REDUCING THE UPTAKE OF Sr^{90} BY PLANTS ON CONTAMINATED OHIO SOILS[1]

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INTRODUCTION

Radioactive debris from atomic explosions deposited on vegetation and soil presents a potential health hazard to man. The element of particular concern is the radioactive isotope of strontium, Sr^{90}. Its long half life (28 years) and similar chemical reactivity to calcium makes Sr^{90} of biological significance. Strontium can be readily absorbed by plants either from the soil or directly through the foliage. Contamination in forage can be carried into the milk of dairy cows and eventually into the calcified bone tissue of man (Comar et al., 1957; Russell et al., 1959). The increasing presence of Sr^{90} in bone tissue has been of concern to geneticists and other biologists.

Methods for decontaminating soils or ways of reducing the uptake of Sr^{90} from the soil by plants have been under study since the late 1940's (Shulz et al., 1959). Strontium is not very mobile in most soils and when deposited from the atmosphere onto the soil surface will not penetrate the surface to any great depth (Romney et al., 1959). The removal of the surface 2 in. of soil will remove most of the Sr^{90}. However, this method of decontamination may not be practical when large acreages are needed for crop production.

Calcium and strontium are similarly absorbed by plant roots. High concentrations of calcium in the rooting media can restrict the absorption of strontium (Fowler et al., 1959). In acid soils the uptake of Sr^{90} can be significantly reduced by liming. Recent experiments conducted at The Ohio Agricultural Experiment Station at Wooster have shown that the amount of Sr^{90} absorbed by plants can be reduced by as much as 60 percent by liming the acid soils (Haghiri et al., 1961).

Various crop species appear to differ markedly in their absorptive capacity of strontium (Haghiri et al., 1961; Vose et al., 1959). For example, sudangrass and corn have been found to be lower accumulators of strontium than buckwheat, soybeans, or alfalfa (Haghiri et al., 1961).

Soil type also seems to be an important factor affecting the availability and uptake of Sr^{90} by plants (Fowler et al., 1959; Haghiri et al., 1961).

The results published in this paper are an account of recent observations on the effect of crop species, liming, and soil type on the uptake of Sr^{90} from Ohio soils.

MATERIALS AND METHODS

Thirteen soil samples representative of the Hoytville, Miami, Alexandria, and Muskingum soil series (Morse et al., 1958) in Ohio were included in this study. The samples were subdivided and limed at various rates to establish a pH range of approximately 5 to 7 for each soil type. Five of the soils had initial pH values of less than 5, while the remaining soils ranged from 6 to 7. Ten μc of carrier-free Sr^{90} were thoroughly mixed into each soil sample, and the soils were cropped in the greenhouse in sequence with corn, soybeans, wheat, and alfalfa. The aerial portions of the plant were harvested when 6 to 10 in. tall. The plant tops were dried at 70°C, weighed, and ground. A 200-mg sample was used for counting. The amount of Sr^{90} in the plant samples was determined using a Berkeley Decimal

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Scaler, model 2000, with a 2.9 mg/cm^2 thin mica window tube. All the plant sample counts were corrected for background.

RESULTS AND DISCUSSION

The amount of Sr^{90} found in the plant tissues varied considerably depending upon the crop species, liming rate, and soil type. The Sr^{90} content of various plant species was in the order: Soybean > corn $\cong$ alfalfa > wheat (fig. 1).

As the soil pH increased (as a result of liming), less Sr^{90} was accumulated in all crop species. An increase in soil pH from 5.0 to 7.0 reduced the Sr^{90} content of all the plants approximately by one-half. These results are similar to those reported by others (Haghiri et al., 1961; Romney et al., 1959).

However, the Sr^{90} content of the plants was not similar in the case of all soils used. A highly significant correlation was found between the percent clay content of soil and the level of Sr^{90} in the plant. As the clay content increased, the Sr^{90} content of the plant decreased (fig. 2). Therefore, it appears that soil texture and soil pH are equally important. Although liming may significantly reduce the uptake of Sr^{90} by plants on all soils irrespective of texture, the use of low clay content soils may result in plants with a sufficiently high Sr^{90} level to make them undesirable for animal or human consumption.

The colloidal clay fraction largely accounts for the cation exchange capacity of mineral soils. As the clay content increases for a particular mineral soil, the cation exchange capacity usually increases. Although soil texture would be expected to have an influence upon the uptake of Sr^{90}, the extent of its influence was unexpected. The colloidal organic matter in soils also exhibits a cation exchange capacity. The soils used in this study varied from 0.7 to 2.4 percent in organic matter content. Soils with similar textures but different percentages of organic matter produced plants of different Sr^{90} contents. As the percent organic matter increased the Sr^{90} content in the plant generally decreased. However, there were exceptions and in some cases the decreases in Sr^{90} uptake were very small compared to magnitude of the organic matter content differences. For example, three clay loam soils having organic matter contents of 0.6, 1.6 and 2.4 percent produced plants with an average Sr^{90} activity of 2700, 2500 and 2110 counts per min respectively. Two silt loam soils having organic matter contents of 0.7 and 2.2 percent produced plants with an average Sr^{90} activity of 6790 and 6860 counts per min respectively. Therefore, the effect of organic matter upon the uptake of Sr^{90} for the soils used in this study is considered of slight significance.

Ions held by the clay colloids are not available to plants until released into the soil solution. Sr^{90} which has been absorbed on the clay colloids is not available to plants. An equilibrium is established between the cations on the clay surfaces and those in the surrounding soil solution. The competitive effect of calcium on strontium is exhibited within the soil solution. Calcium seems to have little effect upon the extent of absorption of strontium on the clay exchange surfaces in acid soils (McLean et al., 1960). However, as the soil pH reaches neutrality, the extent of absorption of strontium is influenced by clay type and calcium saturation (McLean et al., 1960). Therefore, not all of the Sr^{90} added to the soil can be prevented from entering the plant irrespective of clay type, amount of clay or degree of calcium saturation. The asymptotic nature of the curves (with increasing percent clay) in figure 2 tends to confirm McLean's et al. (1960) observations.

The results obtained in this study indicate that the amount of Sr^{90} entering the plant from a contaminated acid soil can be significantly reduced by liming. In addition, texture strongly influences the amount of Sr^{90} absorbed by plants. As the clay content of the soil increases, the Sr^{90} uptake decreases. The uptake of Sr^{90} from an acid soil appears to be equally influenced by soil texture and liming. The Sr^{90} content of plants can be effectively reduced by: (1) liming, (2) a selection

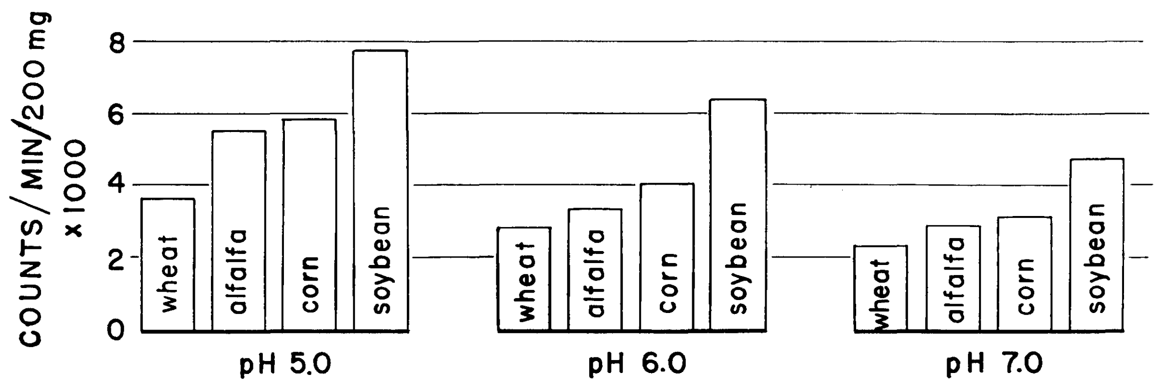

FIGURE 1. Concentration of Sr^{90} (counts/minute/200 mg of dry matter) in wheat, alfalfa, corn and soybean tops grown in soils at the indicated pH levels.

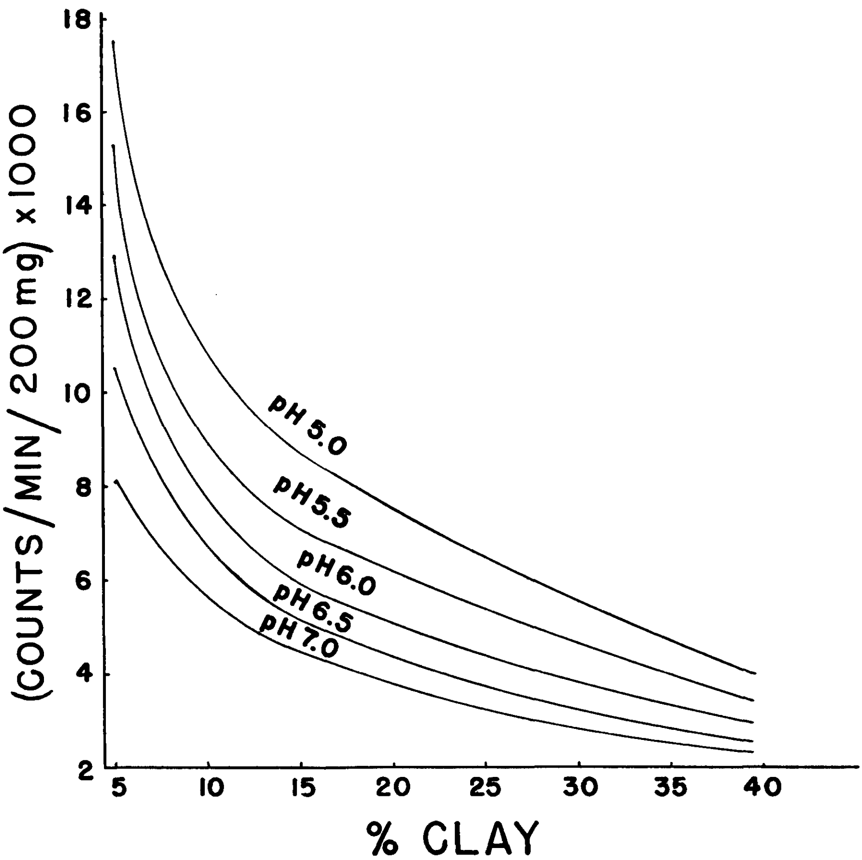

FIGURE 2. Average concentration of Sr^{90} (counts/minute/200 mg of dry matter) for all crops on soils with varying texture (percent clay) and soil pH levels.

of a high clay content soil, and (3) selection of plant species which is a low accumulator of strontium.

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