Effects of Transpiration, Carbon Dioxide and Ozone on the Content of Cadmium and Zinc in Spring Wheat Grain

H PLEIJEL, H DANIELSSON, J GELANG & G SELLDÉN

INTRODUCTION

The heavy metal cadmium (Cd) is considered an important health risk, which may cause kidney dysfunction and affect the mineral metabolism of the skeleton (Elinder & Järup, 1996). Cereal flour is one of the main sources of this element for human intake. The content of Cd in wheat grain has been shown to vary with a number of factors. Important and well studied factors are the soil content of Cd and the pH of the soil (Eriksson, 1990). Both factors depend partly on the use of artificial fertilizers and other nutrient sources. Certain types of artificial phosphorus fertilizers constitute an important input of Cd to arable soils, which has contributed to a general increase in the cadmium content of wheat grain in some areas (Andersson & Bingefors, 1985). In addition, contamination of soils with Cd and other potentially toxic metals may occur for a number of reasons. Furthermore, the geological mother material of the soil may strongly influence the content of Cd in the soil (Söderström, 1995). Less attention has, however, been paid to the importance of atmospheric factors affecting the flux of Cd from soil to the cereal grain, although the possible importance of rainfall and evapotranspiration has been discussed by, for instance, Andersson & Bingefors (1985) and Eriksson et al. (1990). In attempts to model the
uptake of Cd by plants it has been suggested that the amount of Cd taken up by a plant is related to the amount of transpiration water flowing through the plant (Palm, 1994). The aim of the present investigation was to test the importance of atmospheric environmental factors, including temperature, humidity, air mixing, carbon dioxide and ozone, for the cadmium accumulation in wheat grain.

Zinc (Zn) is an element which is chemically closely related to Cd (Dickerson & Geis, 1979). Both have a high solubility in water, but, unlike Cd, Zn is an important micronutrient for plants. Thus, specific mechanisms for the uptake of Zn are present in plant roots, which is not likely to be the case for the nonessential toxic element, Cd. The combination of chemical similarity and pronounced biological dissimilarity between Zn and Cd offers an opportunity to study the difference in accumulation pattern between essential and nonessential elements in plants. Therefore, measurements of the grain content of Zn was also included in the study.

MATERIALS AND METHODS

All measurements were based on experiments with field grown spring wheat (Triticum aestivum L.) performed at Östad säteri, 50 km north-east of Göteborg, south-west Sweden (N57°54', E12°24') in 1988, 1994, 1995 and 1996. In 1988, the cultivar was Drabant, which was grown on a soil rich in clay with a pH-value slightly above 6. In 1994-1996 the cultivar Dragon was studied, while in 1996 also the cultivar Minaret was also studied. In these three years, the soil was a loamy sand with a pH slightly above 6.

In all four years, treatment plots with a diameter of 1.1 m for the ambient air (AA) and with non-filtered air (NF) in the open-top chambers (OTCs) with a diameter of 1.25 m were used. In addition to the AA and NF plots, an OTC treatment with doubled CO₂ concentration was used in 1994, 1995 and 1996. In 1995, one additional OTC ozone treatment with non-filtered air enriched with 25 ppb ozone (NF+) was used. In 1988, three additional OTC ozone treatments, charcoal- filtered air (CF), non-filtered air +25 ppb ozone (NF+) and non-filtered air +35 ppb ozone (NF++) were used. The number of replicate plots were 5 in 1988, 3 in 1994, 5 in 1995 and 6 in 1996. The southern half of each plot was kept untouched and harvested at maturity after which Cd, Zn, crude protein of the grain as well as the grain yield (dry weight) was determined.

Cd and Zn concentrations in the grain and in the soil (only 1996) was determined using atomic absorption spectroscopy (graphite oven). The crude protein content was determined by measuring the nitrogen content according to Kjeldhal and multiplying by 6.25. The grain of the plots was carefully threshed, weighed and the dry weight determined by