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THE EFFECT OF INTERACTION BETWEEN SOIL PH AND CADMIUM ON GROWTH OF CORN (*ZEA MAYS* L.)

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ABSTRACT

A pot experiment was carried out in the plastic house of Agro technology Research Station, University Malaysia Perlis Padang Besar, Perlis, Malaysia. During season of the cultivation of 2014 investigate the impact of soil pH and cadmium on growth of corn plant (*Zea mays* L.). Twenty five were arranged in factorial experiments according to the Complete Randomized Design (CRD), with three replicates. Five levels of soil pH were, pH4, pH5.2 (i.e., the original value), pH6, pH7 and pH8 and five levels of cadmium (Cd), Cd1 (2 mg.kg-1 soil), Cd2 (4 mg.kg-1 soil), Cd3 (6 mg.kg-1 soil) and Cd4 (8 mg.kg-1 soil) with control Cd0 (Without addition of cadmium). Thus, the total numbers of pots were 75 pots. The results of this investigation revealed that; the soil pH superiority significant at pH7 in plants height, stem dry weight of plant and leaves dry weight of plant reached (202.24 cm), (206.95 g) and (37.62 g), respectively, while pH6 led to significant increase in root dry weight of plant reached (29.21 g). As well as, the increased concentration of cadmium in the soil led to reduced growth characters for the plant (plant height, root, stem and leaves dry weight), which gave Cd4 less of the rates reached (146.85 cm), (19.20 g), (147.28 g) and (26.14 g), respectively. Also the interaction between soil pH levels and levels of cadmium affected in plant growth characters.

KEYWORDS: Soil pH, Cadmium, Growth, Corn, Perlis.

1. INTRODUCTION

The effects of low pH on plant growth are nutritional and indirect (Thompson and Toeh, 1978). Acid soil toxicity is a complex of factors that affect plant physiological and biochemical processes. Acidity per se is not harmful to plants except in extreme cases (Mengel and Kirkby. 1979). The problems of plant growth on acid soils are largely due to the large amounts of Al, Fe and Mn (Giller, 2001). At low pH, organic matter mineralisation rate decreases resulting in reduced availability of N, P and S. Nitrification is significantly retarded as bacterial activity is reduced (Landon 1991). Puga et al. (2015) reported that the addetion of biochar to the soil led to increase in the pH (about 0.3 units) and this led to that the N, P, K, and S concentrations increased in stems of Jack bean and Mucuna aterrima with increasing biochar rate.

Among Cd sensitive plants, corn has a high tolerance to Cd (sorghum < cucumber < wheat < corn), with an effective concentration value (EC50) in Cd-amended soils ranging between 208 and 265 mg kg1 (Youn-Joo, 2004). Plant exposure to Cd caused main damage at cellular and physiological level (Benavides et al., 2005). Soil contamination with heavy metals is important problem that hampers plant growth. Wheat and maize are the main crops cultivated in the world and served as staple food in different parts of the world. Stem and root growth of wheat was inhibited by the addition of Cd in nutrient media (Abdel-Latif, 2008). Biomass reduction was observed in maize plant as its exposure to Cd. Cd affect photochemical efficiency, induced oxidative stress and membrane damage (Ekmekci et al., 2008). Growth characters such as root length, stem height, fresh and dry weights of stem and root were decreased with increasing Cd soil addition (Mohamed et al., 2011).

The mobility and bioavailability of heavy metals also increase with decreased soil pH (Wang et al., 2006; Du Laing et al., 2007). Soil pH is considered a primary factor controlling the availability of Cd in soils, since increasing soil pH favors the adsorption of Cd to metal binding sites and decreases the partition of Cd to soil solution (Sauve´ et al. 2000; Kukier et al. 2004). Also Kirkham, (2006) confirm that the pH of the soil is usually the most important factor that controls uptake, with low pH favoring Cd accumulation. Sarwar et al. (2010) considered Cd is a highly toxic heavy metal for both plants and animals. The presence of Cd in agricultural soils is of great concern regarding its entry into the food chain. Compounds of Cd are more soluble than other heavy metals, so it is more available and readily taken up by plants and accumulates in different edible plant parts through which it enters the food chain.

Because of that it was the aim of this study was to determine the effect of the presence of cadmium in the soil, as well as the effect of the level of soil pH in readiness of cadmium to influence on growth of corn.

2. MATERIALS AND METHODS

2.1 Management of the experiment

Soil pH was adjusted to 4.0, 5.2 (i.e., the original value), 6.0, 7.0, and 8.0 by adding a 2 ml solution of 0.15 M HCl, distilled H_2O and 0.06 M, 0.15 M, and 0.6 M NaOH, respectively to 20 g of soil aerobically dried (Huaihai et al., 2015). Then was complete amount to 10 kg soil of each treatment. After than added the all of Cd amount and mixed thoroughly with soil until full homogeneous and then put in pots (10 kg). Thereafter the pots were irrigated with water and incubated for two weeks period before sowing for uniform distribution of Cd. Three seeds were sown in each pot containing 10 kg soil which was thinned to one plant after ten days of germination. All the agronomic practices like weeding; irrigation and plant protection measures were performed as and when necessary. The plants were allowed to grow till maturity. All the plants were planted in 10th of June 2014 and its harvested after 110 days of planting.

Table: 1 Initial physical and chemical properties for soil of study.

Bulk Density (g/cm^3)	Soil pH	CEC ($cmol.\ kg^{-1}$)	EC ($dS.\ m^{-1}$)	Total (N) %	Available P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)	Ca ($mg.kg^{-1}$)	Cd) ($mg.kg^{-1}$)	Organic Metter (OM) %
2.3	5.20	2.03	0.24	1.24	37	95.7	6.4	0.92	0.21

2.2 STATISTICAL ANALYSIS

Data were subjected to statistical analysis using the statistical software GenStat (Payne et al., 2012). Varity ANOVA will used to analyze the experimental results of dependent variables (treatments). the least significant difference (LSD) was calculated at $P \leq 0.01$.

3. RESULTS AND DISCUSSION

3.1 Plant height (cm)

Figure (1) indicated to the soil PH effect on the height of the plant since the highest rate for the plant height was on pH7 i.e. The soil acid balance, it reached (202.24 cm) and it significant superiority on all the levels of the soil acid including pH8 and also the levels of soil acid below pH7 until it reached the least level (117.87 cm) by the level pH4, and this increase in the plant height by the level pH7 was most likely because of plants' good nutrition and the major nutrients readiness such as; Nitrogen, Phosphor, potassium, that increase the roots and green overall aggregation and that what led to the significant full increase to the rest of the growth characteristics in the study by this level such as the dry weight of the stem and the leaves. Also increasing the Chlorophyll percentage increase in the leaves and the in the other hand led to increase the process of photosynthesis and increase the plants growth rates. And that what (Chipo, 2005) supported, when he mentioned that the main influence of the acid soil is to inhibiting the growth of the roots which leads to decrease the vegetative growth and eventually decreasing the grain yield. Regarding figure (2) it appears that there is a negative significant implication for the cadmium regarding the plant height. The more cadmium concentration in the soil the less the plant height, where the highest plant height reach where the Cd0 (179.66 cm) whereas the least plant height (146.85 cm) at the Cd4. And this match exactly what (Ahmad et al., 2013; Iftikhar, 2014) reached. They indicated that the highest rate of the plant height was when treating without cadmium comparing with the other concentrations. And this decrease of the plant height with the concentration of the cadmium might be a result of the root aggregate weakness of the plants planted in high concentrations of cadmium as in figure (5) where the weakness of the root aggregates led to decrease in ratio of the nutrients needed to plants growth correctly. Also the decrease of the chlorophyll percentage leads to decrease the process of photosynthesis in the plant and that leads to an overall decrease in plants' growth. (Cheny et al., 2004).

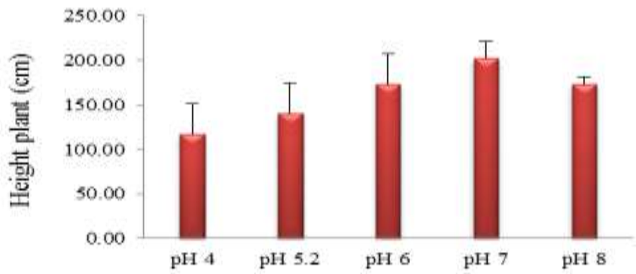

Figure 1: Effect of soil pH levels on plant height

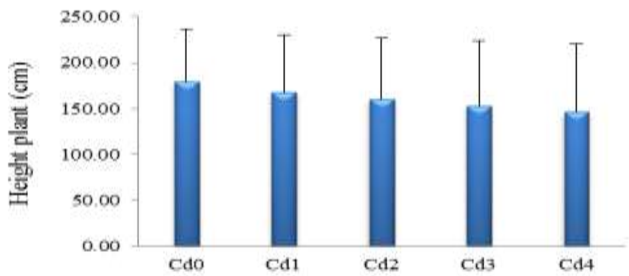

Figure 2: Effect of cadmium levels on plant height

Figure (3) explain the interaction between the levels of the soil acid and the level of the cadmium that significantly affected the characteristic of the plant height, whereas the interaction between the levels of the pH7 with Cd0 to the levels of cadmium the highest level of the plant height that reached (216.69 cm) that significant superiority all the interactions in the study in the increase of the level of the plant height. Whereas the interaction between the level of pH4 and Cd4 gave the least level which was (99.16 cm) that led to a significance decrease in plant height, and assure that the decrease of the pH in the soil led to an increase in cadmium absorbance and negatively affected the plant height (Hong et al., 2008) where he confirmed that the acidity of the soil is considered major factor in controlling the absorption of cadmium from the soil and its ability to move. As well (Sandrin and Hoffman, 2007) who indicated that the decrease of the soil pH will increase the bioavailability of the heavy metals in the soil. And that leads to the increase of the toxicity to the plant because of the cells ability to absorb or contain more from these ions in the acid conditions in the soil (Rudd et al., 1983).

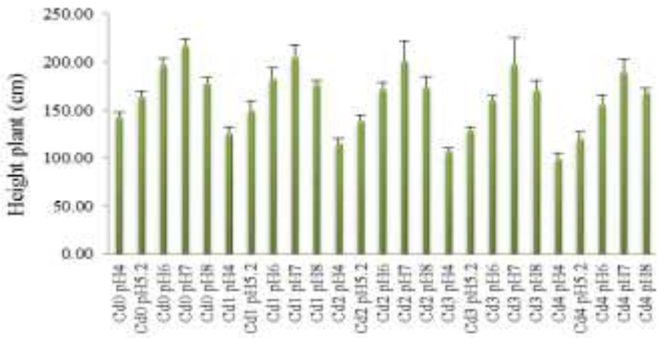

Figure 3: Effect of interaction between soil pH and cadmium levels on plant height

3.2 Root dry weight (g)

The figure (4) indicates to significance differences between the soil pH, whereas the level pH6 significant superiority the rest pH levels used in the study reached (29.21 g) whereas the pH8 level gave the least dry for root weight level as (18.76 g) and this result approves with (Cieslinski et al., 1996) who indicated to that the increase in soil pH will leads to increase in growth of the roots, and that might be the reason of the increase in the readiness of the most nutrients at the level of pH 6-7 and especially Phosphor which helps to increase the growth of the roots and the number of it branches which leads to increase in water absorbance and the other nutrients. Figure (5) explain the effect of cadmium on the root dry weight, where it increased the concentration of cadmium in the soil decreased dry weight of root and that's goes along with (Robert et al., 1973; Iftikhar, 2014) where it gave Cd treatment the highest level for the dry for root weight reached (26.36 g) compared with Cd4, which gave the least level of the dry root weight reached (19.20 g) and this decrease is most likely because of the absorption and the accumulation of the cadmium in the roots, and that's most likely will limits the absorption and the distribution of the other nutrients (Gomes et al., 2013), in addition to that the cadmium decreases the production of the new cells and the growth of the roots (Liu et al., 2004). As for the joint effect of the soil pH and the levels of the cadmium, the interaction between the level pH6 with Cd0 showed a significant superiority to the other interactions in the increase of the root dry weight since it gave the highest rate of the dry for root weight (34.07 g) whereas the interaction of the pH4 with Cd4 gave the least rate (15.87 g) figure (6), and this decrease in the rate of root dry weight is likely because of the effect of the decreased pH on the readiness of the cadmium to be absorb by the roots and accumulation in it. Also the non-readiness of the phosphor to be absorbed by the roots at this level of soil acid that decreases the division of the cells and consequently the growth of the seeds and its spread (Mengel et al., 1987; Uchida, 2000 and Havlin et al., 2005).

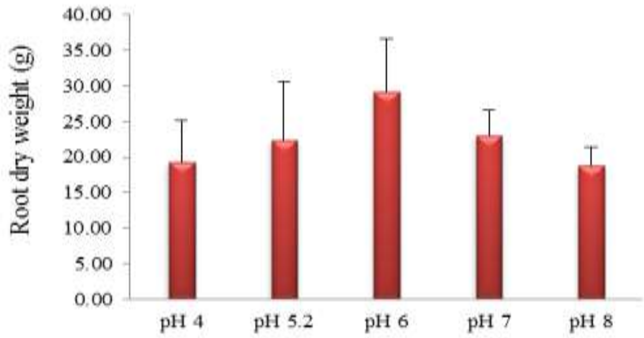

Figure 4: Effect of soil pH levels on root dry weight (g)

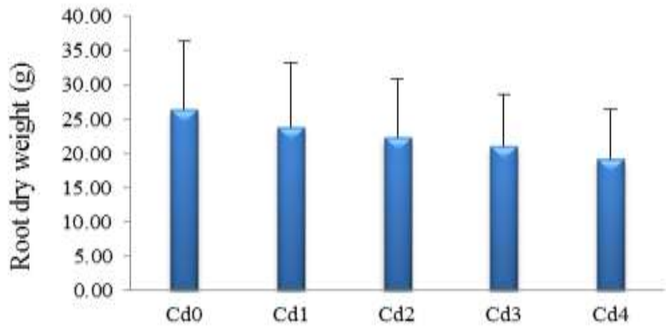

Figure 5: Effect of cadmium levels on root dry weight (g)

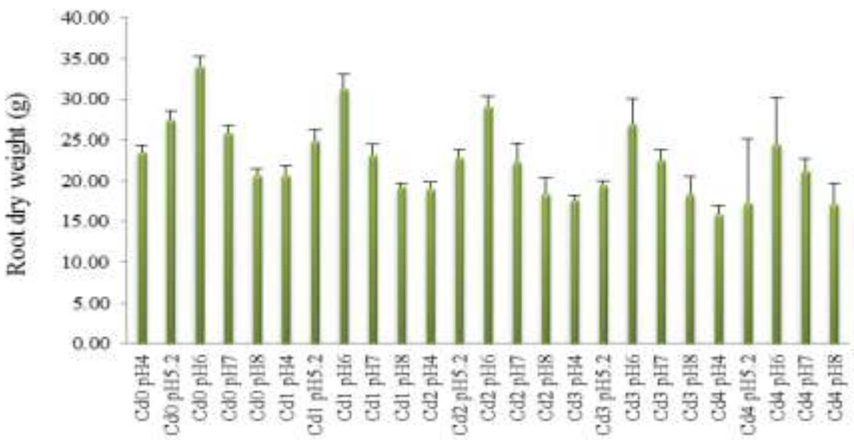

Figure 6: Effect of interaction between soil pH and cadmium levels on root dry weight (g)

3.3 Stem dry weight (g)

Figure (7) shows the effect of the soil pH levels in the rates of the stem dry weight and this increase in soil pH to pH7 led to a significant increase to other levels in the increase of the stem dry weight that reached the highest rate (206.95 g) whereas the pH4 gave the least rate (120.22 g). The same case to the level of the cadmium in the soil, the figure (8) showed that the increase of the cadmium concentration in the soil led to a significant increase in the decrease level of the stem dry weight where it reached the highest rate of the stem dry weight with the Cd0 of (182.37 g) whereas it reached the least rate in the level of Cd4 (147.28 g) and this result goes along with what (Naz et al., 2015 ; Ebrazi et al., 2014) has approved. This decrease might be because of the weakness and the inhibiting of the root growth when the concentration of the soil added cadmium increased figure (5), and this led to decrease the stem dry weight because of not absorbing the water and the other nutrients (Gomes et al., 2013; Mohd et al., 2013) and also the decrease of the rate of the Transpiration (Chen et al., 2003). Regarding the figure (9) it shows the interaction between the pH7 with Cd0 to a significantly superiority on the rest of the interactions in the increase of the stem dry weight, since it gave the highest rate of the stem dry weight (221.03 g) in this significant increase is more likely caused by the effect of the soil pH which was appropriate to readiness the nutrients such as; nitrogen, Phosphor, and some other element to be absorbed by the plant, and its effect on non-readiness and absorption of the cadmium by the plant, that effect the plants cells growth over all (Sauve et al., 2000; Kukier et al., 2004) in the other hand the interaction between the pH4 and Cd4 is the least level of the stem dry weight (101.14 g).

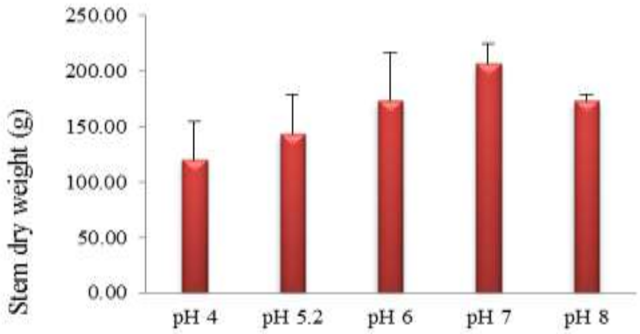

Figure 7: Effect of soil pH levels on stem dry weight (g)

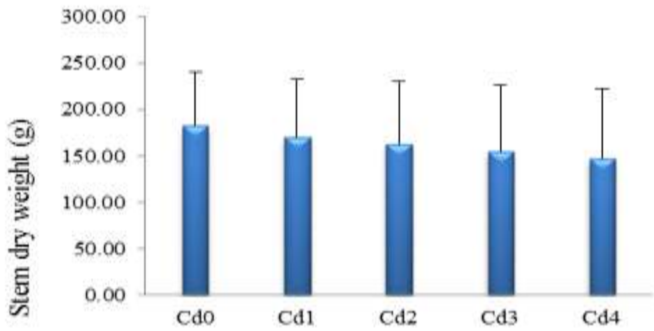

Figure 8: Effect of cadmium levels on stem dry weight (g)

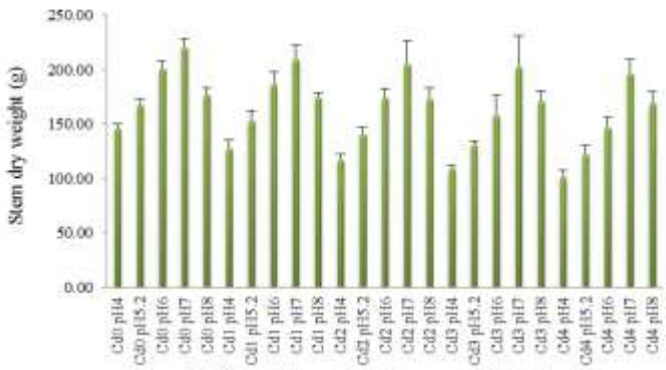

Figure 9: Effect of interaction between soil pH and cadmium levels on stem dry weight (g)

3.4 Leaves dry weight (g)

Figure (10) explains a significant increase in leaves dry weight at level pH7 to the rest of the soil acid levels where it gave the highest rate (37.62 g) whereas the pH4 level gave the lease rate of the leaves dry weight in the plants (21.22 g) and this increase in leaves dry weight when increasing the level of soil pH might be caused by the increase in the nitrogen as a result of the positive increase of the soil pH on the decomposition or mineralization the organic material (Caires, 2010) and this increase in nitrogen was clear through the effect on the increase of stem dry weight (7) at the same level.

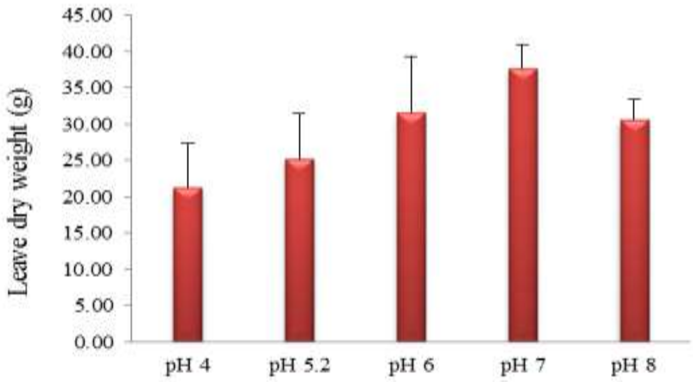

Figure 10: Effect of soil pH levels on leave dry weight (g)

The high level of the cadmium Cd4 effected ambiguously on the leaves in general, since a sudden wilting and falling of some of the plant leaves was noticed under this treatment and this affected significantly in decreasing the leaves dry weight compared with the rest of the treatments and it gave the least rate that reached (26.14 g) when comparing it with the Cd0 treatment that gave the highest rate of the leaves dry weight that reached (32.82 g) as showed in figure (11) and this result goes along with what (Khadijeh et al., 2011) discovered and this leaves falling to be considered an indicator to the toxic of the cadmium to the plants (Ernst et al., 1992; Popova et al., 2009). Also the high concentration of cadmium is to be considered as one of the most important reasons of the decrease of the leaves dry weight whether in the leaves or any part of the plants that leads to Inhibiting the absorption of the major nutreits to the plant (Sanita di Toppi and Gabbrielli, 1999).

The effect of the interaction between the level of pH7 with Cd0 of cadmium levels seems to be obvious on the leaves dry weight and exceeded significantly the rest of interactions where gave the highest value that reached (40.18 g) whereas the interaction between the level pH4 and Cd4 gave the least rate that reached (17.85 g), figure (12), this decrease might be caused by the effect of high soil acid on the movement and readiness of the cadmium in the soil and its accumulation in the leaves that led to not absorption of the rest nutrients and the most important one the nitrogen and consequently decreasing the rate of the leaves dry weight (Sauve et al., 2000) as what happened to the stem dry weight (9).

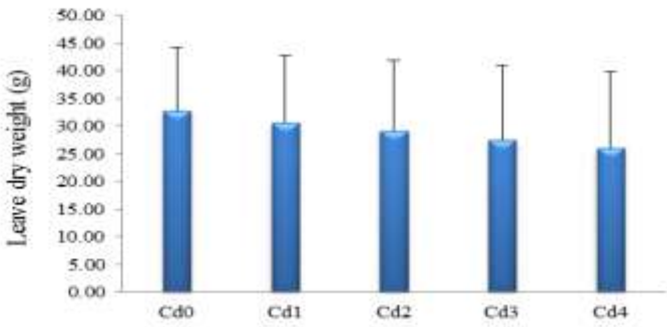

Figure 11: Effect of cadmium levels on leave dry weight (g)

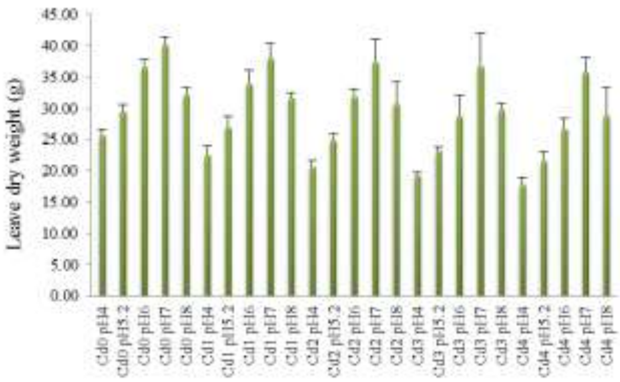

Figure 12: Effect of interaction between soil pH and cadmium levels on leave dry weight (g)

4. CONCLUSION

The study noted to the importance of the pH of soil for the growth of corn where that decreased soil pH to less than pH6, also increase it more than pH7 led to the general weakness in the growth characters (plant height, root, stem and leaves dry weight). As well as, the decrease of soil pH led to increased negative impact of toxic cadmium which significantly affected plant growth when increasing it, leding to the future impact in decreased the corn production So it must be emphasized that the pH of the soil and methods of increase it, especially in soils contaminated by the element cadmium.

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