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THE ABSORPTION AND TRANSLOCATION BY PLANTS OF RADIOACTIVE ELEMENTS FROM "JANGLE" SOIL

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THE ABSORPTION AND TRANSLOCATION BY PLANTS OF RADIOACTIVE ELEMENTS FROM "JANGLE" SOIL

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Metabolism Unit
Biology Section

February 16, 1953

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ABSTRACT

A study was made of the uptake of radioactive elements from "Jangle" test site soil by four species of plants. The addition of nutrients to this soil increased the uptake of these radioactive elements, but in no case was the uptake over 2.8 per cent of the activity in the soil on a concentration basis.

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THE ABSORPTION AND TRANSLOCATION BY PLANTS OF RADIOACTIVE ELEMENTS FROM "JANGLE" SOIL

Introduction

In June of 1952 two experiments were started to determine the uptake by plants of the radioactive elements present in "Jangle" test site soil. While the results presented do not constitute a complete study of the problem, they represent the contribution which this facility was best equipped to make, and the contribution which was requested of us.

The experiments were designed to determine the maximum uptake of the radioactive elements present in this soil by several species of plants, and the effect of the addition of nutrients to the soil on the uptake of these elements. Radiochemical analyses were made on the soil and tomato plants grown in the soil to determine the elemental nature of the radioactive emitters.

Methods

Twelve clay pots, each containing equal volumes of "Jangle" soil, were prepared for planting. Each pot contained one plant of the following 4 species represented in triplicate: Red Kidney bush bean (*Phaseolus vulgaris*), Rutger tomato (*Lycopersicum esculentum*), Sacramento barley (*Hordium vulgare*) and Russian Thistle (*Salsola pestifer*). These pots were watered daily with distilled water. A similar set of 12 pots was prepared as indicated above, but received 20 ml of a complete nutrient solution[1] once a week throughout the experimental period. All plants were grown in the greenhouse during the summer months.

At maturity (87 days for bean and barley, 95 days for Russian Thistle and 103 days for tomato) the aerial portions of the plants were harvested and when possible were divided into samples of leaves, stems, and fruit. These samples were dried in an oven at 70 C for two days, weighed and then digested in concentrated nitric acid. The dry salts from the digestion

were dissolved in a known volume of 5 N nitric acid and duplicate one ml samples of this solution transferred to stainless steel plates for radioactivity counts. An average maximum energy value of approximately 1.7 Mev was determined for the mixed beta radiation and was used in correcting counts for absorption.

To determine the maximum uptake of radioactivity from this soil an experiment was conducted with barley plants using the standard Neubauer technique.[1,2] After a 17-day growth period, the aerial portions were harvested and the radioactivity present determined. Samples were prepared for radioactivity counts in the same manner as described above.

The radiochemical group analyses of the soil and tomato plants were made using the methods outlined by Healy, et al.[3] It was necessary to treat the 5 gram samples of soil with H_2O_2 and HF followed by fusion with Na_2CO_3 in order to effect complete solution.

Results and Discussion

The activity densities of the plant parts from the four species of plants grown with and without nutrient solution in "Jangle" soil are shown in Table 1. The addition of nutrient solution to "Jangle" soil increased the uptake in all plants studies except tomato. Russian Thistle and bean accumulated the greatest concentration of radioactive elements from the soil supplied with nutrients, with barley and tomato following in that order. In all cases, the accumulation of radioactive elements in the fruiting portions of the plant was less than that in other parts.

The experiments involving addition of nutrients to the soil were considered desirable because of the very low organic content of the soil. Total nitrogen determinations showed the soil to have a nitrogen content of 0.3 milligrams of nitrogen per gram of soil. Figure 1 indicates the increased growth resulting from the addition of nutrients. The total dry weight of the aerial portions was increased by a factor of 1.5 or more. The

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TABLE 1

The uptake of radioactive elements by four species of plants from "Jangle" soil of activity density 26 mμc/g, with and without nutrients. Plants grown in pots under greenhouse conditions. Average of three plants.

Plant Parts	With Nutrient mμc/g	Concentration Factor*	Without Nutrient mμc/g	Concentration Factor*
Bean				
Leaves	0.56	0.022	0.42	0.017
Pods	0.16	0.006	0.13	0.005
Stems	0.53	0.020	0.30	0.012
Barley				
Leaves	0.36	0.014	0.09	0.004
Head	0.03	0.001	0.03	0.001
Tomato				
Leaves	0.25	0.009	0.27	0.010
Fruit	0.03	0.001	None Produced	
Stem	0.16	0.006	0.16	0.006
Russian Thistle				
Leaves and Stems	0.57	0.022	0.31	0.012

* The concentration factor is expressed as $\frac{\text{activity density in plant part}}{\text{activity density in soil}}$ on a dry weight basis.

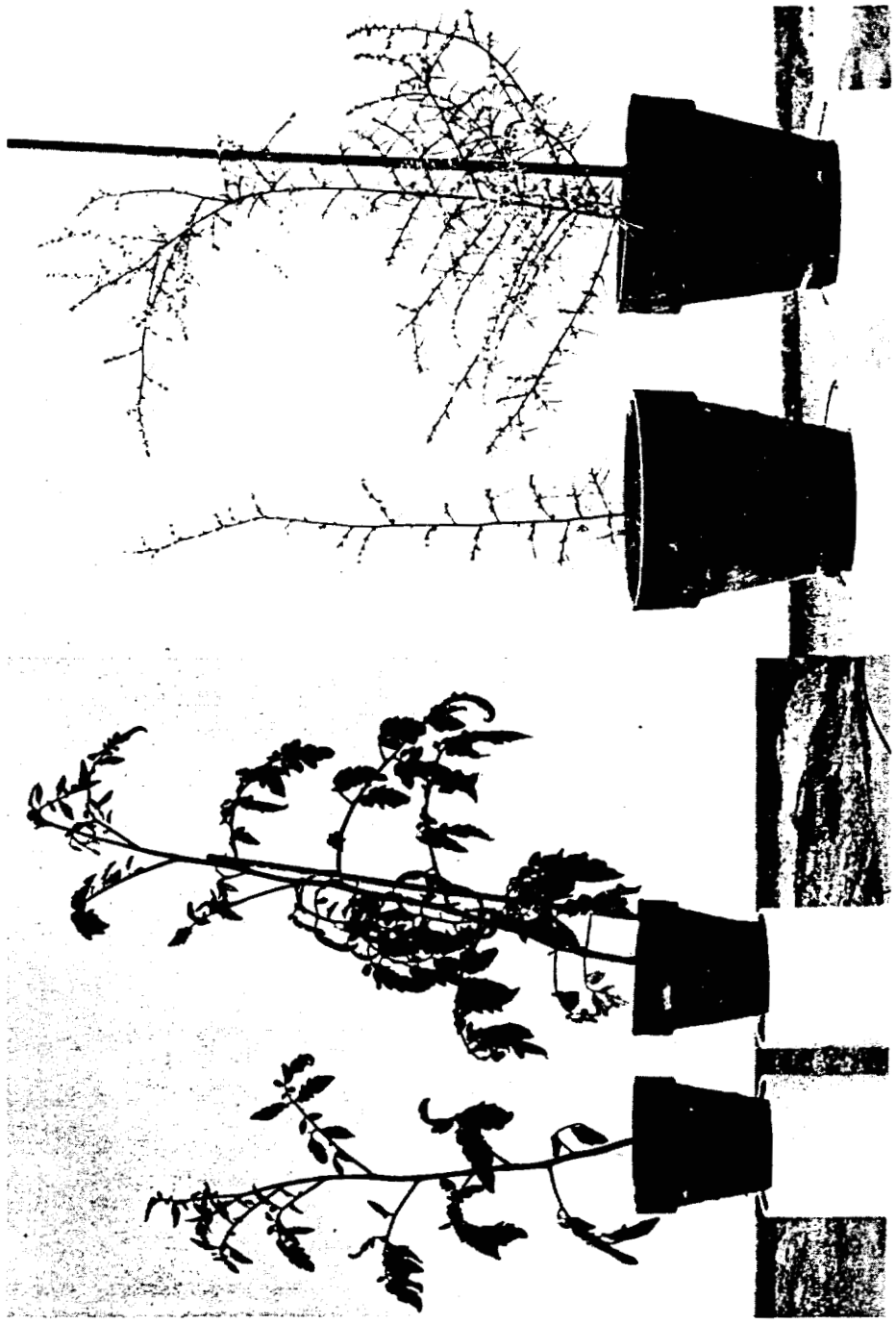

FIGURE 1: The growth of plants in "Jangle" soil as affected by the addition of nutrient solution. The right hand member of each pair received nutrient solution.

increased efficiency of uptake with nutrients added is no doubt due to an improvement in the general well-being of the plant.

No plant parts accumulated in excess of about two per cent of the activity in the soil (0.026 $\mu c/g$) on a dry weight basis. Although the soil had an alpha activity of 35 d/m per gram, the alpha activity of the tomato plant was <1 d/m per gram.

The results of radiochemical group analyses of the "Jangle" soil and tomato plants grown in this soil are given in Table 2. The major portion of the total radioactive material in the soil and tomato plant consisted of elements in the rare earth group. The only elements which were preferentially absorbed by the plants were those in the calcium (alkaline earth) group.

The standard Neubauer technique was used to determine the maximum uptake of elements from this soil. When barley plants were grown until they had exhausted the nutrient capacity of the soil, a maximum of 2.8 per cent of the total radioactivity was removed to the plants.

Summary

1. Four species of plants grown in "Jangle" test site soil concentrated radioactive elements in their aerial portions to a maximum of about 2% of the concentration in the soil (comparison on a dry weight basis).

2. The uptake was in most cases significantly increased by addition of nutrients to the soil.

3. Concentration of radioactive elements in the fruiting portions of the plants was much smaller than in leaves and stems.

4. Radiochemical group analyses showed that approximately three-fourths of the radioactivity in soil and plants was due to rare earths.

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TABLE 2

Composition of radioactive material in "Jangle" soil and in tomato plants grown in this soil, as determined by radiochemical analysis.

Analytical Group*	"Jangle" Soil Activity Density (mμc/g-dried)	Tomato Plant			
		Leaves		Stem	
		Activity Density (mμc/g-dried)	Concentration Factor**	Activity Density (mμc/g-dried)	Concentration Factor
Arsenic-Copper Group	<0.3	<0.002	<0.007	<0.002	<0.007
Phosphate Group	2.8	<0.002	<0.0007	<0.002	<0.0007
Rare Earth Group	19.8	0.180	0.009	0.160	0.008
Iron Group	2.3	0.010	0.004	0.005	0.002
Zinc Group	0.8	0.005	0.006	<0.002	<0.002
Calcium Group	0.8	0.042	0.05	0.030	0.040
Total	~26.8	~0.239	~0.009	~0.201	~0.007

* This classification follows the scheme of McAlpine and Soule ("Prescott and Johnsons Qualitative Chemical Analysis", D. Van Nostrand, 1933). Groups may contain isotopes of any element which forms compounds of similar solubility to those formed by the "group name" elements during the separation process.

** The concentration factor is expressed as $\frac{\text{activity density in plant part}}{\text{activity density in soil}}$ on a dry weight basis.

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5. Elements in the alkaline earth group were the only ones showing preferential absorption.

6. Barley plants were able to accumulate 2.8% of the radioactive elements when grown to exhaustion of soil nutrients (Neubauer technique).

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