TECHNICAL PAPERS

A Principle for Maintaining Earthworms in Farm Soils

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Ever since the classic work of Darwin (*2*), evidence has been accumulating that earthworms have important physical and chemical effects on soils (*1*, *3*, *5*). This information has not been of much direct use in row-crop farming because practical measures have not been devised for maintaining earthworms on clean-tilled land. In recent studies (*4*) on a Maryland soil, the earthworm population was found to be much lower under annual clean-tilled crops than under sod crops. The reason for this difference has since been investigated, with the purpose of finding a practical means of avoiding the decline in earthworms on annually clean-tilled land.

The investigation was conducted on previously established agronomy plots at the Maryland Agricultural Experiment Station (*4*). Monthly, from February 1946 to January 1947, the earthworms in the plow layer were counted. Table 1 gives the results for plots cropped to corn annually with and without a winter cover and to a two-year rotation in which corn is followed by various legumes and grasses. In plots cropped to corn annually the earthworms increased during the growing season until early November. Between November 23 and December 7 a sudden cold period occurred, and most of the earthworms were killed at this time.

TABLE 1

EARTHWORM POPULATION BY SEASONS IN CONTINUOUS ROW-CROPPING AND IN TWO-YEAR ROTATIONS

Season	Earthworms (thousands/acre)		
	Corn annually	Two-year rotation: Sod in spring, corn in summer, wheat in fall	Two-year rotation: Wheat in spring, sod in summer and fall
Early spring	60	290	85
Late spring	140	290	80
Summer	125	300	75
Early fall	240	440	305
Late fall (after freeze)	85	85	335
Winter	80	60	320

During this cold period many of the earthworms in the rotation plots containing young wheat also died. In the rotation plots that contained a sod of wheat stubble plus legumes and grasses, the earthworms survived.

At a nearby weather station, a minimum air temperature of 8° F. was reached at this time. On land that was bare or contained young winter wheat, the soil froze to a depth of about 4 inches; but under the sod, and in other plots covered with straw mulch, no freezing occurred. When the plots were resampled between December 4 and 10, numerous dead earthworms were found in those with frozen soil.

TABLE 2

CHANGE IN BODY WEIGHT ACCORDING TO SOIL TEMPERATURE

Soil temperature (°F.)	Change in body weight (%)
32	−100
36	+3
40	−6
50	−15
55	−6
60	−22
70	−19
80	−58

The response of earthworms to temperature was checked further in the laboratory. Earthworms from a sod field were placed in jars of soil having 40 per cent moisture content. The jars were kept at various temperatures in cold storage chambers. The earthworms did best at 36° F., as judged by changes in body weights, but died at 32° F. (Table 2). In a subsequent test in which earthworms from the various agronomy plots were subjected to a temperature of 32° F., all died, regardless of the plots from which they had been taken.

TABLE 3

EFFECT OF SURFACE PROTECTION ON WINTER SURVIVAL OF EARTHWORMS (January 21, 1947)

1946 crop	Type of surface protection	Earthworms (thousands/acre)
Corn	None	0
	Burlap	995
Corn	None	0
	Lespedeza mulch	1,610
Soybeans	Light residue	335
	Heavy residue	665

These observations indicate that the death of earthworms on the clean-tilled land in the late fall was induced by the sudden drop in temperature to below 32° F. According to observations on three of the plots, this harmful effect can be alleviated by surface protection. These plots were almost bare except for small areas that had been protected with surface coverings of lespedeza hay, soybean residue, and burlap, respectively. The earthworms under the coverings withstood the cold and were highly active (Table 3).

[1] The collaboration of Homer T. Hopkins, formerly associated with this project, is acknowledged with pleasure. Aggregate analyses were made by Jay C. Bryant.

Various practical ways of protecting the soil surface against sudden drops in temperature in the late fall may be suggested. Threshing residues, chopped corn stalks, composts, or manure might be spread early in the fall after the row crop has been removed. Where these materials are not available, a fast-growing catch crop that forms a winter mulch might be interseeded at the last cultivation of the row crop.

References

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Distribution of C^{14} in Photosynthesizing Barley Seedlings[1]

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As part of a program for the biosynthesis of carbon-labeled biologically important compounds, especially sugars, the following exploratory work has been performed on the assimilation of radioactive carbon dioxide in the light by young barley plants.

Plants were grown in a greenhouse on Hoagland's nutrient solution until they averaged 6–7 inches in height. Upon removal to the laboratory, select plants were divided into two groups: (1) those from which primary and secondary roots and hypocotyl had been cut (hereafter referred to as "minus"); and (2) entire plants, except for secondary roots (hereafter referred to as "plus"). Fresh weights of each group were approximately equal. (The minus group therefore had considerably more leaf material, since the roots and hypocotyls of the plus plants constitute a large fraction of their weight.)

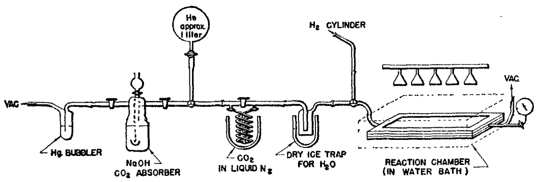

Fig. 1

The reaction chamber housing both groups of plants consisted of a rectangular brass frame sandwiched between two 1-inch glass panes; the free volume was approximately 1 l. The chamber was placed within a tank containing flowing water for cooling (ca. 25°) and illuminated from above, at a distance of 18 inches, with a bank of four GE Projector Spot, 250-watt lamps.

[1] This paper is based on work performed under Contract # W-7405-Eng-48 of the Atomic Energy Commission with the University of California, Berkeley.

[2] With the technical assistance of G. A. Hall.

The setup in the experiment is depicted in Fig. 1. The CO_2 absorber, filled with NaOH, was present to catch any CO_2 escaping the spiral immersed in liquid nitrogen. The helium (or H_2) bulb, containing 2–5 p.s.i. (above atmospheric pressure) of the gas, flushed the spiral containing $C^{14}O_2$ into the chamber. At the beginning and end of the experiment, hydrogen flushed other gases out of the tissue. The dry ice trap was for water.

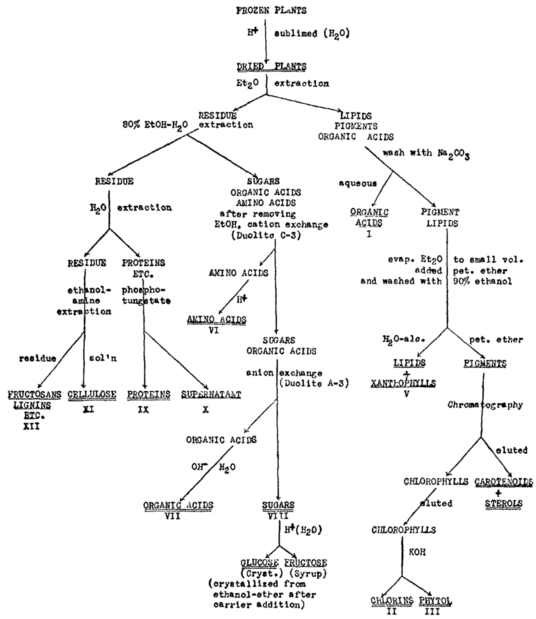

Fig. 2. The substances doubly underlined are materials upon which direct counts were obtained; those singly underlined, materials whose activity was obtained by difference.

TABLE 1

	With roots Total activity fixed (%)	Without roots Total activity fixed (%)
Dried whole plant	100*	100†
Ether extractable acids (I)	[12.5]‡	[7.9]‡
Chlorins (II)		0.8
Phytol (III)		0.9
Carotenoids (IV) (contaminated with sterols)	6.1 / 0.9	3.6
Other lipids (V)		
Amino acids (VI)	7.2	5.6
Acids (VII)	11.3	7.7
Sugars (VIII)	25.8	35.0
Soluble protein (IX)	0.7	6.9
Nonprotein (aqueous) (X)	[3.5]‡	
Cellulose (XI)	2.8	3.6
Lignins, etc. (XII)	[8.3]‡	[9.4]‡
	78.2§	79.7§

* The weight was 2.223 grams—containing 2.00×10^6 c/min.
† The weight was 1.871 grams—containing 0.58×10^6 c/min.
‡ Obtained by calculation rather than direct measurement.
§ Much of the loss is due to incomplete recovery of acids from regenerated adsorption columns.

The chamber was filled with hydrogen and evacuated 5 successive times to remove CO_2, after which the $C^{14}O_2$ (from approximately 45 mg. of $BaC^{14}O_3$) was swept in with the aid of