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ORIGINAL ARTICLE

Accumulation of heavy metals in crop plants from Gaza Strip, Palestine and study of the physiological parameters of spinach plants

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Abstract Measurements of Pb, Zn, Cd and Fe concentrations in the soils and accumulation in edible parts of several crop plants (spinach, wheat, strawberry, carrot, onion, squash, cabbage, potato, faba bean and cucumber) grown in three sites of the northern area of Gaza Strip, Palestine, revealed: (1) Concentrations of metals were in normal range in soil, except for lead concentrations which in some samples were higher, especially in the sites of Al-Monttar and Gaza city center. (2) Accumulation of heavy metals by the crop plants was within normal ranges, except for lead concentration which exceeded normal ranges, yet not reaching toxic levels in all plants but the onion bulb which reached toxic level. (3) Cadmium was concentrated at equal levels in different soil samples, while its accumulation in plant samples was very low and sometimes was not detectable. Measurements of physiological attributes of spinach plants revealed: (1) Growth characters such as root length, shoot height, fresh and dry weights of shoot and root were decreased with increasing Cd soil addition either alone or combined with Zn soil addition at all levels. (2) Plant pigments such as chlorophyll a, chlorophyll b and total carotenoids significantly decreased, with increasing Cd soil addition either alone or combined with Zn at all levels, except for chlorophyll a which increased with increasing Zn soil addition, with some exceptions. (3) Zn addition was highly correlated to growth characters, as well as when combined with Cd at different levels may be overcome the toxicity of Cd on growth characters, mineral concentrations and chlorophyll a content.

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1. Introduction

The Gaza strip–Palestine area is about 360 km^2. It is situated in the south part of Palestine and southeast of the Mediterranean sea. An estimate of 1.6 million people live in the Gaza Strip. This area, being one of the most densely populated areas in the world with limited and deteriorated resources, has already started to suffer the consequences of environment quality deterioration. The situation at the Gaza Strip is below the desired standard, which is attributed to the absence of environmental legislation and public awareness. One of the most

important air pollutants near the city center of Gaza is thousands of motor vehicles commuting every day. Trace metals released in the environment may be considered a hazard to the natural biological system and human health. Plant and soil surfaces are the major sink for airborne metal. Moreover, plants form the basis of food chains by which bio-toxic trace metals are transmitted to man (Alfani et al., 1996).

Improvement of the nutritional quality of our food supply, especially with respect to essential nutrient minerals, could be an important goal of vegetable crops. Cd is classified as probable human carcinogen by inhalation; however, only limited data are available to determine if it causes cancer in humans. The total Zn content in adult human tissue is 2–4 g. The daily requirement of 6–22 mg is provided by a normal diet. Salim et al. (1992) treated the carrot plants by Cd and Pb foliar or root application of 0, 10 and 90 ppm Cd and 0, 18 and 80 Pb. Cd toxicity was more obvious than Pb toxicity and these symptoms were more severe in foliar treated than in root treated plants. Cd application decreased the dry weight of whole plants, shoot and roots, when compared with untreated control plants. William et al. (1977) reported that Cd in soils may be unavailable to plants by the application of hydrated lime and consequently involves the infection of toxicity. Liming is effective because cadmium probably forms an insoluble precipitate with hydroxide and thus becomes unavailable to plants. Somashekaraish et al. (1992) suggested that the inhibition of chlorophyll synthesis by Cd is achieved both by reaction with constituent biosynthetic enzymes as well as peroxide mediated degradation.

Zinc plays essential metabolic roles in the plant, the most significant of which is its activity as a component of a variety of enzymes, such as dehydrogenases, proteinases, peptidases and phosphohydroleases. Other functions related to the metabolism of carbohydrates, proteins, phosphates, RNA and ribosome formation. Baccio et al. (2005) have pointed out that transition metals such as Zinc are essential micronutrients for many physiological processes, but they become toxic at elevated levels, Zinc is one of the most abundant trace heavy metals present in agro-ecosystems. Misra et al. (1994) have mentioned that when *Vicia faba* seeds are treated with 0–10 mg l^{-1} solution of Zn chloride, Zn treatment increases its radical length at low concentrations, but are inhibitory at high concentrations.

The aim of this research was to study the elemental (Pb, Zn, Cd and Fe) concentration on different soils in three sites of the northern area of Gaza Strip, Palestine. The ability of some crop plants (spinach, wheat, strawberry, carrot, onion, squash, cabbage, potato, faba bean and cucumber) grown in the above soils to accumulate different metals was studied. Effects of different levels of Zn and Cd soil addition on the morphological parameters (root length, shoot height, fresh and dry weights of shoot and root, plant pigments such as chlorophyll a, chlorophyll b and total carotenoids) of spinach plants were also examined.

2. Materials and methods

Plant and soil samples were collected in 2006 from the Northern area (120 km^2) of the Gaza Strip, Palestine. The study area has several anthropogenic influences which could be divided into three different sites, (industrial, urban and rural site (Fig. 1), all lying between Israeli borders and the Mediterranean sea. Four samples were collected from each site of the study area, (A, B and C, Fig. 1). Samples of spinach, wheat, strawberry and carrot were collected from Beit-Hanon and Beit-Lahya, industrial and rural site (A). Onion, squash, spinach and cabbage were collected from Al-Monttar and Gaza City Center, industrial and urban site (B). Potato, carrot, faba bean and cucumber were collected from Al-Zytoon and Shakh Ejleen, rural and urban site (C).

All plant samples were taken at the flowering stage, were washed in water, dipped in distilled water and divided into their parts. They were then oven-dried at 70 °C for two days. Soil samples were also oven-dried at 40 °C for two days. Available Fe, Pb, Zn and Cd were extracted by DTPA according to Lindsay and Norvell (1978) and estimated by Atomic Absorption Spectrophotometer GBC 939.

Plastic pots of 80 cm length, 20 cm width and 25 cm depth were used at the pot experiments which carried out in the open field of the Agriculture Research Center (Ministry of Agriculture), Beit-Lahya City, during two successive seasons (2006 and 2007). Each pot was filled with 25 kg soil obtained from the Agriculture Research Center. Spinach seeds (*Spinacea oleracea* var. balady) were used, sown on the 17th of February in the first season (2006) and in the 18th of January in the second season (2007). Each pot received 22 g of ammonium sulfate, 18 g of potassium sulfate and 15 g of calcium superphosphate. The fertilizers were applied to the plants as soil dressing at three doses/season, the first dose was 15 days after seedling emergence and the second and the third dose were applied 15 days in time intervals.

In the second season, before seed sowing, four levels of Cd (0, 10, 20 and 40 mg kg^{-1}) were added to the soil, in contrast to the first season, where three levels of Cd (10, 20 and 40 mg kg^{-1}) were added in the form of cadmium sulphate salt. The pots were divided into four groups in the second season and into three groups in the first season. The first group received the normal level of fertilizers as mentioned above, but

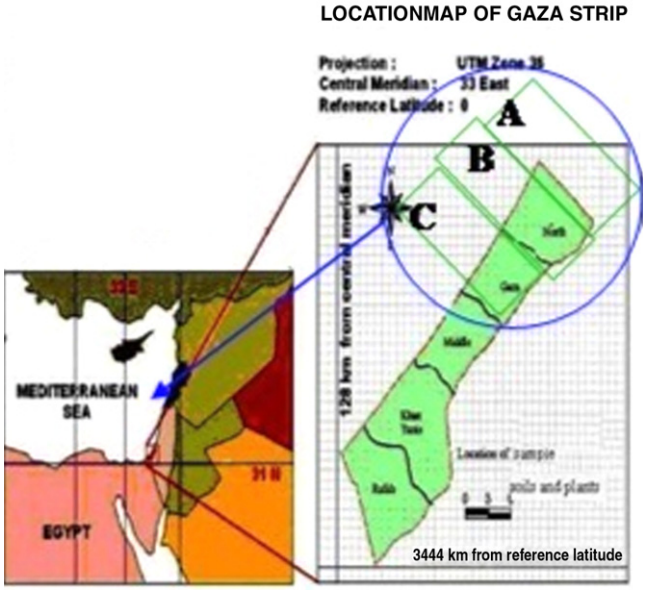

Figure 1 The three sampling sites at the northern area of the Gaza Strip, Palestine.