigation and drainage paper* **20**.

Baker, W.H., Thompson, T.L. 1992: Determination of total nitrogen in plant samples by kjeldahl. *Plant analysis reference procedures for the southern region of the United States* **368**, 13-16.

Bondonno, C.P., Blekkenhorst, L.C., Liu, A.H., Bondonno, N.P., Ward, N.C., Croft, K.D., Hodgson, J.M. 2018: Vegetable-derived bioactive nitrate and cardiovascular health. *Molecular Aspects of Medicine* **61**, 83-91.

Bower, C.A., Wilcox, L.V. 1965: Soluble salts. *In* "Methods of soil analysis", pp. 933-951.

Cataldo, D.A., Maroon, M., Schrader, L.E., Youngs, V.L. 1975: Rapid colorimetric determination of nitrate in plant tissue by nitration of salicylic acid. *Communications in Soil Science and Plant Analysis* **6**, 71-80.

Cavaiuolo, M., Ferrante, A. 2014: Nitrates and glucosinolates as strong determinants of the nutritional quality in rocket leafy salads. *In* "Nutrients", Vol. 6, pp. 1519-1538.

Cheema, M.A., Malik, M.A., Hussain, A., Shah, S.H., Basra, S.M.A. 2001: Effects of time and rate of nitrogen and phosphorus application on the growth and the seed and oil yields of canola (brassica napus l.). *Journal of Agronomy and Crop Science* **186**, 103-110.

Chetty, A.A., Prasad, S., Pinho, O.C., de Morais, C.M. 2019: Estimated dietary intake of nitrate and nitrite from meat consumed in fiji. *Food Chemistry* **278**, 630-635.

Choi, B.C.K. 1985: N-nfrroso compounds and human cancer: A molecular epidemiologic approach. *American Journal of Epidemiology* **121**, 737-743.

Colonna, E., Rouphael, Y., Barbieri, G., De Pascale, S. 2016: Nutritional quality of ten leafy vegetables harvested at two light intensities. *Food Chemistry* **199**, 702-710.

Crook, M.J., Ennos, A.R. 1995: The effect of nitrogen and growth regulators on stem and root characteristics associated with lodging in two cultivars of winter wheat. *Journal of Experimental Botany* **46**, 931-938.

Elhanafi, L., Houhou, M., Rais, C., Mansouri, I., Elghadraoui, L., Greche, H. 2019: Impact of excessive nitrogen fertilization on the biochemical quality, phenolic compounds, and antioxidant power of sesamum indicum l seeds. *Journal of Food Quality* **2019**, 9428092.

Estefan, G. 2013: Methods of soil, plant, and water analysis: A manual for the west asia and north africa region. International Center for Agricultural Research in the Dry Areas (ICARDA).

European, C. 2006: Commission regulation (ec) no 1882/2006 of 19 december 2006 laying down methods of sampling and analysis for the official control of the levels of nitrates incertain foodstuffs. *Official Journal of the European Union* **364**, 32-43.

European Food Safety, A. 2008: Nitrate in vegetables - scientific opinion of the panel on contaminants in the food chain. *EFSA Journal* **6**, 689.

Gee, G.W., Bauder, J.W. 1986: Particle-size analysis. *In* "Methods of soil analysis", pp. 383-411.

Geren, H. 2015: Effects of different nitrogen levels on the grain yield and some yield components of quinoa (chenopodium quinoa willd.) under mediterranean climatic conditions. *Turkish Journal of Field Crops* **20**, 59-64.

Guffanti, D., Cocetta, G., Franchetti, B.M., Ferrante, A. 2022: The effect of flushing on the nitrate content and postharvest quality of lettuce (lactuca sativa l. Var. Acephala) and rocket (eruca sativa mill.) grown in a vertical farm. *In* "Horticulturae", Vol. 8.

Guo, J., Jia, Y., Chen, H., Zhang, L., Yang, J., Zhang, J., Hu, X., Ye, X., Li, Y., Zhou, Y. 2019: Growth, photosynthesis, and nutrient uptake in wheat are affected by differences in nitrogen levels and forms and potassium supply. *Scientific Reports* **9**, 1248.

Hansen, B., Thorling, L., Kim, H., Blicher-Mathiesen, G. 2019: Long-term nitrate response in shallow groundwater to agricultural n regulations in denmark. *Journal of Environmental Management* **240**, 66-74.

Hosono, T., Taniguchi, K., Sakiur Rahman, A.T.M., Yamamoto, T., Takayama, K., Yu, Z.Q., Aihara, T., Ikehara, T., Amano, H., Tanimizu, M., Nakagawa, K. 2023: Stable n and o isotopic indicators coupled with social data analysis revealed long-term shift in the cause of groundwater nitrate pollution: Insights into future water resource management. *Ecological Indicators* **154**, 110670.

Imdad Ullah, Ali, N., Durrani, S., Shabaz, M.A., Hafeez, A., Ameer, H., Ishfaq, M., Fayyaz, M.R., Rehman, A., Waheed, A. 2018: Effect of different nitrogen levels on growth, yield and yield contributing attributes of wheat. *Int J Sci Eng Res* **9**, 595-602.

Jackson, M., New Delhi, India 1973: Soil chemical analysis, pentice hall of india pvt. **498**, 151-154.

Jahangir, M.M.R., Khalil, M.I., Johnston, P., Cardenas, L.M., Hatch, D.J., Butler, M., Barrett, M., O'flaherty, V., Richards, K.G. 2012: Denitrification potential in subsoils: A mechanism to reduce nitrate leaching to groundwater. *Agriculture, Ecosystems & Environment* **147**, 13-23.

Kiani, A., Sharafi, K., Omer, A.K., Matin, B.K., Davoodi, R., Mansouri, B., Sharafi, H., Soleimani, H., Massahi, T., Ahmadi, E. 2022: Accumulation and human health risk assessment of nitrate in vegetables irrigated with different irrigation water sources- transfer evaluation of nitrate from soil to vegetables. *Environmental Research* **205**, 112527.

Kučerová, K., Henselová, M., Slováková, Ľ., Bačovčinová, M., Hensel, K. 2021 :Effect of plasma activated water, hydrogen peroxide, and nitrates on lettuce growth and its physiological parameters. *In* "Applied Sciences", Vol. 11.

Moore, K.P. 1992: Determination of phosphorus in plant tissue by colorimetry. *Plant analysis reference procedures for the Southern region of the United States*.

Nolan, B.T., Malone, R.W., Gronberg, J.A., Thorp, K.R., Ma, L. 2012: Verifiable metamodels for nitrate losses to drains and groundwater in the corn belt, USA. *Environmental Science & Technology* **46**, 901-908.

Page, A., Miller, R., Keeney, D. 1982 :Methods of soil analysis, part 2—chemical and microbiological properties (2d ed.): Madison, wis. *In* "Soil Science Society of America".

Panda, B.B., Sharma, S., Mohapatra, P.K., Das, A. 2012: Application of excess nitrogen, phosphorus, and potassium fertilizers leads to lowering of grain iron content in high-yielding tropical rice. *Communications in Soil Science and Plant Analysis* **43**, 2590-2602.

Parkinson, J.A., Allen, S.E. 1975: A wet oxidation procedure suitable for the determination of nitrogen and mineral nutrients in biological material. *Communications in Soil Science and Plant Analysis* **6**, 1-11.

Pramanik, K., Bera, A.K. 2013: Effect of seedling age and nitrogen fertilizer on growth, chlorophyll content, yield and economics of hybrid rice (oryza sativa l.). *International Journal of Agronomy and Plant Production* **4**, 3489-3499.

Rathke, G.W., Christen, O., Diepenbrock, W. 2005: Effects of nitrogen source and rate on productivity and quality of winter oilseed rape (brassica napus l.) grown in different crop rotations. *Field Crops Research* **94**, 103-113.

Uddin, R., Thakur, M.U., Uddin, M.Z., Islam, G.M.R. 2021: Study of nitrate levels in fruits and vegetables to assess the potential health risks in bangladesh. *Sci Rep* **11**, 4704.

Vinod, P.N., Chandramouli, P.N., Koch, M. 2015: Estimation of nitrate leaching in groundwater in an agriculturally used area in the state karnataka, india, using existing model and gis. *Aquatic Procedia* **4**, 1047-1053.

Walker, R. 1990: Nitrates, nitrites and n-nitrosocompounds: A review of the occurrence in food and diet and the toxicological implications. *Food Additives & Contaminants* **7**, 717-768.

Wang, Z., Li, S. 2004: Effects of nitrogen and phosphorus fertilization on plant growth and nitrate accumulation in vegetables. *Journal of Plant Nutrition* **27**, 539-556.

Zendehbad, M., Mostaghelchi, M., Mojganfar, M., Cepuder, P., Loiskandl, W. 2022: Nitrate in groundwater and agricultural products: Intake and risk assessment in northeastern iran. *Environmental Science and Pollution Research*.

Table1: Some chemical analysis for soil used in plantation.

pH (1:1)	CEC $mmol_c/100g$	$CaCO_3$ %	EC dSm^{-1} (1:2.5)	Soluble cations $mmol_c\ kg^{-1}$				Soluble anions $mmol_c\ kg^{-1}$			
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
7.75	2.16	0.48	0.45	4.2	2.05	3.88	1.15	-	4.55	2.83	3.9

Table 2: Some physical analysis for soil used in plantation.

Particle size distribution				Bulk density $g.cm^{-3}$	Porosity %	S.P %	F.C %	A.W %
Sand	Silt %	Clay %	Texture					
95.7	1.7	2.6	Sand	1.7	23.87	19	9	5

(A.W) available water (F.C) field capacity (S.P) saturation percent %

Table 3: Chemical properties for irrigation water (tap water).

EC dS m^{-1}	pH	Soluble cations mmol$_c$ L^{-1}				Soluble anions mmol$_c$ L^{-1}			
		Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
0.38	7.48	1.26	0.81	1.23	0.42	-	1.22	1.14	1.36

Table 4: Impacts of nitrate content in irrigation water on NPK content, and uptake in straw and grain of wheat yield.

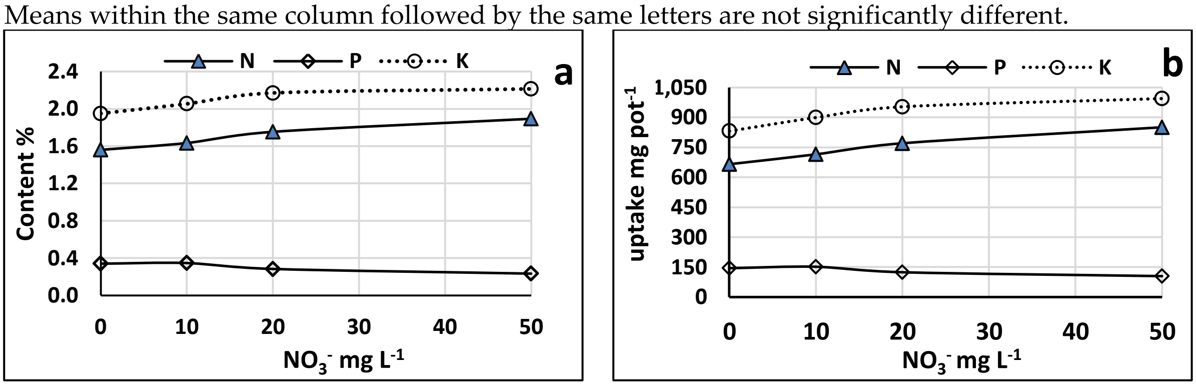
			Straw					
NO_3 mg L^{-1}	Straw g pot^{-1}	Excess %	content %			uptake mg.pot^{-1}		
			N	P	K	N	P	K
0	42.68a	0.00a	1.56c	0.34a	1.95c	665.45c	144.60a	831.30c
10	43.77a	2.82a	1.63c	0.35a	2.05bc	714.73c	151.82a	898.98bc
20	43.93a	3.21a	1.75b	0.28b	2.17ab	770.26b	124.22b	953.09ab
50	44.93a	5.53a	1.89a	0.23c	2.21a	850.37a	104.84c	994.08a
			Grains					
NO_3 mg L^{-1}	Grain g pot^{-1}	Excess %	content %			uptake mg.pot^{-1}		
			N	P	K	N	P	K
0	85.78ab	0.00a	2.37c	0.55a	2.20d	2032.38b	471.90a	1888.98b
10	88.33a	3.04a	2.41c	0.50b	2.38c	2128.43a	438.59a	2104.98a
20	86.80ab	1.28a	2.50b	0.43c	2.51b	2166.63a	370.17b	2179.52a
50	82.75b	-3.52a	2.58a	0.38d	2.67a	2131.79a	311.92c	2209.86a

Means within the same column followed by different letters are significantly different according to Duncan's multiple range test at the 0.05 level (DMRTs).
Means within the same column followed by the same letters are not significantly different.

Table 5: Impacts of nitrate in irrigation water on fresh, dry weight, yield excess %, NO_3, P, and K in head of lettuce.

NO_3 mg L^{-1}	Fresh g pot^{-1}	excess %	Dry g pot^{-1}	Excess %	content % (NO_3 mg kg^{-1} FW)			uptake mg pot^{-1}		
					NO_3	P	K	NO_3	P	K
0.00	666.13b	0.00c	42.62a	0.00a	39.67d	0.75ab	3.34c	26.45d	319.44a	1422.36b
10.00	706.47b	6.07bc	43.57a	2.43a	162.33c	0.78a	3.40b	114.66c	338.02a	1481.65ba
20.00	798.27a	20.08ab	44.63a	4.85a	276.33b	0.71ab	3.45ab	220.66b	316.75a	1541.29a
50.00	859.17a	29.18a	45.07a	5.96a	544.67a	0.70a	3.51a	468.02a	317.04a	1580.63a

Means within the same column followed by different letters are significantly different according to Duncan's multiple range test at the 0.05 level (DMRTs).
Means within the same column followed by the same letters are not significantly different.



2nd International Scientific Conference "Agriculture and Futuristic Challenges (Food Security: Challenges and Confrontation)", Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, October 10th –11th, 2023.

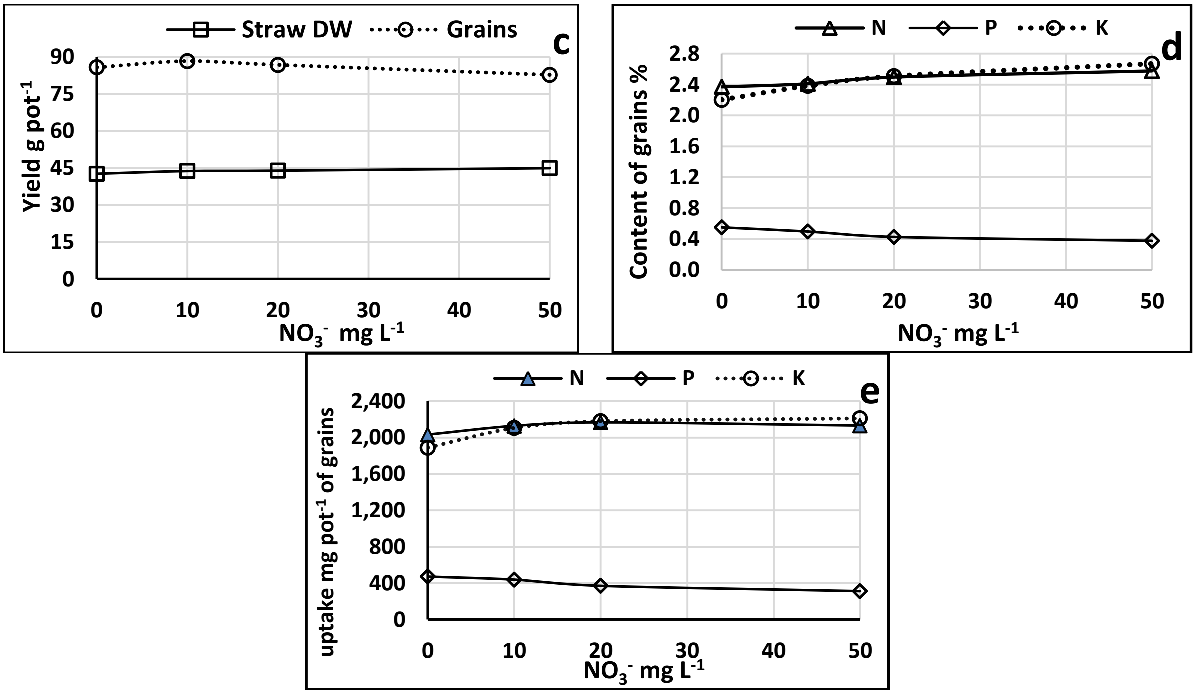
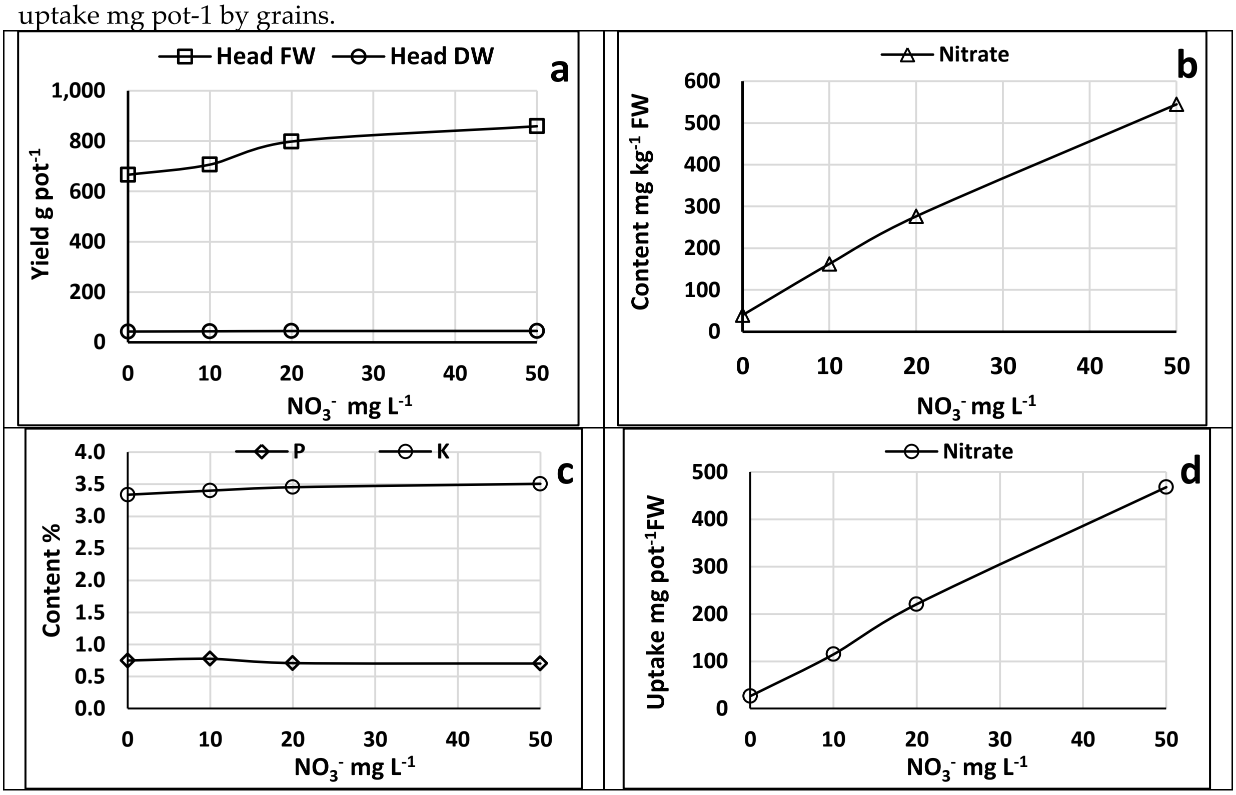


Figure 1: Impact of nitrate in irrigation water on wheat crop: (a) NPK content % in straw. (b) NPK uptake mg pot-1 in straw. (c) yield of straw and grains g pot-1. (d) NPK content % in grains. (e) NPK uptake mg pot-1 by grains.



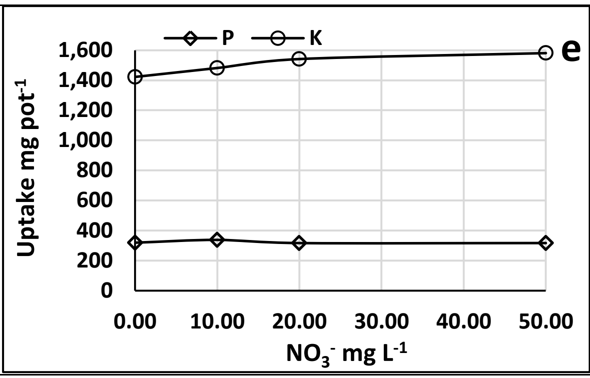


Figure 2: Impact of nitrate in irrigation water on lettuce plant: (a) yield of head fresh weight and head dry weight g pot^{-1} (b) nitrate content in head FW mg pot^{-1} (c) PK content % in head DW (d) nitrate uptake in head FW mg pot^{-1} (e) uptake P and K mg pot^{-1} in head DW.

النترات فى مياه الرى وأثرها على نمو القمح والخس

عصام محمد توفيق [*]**، على محمد عبدالوهاب مشهور، عماد سعيد السيد عبدالهادى.**

قسم الأراضى والمياه،كلية الزراعة، جامعة الازهر، القاهرة، مصر

* البريد الإلكتروني للباحث الرئيسي: esamtawfiek@azhar.edu.eg

الملخص العربي:

أجريت تجربة أصص لمعرفة تأثير النترات فى مياه الرى على نمو كل من القمح والخس. حيث استخدمت تربة رملية. وكان تركيز النترات فى مياه الرى (صفر ، 10 ، 20، 50 ملليجرام لكل لتر)، حيث رويت النباتات من الإنبات حتى الحصاد عند السعة الحقلية بهذه المياه. وقد أشارت النتائج الى أن جميع مقاييس النمو لكلا المحصولين زادت بإرتفاع مستويات النترات فى مياه الرى حتى 50 ملليجرام لكل لتر، بينما محصول الحبوب فى القمح قد انخفض انخفاضاً غير معنوى عند الرى بتركيز 50 ملليجرام لكل لتر نترات بنسبة 3.52% مقارنة بالكنترول.علاوة على ذلك فان محتوى النترات فى أوراق نبات الخس لم تكن ضارة للإنسان لأنها لم تتعدى الحدود المسموح بها. وعلى ذلك يمكن رى محصول القمح بمياه تحتوى على 20 ملليجرام لكل لتر نترات دون حدوث أى نقص فى المحصول. بالإضافة الى رى الخس بمياه تحتوى على تركيز 50 ملليجرام لكل لتر دون حدوث أى ضرر محتمل من تناول الخس.

الكلمات الاسترشادية : جودة مياه الرى، النترات، القمح، الخس.