ARC Journal of Pharmaceutical Sciences (AJPS)
Volume 5, Issue 4, 2019, PP 16-27
ISSN No: 2455-1538
DOI: http://dx.doi.org/10.20431/2455-1538.0504003
www.arcjournals.org

The Effect of Soil PH, High-Calcium Compost and Cadmium on Some of Growth Characters in Corn (Zea *mays*l.)

Rabah S. Shareef[1*], Awang Soh Mamat[2], Mustafa R. Al-Shaheen[3]

[1]*College of Applied sciences, University of Anbar, Iraq.*

[2] *School of Bioprocess Engineering, University Malaysia Perlis, Perlis, Malaysia.*

[3] *College of Agriculture, University of Anbar, Iraq.*

Corresponding Author:** ***Rabah S. Shareef, *College of Education-Al-Qiam, University of Anbar, Iraq*

Abstract: *A pot experiment was carried out in the plastic greenhouse at the Institute of Sustainable Agrotechnology (INSAT), University Malaysia Perlis in Sungai Chuchuh, Perlis, Malaysia. During season of the cultivation of 2014 investigate the impact of soil pH, types of compost and cadmium (Cd) on Plant height, Leaf area and Leaf area index of corn plant (Zea mays L.). Fifty 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, two types of compost, market compost (MC) and product compost (PC) and five levels of Cd; Cd 1, Cd 2, Cd 3, Cd 4 and Cd 0 where the amounts (2, 4, 6, 8 mg. kg-1 soil and control treatment without add Cd) are applied as CdCl2. Thus, the total numbers of pots were 150 pots. The results showed the soil pH 6 led to significant effect in increase the Plant height, Leaf area and Leaf area index. While adding the compost (PC) to increase the Plant height, Leaf area and Leaf area index .as well as, increase concentration of Cd led to significant decreasing in Plant height, Leaf area and Leaf area index.*

Keywords: *pH of Soil, Compost, Calcium, Cadmium, Corn, Perlis.*

1. Introduction

Soil pH is one of the important factors affecting soil fertility and plant nutrition because of it's the large contribution in the soil's ability to process the correct ratio of nutrients needed by the developing plant. Soil pH is also one of the important indicators to the need of soil of the nutrients during fertilization process to reclaim and improve soil fertility to meet the plant nutrients needs. Soil pH can impact the growth of a plant based on its influence on the availability of essential plant nutrients (Tran and Popova, 2013).

Acidity per se is not harmful to plants except in extreme cases (Shrivastava and Kumar, 2015). The problems of plant growth on acid soils are mainly due to the large amounts of Al, Fe and Mn (Giller, 2001). Soil acidity is a major growth-limiting factor for some plant species in many parts of the world especially in tropical and subtropical countries. De Jong (2007) concluded that low soil pH is the number one growth-limiting factor with the most fertility problems in the tropics. Maize yields are significantly affected by acidity in the tropics (Kimatu, 2015). The primary effect of high pH for soil is inhibition of root growth, resulting in shoot growth reductions (Musharo, 2005).The low pH of soils are not suitable for the cultivation of maize where that the growth in the degree of soil pH 5 is bad because of the toxic materials. These materials (aluminum and iron) lead to disorder in the process of nutrition and its exchange, where it contributes to the decrease of the yield, but develops well when the soil pH is neutral (Fernánde and Hoeft, 2009).

Compost application to soils has contributed to increased plant height and leaf area index of corn significantly ($p<0.001$) as compared to the controlled (soil-only) treatment (Desalegnet al., 2014). The corn plant height develops increasingly in the time of planting in the soil with different rates of compost application (John et al., 2013). Cations that are essential for plant growth are K, Mg, Ca, Mn and Fe (Bolan et al., 2003). Ozgenet al. (2011) noted the important roles of calcium on plant growth and development including cell division and cell elongation is well documented. Among the different levels of Ca, 6% level of Ca showed significant increase in plant height and number of plant branches

(Ilyaset al., 2014). Madaniet al.(2013) showed that the increasing of calcium concentration in nutrition solution enhanced stem length and diameter of papaya seedlings.

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 $mg.kg^{-1}$ (An, 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 corn are the main crops cultivated in the world and served as staple food in different parts of the world. Shoot and root growth of wheat was inhibited by the addition of Cd in nutrient media (Amani, 2008). Biomass reduction was observed in corn 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 and shoot height were decreased with increasing Cd soil addition (Auda et al., 2011).

Soil pH is considered a primary factor controlling the availability of Cd in soils, because the increase of soil pH favors the adsorption of Cd to metal binding sites and decreases the partition of Cd to soil solution (Kukier*et al*., 2004; Li *et al*., 2011). Kirkham (2006) confirms that the pH of the soil is usually the most important factor that controls the uptake, with low pH favoring Cd accumulation. Cadmium concentration in crops is influenced by a wide range of factors including crop genetics and soil characteristics such as texture, pH, crop management practices and soil Cd concentration (Cynthia*et al*., 2010).

Corn (or maize) is one of the oldest human-domesticated plants. Known as the third largest planted crop in the world after wheat and rice. It is mostly used as a primary feed crop – for instance it accounts for 95% of the total feed grain production and its use in the United States. Corn is also important as a food crop in many parts of the world, and in food processing for making starch, sweeteners, oil and beverage. Besides food and feed, nowadays corn has been playing an important role in industrial ethanol production (Shi, 2014 ; Qiu, *et al*., 2010).

2. Materials and Methods

2.1. Experimental Design and Treatments

Agricultural experiment was performed inside the plastic greenhouse and arranged by factorial experiments according to the Completely Randomized Design (CRD), with three replicates. This experiment is consisted of two types of compost (PC and MC),five levels of pH value in the soil (4, 5.2, 6, 7 and 8) and five levels of cadmium; Cd 1, Cd 2, Cd 3, Cd 4 and Cd 0 where the amounts it were (2, 4, 6,8mg. kg-1 soil and control treatment without add cadmium) are applied as $CdCl_2$. The five of corn plants were planted for each treatment in plastic pots (20 cm × 20 cm × 20 cm). Where were packed with sandy loam soil, and it were irrigated daily by a drip irrigation system.

2.2. Management of the Experiment

The soil preparation was conducted before eight weeks of cultivation. 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 (Weyman-Kaczmarkowa and Pędziwilk, 2000). A complete amount of 10 kg soil was used for each treatment. Then, 200 g. Kg-1 soil was added from two types of compost - Product Compost (PC) table (1), which was produced in the second experiment of our study and Market Compost (MC) that was bought from local markets. These two types of compost were been mixed thoroughly with soil until full homogeneous and then put in the pots (20 cm × 20 cm × 20 cm) and incubated it in the laboratory at 25 °C for eight weeks beginning with 20th January 2015.During incubation, the pots were irrigated with water and after six weeks of incubating of the soil all the amount of Cd were added to the soil for guaranteed of uniform distribution of Cd. A fertilizer rate of 60 N kg.ha-1, 60 P kg.ha-1 and 40 K kg.ha-1 for the maize was followed recommendation by (MARDI). The fertilizers used were urea (46% N), CIRP (30% P_2O_5) and MOP (60% K_2O).Each seedling was transferred from transplant tray to each pot, which contained 10 kg of soil. The plants irrigation was an average of five minutes per day, using drip irrigation system. Also the agronomic practices like weeding were performed as and when necessary. These plants were allowed to grow till they hit the maturity level. All the plants were planted on 13th March 2015 and were harvested after 110 days.

Table1. *Product compost (PC) specifications and ratios of some important nutrients*

pH	CEC Coml. Kg-1	OM % dm	Ash (%)	C (%)	N (%)	Ca (%)	Mg (%)	K (%)	P (%)	C/N
8.03	29.91	38.7	22.168	43.24	1.64	4.29	0.60	1.02	1.26	26.37

2.3. Statistical Analysis

Data were subjected to statistical analysis using the statistical software GenStat (Payne et al., 2012). ANOVA was used to analyze the experimental results of dependent variables (treatments). The least significant difference (LSD) was calculated at P≤0.05.

2.4. Plant Parameters of Study

Plant height was measured from the soil surface until the flag leaf on average for five plants using ruler. After plants had been harvested, leaves were cut from the stem behind the collar of each plant. With the use of the LI-3100 leaf area meter the leaf area of all the photosynthetic active leaves was determined. Leaf area was measured in square centimeter (cm2) (Wessels, 2014).Leaf area index (LAI) was calculated as the ratio of leaf to ground area by using the following formula given by (Watson, 1952).

$$LAI = \text{Leaf area} / \text{Ground area} \quad (1)$$

3. Results and Discussion

3.1 Plant Height (cm)

Figure 3.1 indicated a big difference between the soil's pH levels in the plant height, where a pH 6 is superior over the other levels, resulting in the highest rate that reached 171.97 cm, whereas a pH 8 resulted in the lowest rate that reached 158.32 cm. This decrease might be caused by the nutrients not being absorbed by the plant at pH 8, where it reached the highest level of soil pH, and after soil incubation, it reached a pH = 9.80. This result agrees with Unagwu et al. (2013).

Figure 3.2 indicated a big difference in the plant height between two types of composts being used, where PC is remarkably superior over MC, resulting in the highest plant height that reached 174.32 cm, while MC gave the least rate that reached 158.45 cm. This increase in plant height is most likely caused by the availability of the nutrients necessary for plant growth in the PC compost more than MC compost, especially N, which is the most important element in plant growth, and Ca, which enhances plants' cells division (Kader and Linolberg, 2010; Ilyas et al., 2014). This result agrees with Makinde, (2007) nadLaekemariam and Gidago, (2012).

In the levels of Cd, it might be remarkably superior to Cd 0 in providing the highest level of plant height that reached 187.52 cm, which is remarkably superior to the rest of Cd levels in terms of the rate of decrease of plant height with increasing Cd concentration in the soil, until it reaches 141.69 cm at Cd 4. This decrease was most likely due to the effect of the high concentration of Cd, as shown in Figure 3.3, which lead to the nutrients' absorption weakness that enhance plant growth (Prasad et al., 2001).

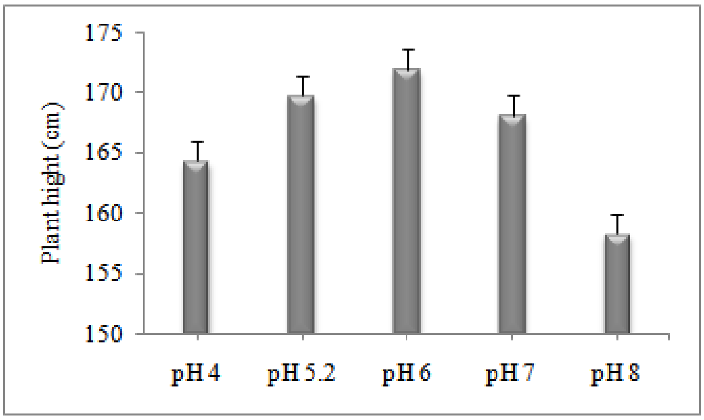

Figure3.1. *Effect of soil pH levels on plant height (cm)*

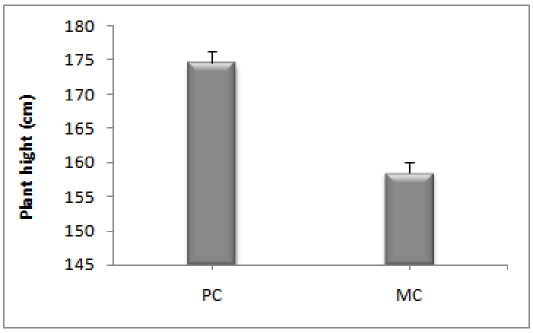

Figure3.2. *Effect of compost types on plant height (cm)*

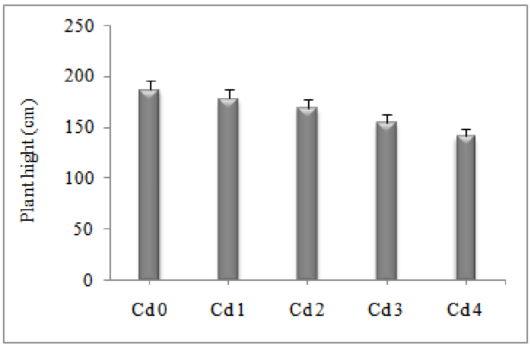

Figure3.3. *Effect of cadmium levels on plant height (cm)*

The interaction between the soil's pH levels and compost types substantially affected the growth rate of plant height. The interaction between pH 4 and PC resulted in the highest rate that reached 197.65 cm, which is remarkably superior over other interactions. This increase can be caused by the availability of the main cations, especially calcium, which leads to the soil's pH increase, consequently providing the correct environment for nutrient release that increase corn growth (Rastijia et al., 2012). These results agree with those reported by Andric et al. (2010). The interaction between pH 4 and MC resulted in the least plant height rate, reaching 131.05 cm Figure 3.4, and this decrease is most likely caused by the influence of decreased soil pH in its un-readiness in absorbing main nutrients such as N and P (Kisinyo et al., 2009).

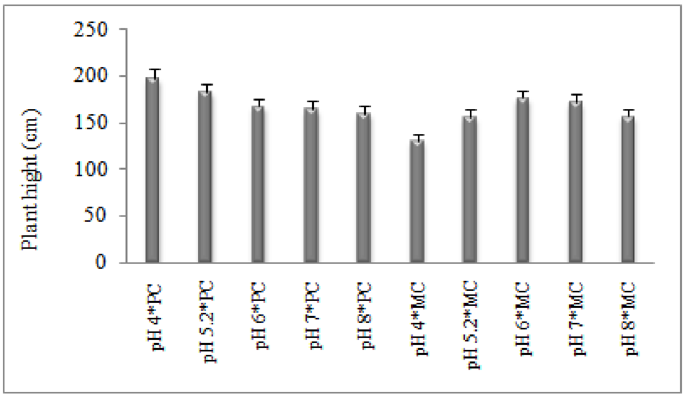

Figure3.4. *Effect of interaction between soil pH levels and compost types on plant height (cm)*

The interaction between PC and Cd 0 is remarkably superior over other interactions between Cd and compost types, where it results in the highest rate of plant height, reaching 192.63 cm as opposed to the lowest rate that reached 128.46 cm in the interaction between MC and Cd 4, Figure 3.5. This increase occurs in the interaction between PC and Cd 0, most likely caused by the effect of the availability of the nutrients in the soil via the addition of PC and the unavailability of Cd, which negatively affect plant growth in general (Chen et al., 2004). In terms of the interaction between the levels of soil pH and Cd in the soil, the interaction between pH 6 and Cd 0 substantially affected the increase of the plant height, and its highest rate reached 194.27 cm, while the interaction between pH 8 and Cd 4 resulted in the lowest rate of 139.58 cm, as shown in Figure 3.6.

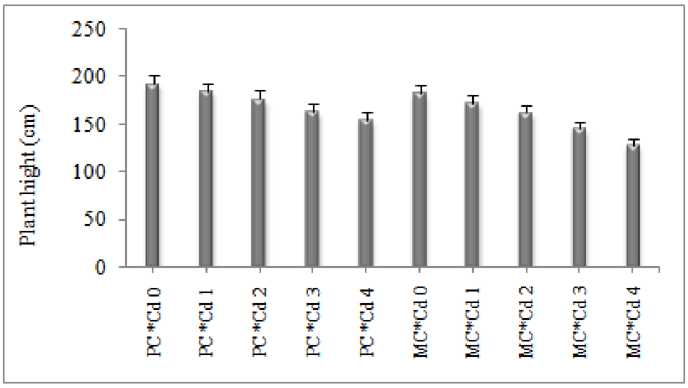

Figure3.5. *Effect of interaction between compost types and cadmium levels on plant height (cm)*

Figure 3.7 showed a substantial interaction between the three factors of study in the increase of the plant height, where the interaction between the pH 4 and PC and Cd 0 resulted in the highest plant, reaching 218.20 cm, which might be caused by PC in increasing the soil's pH from pH 4 to pH 6.48 Figure 4.3.1. It helped introduce nutrients into the soil via PC and decrease the concentration of Cd, which led to the plant absorbing nutrients and growth in height. In terms of the interaction between pH 8 and MC and Cd 4, it resulted in the lowest of plant growth at 127.17 cm. This decrease is most likely caused by the soil's pH decreasing, which in turn increases the readiness of Cd and its corresponding movement in the soil (Hong et al., 2008), which simultaneously decreases the readiness of the competitive nutrients, especially that of compost MC that did not influence the value of the soil's pH compared to PC containing calcium and magnesium, which in turn increased the pH of the soil (Fan et al., 2014).

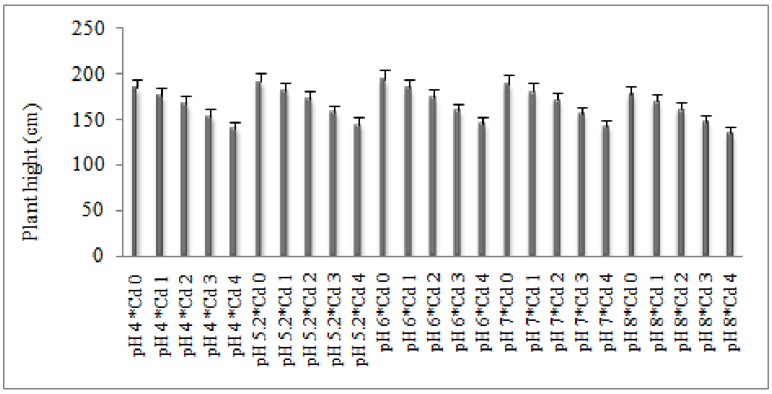

Figure3.6. *Effect of interaction between soil pH levels and cadmium levels on plant height (cm)*

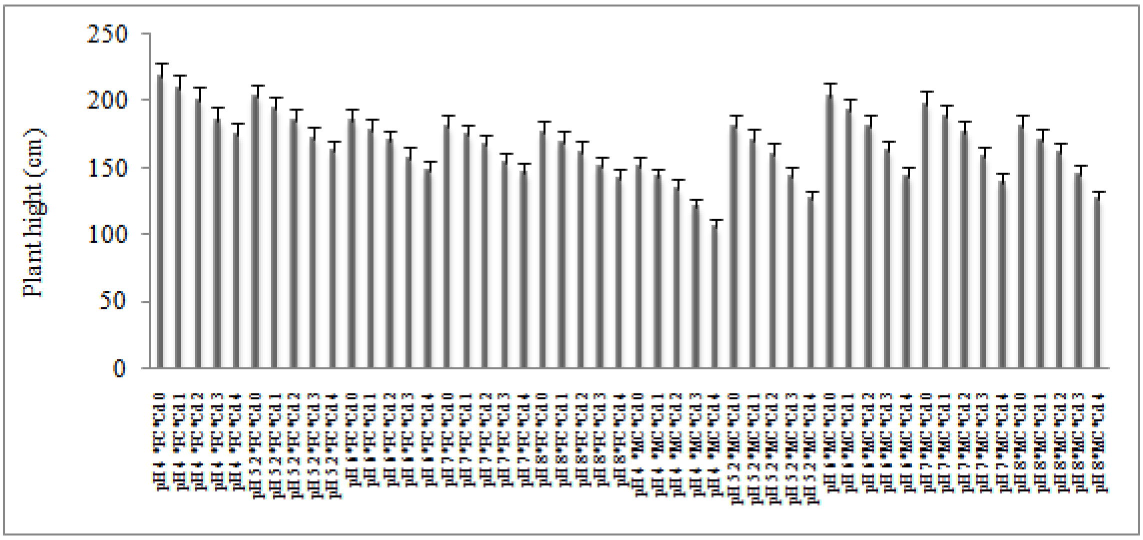

Figure3.7. *Effect of interaction between soil pH levels and compost types and cadmium levels on plant height (cm)*

3.2 Leaf Area (Cm2)

The leaf area is regarded as an indicator of the photosynthesis system and a main source of dry matter, meaning that is has a strong relationship with growth characteristics. The difference in the levels of soil pH led to big differences in the leaf area for plants Figure 3.8, where the pH 6 level resulted in the highest leaf area, reaching 4809.78 cm2, which might be caused by the increase of competency of nutrients absorbance by plants, especially N, regarded as one of the most important macronutrients that interferes with bio-activities. It influences the division of cells and increase plant growth, including its leaf area (Binder et al., 2000), while giving pH 8 lower plant leaf area, reaching 4263.89 cm2.

Figure 3.9 showed big differences in the leaf area between the two types of compost PC and MC, where the former gave the highest leaf area reached 5028.41 cm2, while the latter gave the lowest leaf area that reached 4167.17 cm2, most likely caused by the availability of calcium in PC at levels higher than MC. Calcium is regarded as an important element in biological processes for plants, as it hugely effects the division of cells. and increasing size of the leaf and consequently increased the photosynthesis, and that reflected positively on the leaf area of plant (Abdelrazzag, 2002). These results agree with the one reported by Unagwu et al. (2013). Also, the decrease of the plant leaf area is inversely proportional to the levels of Cd in the soil, Figure 3.10. Cd 0 gave the highest plant leaf area that reached 5078.04 cm2, compared to Cd 4, which gave the lowest 4008.54 cm2. This decrease might be caused by the effect of Cd in absorption and transfer of the nutrients within the plants from the roots to the leaves across the conducting xylem tissue (Sandalio et al., 2001).

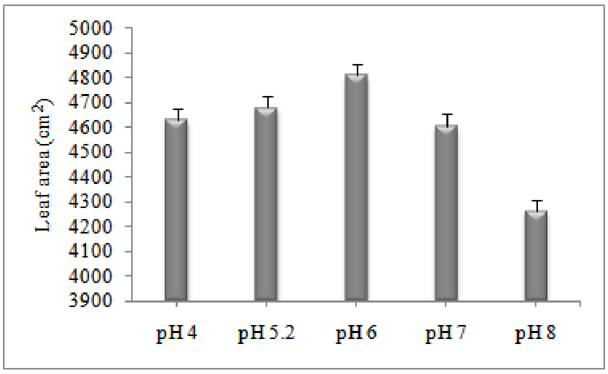

Figure3.8. *Effect of soil pH levels on leaf area (cm^2)*

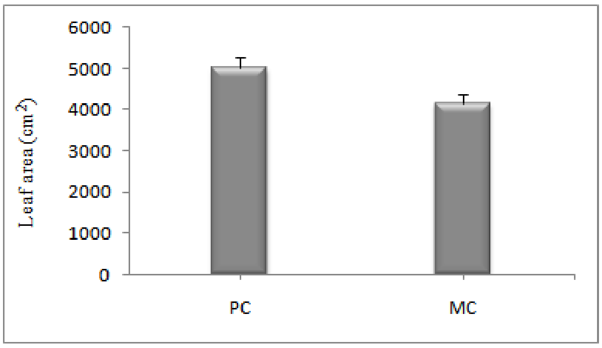

Figure3.9. *Effect of compost types on leaf area (cm2)*

In terms of interactions between the study factors, those between pH 4 and PC substantially affected the increase of leaf area for plants Figure 3.11, where it resulted in the highest rate, reaching 6016.58 cm2, which might be due to the effect of the types of compost in increasing the pH of the soil until it reaches a level where most nutrients are ready for absorption by the plant, especially those that are available in high quantities in the same compost PC (Andric et al., 2010). Whereas the interaction between pH 4 and MC resulted in the lowest plant leaf area, at 3341.77 cm2.

The results confirmed the presence of substantial interactions between the compost types and Cd levels, where the interaction between PC and Cd 0 substantially affected the leaf area for the plant over other interactions Figure3.12, where it resulted in the highest rate at 5370.58 cm2, which might be caused by the presence of nutrients such as N, P, and Ca. These nutrients enhances root growth and the division of cells, which subsequently translate into increased growth and decreased Cd, while the decrease of plant leaf area appears to be the effect of the increase in the level of Cd in the rest of the interactions, especially in MC, where the Cd enter in plant leaves via calcium channels due to the shortage of Ca in the soil, leading to the closing of the stomata, which leads to decrease the rate of transpiration, and inhibition of photosynthesis in the plant (Perfus-Barbeoch et al., 2002), while interactions between MC and Cd 4 resulted in the least plant leaf area that reached 3384.57 cm2. The interaction between pH 6 and Cd 0 substantially effected the increase in the plant leaf area Figure 3.13, where it resulted in the highest 5331.69 cm2. This level of soil pH is suitable for uptaking nutrients from soils (Sadullah, 1999), especially at lower levels of Cd, where the least rate reached were 3703.28 cm2 in the interaction between pH 8 and Cd 4.

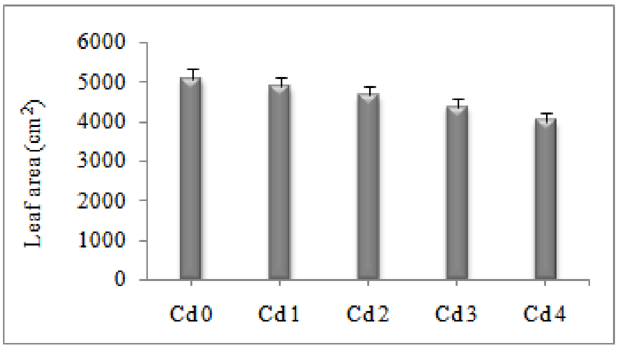

Figure3.10. *Effect of cadmium levels on leaf area (cm2)*

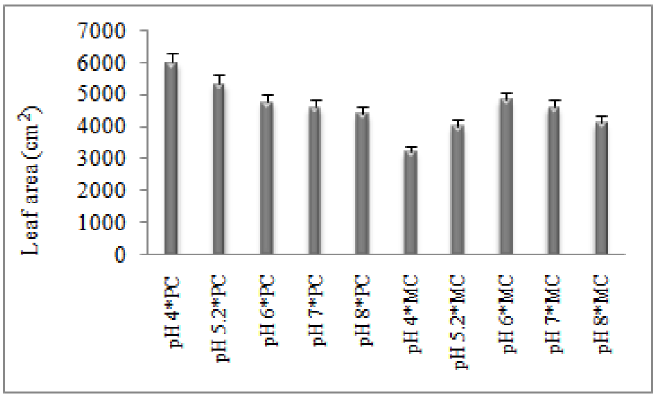

Figure3.11. *Effect of interaction between soil pH levels and compost types on leaf area (cm2)*

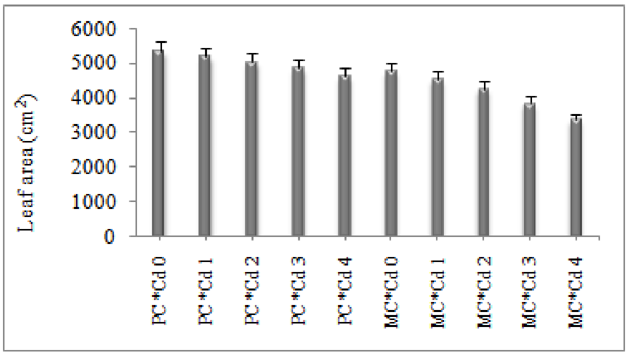

Figure3.12. *Effect of interaction between compost types and cadmium levels on leaf area (cm2)*

In terms of the interaction between the three factors of the study, Figure 3.14 showed a substantial effect of the levels of soil pH and the compost types used and Cd levels, where the interaction between pH 4 and PC and Cd 0 is remarkably superior over all other interactions in the study in providing the highest rate of plant leaf area that reached 6425.99 cm2. This result might be caused by the PC effect on soil's pH increasing from pH 4 to pH 6.48 Due to the presence of high calcium and the availability and readiness of the nutrients to be absorbed and decreasing the concentration of Cd that led to increased growth that generally includes increased leaf area for plants, while the interaction between pH 4 and MC and Cd4 gave the least that reached 2632.97 cm2. This might have been caused by Cd's readiness, due to its high concentration and decreased pH in this treatment (Shaheen et al., 2013; Teng et al., 2015) and the inability of the MC compost to increase the soil's pH that led to the absorption of high quantities of Cd, leading to a decrease in the leaf area and plant growth.

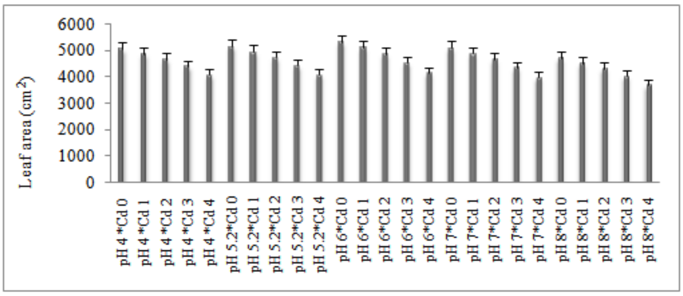

Figure3.13. *Effect of interaction between soil pH levels and cadmium levels on leaf area (cm2)*

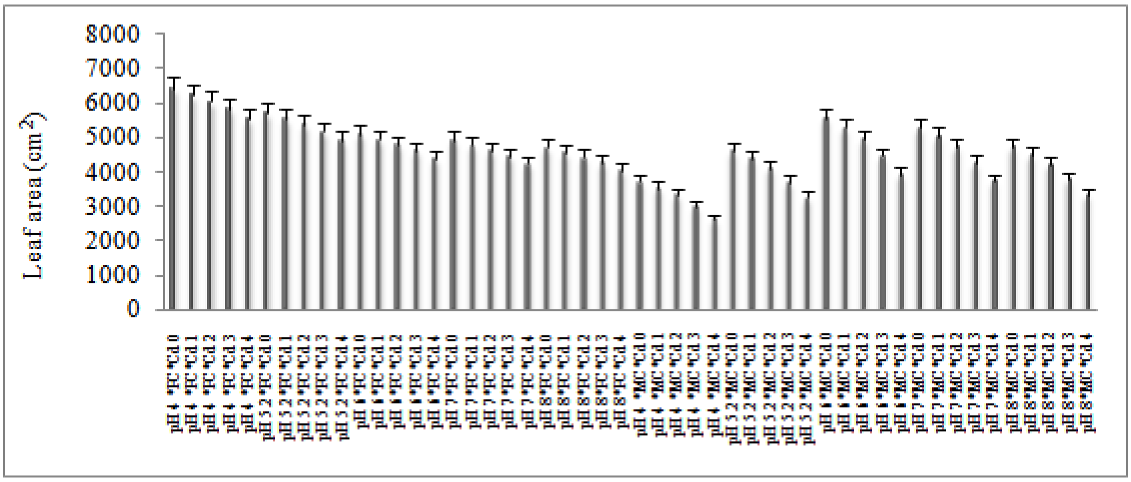

Figure3.14: *Effect of interaction between soil pH levels and compost types and cadmium levels leaf area (cm2)*

3.3 Leaf Area Index

This characteristic identifies the efficiency of sunray interception and reflects the optimum level of the leaf area that produces the highest amount of dry matter (Al Jobouri and Anwer, 2010). Figure 3.15 indicated the highly superiority of pH 6 over other levels, where gave the highest rate at 2.55, compared with pH 8, which resulted in the lowest rate at 2.27. Also, similar effects of the increase of the leaf area is reflected on the increase of the leaf area index at all treatments, where the PC was remarkably superior on MC in the leaf area index, where it resulted in the highest rate of 2.67, compared with MC type, which resulted in the lowest rate at 2.21 Figure3.16. This might have been caused by the increase the leaf area Figure 3.9 at the same treatment PC, which positively reflected on the leaf area index (Al Jobouri and Anwer, 2010; Cavagnaro, 2014). The Cd 0 was remarkably superior to all Cd levels Figure 3.17, where its highest was at 2.70, compared to the lowest at 2.13 at Cd 4 (Sandalio et al., 2001).

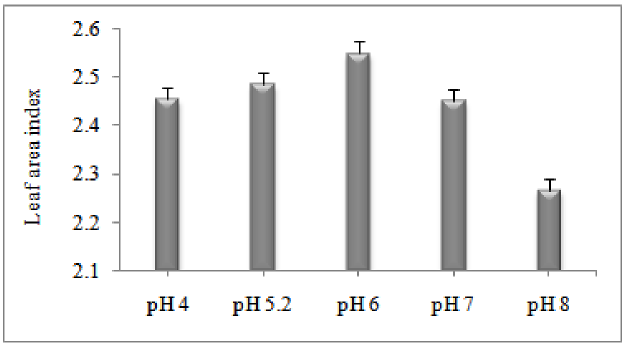

Figure3.15. *Effect of soil pH levels on leaf area index*

The reflection of increased leaf area could explain the increase in the leaf area index. It did not only influence individual treatments, it also reflected the dual and triple interactions, where dual interactions between pH 4 and PC, interaction between PC and Cd 0, and the interaction between pH 6 and Cd 0 and the triple interaction between pH 4 and PC and Cd 0 resulted in the highest leaf area index that reached (3.19, 2.85, 2.83 and 3.41 respectively), which were remarkably superior to the rest of dual and triple interactions of the study, where the dual interactions between pH 4 and MC, interaction between MC and Cd 4, and the interaction between pH 8 and Cd 4 and the triple interaction between pH 4 and MC and Cd 4 resulted in the lowest leaf area index that reached (1.72, 1.80, 1.97 and 1.40 respectively). These results agreed with (Hameed and Ahmed, 2006 ; Al Jobouri and Anwer, 2010), as shown in Figures 3.18 to 3.21.

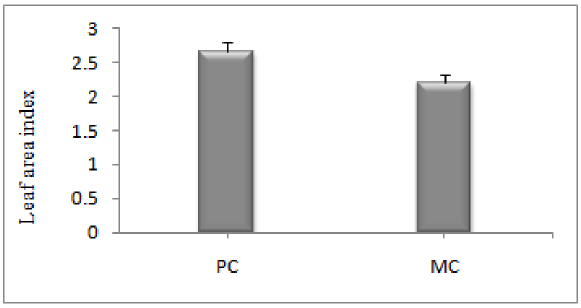

Figure3.16. *Effect of compost types on leaf area index*

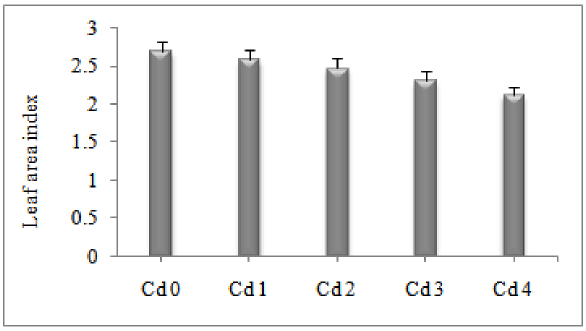

Figure3.17. *Effect of cadmium levels on leaf area index*

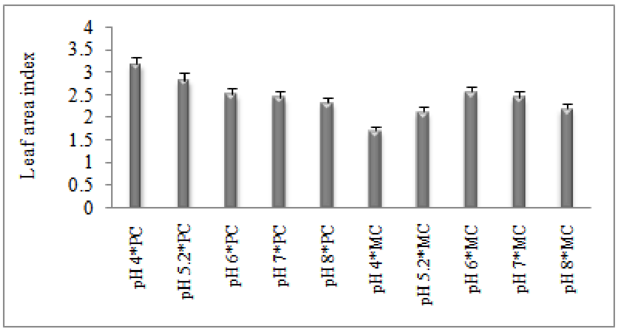

Figure3.18. *Effect of interaction between soil pH levels and compost types on leaf area index*

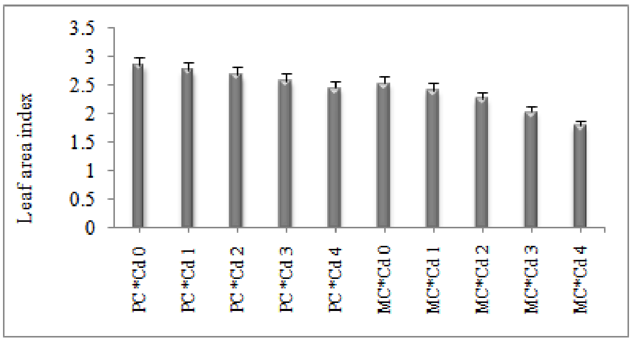

Figure3.19. *Effect of interaction between compost types and cadmium levels on leaf area index*

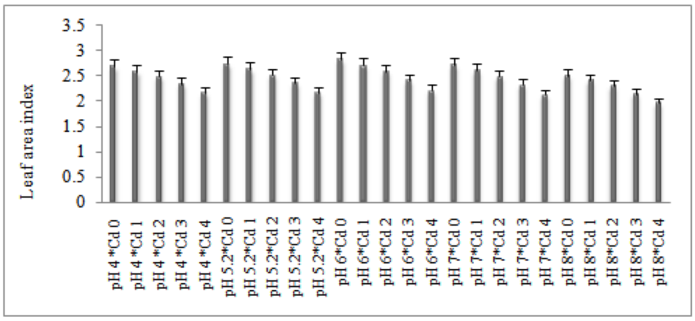

Figure3.20. *Effect of interaction between soil pH levels and cadmium levels on leaf area index*

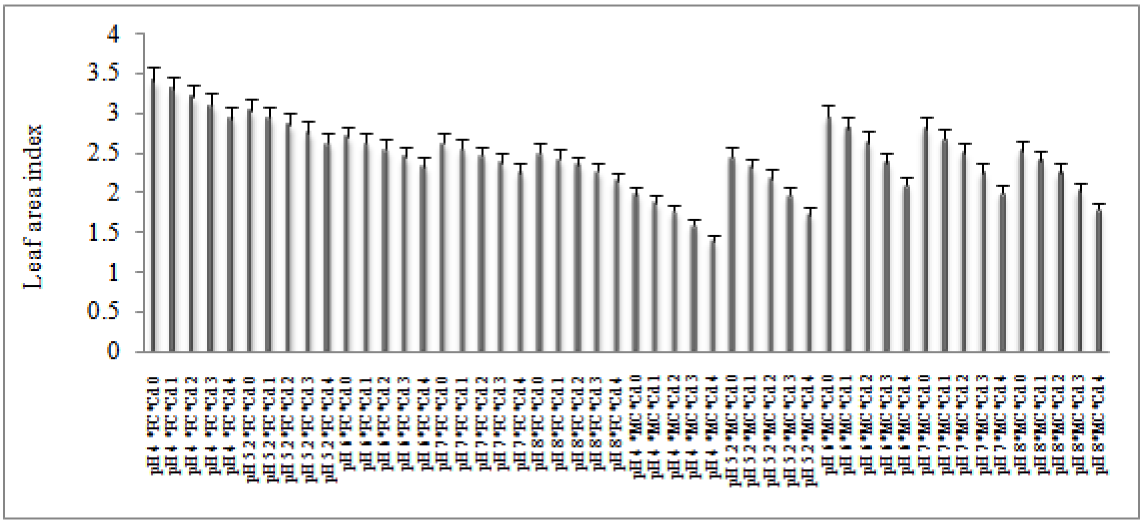

Figure3.21. *Effect of interaction between soil pH levels and compost types and cadmium levels on leaf area index*

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 lead to the general weakness in the growth characters (plant height, Leaf area and Leaf area index). As well as, the decrease of soil pH led to increased negative impact of toxic cadmium which significantly affected plant growth when increasing it, leading 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. Adding high-calcium compost is also necessary for both soil and plant where calcium helps to increase plant growth, as well as helps increase pH of the soil which helps reduce the absorption of cadmium.

References

[1] Abdelrazzag, A. (2002). Effect of chicken manure, sheep manure and inorganic fertilizer on yield and nutrients uptake by onion. *Pak. J. Biol. Sci*,*5*, 266-268.

[2] Al Jobouri, S. M., &Anwer, A. M. (2010). Influence of Different Levels and Application Dates of Nitrogen Fertilizer on Growth of Two Corn Varieties (Zea mays L.). *Jordan Journal of Agricultural Sciences*, *5*(1), 57-72.

[3] Amani, A. L. (2008). Cadmium induced changes in pigment content, ion uptake, proline content and phosphoenolpyruvate carboxylase activity in Triticum aestivum seedlings. *Aust J Basic Appl Sci*, *2*(1), 57-62.

[4] An, Y. J. (2004). Soil ecotoxicity assessment using cadmium sensitive plants. *Environmental Pollution*, *127*(1), 21-26.

[5] Andric, L., Banaj, D., &Jambrovic, A. (2010). Impacts of liming on maize and soil status. In *Növénytermelés* (Vol. 59, No. Supplement, pp. 61-64). AkadémiaiKiadó.

[6] Auda, Mohamed Abou, Ismail Abu Zinada, & Emad El Shakh Ali(2011). Accumulation of heavy metals in crop plants from Gaza Strip, Palestine and study of the physiological parameters of spinach plants. *Journal of the Association of Arab Universities for Basic and Applied Sciences* 10.1: 21-27.

[7] Benavides, M. P., Gallego, S. M., &Tomaro, M. L. (2005). Cadmium toxicity in plants. *Brazilian Journal of Plant Physiology*, *17*(1), 21-34.

[8] Binder, D. L., Sander, D. H., & Walters, D. T. (2000). Maize response to time of nitrogen application as affected by level of nitrogen deficiency. *Agronomy Journal*, *92*(6), 1228-1236.

[9] Bolan, N. S., Adriano, D. C., Mani, P. A., &Duraisamy, A. (2003). Immobilization and phytoavailability of cadmium in variable charge soils. II. Effect of lime addition. *Plant and Soil*, *251*(2), 187-198.

[10] Cavagnaro, T. R. (2014). Impacts of compost application on the formation and functioning of arbuscular mycorrhizas. *Soil Biology and Biochemistry*,*78*, 38-44.

[11] Chen, Y., Clapp, C. E., & Magen, H. (2004). Mechanisms of plant growth stimulation by humic substances: The role of organo-iron complexes. *Soil Science and Plant Nutrition*, *50*(7), 1089-1095.

[12] Cynthia, G., Don, F., Mario, T., Xiaopeng, G., Sukdev, M. and Eugene, G. (2010). Impact of long-term application of phosphate fertilizer on cadmium accumulation in crops. *Soil Science Australalia*, 1, 132-134.

[13] De Jong, F. (2007). Marine eutrophication in perspective: on the relevance of ecology for environmental policy. Springer Science & Business Media.

[14] Desalegn, G., Binner, E., Lössl, A., Vierheilig, H., Liebhard, P., & Lechner, P. (2014). Influence of quality compost on plant growth and mycorrhizal colonisation in corn. *Universität fürBodenkultur Wien Department fürAngewandtePflanzen-wissenschaften und Pflanzenbiotechnologie. Retrieved on*, *5*.

[15] Ekmekci, Y., Tanyolac, D., &Ayhan, B. (2008). Effects of cadmium on antioxidant enzyme and photosynthetic activities in leaves of two maize cultivars. *Journal of plant physiology*, *165*(6), 600-611.

[16] Fan, J., He, Z., Ma, L. Q., Yang, Y., &Stoffella, P. J. (2014). Impacts of calcium water treatment residue on the soil-water-plant system in citrus production. *Plant and soil*, *374*(1-2), 993-1004.

[17] Fernández, F. G., &Hoeft, R. G. (2009). Managing soil pH and crop nutrients. *Illinois agronomy handbook*, 91-112.

[18] Giller, K. E. (2001). *Nitrogen fixation in tropical cropping systems*. Cabi.

[19] Hameed, K. Al. & Ahmed, N. Al. (2006). Effect of source, rate and splitting of phosphorus fertilizers on maize performance. *The Iraqi Journal of Agricultural Sciences*, 37 (6): 35-42.

[20] Hong, C. O., Lee, D. K., & Kim, P. J. (2008). Feasibility of phosphate fertilizer to immobilize cadmium in a field. *Chemosphere*, *70*(11), 2009-2015.

[21] Ilyas, M., Ayub, G., & Hussain, Z. (2014). Response of Tomato to Different Levels of Calcium and Magnesium Concentration. *World Applied Sciences Journal*, *31*(9), 1560-1564.

[22] John, N. M., Uwah, D. F., Iren, O. B., & Akpan, J. F. (2013). Changes in Maize (Zea mays L.) Performance and Nutrients Content with the Application of Poultry Manure, Municipal Solid Waste and Ash Composts. *Journal of Agricultural Science*, *5*(3), 270.

[23] Kader, M. A., & Lindberg, S. (2010). Cytosolic calcium and pH signaling in plants under salinity stress. *Plant signaling & behavior*, *5*(3), 233-238.

[24] Kimatu, J. N. (2015). Correlating aluminium toxicity, heterosis and epigenetic mechanisms in maize yield improvement in acid soils. *Biotechnology and Molecular Biology Reviews*, *10*(2), 12-18.

[25] Kirkham, M. B. (2006). Cadmium in plants on polluted soils: effects of soil factors, hyperaccumulation, and amendments. *Geoderma*, *137*(1), 19-32.

[26] Kisinyo, P., Gudu, S., Othieno, C., Okalebo, J., Ochuodho, J., Agalo, J., Ng'etich, W., Opala, P., Maghanga, J., Osiyo, R. and Ligeyo, D. (2009). Residual effects of lime and phosphorus applications on soil and maize (Zea mays L.) performance in a Kenyan highlands acid soil. *Journal of Agriculture, Pure and Applied Science and Technology*, 2073-8749.

[27] Kukier, U., Peters, C. A., Chaney, R. L., Angle, J. S., &Roseberg, R. J. (2004). The effect of pH on metal accumulation in two species. *Journal of Environmental Quality*, *33*(6), 2090-2102.

[28] Laekemariam, F., &Gidago, G. (2012). Response of Maize (Zea mays L.) to integrated fertilizer application in Wolaita, South Ethiopia. *Advances in Life Science and Technology*, *5*, 21-30.

[29] Li, X., Ziadi, N., Bélanger, G., Cai, Z., & Xu, H. (2011). Cadmium accumulation in wheat grain as affected by mineral N fertilizer and soil characteristics. *Canadian Journal of Soil Science*, *91*(4), 521-531.

[30] Madani, B., Mohamed, M. T. M., Awang, Y., Kadir, J., & Patil, V. D. (2013). Effects of calcium treatment applied around the root zone on nutrient concentrations and morphological traits of papaya seedlings (Carica papaya L. cv. Eksotika II). *Australian Journal of Crop Science*, *7*(5), 568.

[31] Makinde, E.A. (2007). Effects of an organol-mineral fertilizer application on the growth and yield of maize. *Journal of Applied Science Research*, 3, 1152-1155.

[32] Musharo, C. (2005). Tolerance of Selected Maize (Zea Mays L.) and Soyabean (*Glycine Max* L. *Merr*.) Cultivars to Soil Acidity (Doctoral dissertation, University of Zimbabwe).

[33] Ozgen, S., Busse, J. S., & Palta, J. P. (2011). Influence of root zone calcium on shoot tip necrosis and apical dominance of potato shoot: simulation of this disorder by ethylene glycol tetra acetic acid and prevention by strontium. *HortScience*, *46*(10), 1358-1362.

[34] Payne, R.W., Murray, D.A., Harding, S.A., Baird, D.B. &Soutar, D.M., (2012). Introduction to GenStat® for Windows™ (15th Edn), VSN International, Hemel Hempstead, Hertfordshire, UK. © 2012 VSN International.

[35] Perfus-Barbeoch, L., Leonhardt, N., Vavasseur, A., & Forestier, C. (2002). Heavy metal toxicity: cadmium permeates through calcium channels and disturbs the plant water status. *The Plant Journal*, *32*(4), 539-548.

[36] Prasad, M. N. V., Greger, M., &Landberg, T. (2001). Acacia nilotica L. bark removes toxic elements from solution: corroboration from toxicity bioassay using Salix viminalis L. in hydroponic system. *International Journal of Phytoremediation*, *3*(3), 289-300.

[37] Qiu, H., Huang, J., Yang, J., Rozelle, S., Zhang, Y., Zhang, Y., & Zhang, Y. (2010). Bioethanol development in China and the potential impacts on its agricultural economy. *Applied Energy*, 87(1), 76-83.

[38] Rastijia, D., Semialjac, Z., Rastija, M., &Gulisija, A. (2012). Residual effect of liming on soil properties and maize grain yield. In *Third International Scientific Symposium* (pp. 87-91).

[39] Sadullah N. Al. (1999). Fertilizers and soil fertility. Ministry of Higher Education and Scientific Research. University of Al-Mosul. Book.

[40] Sandalio, L. M., Dalurzo, H. C., Gomez, M., Romero-Puertas, M. C., & Del Rio, L. A. (2001). Cadmium-induced changes in the growth and oxidative metabolism of pea plants. *Journal of experimental botany*, *52*(364), 2115-2126.

[41] Shaheen, S. M., Tsadilas, C. D., &Rinklebe, J. (2013). A review of the distribution coefficients of trace elements in soils: Influence of sorption system, element characteristics, and soil colloidal properties. *Advances in colloid and interface science*, *201*, 43-56.

[42] Shi, Y. (2014). Corn Plant Location, Spacing and Stalk Diameter Measurement Using Optical Sensing Technologies.

[43] Shrivastava, P., & Kumar, R. (2015). Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. *Saudi Journal of Biological Sciences*, 22(2), 123–131.

[44] Teng, Y., Feng, D., Wu, J., Zuo, R., Song, L., & Wang, J. (2015). Distribution, bioavailability, and potential ecological risk of Cu, Pb, and Zn in soil in a potential groundwater source area. *Environmental monitoring and assessment*, *187*(5), 1-14.

[45] Tran, T. A., & Popova, L. P. (2013). Functions and toxicity of cadmium in plants: recent advances and future prospects. *Turkish Journal of Botany*,*37*(1), 1-13.

[46] Unagwu, B.O., Asadu, C.L.A. &Ezeaku, P. I. (2013). Residual Effects of Organic and NPK Fertilizers on Maize Performance at Different Soil pH Levels. *IOSR Journal of Agriculture and Veterinary Science,* 5 (5): 47-53.

[47] Watson, D. (1952). The physiological basis of variation in yield. *Adv. Agron*,*4*(1), 101-145.

[48] Wessels, C. F. (2014). Response of a sandy soil and maize plants to zinc fertilizers.Department of Soil, Crop and Climate Sciences. Faculty of Natural and Agricultural Sciences. University of the Free State. Bloemfontein

[49] Weyman-Kaczmarkowa, W., &Pędziwilk, Z. (2000). The development of fungi as affected by pH and type of soil, in relation to the occurrence of bacteria and soil fungistatic activity. *Microbiological research*, *155*(2), 107-112.

Citation: *Rabah S. Shareef, et.al., (2019).” The Effect of Soil PH, High-Calcium Compost and Cadmium on Some of Growth Characters in Corn (Zea maysl.).” ARC Journal of Pharmaceutical Sciences (AJPS), 5(4), pp.16-27. DOI: http://dx.doi.org/10.20431/2455-1538.0504003*