ROTHAMSTED RESEARCH

Report for 1929

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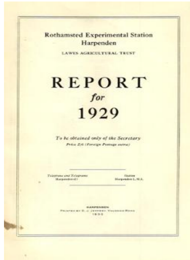
Rothamsted Experimental Station
Harpenden

REPORT
for
1929

Artificial Farmyard Manure

Rothamsted Research

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suitability for cacao growing: the acidity test was applied and gave results difficult to understand. Attempts to clear up the mystery showed that the quinhydrone was reducing manganese dioxide present in the soil, forming manganous hydrate, which neutralised some of the soil acid and so upset the measurement. It was then recalled that many of our own soils contain manganese dioxide: these were re-examined and showed the same action. The International Society of Soil Science has recognised the importance of this discovery and has set up a special Committee to re-examine the European soils which had been tested by the quinhydrone method. Many of these were found also to contain manganese dioxide and, therefore, to be subject to the same error. Experiments are now in hand to get over the trouble.

DECOMPOSITION OF STRAW AND OTHER PLANT RESIDUES.

Artificial Farmyard Manure. The restriction of the area under corn in this country has reduced the output of straw, while the increase in number of cattle has tended to increase the demand for it. At present, therefore, farmers as a rule have barely sufficient straw for their needs, and the whole of it is converted by the animals into farmyard manure. Out in the Empire, however, the case is different and considerable use is being made of the Rothamsted process for making straw and other plant residues into artificial farmyard manure without the use of animals merely by encouraging its decomposition by the micro-organisms already present.

As we do not wish at Rothamsted to be concerned with business operations the process was handed over for commercial exploitation to a non-profit making syndicate, Adco, whose activities now extend to many countries. Shipments of the necessary material were made in 1929 to Africa, Australia, British Columbia, Borneo, Egypt, Fiji, Malaya, Mauritius, Newfoundland, New Zealand, Nigeria and West Indies, the last named being particularly interested because of the great value of the process in making a useful manure for sugar cane plantations out of the "trash." The largest increased consumption was in Natal; but Kenya and Tanganyika also showed marked increases. The Adco officers inform us that the 1929 shipments abroad were 40% greater than in 1928. While the commercial side is left to Adco, the scientific problems arising out of the decomposition of the straw are investigated at Rothamsted. The chemistry of the process is slowly being worked out. The first constituents of the straw to be decomposed are the hemicelluloses, then the cellulose goes, excepting in so far as it is protected by a resistant layer of lignin: it is interesting that cellulose, while fairly resistant to chemicals, is easily broken down by certain micro-organisms. These, however, do not appear to attack the lignin, so that this constituent is left mainly undecomposed but not altogether unchanged. The ratio of cellulose plus hemicelluloses to lignin seems to be the dominant factor in determining the rate of decomposition of the straw, provided sufficient available nitrogen be present. The xylan associated with the cellulose is not unavailable, but is decomposed only as fast as it is exposed by removal of the encrusting cellulosic layers. The small

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amount of pectin present in straw is not removed during normal decomposition, but only if acid conditions set in.

Considerable progress has been made with the study of the organisms effecting the decomposition of the straw. In the main they are fungi, including several aspergilli *(fumigatus, nidulans, niger, terreus)*, several actinomycetes, a *Trichoderma* and a thermophilic organism *Sepedonium*: all these act at relatively high temperatures, the last named has its optimum temperature at 45° to 50° C., and it still survives at temperatures exceeding 60° C., these being far above the usual range: most organisms have their optimum at about 22° C. and fail to grow above about 35° C.

These organisms are not only thermophilic but are strongly thermogenic, and when inoculated on to sterile straw they decompose it so effectively that they rapidly raise the temperature to 40° C. or more.

In the soil, however, there is a much wider range of possibility, as at least three groups of the soil organisms can decompose cellulose : fungi, including actinomycetes; spirochaetes; and bacteria. The reaction of the soil determines which of these groups predominates. In acid soils (pH 4 to 5) the fungi and actinomycetes are most active: at any rate they multiply most when cellulose is added to the soil; in less acid conditions (pH 5.5 to 6.5) *Spirochaeta cytophaga* is most active, multiplying most extensively; and in neutral conditions the short rod-like cellulose-decomposing bacteria appear to be the chief agents: a number of these have been isolated and studied by Dr. Kalnins. This change in the cellulose-decomposing flora with the reaction was observed both in Rothamsted and in tropical and in warm temperate soils, and was independent of soil type. Dr. Jensen found evidence that a portion of the soil humus was formed from fungus mycelium, but that only certain species of soil fungi had the property of yielding humus when decomposed.

Among the bacteria isolated by Dr. Kalnins is one which has the interesting property of converting the cellulose into glucose or a sugar closely resembling it, a change that may prove of great technical value.

All these organisms require nitrogenous and phosphatic foods and they freely absorb nitrates and phosphates from the soil, thus competing with plants. Preliminary experiments at Rothamsted have shown that unrotted straw ploughed into the ground may actually reduce yields of non-leguminous crops: only after the rotting is well advanced is the effect beneficial. It is possible that earlier ploughing in of the straw might be better and, in view of the great importance of the subject, Lord Iveagh is providing funds for a twenty-year field experiment, in which ordinary farmyard manure, artificial farmyard manure and unrotted straw shall be compared with artificial fertilisers over a rotation which is to be repeated several times. The chief factor appears to be the absorption of nitrates from the soil by the cellulose-decomposing organisms. Leguminous crops, which gather their own nitrogen, did not suffer, indeed broad beans benefited from chaff ploughed in and enriched the soil so much that the succeeding wheat also benefited. Apparently the nodule organisms derive some advantage from the straw, for in pot experiments both soy beans and broad

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beans carried more nodules as the result of adding chaff to the soil. Where there are no nodules, the beans suffered from the addition of straw, just as a non-leguminous crop would have done.

This work is being developed simultaneously with the study of the closely allied subject of green manuring. The Woburn experiments show that green manuring does not increase the yield of crops as much as was expected, and tares proved even less effective than mustard. 1929 has been the only exception: in all other years the green crop, whether fed off by sheep or ploughed under, has failed to increase the succeeding crop. One factor is the very small amount of nitrate and ammonia in the soil; even on the folded land the average contents of nitrate nitrogen in the top soil after tares and mustard respectively, were only 1.3 and 1.0 parts per million. Addition of nitrate of soda pushed up the yields considerably.

The decomposition process is very complex and cannot be understood from a study of one section only. Bacteria play a great part, which is not yet, however, fully known. Dr. Thornton's improved method of counting them shows that they are far more numerous than was formerly supposed. Their numbers are not constant, but fluctuate with amazing rapidity from hour to hour during the day. The fluctuations are not clearly related to temperature or soil moisture changes: they may have something to do with the method of reproduction of the organisms, but this is not known. The amount of decomposition effected by the bacteria increases with their numbers, but not proportionally: the efficiency of the individual organisms falls off as their numbers increase. The position is somewhat altered when amoebæ are present: the production of carbon dioxide is then depressed in media relatively rich in nitrogen compounds, such as sand cultures containing peptone, but it is increased in media poor in nitrogen and containing glucose or soil extract.

Perhaps the most striking discovery in the Microbiological Department this year has been that of a group of nitrifying organisms producing nitrites from various ammonium salts, but differing completely from the only forms previously known, *Nitrosomonas* and *Nitrosococcus*, in that they thrive in the presence of organic matter. They were first found in the effluent from the Colwick sugar beet factory, where we have been studying the problems of effluent purification: Mr. Cutler has since found them commonly distributed in the soil.

Effluent from Sugar Beet Factories. For the past three years the Fermentation and Microbiological Departments have been studying methods of purifying the effluent from sugar beet factories so as to render it harmless to the rivers into which it is poured, and their work has been so successful that a 90% purification was obtained in 1929 in the large scale experiment at the Colwick factory. This exceeds the required standard. The essential feature of the method is to pass the effluent over a clinker filter so that the sugar may oxidise completely before it enters the river. More time is needed than for sewage purification, hence a finer grade of clinker is needed. There still remains the difficulty that the mud suspended in the water may choke the filter before the end of the campaign, but this, too, can be overcome.

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