Comments and Communications

Replanting "Discarded" Varieties as a Means of Disease Control

Many soil pathogens accumulate to a high degree in the presence of crops toward which they are virulent. The efficacy of crop rotation as a disease control measure lies in the fact that, in the absence of these crops (i.e., in the presence of nonsusceptible crops), the population of a given pathogen materially decreases. Other pathogens, those to which the alternate crop or crops are susceptible, must as surely increase; but by rotating crops subject to widely different pathogens, effective control is often achieved. Why not then, apply the same general practice in control of such pathogens as the grain rusts, *Helminthosporium* of oats, etc.? Such a practice would involve a rotation of host varieties, rather than of distinct, often widely divergent, crop species.

Development of varieties of crop plants resistant to infectious parasites and insect pests is a significant approach to control of plant diseases. There is now widespread recognition on the part of pathologists, breeders, and practical growers that, contrary to earlier opinion, a new variety represents but a temporary advantage.

''The case of Ceres wheat . . . illustrates this point. This rust-resistant variety was distributed in 1926, and by 1934 was grown on more than four million acres. Race 56 of *P. graminis tritici* was first identified in 1928; in 1930 it comprised only 0.2 percent of the wheat stem-rust population . . . increased to 1.0 percent of the population in 1931, to 2.1 percent in 1932, 3.7 percent in 1933, then increased rapidly to make up 33 percent of the population in 1934 and 66 percent in 1938. Ceres was very susceptible to this race, and in the severe stem-rust epidemics of 1935 and 1937, in which race 56 predominated, Ceres was so heavily damaged that it ceased to be generally cultivated.'' (Christensen, C. M. *et al. Ann. Rev. Microbiol.*, 1948, 1, 61.)

Again, recent experience with a group of new oat varieties is significant. These varieties, deriving a highly valued resistance to virtually all races of crown rust from the variety Victoria were planted in this country about 1942. Very soon, reports of a new *Helminthosporium* disease appeared. Now widely recognized under the name *H. victoriae*, this pathogen has eliminated all Victoria derivatives from general use.

While focusing our attention on the striking and often disturbingly rapid increase in ''new'' races or species of pathogens in the presence of newly emphasized host varieties, we should not forget that some, at least, of the ''old'' races are correspondingly decreasing. There is likely as significant a decrease in the inoculum of hitherto prevalent pathogens as there is increase in hitherto rare ones! This, coupled with the very possible fact that the old host varieties well may be resistant to the new pathogens, leads to our main thesis: that varietal rotation should be studied as a means of disease control.

The simple fact that a pathogen is new stands as direct evidence that the older varieties were highly resistant to it, and that it was therefore formerly rare. After five or ten years of widespread plantings of a new host type, it may well be that formerly well-known species or races of pathogens will have become scarce, and that older host varieties can be replanted with profit. That many of these discarded varieties are highly desirable is clearly shown by Quisenberry's statement regarding Vicland oats: ''It has been stated that in Wisconsin the years 1942 and 1945 were quite similar so far as climatic conditions for oat production were concerned. In 1942 the average yield in the state was 43.0 bushels per acre when only 90,000 acres of Vicland were grown. By 1945 Vicland had increased to nearly 3 million acres and the state average was 51.0 bushels per acre.'' (Quisenberry, K. S. *Chron. Bot.*, 1948, 11, 237.) By selecting for a given crop, such as wheat or oats, several commercially desirable varieties of widely differing susceptibility, it should be possible to work out a type of rotation which would hold disease losses at a low level.

Rotations involving varieties of the same host species will require great care. Yet the principles governing the biological equilibrium between host and pathogen are the same; and such a program seems hardly as difficult as the present constant seach for ever new host varieties. And as McCall points out, ''a change in variety requires no change in farm organization, management, utilization, or general plan of financing.'' (McCall, M. A. *Chron. Bot.*, 1948, 11, 273.)

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Age of Canada's Principal Gold-producing Belt[1]

The east-west trending belt of infolded rocks that extends across Ontario into Quebec and includes many of Canada's largest gold mines has long been known to be very old in terms of earth history. The belt is a trough-like strip of volcanic and sedimentary rocks of so-called Keewatin and Temiskaming age. It probably represents the roots of an ancient mountain belt that seems, by crosscutting relationships, to be older than all other similar zones in the Canadian shield area (Wilson, J. Tuzo. *Trans. Amer. geophys. Union*, 29, 691).

In southeastern Manitoba there is an area in which granitic rocks have invaded similar volcanics and sediments known locally as the Rice Lake series. These granites have been established by both Pb/U and Sr/Rb measurements (Holmes, Arthur. Rep. Comm. Meas. of Geol. Time, National Research Council 1946–47, p. 39; and Ahren‘, L. H. *Nature*, Lond., 1947, 180, 874, to be about 2,000 million years old, the greatest age measured heretofore. This area lies on the line of the above-mentioned east-west belt if extended westward.

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[1] Supported by the Office of Naval Research, in the laboratory established by the Geological Society of America.

Work on the helium method of age determination (Hurley, P. M. and Goodman, C. *Bull. geol. Soc. Amer.*, **54**, 305) has continued since the war, with a further understanding of what conditions are necessary for satisfactory age measurements. Measurements on magnetite in certain "soft host" environments seem to be on a fairly firm footing.

Only three samples of magnetite from this eastern mineral belt have been measured so far, but the agreement in age with each other, and with the Manitoba area to the west, offers some assurance that the determinations are reasonably correct. Samples 1 and 2 were specimens of magnetite from the Larder Lake district, Ontario. Sample 3 was magnetite separated from a quartz veinlet in a piece of massive sulphide ore from the Horne Mine, Noranda, Ontario.

Sample	Alphas/hr/cm^2 from thick source*	Helium 10^{-5} cc/g	Age in millions of years†
1	.36	16.9	2100
2	0.15	8.4	2400
3	.26	11.4	2000

* Nogami, H. H. and Hurley, P. M. *Trans. Am. geophys. Union*, 1948, **29**, 335.

† Assuming 90% of radioactivity due to uranium and 10% to thorium, as is about usual in this type of material.

If these ages are correct, they give us our oldest known orogenic belt.

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Some Simple Calculations Concerning the Efficiency of the Photosynthetic Mechanism

As is well known, the free energy increase resulting from the photosynthetic reaction

$$CO_2 + H_2O = HCHO + O_2$$

is about 120 kcal. Actually, the total amount of energy absorbed is such that the conversion of light into chemical energy is accomplished with an efficiency of 30% or more (Rabinowitch, E. L. *Photosynthesis and related processes.* New York: Interscience, 1945. p. 50.) The reaction above consists of the following oxidation and reduction steps:

$$2H_2O = O_2 + 4H^+ + 4e^-$$

$$CO_2 + 4H^+ + 4e^- = HCHO + H_2O$$

In neutral solution the reversible potential of the first reaction is (Latimer, W. M. *The oxidation states of the elements and their potentials in aqueous solution.* New York: Prentice-Hall, 1938.) + 0.81 v with respect to the standard hydrogen electrode while that of the second is − 0.49 v, the emf of the total reaction being 1.30 v. One will verify that $1.30 \times 4 \times 23 = 120$ kcal.

The formation of oxygen by oxidation of water is, in general, subject to a considerable anodic overvoltage or activation energy. If in particular the formation of molecular oxygen were to require the prior liberation of atomic oxygen from each molecule of water the minimum anodic potential would be the reversible potential for the reaction

$$H_2O = O + 2H^+ + 2e^-$$

which in neutral solution is + 2.00 v.

Similarly the reduction of carbon dioxide to a formaldehyde unit HCHO would be expected to be subject to a considerable cathodic overvoltage. As a matter of fact we have observed (Van Rysselberghe, P. *et al. J. Amer. chem. Soc.*, 1944, **66**, 1801; 1946, **68**, 2047; 2050) that the polarographic reduction of carbon dioxide cannot start until a cathodic potential of about 2 v with respect to the standard hydrogen electrode is reached. The total potential difference would thus be 4 v and the corresponding free energy of the 4-electron oxidation-reduction would be $4 \times 4 \times 23 = 368$ kcal. If the equivalent amount of light energy is absorbed to produce chemical synthesis to the extent of 120 kcal the efficiency of the process is $120/368 = 33\%$, in good agreement with the value given by Rabinowitch (*op. cit.*).

If we accept a mechanism involving eight quanta (which assumption, supported by other evidence, seems logical in view of the fact that there are altogether eight steps of yielding and accepting of electrons for the overall reaction) the average molar quantum would be $368/8 = 46$ kcal, corresponding to an average wavelength of 6210 A. It is interesting to note that the maxima of red absorption in ether solution correspond to 43.3 kcal for chlorophyll a and 44.5 for chlorophyll b (Harris, D. G., and Zscheile, F. P. *Bot. Gaz.*, 1943, **104**, 515). See also our polarographic work on chlorophyll (Van Rysselberghe, P. *et al. J. Amer. chem. Soc.*, 1947, 69, 809).

The original free energy level of one mole of CO_2 and two moles of H_2O is − 208 kcal. The absorption of 368 kcal brings it up to + 160 kcal. If one subtracts from this the loss of free energy of 110 kcal corresponding to the formation of molecular O_2 from the atoms, one arrives at the value of + 50 kcal for the free energy of formation of the activated complex CH_4O_2 from the elements in their standard states. This value might lead to useful speculations concerning the structure and properties of this complex. Since the final free energy level of one mole of HCHO and one mole of H_2O is − 88 kcal the reaction

$$CH_4O_2 = HCHO + H_2O$$

from the reaction complex to the final products involves a free energy decrease of $50 - (-88) = 138$ kcal.

These considerations are submitted as an extension of the reversible electrochemical point of view already familiar in the field of photosynthesis to the more realistic one of overvoltage and activation. It is hoped that they may be of some use towards the final elucidation of the mechanism of the most important of all chemical reactions occurring in nature.

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