Effect of different rates of Cd on growth and chemical composition of spinach

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ABSTRACT: Heavy metals are one of the most important environmental pollutants and their accumulation in agricultural products and food can be dangerous for human health. Vegetables are one of the most important components of our food diet which contain essential elements and may be contaminated with heavy metals. In order to study the effects of different levels of soil available Cd on growth and chemical composition of spinach, a factorial experiment with completely randomized design and three replications was conducted in greenhouse of Zanjan Agricultural Research Center in 2009. In this experiment factorial combinations of five levels of Cd (0, 10, 20, 40 and 80 mg/kg soil) were used as 25 treatments using cadmium sulfate to artificially contaminate soil samples. Three months after sowing spinach seeds, plants from different treatments were harvested and their biomass and chemical composition were determined. The results of the experiment showed that Increase in available form of soil cadmium up to 20 mg/kg increased the dry weight of aerial parts in spinach but higher concentrations of this element decreased the spinach biomass significantly. With increase in available form of soil Cd up to 40 mg/kg the Cd content of leaf increased but at higher concentrations of soil Cd the concentration of Cd in leaf decreased significantly. With increase in concentration of soil Cd the leaf concentrations of Cu, Zn, Mn and P decreased but that of Fe increased significantly.

Keywords: Spinach; Cadmium; Soil pollution

INTRODUCTION

Trace elements referred to as heavy metals, include arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium and zinc. Many of these elements are actually needed by plants for normal growth (Darlington, 2001).

Heavy metals have been increasingly found in soils due to atmosphere deposition, sludge, sewage irrigation, utilization of metal-containing farmyard manures and fertilizers, and industry and mine residues, resulting in a potential risk for human health when these heavy metals are transferred from crops to the human diet. They play an important role in the environment not as a result of human activity but also as toxic species above certain concentrations (Ngayila et al., 2008; 2009).

At high concentrations, a number of heavy metals have been reported to inhibit the growth and decrease the productivity of crops (Liu et al., 2003). Among them, cadmium (Cd) is well known as a highly toxic environmental element due to its great toxicity and high mobility from soil to plants and further down the food chain (Vig et al., 2003). It can be incorporated and accumulated by all organisms in large amounts and disturb physiological metabolisms in plants like transpiration, photosynthesis, respiration, and nitrogen assimilation (Chugh et al., 1999; Zhou et al., 2006; Wang et al., 2008). Additionally, Cd is a divalent heavy metal cation (Cd²⁺) which is readily taken up and causes phytotoxicity. Cd excess in the environment decreases chlorophyll content and growth (Zhou and Qiu, 2005), affects chloroplast function or CO₂ fixation (Krupa and Baszynski, 1995; Seidlecka et al., 1997).

Cadmium contamination in soils has been reported to be the main constraint for food safety and agricultural land quality (Atafar et al., 2010).

Vegetables are one of the most important components of food diet which contain essential elements and maybe contaminated with heavy metals. Thus, contaminated vegetables by heavy metals can be threat for human health...
The aims of this research is to evaluate the effects of soil cadmium on nutrient uptake and biomass of spinach.

**MATERIAL AND METHODS**

The effects of different levels of soil available cadmium on some nutrient uptake foliar growth and accumulation of elements in spinach an factorial experiment were carried out in completely randomized design with 25 treatments in 3 replication in zanjan greenhouse some physical and chemical properties of it were determined like Trace element and phosphourous (Table 1).

Cadmium were used at 5 levels (0,10,20,40,80) mg Cd/kg soil.for this purpose Cd were mixed with the uncontaminated soil surface (0-20 cm) from Cd source.firstly cadmium was dissolved in water and mixed throught with soil in a 3 kg contains. After that 3 spinach seed were cultivated in each contains. During the spinach growth all of the contains were irrigated with distilled water and 3 month after seedling, leaves and stems of spinach were sampled for measuring of some leaves elements and dry weight of foliar part of plant.

**RESULTS AND DISCUSSION**

**Dry matter of aerial part of spinach**

The result showed that (table 2), soil available cadmium had significant effect on aerial dry matter of spinach. With increasing the Cd concentration up to 20 mg/kg soil, the dry weight increased too. But in higher cadmium concentrations (40-80 mg/kg soil) the bio mass of decreased (fig,1). Talatam et al (2009) showed that with increasing Cd concentration wet and dry weight of foliar part of spinach decreased because of negative effect of Cd on energy production mechanism in mitochondry and chloroplast.

Deheri et al (2007), and Mensah, et al (2008), had attained similar results in spinach and lettuce respectively.

**Cd concentration of aerial part of spinach**

Soil available Cd concentration had significant effects on Cd concentration in spinach plant (table 2). With increasing the Cd concentration up to 40 mg Cd/kg soil, Cd concentration in plant increased but at higher concentration (80 mgCd/kg soil) its concentration decreased (fig,2). Yildiz (2005) stated that with increasing soil Cd concentration in tomato bed, its concentration in foliar part of plant increased too. and also sauerbeak et al ( 1991) reported similar results in carrot and celery.

**Cu concentration of aerial part of spinach**

Soil available Cd concentration had significant effects on Cu concentration in spinach plant (table 2). With increasing the Cd concentration in soil, Cu concentration in plant decreased (fig,3). Liu et al (1994) reported that there is an antagonistic competition between ionic transportation of Cu and Cd in plant . Aydin et al (2001) reported similar results in radish.

**The phosphorous concentration of aerial part of spinach**

Soil available Cd concentration had significant effect on P concentration in spinach leaves (table 2). With increasing the Cd concentration in soil, the P concentration in plant declined (fig,4). phosphorous absorption in plant is active and Cd have a negative effects on ATP synthesis, therefore it causes low absorption of phosphorous by plant. (Akay et al., 2007)

**Fe concentration of aerial part of spinach**

Soil available Cd concentration had significant effect on Fe concentration foliar in spinach leaves (table 2). With increasing the Cd concentration in soil, the Fe concentration in spinach leaves increased.(fig,5). Increasing Fe concentration in leaves maybe due to dilution effect because Cd had a negative effects of spinach dry matter. Cadmium have an antagonistic effects on zinc absorption ,on the other hand Fe and Zn have similar effects, therefore by decreasing Zn absorption, iron concentration in plant increases too.
Zn concentration of aerial part of spinach

Soil available Cd concentration had significant negative effect on Zn concentration in spinach leaves (table 2). With increasing the Cd concentration in soil, the Zn concentration in spinach leaves decreased. (Yildiz, 2005) and (Root et al., 1975), showed that Cd have negative effect on Zn concentration in tomato plant because of antagonistic effects of Cd on Zn absorption. Zinc deficiency is lead to iron (Fe) deficiency, due to prevent of transfer of Fe from root to shoot in zinc deficiency conditions (Rengel and Romheld, 2000; and Rengel et al., 1998). It is generally accepted that Zn status in soils and plants plays an important role in Cd accumulation in crop plants (Sarwar et al., 2010).

Mn concentration of aerial part of spinach

Soil available Cd concentration had significant effect on Mn concentration in spinach leaves (table 2). With increasing the Cd concentration in soil, the Mn concentration in spinach leaves decreased (fig,7). In a research Safarzadeh (2013) showed that Cd treatment resulted in a decrease in Mn concentration in shoot and root in seven rice cultivars. Zarko et al (2003) have attained similar result in pea.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Dry matter</th>
<th>Cd</th>
<th>Cu</th>
<th>P</th>
<th>Fe</th>
<th>Zn</th>
<th>Mn</th>
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<td>9.42</td>
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<td>9.23</td>
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</tbody>
</table>

** Significant at α= 1%
REFERENCES


