^{203}Hg Tracer Studies on Mercury Uptake from Soil by Wheat and Barley

by

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The uptake of mercury from soil by food crops is of interest and recently, JOHN (1972) has reported on the effects of application of 4 or 20 μg.Hg/g soil on the Hg levels and distributions in 8 plant species including oats and 7 vegetables. There has also been some interest on the possible translocation of Hg from the fungicidal seed coating to the mature plant. JAMES et al (1971) have noted an increase in Hg accumulation in peas and wheat grains from treated seeds relative to untreated ones. These results, however, were strongly disputed by SAHA (1972) since SAHA et al (1970) have found that wheat and barley contained 0.008 to 0.016 p.p.m. Hg whether or not the crops were grown from treated seeds. The present communication reports the results from a study on the uptake of ^{203}Hg-labeled mercuric cations from the soil by wheat and barley.

Manitou wheat and Conquest barley were grown in the greenhouse, one plant per pot, each pot containing 400 g. of soil. Two Elstow loam soils differing in acidity (pH 6.7 and 5.2), obtained from separate locations in the Scott Experimental Farm, were utilized. The ^{203}Hg activity, as mercuric nitrate, was applied at the rate of 0.5 μg. Hg/g. soil, either in a 1.0-ml. aqueous solution added as one spot near the seed, or as a 25-ml. solution thoroughly mixed with the 400 g. of soil. Each experiment was carried out in 5 replicates with the pots arranged in a randomized design. At the heading out and the mature stages of growth, the entire above ground portion of each plant was harvested, dried and weighed. After wet ashing in HNO_3-$HClO_4$, the ^{203}Hg activity was determined in a scintillation counter. The results, expressed as % of the added ^{203}Hg taken up per gram of dried plant, are summarized in Table I.

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TABLE I

Percent Uptake of Added ^{203}Hg from Soil per Gram of Dried Wheat or Barley Plants

^{203}Hg Application	Soil pH	Wheat* Heading Out	Wheat* Mature	Barley* Heading Out	Barley* Mature
As one spot	6.7	0.014 ± 0.003^{a}	0.012 ± 0.001^{a}	0.007 ± 0.001^{a}	0.011 ± 0.002^{a}
	5.2	0.011 ± 0.002^{a}	0.011 ± 0.001^{a}	0.007 ± 0.002^{a}	0.009 ± 0.001^{a}
Mixed in soil	6.7	0.024 ± 0.004^{b}	0.017 ± 0.001^{b}	0.023 ± 0.002^{b}	0.013 ± 0.002^{a}
	5.2	0.027 ± 0.001^{b}	0.017 ± 0.002^{b}	0.021 ± 0.001^{b}	0.011 ± 0.001^{a}

*Mean values from 5 replicates ± S.E.
Within each stage of growth, values followed by the same letter (a or b) do not differ significantly at the 5% level of probability (P = 0.05) by the Duncan multiple range test.

For comparison between means at different stages of growth, the Least Significant Difference (LSD) at the 5% level = 0.005; at the 1% level = 0.007.

From the statistical results given in Table I, it can be seen that, except for mature barley, the uptake per gram of plant tissues is significantly greater when the ^{203}Hg is mixed in the soil than when the activity is added as one spot. The overall average of uptakes (0.019% per gram) for all samples derived from mixed application is also significantly greater than the analogous overall average value (0.010% per gram) for all samples derived from ^{203}Hg application as one spot. Moreover, when the activity is mixed in the soil, the uptake per gram is significantly higher at the heading out stage than at the mature stage. These findings may be reasonably rationalized on the basis of more rapid rates of assimilation in the earlier stages of growth and the greater availability of the added mercuric ions to the root system when the ^{203}Hg is thoroughly mixed in the soil. There is no significant difference in uptake for the plants grown in the two soils employed in the present study. JAMES et al (1971) reported that for peas, there was more Hg assimilation from acidic than from neutral soil; whereas for wheat, the uptake was about the same in both acidic and neutral soils, and this is also indicated by the present results.

Of general interest is the fact that while the present results show that wheat and barley do assimilate some of the added mercuric ions, the actual magnitudes of these uptakes are very small, ranging from about 0.01 to no more than 0.03% per gram of dried bulk plant tissues. In contrast to similar studies with radiostrontium, the uptake, for example, into the leaves of wheat plants was nearly 0.4% per gram (LEE, 1959; 1961). This low extent of uptake is of pertinence in relation to the matter of Hg assimilation from fungicidal seed coatings. Such coatings normally

are organic mercurials. In a study on the uptake of ^{203}Hg-labeled phenylmercuric acetate and mercuric acetate by pea roots, RAO et al (1966) have noted a complete exchange between Hg atoms of the organic phenylmercuric acetate and the inorganic mercuric acetate and reported that the amount of uptake was similar whether inorganic mercury or PhHgOAc was utilized. In the present work, it was also found that the Hg atoms of methylmercuric chloride and mercuric chloride readily exchange. Since exchanges between organic and inorganic mercury can occur, it may be reasonably assumed that the uptake of Hg from fungicidal seed coatings should at least be of the same order of magnitude as those recorded in Table I. If the mercurial coatings were applied in amounts equivalent to about 15 to 20 mg. of Hg per kg. of seeds (SAHA et al, 1970), and since each seed weighs no more than about 50 mg., a treatment with 20 p.p.m. of Hg would mean the presence of only 1 µg. of Hg per seed. If the uptake were of the order of 0.01 - 0.03% of the added Hg per gram of plant material (Table I), the amount of Hg derived from the coating per seed would be about 0.0001 - 0.0003 µg./g. of plant tissues, and this would constitute only a relatively minute portion of the approximately 0.01 p.p.m. of Hg normally found in the grains of wheat and barley (SAHA, 1972). The present findings thus support the conclusion of SAHA (1972) that the main concern regarding the use of mercurial seed coatings centers on the contamination of seed eating birds and their predators rather than on the translocation of the Hg from the coating to the mature grain.

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