HEAVY METALS (COPPER AND CADMIUM) EFFECT OVER THE PLANT GROWTH AND DEVELOPMENT AT CABBAGE PLANTS (*BRASSICA OLERACEA* L.) VARIETY SILVIANA

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Abstract

The impact of heavy metals on the growth and development of cabbage plants (Brassica oleracea L.) variety Silviana, patented by Vegetable Research and Development Station Bacău, was studied in this paper. The experiment was focused on soil contaminated with different concentrations of Copper (20, 100, 250, 500 mg/kg soil) and Cadmium (1, 3, 5, 10 mg/kg soil) and after approximately six weeks the dynamics of plant growth and development was measured. The main parameters that were investigated were: length of a plant (cm), length of the plant root (cm), number of leaves per plant and fresh and dry weight of a plant (g). The results obtained demonstrated that the variety of cabbage plants Silviana had different responses highly related to the concentrations of the studied heavy metals. The maximum value of plant and root length was registered on V_7 treated with 3 mg Cd / kg soil (46,86 cm respectively 15,86 cm). The average number of leaves per plant is higher on variants treated with Cd and in control compared to plants grown on the soil treated with Cu. The average weight of plants it's higher also in V7 treated with 3 mg Cd / kg soil compared with control while the lower weight of plants was registered in V2 variant - soil treated with 100 mg Cu / kg soil (1,023 g).

Keywords: *Pepper plants, Capsicum annuum L., dynamic of plant growth, heavy metals, Copper and Cadmium*

1. INTRODUCTION

Is important to humans to know the toxicity of heavy metals to crop plants because the toxicity varies from metal to metal (Cooper et al., 2020) and from crop to crop (Sandeep et al., 2019). White cabbage is grown for heads that are used in fresh or pickled food in the form of salads and in the preparation of dishes (Ciofu et al., 2003). White cabbage - *Brassica oleracea* var. capitata forma alba - is the most widespread variety in culture, being found in all countries of the European and North American continents, as well as in countries with temperate, subtropical or even tropical climate (Ciofu et al., 2003, Stan et al., 2003). In Romania, the culture of white cabbage is widespread in all areas except the high mountain regions (Cristea, 2008). The very favorable regions are represented by the river meadows in the hilly area of Transylvania, Moldova, but also in the plain area in the south and west of the country (especially for extra-early crops in solariums and early in the field) (Ciofu et al., 2003).

Heavy metal studies have shown that cabbage can accumulate heavy metals, and this may be due to the application of foliar fertilizers with high Cu and / or Cd content (Stoleru et al., 2011, Iosob et al., 2019).

Copper-based nanoparticles are used today as gas sensors in catalysts, electronics, semiconductors and agriculture. They are used in the form of pesticides, herbicides and fertilizers due to their antifungal and antibacterial properties (Rawat, 2018). Excess Copper (Cu) in plant tissue is still not well known in the literature (Schmitt et al., 2020). But we know that may cause toxicity and pose a risk to human health (Ozores-Hampton et al., 2005).

Among the most dangerous environmental pollutants is Cadmium (Cd) (Zhu et al., 2019). Is a heavy non-essential metal, odorless, toxic, which is perceived as a severe pollutant of the harmful environment, even at low concentrations (Bali et al., 2019). It causes serious damage to plants, including growth

retardation, leaf chlorosis, inhibition of photosynthesis (Zhu et al., 2019). Like any non-essential metal it is missing from the human body to, but accumulates with age. Chronic exposure causes lung disease, decreases olfactory function and increases bone demineralization, and can lead to osteoporosis. Once in or on food, it causes kidney and liver damage, causes digestive damage with erosion in the gastrointestinal tract. Acute Cd ingestion can lead to coma (Khanam et al., 2020, Tchounwou et al., 2012).

In this paper a simple chemical approach was adopted to observe the effect of heavy metals (copper and cadmium) from soil on growth and development of cabbage seedlings (*Brassica oleracea* L.) variety Silviana.

2. MATERIAL AND METHODS

The experiment was conducted in the laboratory of Biotechnologies-In Vitro Cultures from Vegetable Research and Development Station Bacau.

Five cabbage seeds were placed in peat pots and the peat substrate was contaminated with different concentrations of Cu and Cd: V_1 = 20 mg Cu, V_2 = 100 mg Cu, V_3 = 250 mg Cu, V_4 = 500 mg Cu, V_5 = Control - distilled water, V_6 = 1 mg Cd, V_7 = 3 mg Cd, V_8 = 5 mg Cd, V_9 = 10 mg Cd and V_{10} = 500 mg Cu + 10 mg Cd. The values of the solutions of Cd and Cu were correlated with the values established in Order no. 756/3 November 1997 with regard to traces of chemical elements in the soil, reported as mg per kg soil. The experiment was completed in accordance with OECD Protocol 208 (Guidelines for the Testing of Chemicals). For the experiment standard solutions of Cu and Cd (1 mg/mL in 5% HNO3) were used. The pots were placed in optimal conditions for germination in the Sanyo growing chamber. Watering with test solutions was done daily at ground level and after emergence the plants were watered every two days and only if necessary watering was done more often. After germination and emergence of cabbage, observations were made on visual phytotoxicity and plant mortality. It was found that the cabbage plants were dried and died in a proportion of 100% on the variant treated with 500 mg Cu (V_4) but also on the variant treated with 500 mg Cu + 10 mg Cd (V_{10}). Plants on the 250 mg Cu (V_3) treated variant had a slow growth and necrosis points appeared and died approximately 25 days after the emergence.

To measure the length of the plant and the roots the ruler and graph paper (figure 1) was used. Three plants were measured for each variant. For each plant measured the leaves were also counted.



Fig. 1. Measuring the cabbage plants (*Brassica oleracea* L. var Silviana)

To determine fresh weight (FW), dry weight (DW) and the dry matter in the plants, the thermobalance KEREN MLB 50-3 (figure 2) was used. The plant was cut into small pieces and evenly distributed in the aluminum tray. Each sample was prepared separately. The thermobalance offers 7 different mode types and Mode 2 "Dry matter as a percentage (%) as against output value" was used and calculated according to the formula:

$$W(\%) = \frac{\text{residual weight}}{\text{start} - \text{up weight}}\ x\ 100\% \quad (1)$$

If the weighing result of 3 time intervals in succession remains unchanged, drying will be terminated.

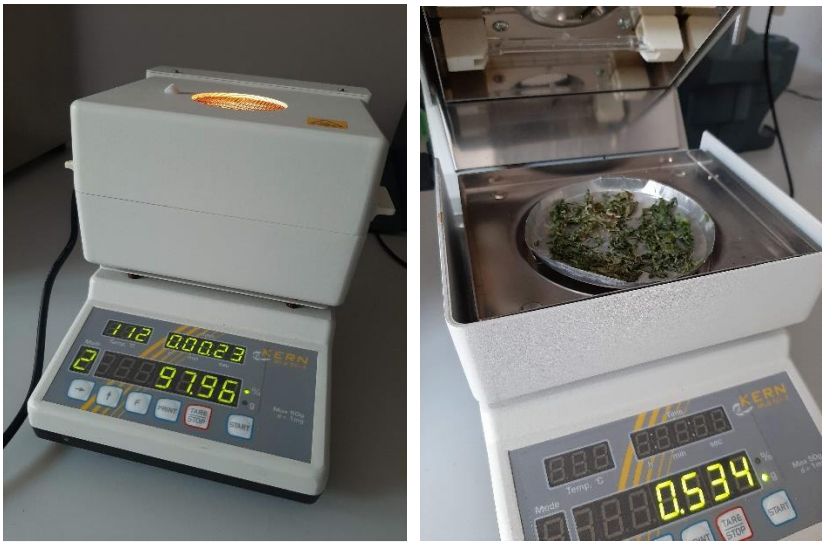


Fig. 2. The thermobalance KEREN MLB 50-3 used to determine FW, DW and the dry matter (%) from the cabbage seedling plants

3. RESULTS AND DISCUSSIONS

The tests performed on seedling aimed at quantifying the degree of acute toxicity to cabbage in the seedling stage, the parameters on the basis of which to make predictions about the impact of heavy metal ecotoxicity (Cu and Cd). The plants on the variant treated with 100 mg Cu (V_2) had a slow growth compared to the plants on the variants treated with Cd and the control variant and on the leaves necrosis points appeared. However, the seedling developed and could be analyzed from the point of view of the quality indices followed in this paper.

It can be seen that the total length of the plant seems to be influenced by heavy metal treatments (figure 3). The highest average seedling length is recorded in V_7 treated with 3 mg Cd followed by the variant treated with 5 mg Cd (V_8). The lowest value of the seedling was recorded on the variant treated with 100 mg Cu (V_2). The control variant (V_5) recorded an average seedling size equal to V_6 (1 mg Cd). Following the observations made and the analysis, we can say that the concentrations of heavy metals studied influence the size of the cabbage seedling. In the case of the higher the concentration, the shorter the plant will be and it is observed. Regarding the length of the root, the cabbage seedlings have the largest root in V_7 and the smallest root was measured in the seedlings that developed on the soil substrate treated with 10 mg Cd (V_9). The control plants (V_5) had an average root length equal to V_6 (1 mg Cd). The seedlings treated with 20 mg Cu (V_1) is bigger than variant treated with 100mg Cu (V_2). A large standard error in the variants V_6, V_7, V_8, shows that there is a large variation in terms of root length for each plant.

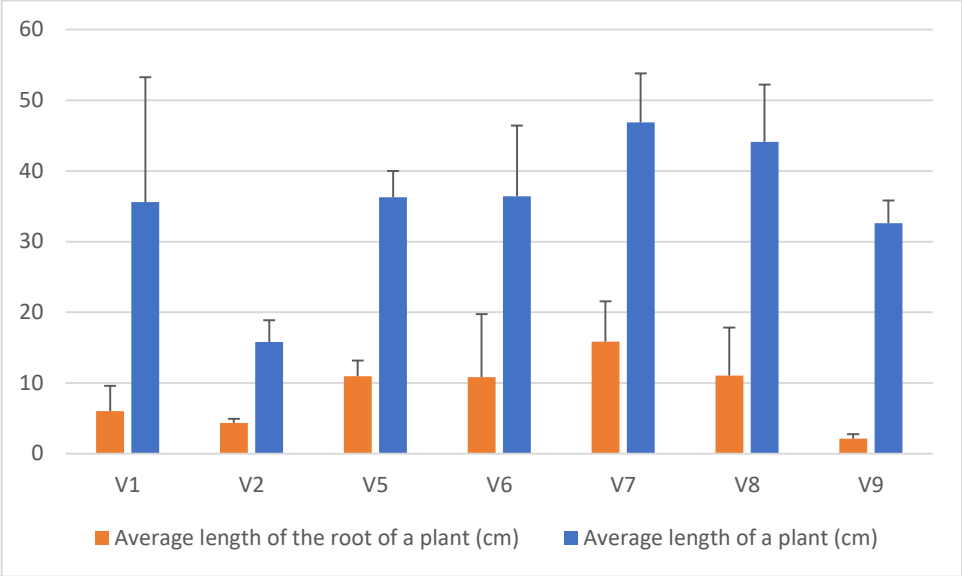


Fig. 3. The average length of cabbage plant seedlings (cm)

The calculation of the average number of leaves per plant was analyzed to see if there is a correlation between the concentration of heavy metal studied and the number of cabbage seedling leaves. From figure 4 we notice that the differences are not significant. The highest average of the leaves was registered for the variant treated with 3 mg Cd (V_7) and the lowest for the variant treated with 100 mg Cu (V_2). The control variant (V_5) obtained an average of 9 leaves per plant smaller than the V_7 but the difference is insignificant.

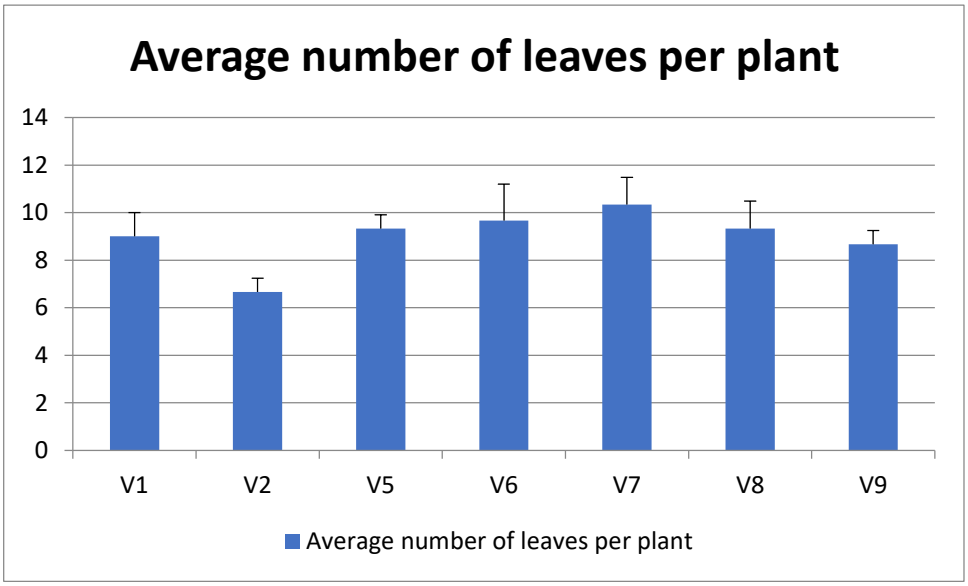


Fig. 4. The average number of leaves on cabbage seedlings

It can be seen from figure 5 that the lowest average seedling weight was recorded on the variant treated with 100 mg Cu (V_2). The highest wet weight was recorded in the 3 mg Cd (V_7) variant followed by the 5 mg Cd (V_8) treated variant. The control variant (V_5) has a wet weight equal to V_9. For the average dry weight of the analyzed plants we cant see that the V_5 has a dry weight less than the variants treated with

Cd (V_6, V_7, V_8, V_9) but the highest dry weight is registered on V_8. The lowest average final weight is recorded in the variant treated with 100 mg Cu (V_2).

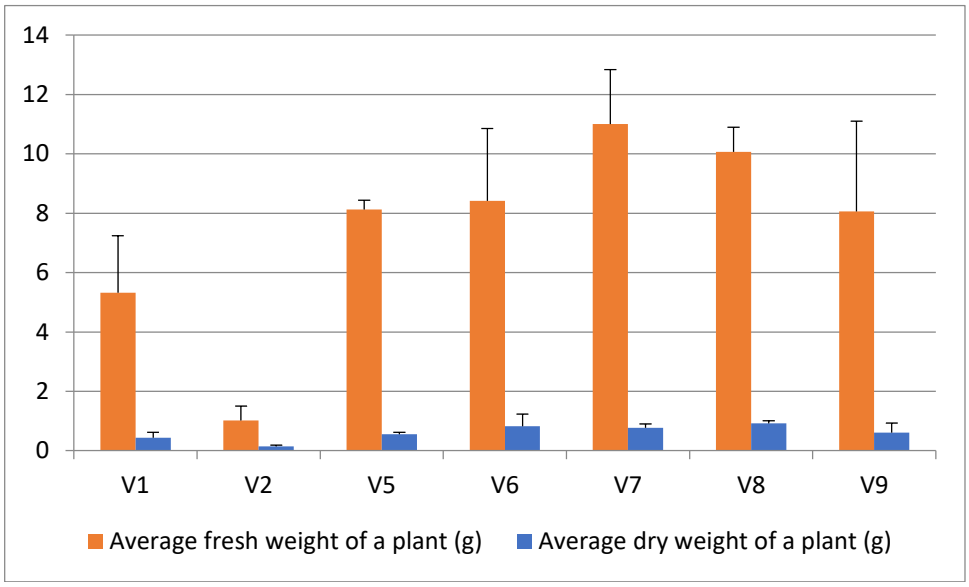


Fig. 5. The average of fresh and dry weight of cabbage seedling plant (g)

The dry matter content of the cabbage seedling is shown in figure 6, it is observed that the plants developed on the variant treated with 100 mg Cu (V_2) have the highest value of dry matter followed by the variant treated with 20 mg Cu (V_1). The control variant (V_5) has a dry matter percentage of 6.98%.

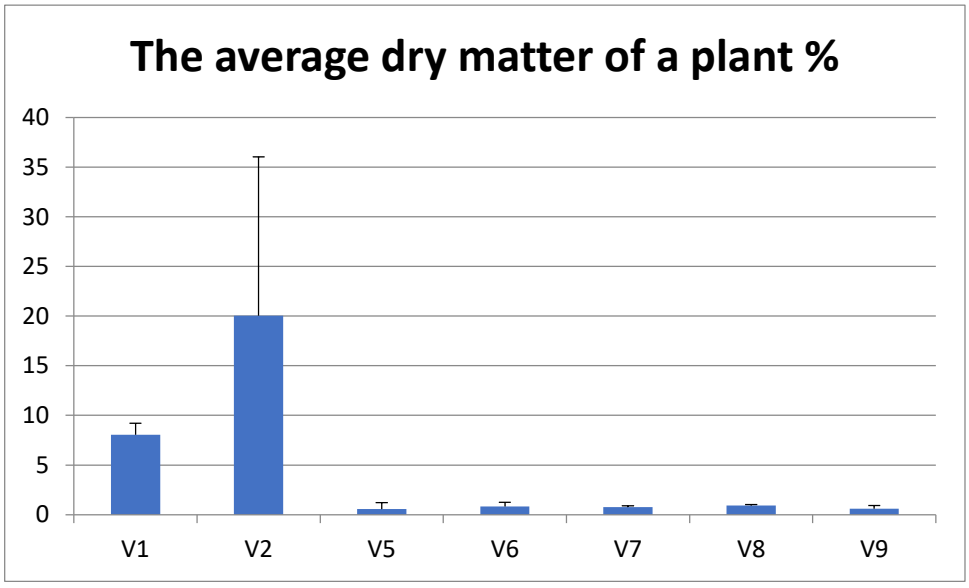


Fig. 6. The average dry matter of cabbage seedling plant (%)

4. CONCLUSIONS

This study shows the effects of two heavy metals (Cu and Cd) on the dynamics of seedlings plant growth and development of cabbage (*Brassica oleracea* L) var. Silviana responded differently to different concentrations of the studied heavy metals. It was observed that that the total length of the plant seems to be influenced by heavy metal treatments. The highest average seedling length is recorded in V_7 treated with 3 mg Cd and the lowest value of the seedling was recorded on the variant treated with 100 mg Cu (V_2). The number of cabbage seedling leaves is not significant. The lowest average seedling weight was recorded on the variant treated with 100 mg Cu (V2) and the highest wet weight was recorded in the 3 mg Cd (V7). And the dry matter content of the cabbage seedling is higher in plants grown on soil contaminated with Cu solution.

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