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# EFFECTS OF Pb LEVELS ON GROWTH AND MINERAL CONTENTS OF DIFFERENT CORN CULTIVARS GROWN IN NUTRIENT CULTURE

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**Abstract**

The aim of this study was to determine plant dry matter and contents of N, P, K, Ca, Mg, Fe, Zn, Mn and Pb of corn cultivars (Akpinar, TTM813, Karadeniz yildizi) grown in nutrient culture until flowering in relation to increasing Pb levels (0, 0.5, 1, 2, 5 and 20 ppm Pb/pot). In this study one-week-old maize seedlings grown in Arnon's nutrient culture were transferred to the nutrient solution with or without Pb. Significant variations in accumulation and non-tolerance to Pb in corn cultivars were observed. In all the cultivars of maize dry matter content decreased and accumulation of N, P, K, Ca, Mg, Fe, Zn and Mn were inhibited.

## Introduction

In recent years there are a vast number of reports on the presence of heavy metals *viz.*, cadmium, chromium, lead and mercury in higher plants. Most of these reports are concerned mainly with environmental pollution, the presence of heavy metals in the food chain and genotypical differences in the critical toxicity levels of heavy metals in plants. (Ernst and Josse-Van Damme 1983 and Marschner 1986).

High concentrations of some heavy metals in soils originating either from natural sources or pollution, can adversely affect crops, animals and humans. Although plant availability is also associated with assessing metal pollution of soils, accurate quantification of metals in soils for evaluation of degree of contamination and potential for movement of leachates is desirable. A variety of extraction procedures are available and the choice of procedure of use will depend on interest and objective for quantifying the metal loading in the soil (Yildiz 2001).

Lead (Pb) is a heavy metal which is believed to be toxic when present in excessive amount. Excess of Pb in most plants alters several physiological and biochemical processes. For example, seed germination of wheat and *Lens* species grown on soaked filter paper with at 20 mM $Pb(NO_3)_2$ was highly (60%) inhibited (Mesmar and Jaber 1991).

Using the root test, the relationship between the amount of lead in tissues and the level of the root growth inhibition was examined for 12 food plant species. 345 - 8152 mg Pb/Kg dry wt. inhibited root growth by 5 to 36% as compared to the control (Wicrzbicka and Antosiewiez 1993).

Contaminated soils can be a source for crop plants of such elements like As, Cd, Cr, Cu, Ni, Pb and Zn. The excessive transfer of As, Pb, Hg, Ni, Se and Zn to the food chain is regulated if soil plant barrier fail. About half of human Pb intake is through food, of which more than half originates from plants. Dietary intake of Cd and Pb may be increased by application of sludges on crop land with already high levels of these metals. Soils amended with sludges in USA is permitted to accumulate Cr, Cd, Cu, Pb, Hg, Ni, Sc and Zn levels from 10 - 100 times of the present baseline concentrations. These levels are very permissive by international standards. Because of the limited supply of toxicity data obtained from metals applied in sewage sludge predictions as to the new regulations will protect crop plants from metal toxicities but food chain from contamination are difficult to estimate (Dudka and Miller 1998).

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In rice varieties the root biomasses of the tolerant varieties were approximately tenfold higher than those of the sensitive ones (Yang *et al*. 2001). The greatest morphological difference between the two groups was in the growth of the adventitious roots, as tolerant lines were able to develop adventitious roots after six days of Pb treatment, whereas sensitive ones did not develop any even after 15 days. The growth of adventitious roots in the tolerant varieties is such that Pb was altered to a form that cannot be taken up by the tissue (Yang *et al.* 2001).

**Materials and Methods**

This study was conducted to test Pb toxicity on corn cultivars under the condition of laboratory and greenhouse. In this experiment, three corn cultivars (*Zea mays* L. cv. Akpinar, TTM 813, Karadeniz yildizi) were used. Arnon (1938) culture solution was used in growth medium. The corn seeds were germinated in soil and sand mixed (1 : 3) for two weeks. Seedlings were transferred to pots containing nutrient solution (3 litre/pot). After one week seedlings were transferred, $PbNO_3$ were added to standard nutrient cultures at the concentrations of 0, 0.5, 1.,0, 2.0, 5.0 and 20.0 μm/ml Pb.

This research has been carried out in glasshouse conditions for a period of two months. The test plants were harvested just before flowering. All nutrient solutions were aerated with a air compressor every day and the solution was changed once in two weeks. Before flowering the plants were harvested for evaluation of their mineral content and dry matter as per Kacar (1994).

**Results and Discussion**

In all the cultivars of maize dry matter content decreased (Tables 1, 2). N, P, K, Ca, Mg, Fe, Zn and Mn mostly decreased, but in some cases increased with the increase in Pb level from 0.5 to 20 μg/ml. The inhibition of dry matter in var. Akpiner was 15% (at 0 Pb) and that of Karadeniz yildizi was 33 % as compared to control. N, P, K, Ca, Mg, Fe, Zn and Mn content decreased from 11 - 18% in different cultivars as compared to control (Tables 2, 3).

**Table 1. Results of variance analyses in relation to increasing Pb (F values).**

| Variation source | | Dry matter | N | P | K |
|---|---|---|---|---|---|
| Corn cultivar | | 13.76** | 88.71** | 11.57** | 21.14** |
| Pb level | | 115.8*** | 197.6** | 27.25** | 108.3** |
| Pb level × corn cultivar | | 3.31*** | 50.69** | 17.03** | 8.12** |
| CA | Mg | Fe | Zn | Mn | Pb |
| 3.10* | 6.94** | 45.98** | 183.4** | 317.1** | 181.6** |
| 0.45 | 12.48** | 30.56** | 2.42 | 35.65** | 385.9** |
| 0.61 | 2.03 | 9.96** | 36.57** | 10.16** | 215.0** |

** = $p < 0.01$, *** = $p < 0.001$ level.

Pb tolerance indexes were calculated on the basis of follow model Tolerance indexes = Growth vs. increasing Pb level/growth vs. without add. Pb × 100. The results of the present study summarized in Table 3 showed that tolerance indexes of corn cultivars varied between 89 - 75 in Akpinarm 89 - 81 in TTM 813 and 97 - 67 in Karadeniz yildizi in response to increasing Pb levels. It showed that the corn cultivars are sensitive to lead toxicity. Karadeniz yildizi corn cultivar has had the lowest tolerance index at 20 μmg/ml Pb level application. TMM 813 corn

**Table 2. The effect of Pb levels on dry matter and N and P content of corn cultivars grown in nutrient culture.**

| Parameter | Pb level (µg/ml) | Akpinar | TTM 813 | K.yildizi |
|---|---|---|---|---|
| Dry. mat. | 0 | 1.94 | 1.67 | 1.40 |
| | 0.5 | 1.73 | 1.49 | 1.36 |
| | 1.0 | 1.65 | 1.42 | 1.27 |
| | 2.0 | 1.60 | 1.40 | 1.08 |
| | 5.0 | 1.57 | 1.40 | 1.08 |
| | 20.0 | 1.47 | 1.38 | 0.95 |
| N (g/kg) | 0 | 3.94 | 4.10 | 2.74 |
| | 0.5 | 2.70 | 3.13 | 2.78 |
| | 1.0 | 3.62 | 3.11 | 3.05 |
| | 2.0 | 3.92 | 2.55 | 3.33 |
| | 5.0 | 3.65 | 3.25 | 2.87 |
| | 20.0 | 3.25 | 2.59 | 2.24 |
| P (g/kg) | 0 | 0.57 | 0.50 | 0.51 |
| | 0.5 | 0.48 | 0.56 | 0.61 |
| | 1.0 | 0.60 | 0.49 | 0.55 |
| | 2.0 | 0.55 | 0.56 | 0.50 |
| | 5.0 | 0.59 | 0.42 | 0.54 |
| | 20.0 | 0.46 | 0.41 | 0.55 |
| K (g/kg) | 0 | 9.15 | 7.15 | 7/66 |
| | 0.5 | 8.11 | 6.90 | 7.62 |
| | 1.0 | 7.80 | 6.82 | 7.55 |
| | 2.0 | 7.50 | 6.85 | 6.94 |
| | 5.0 | 7.60 | 7.27 | 6.96 |
| | 20.0 | 7.75 | 6.96 | 6.86 |
| Ca (g/kg) | 0 | 3.33 | 2.96 | 2.89 |
| | 0.5 | 3.00 | 2.85 | 2.94 |
| | 1.0 | 2.48 | 2.80 | 2.75 |
| | 2.0 | 2.52 | 2.28 | 2.16 |
| | 5.0 | 1.92 | 2.51 | 2.28 |
| | 20.0 | 2.68 | 2.69 | 2.25 |
| Mg (g/kg) | 0 | 1.15 | 1.47 | 1.06 |
| | 0.5 | 1.37 | 1.39 | 1.22 |
| | 1.0 | 1.23 | 1.03 | 0.95 |
| | 2.0 | 1.18 | 1.32 | 0.86 |
| | 5.0 | 1.17 | 0.96 | 0.85 |
| | 20.0 | 1.13 | 0.99 | 0.80 |
| Fe (µg/ml) | 0 | 196 | 274 | 124 |
| | 0.5 | 205 | 209 | 131 |
| | 1.0 | 175 | 304 | 140 |
| | 2.0 | 180 | 194 | 186 |
| | 5.0 | 71 | 115 | 109 |
| | 20.0 | 70 | 65 | 100 |
| Zn (µg/ml) | 0 | 76 | 108 | 88 |
| | 0.5 | 87 | 81 | 82 |
| | 1.0 | 57 | 98 | 89 |
| | 2.0 | 64 | 62 | 56 |
| | 5.0 | 62 | 43 | 52 |
| | 20.0 | 53 | 22 | 52 |
| Mn (µg/ml) | 0 | 280 | 279 | 269 |
| | 0.5 | 280 | 313 | 268 |
| | 1.0 | 267 | 311 | 220 |
| | 2.0 | 207 | 212 | 193 |
| | 5.0 | 200 | 155 | 165 |
| | 20.0 | 136 | 95 | 75 |
| Pb (µg/l) | 0 | 5.35 | 10.2 | 11.42 |
| | 0.5 | 10.4 | 11.61 | 14.23 |
| | 1.0 | 16.04 | 12.55 | 15.30 |
| | 2.0 | 18.0 | 13.77 | 16.50 |
| | 5.0 | 19.6 | 21.73 | 26.83 |
| | 20.0 | 22.6 | 52.79 | 58.19 |

cultivar has had the highest index value at 20 µg/ml Pb level. Karadeniz yildizi corn cultivar has shown the earliest sensitivity to Pb at 0.5 µg/ml level. The sensitivity of Pb to maize may be due to decrease in oxalate following Pb treatment as was reported by Yang *et al.* (2001).

**Table 3. Tolerance indexes of corn cultivars.**

| Pb level (µg/ml) | Akpinar | TTM 813 | Karadeniz yildizi |
|---|---|---|---|
| 0.5 | 89 | 89 | 97 |
| 1.0 | 85 | 85 | 90 |
| 2.0 | 82 | 83 | 77 |
| 5.0 | 80 | 83 | 77 |
| 20.0 | 75 | 81 | 67 |

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