

rendered antirachitic is not readily extracted with ether.

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THE DEVELOPMENT OF MORE EFFECTIVE DUST FUNGICIDES BY ADDING OXIDIZING AGENTS TO SULPHUR

SUGAR-CANE fields in Hawaii can not be treated effectively with liquid fungicidal sprays, because the matted cane growth prevents passage of men or work animals through a field. For this reason we have attempted the use of fungicidal dusts which can be applied to the cane from the edges of the fields by motor-driven dusting machines or by airplanes.

The problem we are working with is a serious infectious leaf and top disease of the cane, called eye spot, caused by the fungus *Helminthosporium sacchari* Butler. Our first attempts against this disease were ineffectual, not from any difficulty in placing the dust on the cane but because the fungicidal dusts used caused little or no reduction of the disease. In field-plot tests with adequate replications Bordeaux dust, and other copper mixtures, organic-mercury mixtures, sulphur mixtures, chlorine mixtures and coal-tar disinfectants gave little or no control of the disease. The best result in these earlier attempts was in plots treated with ordinary dusting sulphur in which we obtained 27 per cent. less infection than in alternating untreated plots which served as controls. This reduction of the disease was not sufficient to recommend for plantation practice but was sufficient to encourage us to seek further for more effective compounds.

Previous research by Young¹ showed that the fungicidal action of sulphur was due to the formation of pentathionic acid formed by oxidation in the air. Young went further with this and secured greater fungicidal action by using more finely divided sulphur which would adhere to foliage better and oxidize more readily. Young's conclusions have been questioned in England,² however.

The slight reduction of our disease with dusting sulphur nevertheless led us to follow up Young's work; instead of depending upon the oxidizing effect of the air, such oxidizing agents as nitric acid, one fourth of one per cent., and pulverized potassium permanganate, 1 per cent., were added to the sul-

phur. Seven plots of cane treated with the latter mixture have shown a reduction of 89.9 per cent. of infections as compared with seven undusted plots as controls; at the same time finely divided sulphur on seven plots has reduced the number of infections but 9 per cent. Sulphur plus one fourth of one per cent. nitric acid in eight similar plots reduced the disease 61 per cent. We have since increased the effectiveness of the oxidized sulphur even further by increasing the concentration of potassium permanganate to 5 per cent. No burning of sugar-cane foliage resulted, even when the concentration of potassium permanganate was increased to 10 per cent.

Potassium permanganate in a non-sulphur carrier such as kaolin has not reduced the disease as compared to untreated cane in control plots, indicating that the fungicidal effect is not due to the direct effect of the permanganate as a disinfectant but to its oxidizing effect on the sulphur.

It is possible to get quantitative data on the results of our treatments by marking an equal number of cane stalks in each plot and having counts of infections per leaf made at two-week intervals. The figures given above are from 140 leaf counts per treatment.

At the same time that our oxidized sulphur preparations gave a good control of the disease, we received a stimulation of growth, apparently independent of the disease-control, as shown by growth measurements of 70 cane stalks per treatment. The total increased growth was 8.8 inches per stalk, which would mean from two thirds to three fourths ton of sugar more per acre, a very profitable increase in yield.

It is our impression that dust fungicides against plant diseases have generally been less effective than liquid fungicides and that some of the sales of fungicide dust mixtures have been made by high-pressure salesmanship rather than on the basis of proven results in the field. We believe that our oxidized-sulphur mixtures will place fungicidal dusts more nearly on a competitive basis with liquid sprays, with the added advantage of greater economy of application. Care must be taken to keep these mixtures dry and away from fire, but millions of people have learned that gasoline can be used, with a few ordinary precautions.

Concerning mixtures of oxidizing agents in sulphur as fungicides, a patent has been applied for and if any royalties do occur they will be applied for the furtherance of research.

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EXPERIMENT STATION OF THE
HAWAIIAN SUGAR PLANTERS'
ASSOCIATION

¹ Young, Harry Curtis. "The Toxic Property of Sulphur." *Annals of the Missouri Botanical Garden*, Vol. IX, p. 403, 1922.

² The Association of Economic Botanists. Discussion on "The Fungicidal Action of Sulphur." Ordinary Meeting, Oct. 20, 1925; *The Annals of Applied Biology*, Vol. 13, No. 2, p. 308, May, 1926.