

"Mercury as a Control for stored grain pests," *Bul. Ent. Res.*, 1944, 35, Part 2, 143-60.

*Note.*—The cost of printing this contribution has been defrayed by a generous grant from the Rockefeller Foundation for the publication of results of scientific work made to us through the kindness of the National Institute of Sciences, India.—*Ed.*

## A CHLOROSIS OF PADDY (*ORYZA SATIVA* L.) DUE TO SULPHATE DEFICIENCY

BY S. P. AIYAR

(Agricultural Chemist, Burma, Delhi)

SINCE 1926 the author has been engaged in studies on the nutritional disorders of the paddy plant and on their correction by manurial treatment. A large volume of work has been carried out but publication was held up in the hope of completing the studies and presenting the work in comprehensive form. Owing to unexpected developments, however, further work on the subject is likely to be indefinitely delayed so that the publication of important facts appears to be desirable. This note deals with the effects of sulphate deficiency.

A chlorosis of paddy, fairly widespread on the Mandalay Agricultural College Farm, was attributed by the author to a possible deficiency of sulphur on the basis of the following observations:—

(1) Experiments on the manuring of paddy on the Farm soil with cyanamide, urea and ammonium bicarbonate during 1926-29 showed that the treated plants were generally chlorotic whereas treatment with ammonium sulphate gave healthy green plants. (2) In the Permanent Manurial Experiment on the Farm, treatment of paddy with sodium nitrate gave chlorotic plants while ammonium sulphate gave normal green plants. (3) There was no trace of chlorosis in the Farm area under the control of the Economic Botanist, Burma, apparently owing to the regular application of Nicifos II on this land, whereas elsewhere on the Farm chlorotic patches were numerous and extensive.

The plants affected by the disorder had the following characteristics:—(1) A general chlorosis with leaves of yellowish green colour, the older leaves being somewhat more greenish than the younger leaves. (2) There was no tendency for the premature death of the older leaves as is usual in cases of nitrogen deficiency. (3) The affected plants were relatively stunted and had fewer tillers and a smaller leaf area than the healthy plants. (4) The chlorotic plants gradually recovered their green colour and remained green and immature at the usual harvest time when the healthy plants had become golden yellow in colour indicating full maturity. (5) Grain formation was not suppressed but the yield of both straw and grain was greatly reduced. (6) The ratio of straw to grain was much

narrower in the chlorotic plants than in the healthy plants.

The first experiment to test the effect of sulphate on the chlorotic plants was carried out by the author<sup>1</sup> during the season 1931-32 with the collaboration of the Professor of Agriculture, who provided the necessary facilities. The treatments included magnesium oxide, magnesium chloride and magnesium sulphate with and without ammonium phosphate (free from sulphate). In all cases where sulphate was present the chlorotic plants recovered their normal green colour, made rapid growth and were ripe and ready for harvest along with the healthy plants. On the other hand the plants remained stunted and characteristically immature in all the other treatments. It was thus evident that the chlorosis was not due to a deficiency of nitrogen, phosphate or magnesium. The author's finding that sulphate is the curative agent for the chlorosis was subsequently confirmed by the Mycologist<sup>2</sup> and the Agricultural Chemist,<sup>3</sup> Burma, but neither of them attributed the trouble to sulphur deficiency. The latter<sup>3</sup> also expressed a warning against expecting a beneficial effect from applications of sulphur under normal conditions of growth.

As sources of sulphate for the plant the author found that gypsum, powdered sulphur, iron pyrites and the usual sulphate-containing fertilisers were equally effective, and that a rate of application of ten pounds of sulphur per acre in any of these forms was sufficient to cure the trouble and produce the maximum yield in this soil. The treatments produced their effect within three days after application. Under Burma conditions, iron pyrites appeared to be the most suitable source of sulphate as the mineral is found extensively in the country.

Since many areas on the College Farm were found to respond to ammonium sulphate and to superphosphate, comparative tests were carried out in areas of sulphate deficiency to discover whether the action of these fertilizers was due to their characteristic constituents or due to their sulphate content. It was found that treatment with nitrogenous and phosphatic fertilizers gave large increases in yield when they contained sulphate but not when they contained only chloride or nitrate in place of the sulphate. For instance, ammonium sulphate was far superior to ammonium chloride, urea mixed with calcium sulphate to urea alone, superphosphate to pure monocalcium phosphate, and Nicifos II superior to pure ammonium sulphate. The significance of sulphate in the manuring of paddy has been pointed out by the author<sup>4,5</sup> elsewhere.

The composition of the crop showed the following characteristics:—(1) In the chlorotic plants the straw as well as the grain contained abnormally high percentages of nitrogen compared to the healthy plants, and the yield of crop was found to vary inversely with the nitrogen content (Sen,<sup>6</sup> however, did not find any difference in nitrogen content between the untreated yellow plants and the plants treated with gypsum). The nitrogen test was found to be so sensitive that it could be used to detect the existence of abnormality in the

TABLE I

Yield and Composition of Sulphate-Deficient Paddy after Various Treatments

Season	Treatments	Appearance of crop after treatment	Yield per plot of 180 sq. ft.		Composition of crops at maturity (on dry matter)			
			Straw lb.	Grain lb.	Straw		Grain	
					N%	S%	N%	S%
A	Untreated-affected	Chlorotic	6.5	5.3	0.85	0.062	1.22	0.094
	Untreated-healthy	Green	11.5	9.7	0.40	0.22	0.98	0.138
	MgCl <sub>2</sub>	Chlorotic	5.8	4.9	0.88	0.064	1.28	0.08
	MgSO <sub>4</sub>	Green	12.3	9.0	0.38	0.133	0.99	0.128
B	Untreated-affected	Chlorotic	6.0	4.6	0.82	0.057	1.32	0.084
	Untreated-healthy	Green	11.4	9.8	0.9	0.118	1.00	0.119
	Gypsum (CaSO <sub>4</sub> )	"	12.6	10.2	0.38	0.138	0.95	0.135
	Iron pyrites	"	13.1	11.3	0.39	0.129	0.98	0.129
	Sulphur	"	13.5	11.6	0.7	0.127	0.97	0.115
	NH <sub>4</sub> Cl	Chlorotic	6.8	5.2	0.85	0.061	1.21	0.081
	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Green	11.2	9.5	0.42	0.133	0.97	0.124
	Urea	Chlorotic	7.5	6.2	0.77	0.09	1.28	0.88
	Urea + CaSO <sub>4</sub>	Green	12.4	10.2	0.41	0.118	0.96	0.119
	Ca-H <sub>2</sub> P <sub>4</sub>	Chlorotic	6.2	5.8	0.78	0.149	1.26	0.80
	Superphosphate	Green	12.0	9.9	0.40	0.124	1.01	0.115

plant. The test is, however, not specific because nitrogen accumulation has been found to occur also in certain other deficiencies studied by the author.<sup>7</sup> (2) The chlorotic plants contained much less total sulphur than the healthy plants. Microtests with benzidine hydrochloride showed the complete absence of sulphate in the chlorotic plants whereas the healthy plants always showed the presence of sulphate. (3) There was no difference between the chlorotic and the healthy plants in regard to their calcium, magnesium or phosphate contents. (4) The manganese contents of the healthy plants and the sulphate-treated plants were distinctly higher than those of the chlorotic plants. (5) The chlorotic plants contained higher percentages of soluble nitrogen and lower percentages of soluble sugars than the healthy plants.

Selected data are presented in the accompanying table to illustrate the salient features of the work. Only the percentages of nitrogen and sulphur are given as these represent the most important information. Full details will be published shortly.

From the experimental work summarized above it will be seen: (1) that the chlorotic plants contained much less sulphur than the healthy plants; (2) that these chlorotic plants responded to sulphate treatment which led to maximum yields and caused a large increase in sulphur content in the plant; and (3) that sulphate treatment corrected all the abnormalities in the chlorotic plants. It may, therefore, be concluded that the symptoms shown by the chlorotic plants are due to a deficiency of sulphate and that added sulphate acted as a direct nutrient to the plant.

It is necessary to point out that from the data

in hand no conclusion can be drawn in regard to the minimum percentage of sulphur in the plant or in the soil which will prevent the chlorosis.

1. "Annual Report of the Professor of Agriculture, Agricultural College, Mandalay, for 1931-32."
2. "Annual Report of the Mycologist, Burma, for 1932-33," page 3.
3. "Report on the Operations of the Department of Agriculture, Burma, for 1933-34," page 14.
4. Aiyar, S. P. *Proc. Nat. Inst. Sciences, India*, 1937, 3, Part 2, 267.
5. —, *Science and Culture*, 1934, 10, 148-51.
6. "Report on the Operations of the Department of Agriculture, Burma, for 1937-38," p. 36.
7. "Annual Report of the Agricultural Chemist, Burma, for 1940-41."

*Note*—The cost of printing this contribution has been defrayed by a generous grant from the Rockefeller Foundation for the publication of results of scientific work made to us through the kindness of the National Institute of Sciences, India.—Ed.

## NEW YEAR'S HONOURS

HIS MAJESTY THE KING has been pleased to confer the distinction of Knighthood on Dewan Bahadur A. Lakshmanaswami Mudaliar, Vice-Chancellor, University of Madras, Dr. C. W. B. Normand, Department of Meteorology, Mr. C. C. Inglis, Director, Indian Waterways Experiment Station, Poona, Mr. B. J. Wadia, Vice-Chancellor, Bombay University, and Mr. J. J. Gandhi, of the Tata Iron and Steel Company. Mr. F. C. Minett, Director, Imperial Veterinary Research Institute, Izatnagar, becomes a C.I.E. These distinguished personages are all familiar to readers of *Current Science*. Our heartiest felicitations to them!