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THE IMPACT OF HEAVY METALS (CADMIUM & NICKEL) ON SEED GERMINATION, PHOTOTHYNSISES PIGMENTS AND VEGETATIVE GROWTH OF FENUGREEK (*Trigonell afoenum*-Graecum) PLANT

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ABSTRACT

This study was conducted at the College of Agricultural Engineering Science, University of Duhok, Kurdistan region. The aim of this work is to study the influence of Cadmium at (0, 50, 100) mg/kg^{-1} and Nickel fertilizer at (0, 50, 100, 150) mg/kg^{-1} concentrations on the seed germination, photosynthesis pigments and vegetative part of *Trigonell afoenum-graecum* .The results conducted that the heavy metals (Cd and Ni) and interaction between 50mg/kg^{-1} of nickel with control has a significant effect on the high of plant. Moreover, the 100 mg/kg^{-1} of cadmium and the interaction of 100 mg/kg^{-1} cadmium with control of nickel produce a high value of fresh weight of vegetative part, in addition, the application of 100 mg/kg^{-1} cadmium and combination with the control and interaction between 100 mg/kg^{-1} of cadmium and nickel had a great effect on the weight of root. The dry weight of plant was improved by adding 100 mg/kg^{-1} for each of cadmium and nickel but the best value was the combination of 100 mg/kg^{-1} of cadmium with nickel, as well as, the interaction 50 mg/kg^{-1} of cadmium with control had great impact on the seed germination, There was a significant influence of Cd and Ni on the 50 mg/kg^{-1} and 100 mg/kg^{-1} of cadmium and 150 mg/kg-1 of nickel, ß carotene 100 mg/kg^{-1} both of the Cd and Ni, while the total carotene concentration was effected by the 50 mg/kg^{-1} for both and 150 mg/kg^{-1} of nickel and Zeazanthen concentration 100mg/kg^{-1} of cadmium with effect of all levels of nickel, additionally, the concentration of £ carotene, ß carotene and Zeazanthen was effected by the interaction of 100 mg/kg^{-1} of Cd and Ni and interaction of all levels of Cd and Ni was significantly affected total carotene concentration.

KEYWORD: Nickel, Cadmium, Fenugreek, Photothynsises Pigments, Vegetative Growth, Phytotoxicity

1. INTRODUCTION

Industrialization and rapid urbanization have has accumulate some of pollutants like heavy metals, chemical fertilizers, pesticides in the resources of nature such as air, water and soil, as well as the heavy metal present naturally in the soil, the geological and anthropogenic activities increase the rate of concentration of compounds to be harmful and toxic to both animals and plants (Singh, 2020). The heavy metals toxicity is an issue for the reasons of environment, ecological and evolutionary reasons (Nagajyoti *et al.,* 2008). Heavy metals are common pollutants in urban aquatic ecosystems and in contrast to most pollutants, are not biodegradable and are thus persistent in the environment. Many metals, a number of which are non-essential to plant and animal metabolism, are often toxic in low concentrations (Baker, 1981). Furthermore, heavy metals such as mercury, cobalt, copper, chromium, lead, nickel and cadmium are pollutants of environment that led to toxic influence on plants (Singh, 2020). Nickel and Cadmium are the most abundant heavy metals. It is well known that heavy metals are among the most toxic and environmentally hazardous pollutants. The toxicity of nickel obvious on affecting activities of enzyme such as protease, ribonuclease and amylase hence led to retarding plant growth and seed germination (Ahmad *et al*., 2011). As well as, impact on the mobilization and digestion of some reserved food such as carbohydrates and proteins in seed germination (Ashraf *et al.,* 2011). Moreover, it reduce root length, plant height, activities of carbonic anhydrase enzyme, chlorophyll content and fresh and dry weight of plant (Siddiqui, *et al*., 2011). The stress of nickel also highlighted in another study that influence on lessen yield, accumulation of K+, Ca+ and Na+ and photosynthetic pigments (Ahmad *et al*., 2007). Rising the rate of Ni concentration can alter the metabolism of plant that cause growth and germination inhibition (Khan and Khan, 2010). The visible symtoms of Ni toxicity is existing of necrosis, chlorosis and stunted growth on the leaf of plant (Seregin and Kozhevnikova, 2006). Ni with the high rate of concentration can inhibit chlorophyll biosynthesis and production of dry matter (Ahmed *et al*., 2010). In addition, the high toxicity of cadmium as a heavy metal has a 10-30 years of half-life elimination (Jan, *et al*., 1999). A high cadmium concentration in soil led to high threats to the health of human (Alvarez-Ayuso, 2008). Also it's been investigated by Iqbal and Mehmood (1991) that some trees growth and germination affected by the toxicity of cadmium. Cadmium reduce carotenoid and chlorophyll content content, but increase the quenching non-photochemical in *Brassica napus* (Ali *et al*., 2015). The decreasing in the content of chlorophyll is caused by the chloroplast structures destruction by cadmium also increase degradation and chlorophyll synthesis inhibition (Liu *et al.,* 1995). Moreover, cadmium damage photosystems I and II (Siedlecka, 1996) and harvesting complex light II (Krupa, 1988).

Fenugreek (*Trigonell afoenum*-graecum) is an annual plant in the family of *Fabaceae*. The seeds of this plant are used by people in Asia, Africa and Mediterranean countries as one of the ingredients in daily diet (Smith, 2003). Today, it is considered as one of the leading functional foods in the market with anecdotal traits ranging from ameliorating diseases to improving health. The fenugreek seeds contain polyphenolic compounds, which have been correlated to the beneficial health effects of fenugreek (Rayyan *et al*, 2010). Steroidal saponins in fenugreek seeds increase appetite, while inducing hyper in sulinemia and decreasing plasma total cholesterol levels (Taylor *et al.,* 1997; Yoshikawa *et al.,* 1997). It is also a rich source of polysaccharides and galactomannan (Jiang *et al.,* 2007). The seeds of fenugreek plant (*Trigonell afoenum*-graecum) are widely used in the preparation of seasonings, pickles, curry powders and dietary supplements. The fenugreek seeds are also used in traditional Medicine to relieve the common cold, arthritic pain and high blood sugar. Thus, the main aim of this research is to determine the effect of heavy metals specially (cadmium and nickel) on all of photosynthesis pigments, seed germination and vegetative growth of fenugreek plant.

MATERIALS AND METHODS

This study was carried out in the greenhouse of department Horticulture / College of agricultural Engineering Science /University of Duhok from 1/February /2011 to 31/October /2011. The seeds were bought from the local market and the variety was confirmed by plant classification specialist in the College of agricultural Engineering Science. Seeds were germinated in petri dishes after being soaked in the solutions of cadmium at (0, 50, 100) mg/kg^{-1} and then Nickel was added sequentially by irrigation at (0, 50, 100, 150) mg/kg^{-1} for two days then incubated to tested the percentage of seed germination and imbibition of seeds. Then for the rest of studied characteristics another group of seeds socked in water for two days were planted in the pots that filled with sandy soils (3 kg) rinsed by water several times placed in the greenhouse. After the formation of 4-6 pairs of leaves on the plants was added as a first batch the solution of cadmium at different concentrations (0, 50, 100) mg/kg^{-1} and then solution of Nickel was added sequentially at different concentrations (0, 50, 100, 150) mg/kg^{-1}. The plants were followed up and all agricultural service operations were carried out by irrigation, deforestation, and provision of light, humidity and suitable temperature according to plant requirements. The experimental treatments consisted of three replications in Random Complete Block Design (RCBD). The experimental measurements are high of plant, number of leaves per plant, number of branches per plant, number of legume per plant, number of seeds, fresh weight of vegetative part, fresh weight of roots system, dry weight of vegetative part, dry weight of roots system, imbibition of seeds , seeds germination percentage ,Chlorophyll pigments; Chlorophyll content and Zeazanthen (mg.g^{-1} fresh weight); For determining chlorophylls a, b and total chlorophyll, 5 to 10 leaves from each transplant were taken, collected in polyethylene bags, and transferred quickly to laboratory. One g from each sample was taken and transferred to 30 ml ethanol (98%) for 72 hrs and repeated 3 times. When chlorophyll pigment was completely extracted into ethanol, the maximum absorbance (a and b) of the solution were determined spectrophoto-metrically at 2 wavelengths (642 and 660 nm) respectively, as well as, the zeazanthen was estimated by the same way with wavelength (453nm). Total chlorophyll content of leaves (mg.g-1 fresh weight) was calculated according to (Knudson *et a.l*, 1977) and shown in the equations (1, 2 and 3)

$$\text{Chlorophyll (a)} = \frac{(13.70\times660A - 5.76\times642A) \times \text{Final extract volume}}{\text{Sample weight} \times 1000} \ldots\ldots(1)$$

$$\text{Chlorophyll (b)} = \frac{(25.8*649A - 7.60*660A) \times \text{Final extract volume}}{\text{Sample weight} \times 1000} \ldots\ldots(2)$$

Total Chlorophyll = Chlorophyll a + Chlorophyll b……………………………………(3)

660A = wavelength value at 660

642A = wavelength value at 642

While Total, £ and β carotene were estimated at wave lengths (480, 424 and 429 nm) respectively by the method described by taking 5-10 leaves from each transplant (Tattini *et al*., 1988), mixed, collected in polyethylene bags, and transferred quickly to laboratory, 0.5g of each fresh soft leaves sample was taken and ground with 10 ml of 80% acetone. It was then centrifuged at 5000 –10000 rpm for 5 min. One ml from the supernatant solution was taken and 10 ml of acetone was added to it. The absorbance of the solution was red at 480 nm compared with the blank (acetone), and the concentration of carotene as ($mg.g^{-1}$) fresh weight was measured using equation (4)

Total carotene (mg.g-1) = $mg.kg^{-1} \times 100/1000 \times$ sample weight……………………………(4)

2. RESULTS AND DISCUSSION

Data in table (1) clearly showed that the both cadmium and Nickel had no significant effect on the high of the plant. The interaction of control of Cadmium with 50 mg/kg^{-1} of Nickel produce a high value of high of plant which was recorded as (41.417cm) compared with other combinations treatments. It's clearly found in the table (1) that the Cadmium and Nickel and the interaction among them don't had any effect on modifying the number of leaves, number of branches and number of legume per fenugreek plant. It was obviously showed that the cadmium had no significant effect on number of seeds per plant. While, a control of Nickel had a significant effect on number of seeds per plant compared with other treatments with (17.778), the result was agreed with the finding of Singh and Singh (1996) and Farooqui *et.al.* (2009), whom also reported decreasing seed germination by increasing the rate of added Nickel, this might be due to existing of toxic or inhibitory materials which degraded metabolic reaction, and this toxic materials disturb the repair mechanism and metabolism which directly influence cell elongation and division, As well as, impact on the mobilization and digestion of some reserved food such as carbohydrates and proteins in seed germination (Ashraf *et al.*, 2011). The interaction among Cadmium and Nickel don't had any effect on modifying the number of seeds per plant. Decreasing in nickel content in plant will decrease the shoot system, Khalid and Tinsley (1980), reported that decreasing the nickel in the plant will lead to reduction in shoot yield of the Rye grass. In addition, cadmium toxicity may reduce the growth of root and shoot system of wheat plant (Ahmed *et al*., 2012). The plant does not need a large amount of Nickel for their growth which include branches, leaves and number of seeds. Thus, the plant during their growth needs very low amount of Nickel (Asati *et al.*, 2016), moreover, there was a reduction in leaf area, SPAD value of leaves, transpiration, shoot growth and photosynthesis of leaves after applying heavy metal especially cadmium and lead on hackberry seedlings (Hatamian, *et al.*, 2020), as well as, Shanker *et al.*, (2005) highlighted that a healthy leaves development, growth and total number of leaves contribute in the yield of crops.

Table (1): Effect of Cadmium and Nickel concentration on high of plant^{-1}, number of leaves per plant^{-1}, number of branches per plant, number of legume per plant and number of seeds of fenugreek plant (*Trigonell afoenum*-graecum).

Cadmium concentrations	**High of plant(cm)**				**Mean of cadmium**
	Nickel concentrations				
	0.0 mg/kg^{-1}	50 mg/kg^{-1}	100 mg/kg^{-1}	150 mg/kg^{-1}	
0.0 mg/kg^{-1}	35.083ab	41.417a	33.943ab	29.333ab	34.944 a
50 mg/kg^{-1}	26.553b	32.833ab	33.750ab	39.470ab	33.152a
100 mg/kg^{-1}	37.667ab	40.250ab	39.387ab	35.470ab	38.193a
Mean of nickel	33.101a	38.167a	35.693a	34.758a	
Cadmium concentration	Number of leaves per plant				Mean of cadmium
0.0 mg/kg^{-1}	24.670a	28.670a	27.000a	37.330a	29.417a
50 mg/kg^{-1}	52.000a	30.670a	40.000a	55.670a	44.583a
100 mg/kg^{-1}	37.670a	29.670a	56.330a	34.000a	39.417a
Mean of nickel	38.111a	29.667a	41.111a	42.333a	
Cadmium concentration	Number of branches per plant				Mean of cadmium
0.0 mg/kg^{-1}	3.000a	5.000a	4.333a	5.333 a	4.417a
50 mg/kg^{-1}	7.000a	3.667a	5.000a	7.000 a	5.667a
100 mg/kg^{-1}	4.667a	4.000a	8.000a	4.333a	5.250a
Mean of nickel	4.889a	4.222a	5.778a	5.556a	
Cadmium concentration	Number of legume per plant				Mean of cadmium
0.0 mg/kg^{-1}	4.333a	4.333a	4.000a	5.000a	4.417a
50 mg/kg^{-1}	7.333a	5.000a	6.667a	10.000a	7.250a
100 mg/kg^{-1}	5.333a	4.000a	6.667a	3.667a	4.917a
Mean of nickel	5.667a	4.444a	5.778a	6.222a	
Cadmium concentration	Number of seeds per plant				Mean of cadmium
0.0 mg/kg^{-1}	18.333a	17.000a	16.667a	14.667a	16.667a
50 mg/kg^{-1}	16.333a	17.667a	18.333a	15.000a	16.833a
100 mg/kg^{-1}	18.667a	14.000a	13.667a	14.000a	15.083a
Mean of nickel	17.778a	16.222ab	16.222ab	14.556b	

*Means followed by the same letter for each factor and interaction do not differ significantly from each other's according to Duncan's Multiple range Test at 5% level.

The data in the table (2) clearly showed that the cadmium had a significant increase in the fresh weight of vegetative part of the plant especially at 100 mg/kg^{-1} which recorded (7.208g) compared with control which was (4.716g). Nickel had no significant effect on the fresh weight of vegetative part of plant. The interaction of 100mg/kg^{-1} of Cadmium with control of Nickel produce a high value of fresh weight which recorded as (9.600g) compared with other combinations treatments. The fresh weight of roots was highly effected by the application of cadmium especially at third concentration 100 mg/kg^{-1} which was (2.266g) which not differed significantly with second concentration of Cadmium (2.016g) but in compaction with control there was a clear effect. In the same table it found that Nickel had no significant effect on fresh weight of roots system. In the duel interaction between 100 mg/kg^{-1} of cadmium and 100 mg/kg^{-1} of Nickel was the best interaction affecting the fresh weight of root compared with all other combinations. The data in this table showed that the cadmium lead to improve the dry weight of fenugreek plant mainly at 100 mg/kg^{-1} which recorded high value (4.033g) as compared with control (2.058g). And the high value of dry weight was obtained with 100 mg/kg^{-1} of Nickel compared with other treatments. The high rate of Ni reduce root length, plant height, activities of carbonic anhydrase enzyme, chlorophyll content and fresh and dry weight of plant (Siddiqui *et al*., 2011). Rising the rate of Ni concentration can alter the metabolism of plant that cause growth and germination inhibition (Khan and Khan, 2010). The best interaction affecting on dry weight was cadmium 100 mg/kg^{-1} with Nickel 100 mg/kg^{-1}. It's clearly found in the table that the Cadmium and Nickel and the interaction among them don't had any effect on modifying the dry weight of fenugreek plant roots and Imbibition of seeds. The data in the same table indicated that the cadmium had no significant effect on seed germination, in the other hand the Nickel become a reason on deceasing the seed germination rate compared with control. The finding was agreed with the result of (Singh and Singh (1996) and Farooqui *et al.,* (2009), whom highlighted that there was a declining in the survival of seedlings and seed germination percentage with the increasing the rate of nickel concentration. This may be due to the existing of the certain toxic and inhibitory substances which led to disturb the activity of metabolism (Ananthaswamy *et al.,* 1971). As well as the most obvious response of Ni on the division of cell is sharp decrease in the activity of mitotic stage with the increasing of Ni concentrations while in control is quite normal (Singh, 2020), in addition, The toxicity of nickel obvious on affecting activities of enzyme such as protease, ribonuclease and amylase hence led to retarding plant growth and seed germination (Ahmad *et al*., 2011). Which recorded high germination rate (91.333%). The interaction between 50 mg/kg-1 of Cadmium and control (0 mg/kg-1) of Nickel had a high rate of seed germination which was (95%) as compared with other treatment combinations. There are many studies work on the effect of the heavy metals on plant (Aery and Tiagi, 1985; Ghosh and Singh, 2005) and has an impact on plant under condition of stress (Shah and Dubey, 1995). Menon *et al.,* (2016) reported that the heavy metals (Cr, Cu and Zn) have a toxic effect on the growth of the fenugreek which decrease the germination percentage of their seedlings compared to the control.

Table (2): Effect of Cadmium and Nickel concentrations on fresh weight of vegetative part (g.plant^{-1}), fresh weight of roots (g.plant^{-1}), dry weight of vegetative part (g.plant^{-1}), dry weight of roots (g.plant^{-1}), imbibition of seeds and seeds germination % of fenugreek plant (*Trigonell afoenum*-graecum).

Cadmium concentrations	**Fresh weight of vegetative part(g)**				**Mean of cadmium**
	Nickel concentrations				
	0.0 mg/kg^{-1}	50 mg/kg^{-1}	100 mg/kg^{-1}	150 mg/kg^{-1}	
0.0 mg/kg^{-1}	3.800c	5.933a-c	4.367bc	4.767bc	4.716b
50 mg/kg^{-1}	8.933a	7.167a-c	8.033ab	4.700bc	7.208a
100 mg/kg^{-1}	9.600a	3.703c	7.567a-c	4.100bc	6.267ab
Mean of nickel	7.444a	5.601ab	6.655a	7.444a	
Cadmium concentration	Fresh weight of roots				Mean of cadmium
0.0 mg/kg^{-1}	1.266c	1.633bc	1.100c	1.233c	1.333b
50 mg/kg^{-1}	2.500a-c	1.700bc	1.900a-c	1.966a-c	2.016ab
100 mg/kg^{-1}	3.033ab	1.500bc	3.400a	1.133c	2.266a
Mean of nickel	2.266a	1.611a	2.166a	1.444a	
Cadmium	Dry weight of vegetative part(g)				Mean of cadmium

concentration					
0.0 mg/kg-1	2.267bc	3.000a-c	1.900c	1.067c	2.058b
50 mg/kg-1	3.767a-c	3.100a-c	4.433a-c	3.233a-c	3.658a
100 mg/kg-1	5.600ab	1.933c	6.367a	2.233bc	4.033a
Mean of nickel	3.877ab	2.711ab	4.233a	2.711ab	
Cadmium concentration	Dry weight of roots system(g)				Mean of cadmium
0.0 mg/kg-1	0.433a	0.666a	0.233a	0.366a	0.425a
50 mg/kg-1	0.800a	0.466a	0.633a	0.800a	0.675a
100 mg/kg-1	0.900a	0.500a	1.000a	0.150a	0.675a
Mean of nickel	0.711a	0.544a	0.622a	0.488a	
Cadmium concentration	Imbibition of seeds				Mean of cadmium
0.0 mg/kg-1	3.623a	4.307a	3.833a	3.712a	3.869a
50 mg/kg-1	3.873a	4.130a	3.871a	3.903a	3.944a
100 mg/kg-1	4.016a	3.916a	4.209a	4.278a	4.105a
Mean of nickel	3.837a	4.117a	3.971a	3.964a	
Cadmium concentration	Seeds germination%				Mean of cadmium
0.0 mg/kg-1	90.000ab	65.000d	79.667bc	63.333d	74.500a
50 mg/kg-1	95.000a	45.000e	70.000cd	95.667a	76.417a
100 mg/kg-1	89.000ab	79.333bc	74.000cd	74.667cd	79.250a
Mean of nickel	91.333a	63.111c	74.556b	77.889b	

*Means followed by the same letter for each factor and interaction do not differ significantly from each other's according to Duncan's Multiple range Test at 5% level.

The findings in the table (3) showed that the cadmium had a significant increase in the £ carotene concentration of the plant especially at 50 and 100 mg/kg^{-1} which recorded (1.232 and 1.446mg g^{-1}) respectively compared with control which was (0.889mg g^{-1}). Cadmium reduce carotenoid and chlorophyll content, but increase the quenching non-photochemical in *Brassica napus* (Ali *et al*., 2015). The decreasing in the content of chlorophyll is caused by the chloroplast structures destruction by cadmium also increase degradation and chlorophyll synthesis inhibition (Liu *et al*., 1995). Moreover, cadmium damage photosystems I and II (Siedlecka, 1996) and harvesting complex light II (Krupa, 1988), sometime the reduction that caused by cadmium to the Fe II this decrease affect photosynthesis (Alcántara *et al*, 1994). Nickel had a significant effect on the £ carotene concentration of plant at 150mg/kg^{-1} with (1.311mg g^{-1}) compared to control (0.975mg g^{-1}). The interaction of 100 mg/kg^{-1} of cadmium with 100mg/kg^{-1} of Nickel produce a high value of £ carotene concentration which recorded as (1.677mg g^{-1}) compared with other combinations treatments. The result also revealed that the cadmium had a significant increase in the ß carotene concentration of the plant at 100 mg/kg^{-1} which recorded (1.324mg g^{-1}) compared with control which was (0.903mg g^{-1}). Nickel had a significant effect on the ß carotene concentration of plant at 100 mg/kg^{-1} with (1.209mg g^{-1}) compared to control (0.915mg g^{-1}). The interaction of 100mg/kg^{-1} of cadmium with 100mg/kg^{-1} of Nickel produce a high value of ß carotene concentration which recorded as (1.592mg g^{-1}) compared with other combinations treatments. Moreover, the cadmium had a significant increase in the total carotene concentration of the plant at 50 mg/kg^{-1} which recorded (0.663mg g^{-1}) compared with control which was (0.474mg g^{-1}) in the table (3). Nickel had a significant effect on the total carotene concentration of plant at 50 and 150 mg/kg-1 with (0.662 and 0.648mg g^{-1}) respectively compared to control (0.429mg g^{-1}). Almost all the interaction rates of cadmium with Nickel produce a high value of total carotene concentration except control of cadmium with control of Nickel which was the lowest (0.100mg g^{-1}). Furthermore, the cadmium had a significant increase in the Zeazanthen concentration of the plant at 100 mg/kg-1 which recorded (0.970mg g^{-1}) compared with control which was (0.578mg g^{-1}). Nickel had a significant effect on the Zeazanthen concentration of plant at all levels with (0.914, 0.816 and 0.802mg g^{-1}) respectively compared to control (0.588mg g^{-1}). The interaction of 100mg/kg^{-1} of cadmium with 100mg/kg^{-1} of Nickel produce a high value of Zeazanthen concentration which recorded as (1.082mg g^{-1}) compared with other combinations treatments.

In addition, the table (3) shows that the cadmium had a significant increase in the Chlorophyll a concentration of the plant at 100 mg/kg-1 which recorded (0.383mg g^{-1}) compared with control which was (0.241mg g^{-1}). Nickel had a significant effect on the Chlorophyll a concentration of plant at 100 mg/kg^{-1} with (0.423mg g^{-1}) compared to control (0.268mg g^{-1}). The interaction of 100mg/kg^{-1} of cadmium with 100mg/kg^{-1} of Nickel produce a significant increase of Chlorophyll a concentration which recorded as (0.523mg g^{-1}) compared with other combinations treatments. As well as, the cadmium had a significant increase in the Chlorophyll b concentration of the plant at 100 mg/kg^{-1} which recorded (0.802mg g^{-1}) surprisingly the control had the same value of (0.802mg g^{-1}). Nickel had a significant effect on the Chlorophyll b concentration of plant at 50 mg/kg^{-1} with (0.717mg g^{-1}) compared to control value of (0.565mg g^{-1}). The interaction of 100mg/kg-1 of cadmium with 100mg/kg^{-1} of Nickel produce a significant increase of Chlorophyll b concentration which recorded as (0.872mg g^{-1}) compared with other combinations treatments. Additionally, the cadmium had a significant increase in the total Chlorophyll of the plant especially at 50 and 100mg/kg^{-1} which recorded (1.075 and 1.269mg g^{-1}) respectively compared with control which was (0.750mg g^{-1}). While there was significant difference of the Nickel on the total Chlorophyll content of plant in compare of control. It reduce root length, plant height, activities of carbonic anhydrase enzyme, chlorophyll content and fresh and dry weight of plant (Siddiqui *et al*., 2011). The interaction of 100mg/kg-1 of cadmium with 150mg/kg-1 of Nickel produce a high value of total Chlorophyll content which recorded as (1.463mg g^{-1}) compared with other combinations treatments (table 3).

There was a reduction in chlorophyll a and b in some legume plant species under Ni stress which seen that number of leaves has been increased despite of reduction in content of chlorophyll (Gopal *et al.,* 2002; Singh and Pandey, 2011). Hence, our findings were in agree with these studies. Decreasing in green pigments of photosynthesis might be because of some possible reasons including chloroplast membranes damage by the process of oxidation, chlorophyll biosynthesis inhibition and/or Mg ions replacement in a rings of tetrapyrole that is well reported in various plant groups in the heavy metal response (Nagajyothi *et al.,* 2009; Talukdar, 2011). The attack on the photosynthetic apparatus is the basic effect of heavy metals on the plant. This features is not specific to an obvious metal but common to all of it that make photosynthetic activities measurement a great method to detect the stress that come by heavy metals (Appenroth, 2010). Photosynthetic apparatus damage is a significant result of metals that is initiate to pollution combat by its increase in the pheophytin which in turn launch the mode of adaptation reported by the increasing in the chlorophyll (Houri *et al,* 2020). Sewelam *et al.,* (2016) revealed that the chlorophyll destruction supporting the debate that chloroplast is attack and affected in first place by the air pollution. Chlorophyll under conditions of stress undergoes in many reactions of photochemical for example pheophytinisation, oxidation and reduction (Govindaraju *et al.,* 2010). The plant cell protection is the main role of carotenoid which is started in the defense system of the plant against oxidation damage, carotenoids obtain the sun light energy to the photosystem of plant and dissipation this light by using quenching non phytochemical (McElroy and Kopsell, 2009). The main role of carotenoid is also photosynthetic system protection from oxidative degrade by oxygen reactive (You and Chan, 2015). Houri *et al.*, (2020) demonstrated that the cadmium levels sharply decrease after two month of beginning of study works.

Table (3): Effect of Cadmium and Nickel on £ carotene concentration, ß carotene concentration, total carotene concentration, Zeazanthen concentration ,Chlorophyll a concentration, Chlorophyll b concentration and total Chlorophyll concentration of fenugreek plant (*Trigonell afoenum*-graecum).

Cadmium concentrations	**£ carotene concentration (mg g^{-1})**				**Mean of cadmium**
	Nickel concentrations				
	0.0 mg/kg^{-1}	50 mg/kg^{-1}	100 mg/kg^{-1}	150 mg/kg^{-1}	
0.0 mg/kg^{-1}	0.664e	0.989c-d	0.923 de	0.982d-c	0.889b
50 mg/kg^{-1}	1.092b-e	1.227a-d	1.115b-e	1.493ab	1.232a
100 mg/kg^{-1}	1.168b-d	1.481a-c	1.677a	1.458a-c	1.446a
Mean of nickel	0.975b	1.232ab	1.238ab	1.311a	
Cadmium concentration	ß carotene concentration (mg g^{-1})				Mean of cadmium
0.0 mg/kg^{-1}	0.654c	0.868bc	0.950bc	1.143ab	0.903b
50 mg/kg^{-1}	0.938bc	1.301ab	1.085bc	1.051 bc	1.094b
100 mg/kg^{-1}	1.152ab	1.317ab	1.592a	1.237ab	1.324a
Mean of nickel	0.915b	1.162ab	1.209a	1.143ab	
Cadmium concentration	Total carotene concentration (mg g^{-1})				Mean of cadmium
0.0 mg/kg^{-1}	0.100b	0.485ab	0.636a	0.575a	0.474b
50 mg/kg^{-1}	0.619a	0.700a	0.701a	0.632a	0.663a
100 mg/kg^{-1}	0.470ab	0.801a	0.473ab	0.736a	0.620ab
Mean of nickel	0.429b	0.662a	0.603ab	0.648a	
Cadmium concentration	Zeazanthen concentration (mg g^{-1})				Mean of cadmium
0.0 mg/kg^{-1}	0.400e	0.731b-d	0.523de	0.657c-e	0.578c
50 mg/kg^{-1}	0.619de	0.967a-c	0.842a-d	0.741b-d	0.792b
100 mg/kg^{-1}	0.746b-d	1.044ab	1.082a	1.009ab	0.970a
Mean of nickel	0.588b	0.914a	0.816a	0.802a	
Cadmium concentration	Chlorophyll a concentration (mg g^{-1})				Mean of cadmium
0.0 mg/kg^{-1}	0.182b	0.198b	0.297ab	0.288ab	0.241b

50 mg/kg^{-1}	0.331ab	0.335ab	0.448ab	0.280ab	0.348ab
100 mg/kg^{-1}	0.292ab	0.380ab	0.523a	0.339ab	0.383a
Mean of nickel	0.268b	0.304ab	0.423a	0.302ab	
Cadmium concentration	Chlorophyll b concentration(mg g^{-1})				Mean of cadmium
0.0 mg/kg^{-1}	0.357e	0.628a-d	0.513c-e	0.459de	0.802a
50 mg/kg^{-1}	0.533d-c	0.782ab	0.583b-c	0.618b-c	0.629b
100 mg/kg^{-1}	0.805ab	0.742a-c	0.872a	0.790ab	0.802a
Mean of nickel	0.565b	0.717a	0.656ab	0.622ab	
Cadmium concentration	Total Chlorophyll (mg g^{-1})				Mean of cadmium
0.0 mg/kg^{-1}	0.539d	0.860cd	0.810cd	0.792cd	0.750b
50 mg/kg^{-1}	1.253a-c	1.117a-c	1.031a-d	0.898b-d	1.075a
100 mg/kg^{-1}	1.097a-c	1.122a-c	1.396ab	1.463a	1.269a
Mean of nickel	0.963a	1.033a	1.079a	1.051a	

*Means followed by the same letter for each factor and interaction do not differ significantly from each other's according to Duncan's Multiple range Test at 5% level.

3. CONCLUSION

Heavy metals are common pollutants in urban aquatic ecosystems and in contrast to most pollutants, are not biodegradable and are thus persistent in the environment. Nowadays plant become a main source of medicinal plant and food, thus Fenugreek plant is a widely used plant for such purposes. The study aimed to reveal the influence of cadmium and nickel on photosynthesis, seed germination and vegetative growth of fenugreek plant. The findings obviously showed that the interaction between controls with nickel 50 mg/kg^{-1} effect on high of plant. While other treatment had no significant impact on high of plant, the number of leaves, number of branches and number of legume of plant. The interaction of 100mg/kg^{-1} cadmium with control of nickel produce a high value of fresh weight. The results also showed the application of the interaction between 100mg/kg^{-1} of cadmium and nickel and 100mg/kg^{-1} cadmium and combination with control had a great effect on the weight of root, furthermore dry weight was affected by the combination of 100mg/kg^{-1} of cadmium with nickel. Moreover, the interaction of 50mg/kg^{-1} cadmium with control of nickel recorded the highest value seed germination. Almost all levels of interaction between cadmium and nickel had a significant effect on concentration of total carotene, £ carotene and ß carotene and Zeazanthen concentration.

REFERENCES

Aery, N. C., & Tiagi, Y. D. (1985). Studies on the reclamation of tailings dam at Zawar Mines, Udaipur, India. In *Asian mining'85. Conference. 2* (pp. 65-70).

Ahmad, I., Akhtar, M. J., Zahir, Z. A., & Jamil, A. (2012). Effect of cadmium on seed germination and seedling growth of four wheat (Triticum aestivum L.) cultivars. *Pak. J. Bot*, *44*(5), 1569- 1574.

Ahmad, M. S. A., & Ashraf, M. (2012). Essential roles and hazardous effects of nickel in plants. *Reviews of environmental contamination and toxicology*, 125-167.

Ahmad, M. S. A., Hussain, M., Saddiq, R., & Alvi, A. K. (1007). Mungbean: a nickel indicator, accumulator or excluder?. *Bulletin of* *environmental contamination and toxicology*, 78(5), 319-324.

Ahmed, A., Hasnain, A., Akhtar, S., Hussain, A., Yasin, G., Wahid, A., & Mahmood, S. (2010). Antioxidant enzymes as bio-markers for copper tolerance in safflower (*Carthamus tinctorius* L.). *African Journal of Biotechnology*, 9(33).

Alcántara, E., Romera, F. J., Cañete, M., & De la Guardia, M. D. (1994). Effects of heavy metals on both induction and function of root Fe (lll) reductase in Fe-deficient cucumber (*Cucumis sativus* L.) plants. *Journal of Experimental Botany*, 45(12), 1893-1898.

Ali, E., Maodzeka, A., Hussain, N., Shamsi, I. H., & Jiang, L. (2015). The alleviation of cadmium toxicity in oilseed rape (*Brassica napus*) by the application of salicylic acid. *Plant Growth Regulation*, 75(3), 641-655.

Alvarez-Ayuso, E. (2008). Cadmium in soil- plant systems: an overview. *International Journal of Environment and Pollution*, 33(2-3), 275-291.

Appenroth, K. J. (2010). Definition of “heavy metals” and their role in biological systems. In *Soil heavy metals* (pp. 19-29). Springer, Berlin, Heidelberg.

Asati, A., Pichhode, M., & Nikhil, K. (2016). Effect of heavy metals on plants: an overview. *International Journal of Application or Innovation in Engineering & Management*, *5*(3), 56- 66.

Ashraf, M. Y., Sadiq, R., Hussain, M., Ashraf, M., & Ahmad, M. (2011). Toxic effect of nickel (Ni) on growth and metabolism in germinating seeds of sunflower (*Helianthus annuus L*.). *Biological trace element research*, 143(3), 1695-1703.

Baker, A. J. (1981). Accumulators and excluders-strategies in the response of plants to heavy metals. *Journal of plant nutrition*, 3(1-4), 643-654.

Farooqi, Z. R., Iqbal, M. Z., Kabir, M., & hafiq, M. (2009). Toxic effects of lead and cadmium on germination and seedling growth of Albizia lebbeck (L.) Benth. *Pakistanian Journal of. Botany*, 41(1), 27-33.

Ghosh, M., & Singh, S. P. (2005). A comparative study of cadmium phytoextraction by accumulator and weed species. *Environmental pollution*, *133*(2), 365-371.

Gopal, R., Mishra, K. B., Zeeshan, M., Prasad, S. M., & Joshi, M. M. (2002). Laser-induced chlorophyll fluorescence spectra of mung plants growing under nickel stress. *Current Science*, 880-884.

Govindaraju, M., Ganeshkumar, R.S., Suganthi, P., Muthukmaran, V.R., & Visvanathan, P. (2010). Impact assessment of air pollution stress on plant species through biochemical estimations. *International Journal of Environmental and Ecological Engineering*, *4*(12), 696-699.

Hatamian, M., Nejad, A. R., Kafi, M., Souri, M. K., & Shahbazi, K. (2020). Interaction of lead and cadmium on growth and leaf morphophysiological characteristics of European hackberry (Celtis australis) seedlings. *Chemical and Biological Technologies in Agriculture*, *7*(1), 1-8.

Houri, T., Khairallah, Y., Al Zahab, A., Osta, B., Romanos, D., & Haddad, G. (2020). Heavy metals accumulation effects on the photosynthetic performance of geophytes in Mediterranean reserve. *Journal of King Saud University-Science*, *32*(1), 874-880.

Jiang, J. X., Zhu, L. W., Zhang, W. M., & Sun, R. C. (2007). Characterization of galactomannan gum from fenugreek (Trigonella foenum-graecum) seeds and its rheological properties. *International Journal of Polymeric Materials*, *56*(12), 1145- 1154.

Khalid, B. Y., & Tinsley, J. (1980). Some effects of nickel toxicity on rye grass. *Plant and Soil*, *55*(1), 139-144.

Khan, M. R., & Khan, M. M. (2010). Effect of varying concentration of nickel and cobalt on the plant growth and yield of chickpea. *Australian Journal of Basic and Applied Sciences*, 4(6), 1036- 1046.

Knudson, L. L., Tibbitts, T. W., & Edwards, G. E. (1977). Measurement of ozone injury by determination of leaf chlorophyll concentration. *Plant physiology*, 60(4), 606-608.

Krupa, Z. (1988). Cadmium-induced changes in the composition and structure of the light-harvesting chlorophyll a/b protein complex II in radish cotyledons. *Physiologia Plantarum*, 73(4), 518-524.

Lewis TE, McIntosh AW. Covariation of selected trace elementswith binding substrates in ores from two contaminated sediments. Bull Environ ContamToxicol 43: 518-528, 1989.

Liu, D., Jiang, W., Wang, W., & Zhai, L. (1995). Evaluation of metal ion toxicity on root tip cells by the Allium test. *Israel Journal of Plant Sciences*, 43(2), 125-133.

Mcelroy, J. S., & Kopsell, D. A. (2009). Physiological role of carotenoids and other antioxidants in plants and application to turfgrass stress management. *New Zealand*

Journal of Crop and Horticultural Science, *37*(4), 327-333.

Nagajyothi, P. C., Dinakar, N., Suresh, S., Udaykiran, Y., Suresh, C., & Damodharam, T. (2009). Effect of industrial effluent on the morphological parameters and chlorophyll content of green gram (*Phaseolus aureus* Roxb). *J. Environ. Biol*, 30(3), 385-388.

Nagajyoti, P. C., Dinakar, N., Prasad, T. N. V. V., Suresh, C., & Damodharam, 1. T. (2008). Heavy metal toxicity: Industrial effluent effect on groundnut (*Arachis hypogaea* L.)*Journal of Applied Sciences Research*, 4(1), 110-121.

Rayyan, S., Fossen, T., & Andersen, Ø. M. (2010). Flavone C-glycosides from seeds of fenugreek, Trigonella foenum-graecum L. *Journal of agricultural and food chemistry*, *58*(12), 7211-7217.

Seregin, I., & Kozhevnikova, A. D. (1006). Physiological role of nickel and its toxic effects on higher plants. *Russian Journal of Plant Physiology*, 53(2), 257-277.

Sewelam, N., Kazan, K., & Schenk, P. M. (2016). Global plant stress signaling: reactive oxygen species at the cross-road. *Frontiers in plant science*, *7*, 187.

Shah, K., & Dubey, K. (1995). Effect of cadmium on RNA level as well as activity and molecular forms of ribonuclease in growing rice seedlings. *Plant physiology and biochemistry (Paris)*, *33*(5), 577-584.

Siddiqui, M. H., Al-Whaibi, M. H., & Basalah, M. O. (2011). Interactive effect of calcium and gibberellin on nickel tolerance in relation to antioxidant systems in *Triticum aestivum* L. *Protoplasma*, 248(3), 503-511.

Siddiqui, A. D. (1992). Effects of lead toxicity on seed germination and seedling growth of some tree species. *Pakistan Journal of Scientific and Industrial Research*, 35, 149-149.

Siedlecka, A. (1996). Interaction between cadmium and iron and its effects on photosynthetic capacity of primary leaves of Phaseolus vulgaris. *Plant Physiol Biochem*, 34, 833-841.

Singh, K., & Pandey, S. N. (2011). Effect of nickel-stresses on uptake, pigments and antioxidative responses of water lettuce, Pistia stratiotes L. *Journal of environmental biology*, 32(3), 391.

Singh, P. (2020). The effect of nickel on seed germination and seedling growth of *Raphanus sativus cv. Jaunpuri*. *Journal of Emerging Technologies and Innovative Research*, 7 (8), 1328-1330.

Singh, R., & Singh A. (1996). Stimulating and Toxic effect of Cannabis Extract on Seed Germination and Seedling Growth of Pea (*Pisum sativum*), *Flora and Fauna* 96/05/75.

Smith, M. (2003). Therapeutic applications of fenugreek. *Alternative Medicine Review*, *8*(1), 20-27.

Staessen, J. A., Roels, H. A., Emelianov, D., Kuznetsova, T., Thijs, L., Vangronsveld, J., & Fagard, R. (1999). Environmental exposure to cadmium, forearm bone density, and risk of fractures: prospective population study. *The Lancet*, 353(9159), 1140-1144.

Talukdar, D. (2011). Effect of arsenic-induced toxicity on morphological traits of *Trigonella foenum- graecum L.* and *Lathyrus sativus L.* during germination and early seedling growth. Current Research *Journal of Biological Sciences*, 3(2), 116-123.

Tattini, M., Carmi, V., Tafani, R., & Traversi, M. L. (1987, September). Container growth of peach: some aspect of nutritional and substrate requirements. *In Symposium on Horticultural Substrates and theirAnalysis*221 (pp.167-174).

Taylor, W. G., Zaman, M. S., Mir, Z., Mir, P. S., Acharya, S. N., Mears, G. J., & Elder, J. L. (1997). Analysis of steroidal sapogenins from amber fenugreek (*Trigonella foenum-graecum*) by capillary gas chromatography and combined gas chromatography/mass spectrometry. *Journal of Agricultural and Food Chemistry*, *45*(3), 753-759.

Yoshikawa, M., Murakami, T., Komatsu, H., murakami, n., yamahara, j., & matsuda, h. (1997). Medicinal foodstuffs. IV. Fenugreek seed.(1): structures of trigoneosides Ia, Ib, IIa, IIb, IIIa, and IIIb, new furostanol saponins from the seeds of Indian *Trigonella foenum-graecum* L. *Chemical and pharmaceutical Bulletin*, *45*(1), 81-87.

You, J., & Chan, Z. (2015). ROS regulation during abiotic stress responses in crop plants. *Frontiers in plant science*, *6*,1092. Zafar Iqbal, M., &

کارتیکرنا کانزایین گران (کادمیوم و نیکل) ل سەر شینبونا توڤی، بویاغین روشنەپیکهاتن، و شینبونا روەکی حلبە (Trigonell afoenum-graecum)

پوختە

ئەڤ کارە ل کولیژا زانستێن ئەندازیاریا چاندنێ، زانکوتا دهوک، هەرێما کورستانێ هاتیە ئەنجامدان،، مەرەم ژ ڤێ ڤەکولینێ ئەوە کو کارتێکرنا ماده کادمیوم ب رێژا (100,50,0) ملگم/لتر-1 و سمادێ نیکل ب رێژا (150,100,50) ملگم/لتر-1 لسەر دەست ڤەهاتیێ خاسلەتێن گروپێ کەسکاتی و بەرهەمێ رووەکێ (الحلبە) (Trigonell afoenum- graecum) بو مە ئەنجام دیاربوون کو کانزایین گران (کادمیوم و نیکل)و کارتێکرنێت دناڤبەینا وان دا ب رێژا (50 ملگم/لتر-1) ل سەر و کارتێکرنا بە چاف ل سەر بلنداهیا رووەکی یە و زێدەهی ل سەر هندێ، هندی (100 ملگم/لتر-1) ژ کادمیوم و تیکەلبونا دناڤبەینا 100 ملگم/لتر-1 ژ کادمیوم دگەل سەرەدەریا بەروارکرنێ و تیکەلبونا دناڤبەینا 100 ملگم/لتر-1 ژ کادمیوم و نیکل ئەوە کو کارتێکرنەکا مەزن یا هەی ل سەر سەنگا رها و پاشی ئەڤ کارە باشتر هاتە کرن ب کێشاتیا هشک یا رووەکی ب زێدەکرنا (100 ملگم/لتر-1) بو هەردوو توخما کادمیوم و نیکل بەلێ باشترین بها ئەوە کو کومڤەکرنا دناڤبەینا (50 ملگم/لتر-1) ژ کادمیوم دگەل سەرەدەریا کونترولکرنا کارتێکرنەکا مەزن ل سەر شینبونا توڤی، هەروەسا کارتێکرنا بەچاڤ ل سەر کادمیوم و نیکل بەلێ کارتێکرنا گشتی ب رێژا کادمیوم و ب رێژا 50 ملگم/لتر-1 بو هەر ئێک ژ رێژا (کادمیوم و نیکل) ل سەر رێژا (100 و 150 ملگم/لتر-1) بو الکادمیوم ب کارتێکرنا هەمی ئاستێن النیکل ، زێدەهی ل سەر ڤێ چەندێ ، کارتێکرنا رێژا الفا کاروتین و بیتا کاروتین ، الزیانپین دبیت کارتێکرنێ ب تیکەلبونا دناڤبەینا 100 ملگم/لتر-1 ژ کادمیوم و نیکل ب شێوەیەکێ مەزن ل سەر رێژا الکاروتینی هەمیێ.

تأثير المعادن الثقيله (الكادميوم والنيكل) على إنبات البذور، أصباغ التمثيل الضوئى والنمو النباتى للحلبه (Trigonell afoenum-graecum)

الخلاصة

اجريت هذه الدراسة في كلية علوم الهندسة الزراعية ، جامعة دهوك ، إقليم كوردستان ، وكان الهدف من هذه التجربة هو دراسة تأثير مادة الكادميوم بمقدار (0 ، 50 ، 100) ملغم/ لتر$^{-1}$ وسماد النيكل عند التراكيز (50 ، 100 ، 150) ملغم / لتر$^{-1}$ على حاصل صفات المجموع الخضري والانتاجي لنبات الحلبة *Trigonell afoenum-graecum* . أظهرت النتائج أن المعادن الثقيلة (الكادميوم والنيكل) والتداخلات بينهما عند التركيز 50 $^{-1}$ لها تأثير معنوي على ارتفاع النبات علاوة على ذلك ، فإن 100 ملغم/ لتر-1 من الكادميوم والتداخل بين 100 ملغم/ لتر$^{-1}$ من الكادميوم مع معاملة المقارنة للنيكل له تأثير معنوي على ارتفاع النبات و الوزن الطازج ، بالإضافة إلى أن تطبيق 100 ملغم/ لتر$^{-1}$ من الكادميوم والتداخل بين معاملة المقارنة والداخل بين 100 ملغم/ لتر$^{-1}$ من الكادميوم والنيكل كان له تأثير كبير على وزن الجذر. تم تحسين الوزن الجاف للنبات بإضافة 100 ملغم/ لتر$^{-1}$ لكل من الكادميوم والنيكل ولكن أفضل قيمة كانت عند الجمع بين 100 ملغم/ لتر$^{-1}$ من الكادميوم مع النيكل ، وكذلك كان للتداخل بين 50 ملغم/ لتر$^{-1}$ من الكادميوم مع معاملة الكونترول تأثير كبير على إنبات البذور ، وهناك كان تأثيرًا معنويًا لـ الكادميوم والنيكل على 50 ملغم/ لتر$^{-1}$ و 100 ملغم/ لتر$^{-1}$ من الكادميوم و 150 ملغم/ لتر$^{-1}$ من النيكل ، و ß كاروتين 100 ملغم/ لتر$^{-1}$ من الكادميوم والنيكل ، بينما تأثر إجمالي تركيز الكاروتين بنسبة 50 ملغم/ لتر$^{-1}$ لكل من تركيز النيكل والزيانثين على التركيز 100 ملغم/ لتر$^{-1}$ و 150 ملغم/ لتر$^{-1}$ من الكادميوم مع التأثر بجميع مستويات النيكل ، بالإضافة إلى ذلك ، تأثر تركيز الفا كاروتين ، بيتا كاروتين و الزيانثين قد تاثر بالتداخل بين 100 ملغم/ لتر$^{-1}$ من الكادميوم والنيكل وتاثر بمعاملة التداخل بين جميع مستويات الكادميوم والنيكل بشكل كبير على تركيز الكاروتين الكلي.