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INTERACTION BETWEEN CD AND K ON PLANT HORMONES CONCENTRATIONS OF TOMATO (*LYCOPERSICON ESCULENTUM* L.) LEAVES

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ABSTRACT

Seedlings of tomato (*Lycopersicon esculentum* L. var. Al-Wejdan) at 35 days age treated with different concentrations of $CdCl_2$ (0, 1, 10, 50 and 100 mg/kg soil), KCl (0, 20, 40, and 60 mg/kg soil), and combinations between these concentrations. At 95 days age of tomato, estimated the plant hormones in the 5th leaves from the tip of plant. Indole-3- Acetic Acid (IAA) decreased by Cd concentrations but it increased by K concentrations. Gibberellic Acid ($GA_{3)}$ increased by 50 mg/kg soil. However, not changed significantly by all concentrations of K. Zeatin increased by almost concentrations of K and Cd. Abscisic Acid (ABA) decreased significantly by all concentrations of K andby the 50 and 100 mg/kg soil of Cd. The combinations different in their effects on hormones concentrations, many of combinations treatments caused decreasing in ABA, increasing Zeatin and elevated the inhibition effect of high Cd concentration for GA_3 and IAA.

Keywords : Tomato plant, cadmium, potassium, plant hormones

Introduction

At the recent years, an increasing in the activates of human leads to raise pollutants especially the heavy metals (Sakan *et al*., 2015). Cadmium (Cd) is a heavy metal which wide speared, none essential and highly toxic because it persist longer in a different environments as soil, water and air (Salt *et al*.,1998; Yurekli & Porgali, 2006; Kurtyka *et al*., 2008). In many sites of the world, the soils that contaminated with Cd which poses a harmful effects on productivity of crops human health (Sebastian & Prasad, 2014). Some studies referred to the harmful effect of Cd at high concentration on some growth parameters (Shaheed & Kadhim, 2014), or on the nutritional elements contents of it as potassium (Tian *et al*., 2016).

In plant tissues, potassium (K) is the most abundant nutritive cation, which represents one of the micronutrient. K is impact in many metabolic processes such as osmotic organization and synthesis of protein (Marschner, 1995). According to Abdullahil Baque *et al*. (2006), the K at high levels increased the dry mater accumulation and grain yield in wheat at water stress or by heavy metals stress (Kurtyka et al., 2008).

Growth of plant and development controlled by plant growth regulators, which can produce many desirable effects in crops. The studies indicate that abscise acid (ABA) can be elevated in vegetative tissues in response to various environmental stresses; therefore it isattributed to be the hormone of stress (Zhang *et al*., 2006). ABA and and Cytokinins (CK) have been regarded as signals in the root-to-shoot communications, coordinating the transport of water and nutrients from roots to the current growth requirements of shoots (Zdunek & Lips, 2001). The levels of endogenous hormones: IAA, AG_3 and Cytokinins (CK) decreased significantly by water stress (Pospisilova *et al*., 2005) or when subjected to drought conditions, while ABA content increased (Sadeghipour & Aghaei, 2012). The study of Parmar & Chanda, (2005) indicated that IAA oxidase increasing by mercury (Hg) or Chromium (Cr), and this enzyme is regulate the cellular level of IAA. IAA have a roles in plant growth regulation as cells division and it enlargement (Perrot-Rechenmann, 2010), the increasing of IAA concentration as adding it to plant make the plant more tolerance for stress (Javid *et al*., 2011). GA_3 similar to IAA and calcium (Ca) which arealleviated the inhibitory effect of copper (Cu) (Ben Massoud *et al*., 2017).

Some studies show that the possibility of use the nutritive elements as K as exogenous substances to alleviate the harmful effects of Cd contamination (Shaheed & Kadhim, 2014) or Ca (Huang *et al*., 2017). The current study aimed weather K as nutrition element may protect plant from Cd toxicity depending on the plant hormones concentrations detection in leaves of tomato plant.

Materials and Methods

Plant material and treatments:

Seedlings of tomato (*Lycopersicon esculentum* L. var. Al-Wejdan) with 35-day age were grown in earthen pots (24cm in diameter, 18cm in height), each pot filled with 4kg of soil. The texture of soil was sandy loam (pH 7.07, EC 21.5 ms/cm and organic carbon 0.69). The soil was mixed with preparation amounts of $CdCl_2$ to supply a (0, 10, 50 and 100 mg Cd/kg soil), KCl to supply (0, 20, 40, and 60 mg K/kg soil). There was a combination among these concentrations. The arrangement of these treatments were in a randomized design, and each treatment was replicated three times. The pots were kept in naturally illuminated plastic house with day/night temperature equal to 25/20 ±5C° and relative humidity 70±5%. This experiment conducted in Botany labs of Department of Biology, College of Science, University of Babylon.

Plant hormones estimation:

At the 95-day age, the 5th leaves from the tip of tomato plants were cut to estimate the plant hormones. The leaves washed, air-dried and grinded well. One gram of each replication was prepare to estimate the IAA, GA_3, ABA and Zeatin depending on the method of Unyayar *et al*. (1996). Plant hormones measured by using UV-Spectrophotometer (Libra S22, Biochrom) at the following wavelengths: IAA at 222nm, GA_3 at 256nm, ABA at 263nm and Z at 269nm. Pure plant hormones used as standard curves.

Statistical analysis:

Statistically, data were analyzed by two-way analysis of variance (ANOVA). Calculation the least significant difference (L.S.D.) to identify significant differences between treatment at ρ= 0.05.

Results

Table 1 shows that the K at all its concentrations (20-60 mg/kg) caused a significant increasing in IAA concentration compared with control treatment. Cd caused inhibition in IAA concentrations; however, this inhibition was significant at both 50 and 100 mg/kg soil. The combinations differs in their effects, there were no significant decreasing in IAA concentration at Cd1+ K60 and Cd100+K20. Almost combinations caused significant increasing compared by control, and by all concentrations treatments of Cd. The combination of Cd50+K40 give the higher value of IAA concentration (52.64μM) among all the combinations.

Table 1: IAA concentration (μM) of tomato leaves treated with different concentrations of KCl and $CdCl_2$ (mg/kg soil) with their combinations

Cd \ K	0	20	40	60
0	15.52	24.75	22.76	51.50
1	12.99	23.95	22.34	10.77
10	9.21	35.98	20.54	41.96
50	6.25	46.50	52.64	29.13
100	6.02	11.38	17.60	38.91
L.S.D. ≥ 6.38 (ρ = 0.05)				

Table 2 demonstrated the GA_3 concentrations that increased significantly by both Cd at 50 mg/kg soil and by combination Cd100 + K20, which produced the higher value (52.60mM). The combination Cd10 + K20 represents the lower concentration value of GA_3 (1.626 mM) which is not changed significantly comparing with treatment of control. GA_3 concentrations by K treatments and for many combinations not affected significantly.

Table 2: AG_3 concentration (mM) of tomato leaves treated with different concentrations of KCl and $CdCl_2$ (mg/kg soil) with their combinations

Cd \ K	0	20	40	60
0	2.690	2.594	3.128	2.210
1	3.152	2.738	2.744	4.208
10	4.089	1.626	4.639	2.100
50	5.346	4.387	2.183	2.558
100	3.617	6.468	2.996	4.397
L.S.D. ≥ 2.142 (ρ = 0.05)				

Zeatin concentration as in table 3 increased significantly by K at 20 and 40 mg/kg soil and Cd at 50 and 100 mg/kg soil when compare with treatment of control. Almost combinations enhanced concentration of Zeatin especially at Cd100 + K20, which represent the highest value of Zeatin in tomato's leaves (0.849 mM). The combinations Cd10+K20 and Cd50+K40 caused no significant decreasing in BA concentration compared with control, while other combinations caused enhancing in Z concentrations as compared by control treatments in addition to Cd at 50 mg/kg soil.

Table 3: Zeatin concentration (mM) of tomato leaves treated with different concentrations of KCl and $CdCl_2$ (mg/kg soil) with their combinations

Cd \ K	0	20	40	60
0	0.162	0.481	0.481	0.290
1	0.651	0.689	0.652	0.388
10	0.560	0.100	0.626	0.346
50	0.168	0.475	0.134	0.487
100	0.136	0.849	0.340	0.206
L.S.D. ≥ 0.216 (ρ = 0.05)				

The results in table 4 show decreasing in ABA concentration of tomato leaves when treated by all concentrations of K (20-60 mg/kg soil) and by Cd at 1 and 10 mg/kg soil. The highest concentrations of Cd (50 and 100 mg/kg soil) caused increasing in ABA concentration significantly in compare with control and almost treatments. The combinations of Cd50+K20, 40 & 60 and Cd100+K20, 40 & 60 give a significant decreasing in ABA concentration compared with Cd at 50 and 100 mg/Kg soil treatments. The lowest value was 0.33mM at a combination Cd100+K40.

Table 4: ABA concentration (mM) of tomato leaves treated with different concentrations of KCl and $CdCl_2$ (mg/kg soil) with their combinations

Cd \ K	0	20	40	60
0	24.99	6.34	7.45	3.55
1	13.47	6.83	11.33	5.40
10	16.30	16.58	28.25	29.63
50	34.84	21.05	7.94	0.74
100	35.78	27.01	0.33	8.98
L.S.D. ≥ 6.72 (ρ = 0.05)				

Discussion

Some articles subjected to the interaction between heavy metals and plant hormones by emphasizing that hormone application reduce the harmful effect of heavy metals, or by knowing the important of heavy metals in plant hormones (Falkowska *et al*., 2011; Bucker-Neto *et al*., 2017). The values of IAA concentrations (Table 1) showed increasing of IAA with raise levels treatments of K, while it decreased with increasing of Cd levels. Parmar & Chanda, (2005) refer to inhibit the plant growth by Mercury (Hg) and Chromium (Cr) with increasing in IAA oxidase, which is important in IAA cellular level regulation. It is known that K is important in many processes of physiologyin plants; therefore, K can have a direct effect on crop productivity (Pettigrew, 2008; Neenu & Sudharmaidevi, 2012). Cd at high concentrations caused decreasing in IAA concentration of tomato leaves reached to 6.02 µM. this indicate that Cd cause disturbing of IAA homeostasis (Zelinova *et al*., 2015) or it may repress IAA transport and reduce root meristem size as in *Arabidopsis thaliana* (Yuan & Huang, 2016).

Depending on results presented in Table 2, GA_3 concentrations not affected by the treatments of K, but it increased by Cd at 50 mg/kg soil. The gibberellins are implicated in abiotic stresses adaptation as salinity in some crops plants (Tuna *et al*., 2008). In another study, Jasim *et al*. (2016) indicated that stress of salt inefficient on change GA concentrations significantly of *Raphanus sativus* L. seeds. Zeatin have an opposite behavior (Table 3) to the GA_3, which increased by K treatments at 20 and 40 mg/kg soil. The zeatin was more affected by almost treatments by increasing its concentrations in compare with control. This enhancement of zeatin concentration may be reflect the increase in leaf area and chlorophyll content that revealed in a previous study for same treatments on tomato plant (Shaheed & Kadhim, 2014). Hormones plant are consider as main communication signals in root-to-shoot and vice versa. This communications may change depending on plant type or treatments; there was antagonism between zeatin and ABA when some economic plant subjected to the stress of water (Pospisilova *et al*., 2005), whereas the ABA increased more than zeatin. The current study showed that Cd at low concentrations of treatments (1 and 10 mg/kg soil) caused increasing in ABA concentration (table 3), while at 50 and 100 mg/ kg soil concentrations of Cd, the opposite happened (Table 4). ABA concentrations decreased by K treatments and by almost combinations (Cd+K) which were reduced harmful effect of high concentrations of Cd (Table 4). Chen *et al*. (2017) show that K fertilizer application on cotton can reduce ABA significantly at the same time caused increasing in the IAA, GA_3 and Z. these results are compatible with the values in table 4 for the present study. The K at all concentrations caused decreasing ABA concentration, while the Cd at 50 and 100 mg/kg soil concentrations caused increasing ABA concentration. The plants can responded differentially against Cd induced oxidative stress (Irfan *et al*., 2014), and the Cd concentrations of leaves increasing within the first 14 days and then constant as Lefevre *et al*.(2014) study showed. This may be a reason for the alleviation of Cd by K at any concentrations of the treatment combinations.

Previous study revealed that ABA accumulation in plant due to K deficiency as in *Ricinus communis*, which supply with low K that lead to biosynthesis of ABA in roots and then conducted from roots to shoots (Peuke *et al*., 2002). In the present study, Cd at higher concentrations have a harmful effects on hormones of tomato leaves, which was behavior as another abiotic stresses as draught. Sadeghioour & Aghaei, (2012) referred to decrease the endogenous IAA, GA_3 and Cytokinin levels while increase ABA concentration when plant subjected to draught stresses.

Conclusions

1. IAA, GA_3 and zeatin are inhibited by high concentrations of Cd, while ABA increased.
2. IAA and Z are increased by K, while ABA decreased. GA_3 not affected.
3. K in all combination treatments (Cd+K) caused the alleviation of the harmful effect of Cd.
4. Cd at low concentrations (1 and 10 mg/kg soil) have no toxic effects on plant depending on hormones concentration values.

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