A simple catalytic analysis to detect the effects of eradicant treatments on nursery soils

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The rate of oxygen release, as a result of adding hydrogen peroxide, can indicate the level of live microorganisms in a soil.

Catalytic analyses determine the ability of soils to break down hydrogen peroxide into water and free oxygen. This reaction is caused largely by catalase and related enzymes produced by soil microorganisms and roots of live plants. Organic matter free from live organisms, such as moss peat and inert raw humus, exert very little influence on catalytic reactions. Control of soil organisms by potent eradicants drastically reduces the catalytic effectiveness of soil, even those with a high content of organic matter (2). In turn, catalytic reactions may serve to indicate the soil's content of living constituents, and thus measure its decrease inflicted by biocidic treatments or its restoration effected by green manure crops or other ameliorating amendments (4).

The release of oxygen is measured with an aneroid manometer and the results are expressed in millimeters of mercury (mmHg). With the apparatus used in these studies, the catalytic capacity of nursery soils not treated with toxic chemicals may exceed the level of 100 mm Hg. Severe or prolonged eradication treatments may decrease the catalytic effectiveness to below 10 mm Hg. A crop of rye or yellow lupine, plowed under the treated soils, raises the catalytic capacity by 30 to 40 mm.

Method

For analyses of nursery soils, the standard determination of the catalytic capacity (3) was refined by the following modification. A sample of freshly collected, undried soil is taken with a 7 cc calibrated scoop. The sample is placed into a 200 ml widenecked reaction flask provided with a perforated No. 9 rubber stopper. The stopper has a small glass tube inserted for attachment of Tygon tubing, and an 18-nil reagent container, held by a wire (figure 1). The container is filled with 15 nil of dilute hydrogen peroxide (one part of 30 percent peroxide and 4 parts of water) and carefully introduced into the reaction flask. The flask is stoppered tightly and the stopper fastened by a strong rubber band.

The Tygon tubing is attached by means of a leuer connector to an aneroid manometer (an inexpensive 200 mm pressure gauge). The flask is tipped to allow the hydrogen peroxide to pour onto the soil and is' shaken intermittently to bring all of the soil in direct contact with the liquid. After exactly 3 minutes of oxygen evolution, the manometer reading is taken. Second determinations, as a rule, do not differ more than 5 min from the first manometer reading. Analysis of one sample takes between 5 and 7 minutes.

The significance of catalytic reactions is illustrated by analyses conducted in two Wisconsin State nurseries: Hugo Sauer nursery, located in the vicinity of Rhinelander on a light sandy loam developed from a granitic outwash, and Hayward nursery, located near Hayward on a river terrace sandy loam high in silicate minerals. Soils of these nurseries had been subjected to biocidic treatments, including organo-fumigants, for a period of 27 years.

The random sampling was confined to fallow areas, and the averages were derived from five composite samples, each of seven 6-inch cores of the surface soil layers. For comparison, eradicant free soils from the adjacent plantation were also sampled. In addition to the catalytic

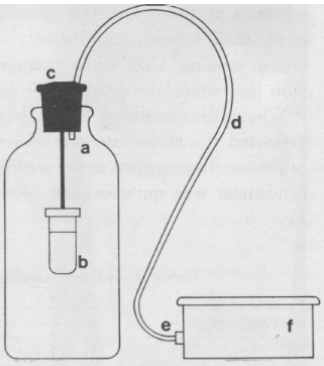

Figure 1.—Equipment for the determination of the catalytic capacity of soils: (a) 200 ml reaction flash; (b) 18 ml reagent container; (c) No. 9 rubber stopper; (d) Tygon tubing; (e) leuer connector; (f) aneroid manometer.

Table 1.—Content of soil organic matter, catalytic capacity, and restoration indexes of the Hugo Sauer and Hayward State nurseries of Wisconsin.

Soil sample No.	Organic matter	Catalytic capacity	Restoration index
	(percent)	(mm Hg)	(0.01 h.c.)
		HUGO SAUER NURSERY	
Mixed conifers			
35 yrs	2.2	143	
1	1.0	25	0.25
2	1.9	38	0.72
3	1.1	67	0.74
4	1.8	42	0.76
Average of 1–4	1.45	43.0	0.62
		HAYWARD NURSERY	
Red pine			
30 yrs	3.4	205	
5	3.0	40	1.20
6	2.3	19	0.43
7	2.2	24	0.53
8	2.6	37	0.96
Average of 5–8	2.50	30.0	0.75

capacity, determinations included the contents of soil organic matter of the sampled areas. The results are given in table 1.

Discussion

The average results of analyses, and especially the results obtained with samples 3 and 5, show clearly that catalytic capacity is influenced primarily by the supply of enzymes in the soil rather than its organic matter content. Yet, in the realm of plant nutrition, the live ingredients

of the soil can never be divorced from their dead tissues or exoskeletons. The restricted catalytic capacity of organic matter does not in the least diminish its importance as a buffering and biodegrading agent. Organic matter, because of its absorbing and polymeric properties, moderates the toxicity of chemicals and provides energy material for microorganisms essential in plant nutrition and breakdown of residual eradicants. Therefore, the summary effect of biocidic treatments can he appraised only by taking into account both living and non-living soil constituents, as incorporated in the following equation:

$$R=0.01\,h.c.,$$

where R is the restoration index, h is the percent of soil organic matter, and c is the soil catalytic capacity. Obviously, a large value of R shows little adverse effect of eradication treatments and indicates that it will be easy to ameliorate the soil.

The results, (table 1), show that the average catalytic capacity of 13 mm for the Hugo Sauer nursery is considerably higher than that of 30 mm for the Hayward nursery. These values indicate the relative severity or duration of eradication treatments. The detoxification or re. generating capacities of the two soils are defined by their average restoration quotients of 0.62 and 0.75, respectively.

According to some greenhouse and nursery trials, a single crop of rye or yellow lupine green manure, plowed under, raises the catalytic capacity of the 6-inch surface soil layer between 30 and 40 mm Hg, an effect deserving particular attention.

Green manure crops do not significantly augment the supply of soil organic matter or the soil's nitrogen content. On the other hand, temporary crops of either legumes or nonlegumes are highly beneficial when used as cover to protect soil from erosion or to convert soluble chemicals into slowly acting organo-mineral fertilizers. The introduction of potent eradicants gives herbaceous plants an additional, highly important function of lowering toxicity and revitalizing the soil' (1).

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