METHODS OF DIAGNOSING "AKIOCHI", IRON AND HYDROGEN SULPHIDE TOXICITY IN THE WET-ZONE RICE FIELDS OF CEYLON

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1.—DIAGNOSIS OF IRON TOXICITY IN PADDY FIELDS

Comparable physiological diseases of rice occur in various countries in Asia. These include "akagare" of Japan, "mentek" of Java, "penyakit mereh" of Malaya and "bronzing" of Ceylon. In these diseases the leaves of the affected plants turn reddish-brown.

"Akagare" disease in Japan is characterized by reddish-brown spots at the tip of lower leaves. The discoloration spreads over the entire leaf and causes ultimate dying-off. It resembles potassium deficiency in its symptoms as well as in its positive response to potassium application (Baba, 1954).

On sandy soils or peaty ones along the western coast of Ceylon, diseases of the same type are found, but in Ceylon, diseases of other types called "bronzing" or "browning" occur in which the whole leaf gets discoloured reddish-brown or dark-brown, starting from the leaf tip; potassium fertilization has no appreciable effect on this type of disorder (Kandiah, 1952). The writer also observed in Ceylon the occurrence of physiological diseases resembling potassium deficiency and it was, according to the writer's observation, "bronzing" that occurred most extensively.

Ponnamperuma, Bradfield & Peech (1955) found an intimate relationship between the occurrence of "bronzing" and the ferrous concentration in the soil percolate, and they postulated that the reduced products in the soil, especially ferrous iron, were the causative agents of the disease.

The writer agrees that "bronzing" is related to the absorption of ferrous iron in excess, judging from (*a*) the marked color reaction

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at the base of the shoot of an affected rice plant when it is treated with ortho-phenenthroline, an indicator of ferrous iron, and (*b*) the existence of a close correlation between the severity of the incidence of bronzing and the degree of reddish-brown coloration of the roots due to oxidized iron adherent to its surface.

Excessive ferrous iron in the soil may have a toxic effect on the functions of the root even when "bronzing" is not recognized. "Bronzing" is a typical expression of the existence of excessive ferrous iron in the soil, and may be considered an indicator of iron toxicity. The writer describes below some methods of recognizing iron toxicity.

1. Diagnosis by Soil Properties

Iron toxicity is liable to occur on those low and wet fields which are adjacent to the highlands of tea or rubber estates, soil of which is ferruginous acidic laterite. Such fields are usually irrigated by streams originating from highland springs, or by the drainage water from such highlands. Springs from underground streams, originating from highland drainage water, often occur within paddy fields.

Irrigation water under the above conditions is acidic and has a pH ranging from 5.0 to 5.8. In contrast to this, the usual irrigation water has a pH of 6.0 to 7.0.

The pH of irrigation water can be roughly determined by the following colorimetric method :

Pour a small amount of the irrigation water to be tested into a porcelain dish and add two or three droplets of the universal indicator. The water will develop one of the following colours according to its pH value :

pH 4, red-orange ; 5, orange ; 5.5 orange-yellow ;

It is better to prepare by the use of a pH meter, a series of colour standards showing rough values of pH.

Various types of soils are badly affected by iron toxicity, viz. sandy, sandy loam, loam clay, and peaty soils ; of these sandy and sandy loam soils are most common.

The affected soils contain organic matter (humus) to some extent and have the property to be rapidly reduced when irrigated.

On the soil surface of the irrigation channels and the field, there develops a thin film of oxidized iron of red, rusty colour.

Euglenas occurring at the surface of the water should not be mistaken for a film of oxidized iron, as the former produce a thin red film under direct sunlight. This film of Euglenas can easily be distinguished from oxidized iron as, according to Mr. I. Gunawardena's observation, it changes into green when the sunlight becomes dim, or the sky becomes cloudy.

2. Diagnosis by Crop Characteristics

The past occurrence and severity of " bronzing " should be first investigated. In investigating them, cases in which non-resistant varieties (e.g. Murugakayan 302) were cultured should be examined, as many of the native local varieties are resistant to " bronzing ".

Usually, " bronzing " occurs on two occasions. The first one, at the maximum tillering stage, i.e. 5 to 7 weeks after sowing or transplanting, and the second one, at the booting or heading stage. The occurrence may be only once, according to the soil, climate or the year.

A survey must be carried out at these most susceptible stages, as in most cases the disease is not so severe at other stages.

By examination it can be found out that the roots of rice plants grown on fields subject to iron toxicity are coarse and are dark reddish-brown or dark-brown in colour.

The roots are short with only a few rootlets. Black roots are not found, showing that hydrogen sulphide is not produced in the soil due to the abundance of iron. On rare occasions, however, black roots may be found intermingled with the other roots after the booting stage. It is recommended that such roots be compared with the roots of rice plants grown on nearby healthy fields. The roots of a healthy plant are yellowish-brown or light reddish-brown. Fields which have undergone a drought should not be sampled, as rice roots on such fields become healthier and lighter in colour.

(3) Immediately after pulling out a test plant, cut its base longitudinally and place two or three droplets of 0.2 per cent. orthophenanthroline solution on the cut surface with a filler or immerse the cut surface into the solution. A red coloration, of an intensity which is proportionate to the Fe" ion concentration in the base of the leaf sheath will develop.

As the colour becomes clearer with the lapse of time, over a period of half to one-half hour, the Fe" reaction at the basal end (2 to 3 ins.) may be estimated by the intensity of red coloration. For purposes of comparison, the roots of a plant grown on a field devoid of iron toxicity

naturally or by drainage should be examined simultaneously with the test roots. As the red coloration caused by ortho-phenanthroline does not fade, comparison can be made even with preserved material.

II.—DIAGNOSIS OF "AKIOCHI" AND HYDROGEN-SULPHIDE-TOXCITY

In Japan, about 600,000 hectares, which is 20 per cent. of the total rice area, are badly affected by a physiological disease called "akiochi". "Akiochi" is caused by the deficiency of nutrients such as silica, potassium, manganese and magnesium, and by injury caused to the roots by hydrogen sulphide (Baba & Harada, 1954). In Japan, such nutrient deficiency is commonly found in combination with root-injury due to hydrogen sulphide.

In Ceylon, the area of "akiochi" fields is not so large at present, but the writer fears that the area will expand with the increase in the amount of fertilizers used. Though further investigation will be needed to elucidate the cause of "akiochi" in Ceylon, in most cases "akiochi" is accompanied by the root-rot due to hydrogen sulphide. A field subject to hydrogen-sulphide-toxicity may accordingly be considered identical with one subject to "akiochi".

In Japan, there are two types of paddy soils in respect to "akiochi", viz. sandy soils (in most cases, well-drained) and boggy soils (ill-drained). In the former type of soil, root injury is mainly caused by hydrogen sulphide, while in the latter type of soil, root injury is believed to be caused by hydrogen sulphide, as well as by carbon dioxide and toxic organic acids such as acetic and butyric acids (Baba & Harada, 1954). In Ceylon too, "akiochi" is seen in sandy soils and boggy soils.

There are two methods of diagnosing "akiochi" and hydrogen-sulphide-toxicity. One is by the soil, and the other is by the crop characteristics.

1. Diagnosis by Soil Properties

(1) Soil

In most cases, the soil is a sandy or sandy loam, poor in iron.

In some cases the soil is ill-drained, particularly when mucky or boggy, containing too much organic matter (humus).

(2) Generation of hydrogen sulphide

On sandy soils, the odour of hydrogen sulphide can be detected. Transfer some surface soil from an irrigated field, into an Erlenmeyer's flask as to fill half the flask. Then place a small funnel over it, and suspend a piece of blotting paper wetted with lead acetate solution deep in the flask. A black colour will slowly develop on the blotting paper. This is due to the formation of PbS P_2 S. As the blotting paper wetted with lead acetate solution does not blacken unless there is a large quantity of hydrogen sulphide produced by the soil sample, this method is not very sensitive if the production of hydrogen sulphide is small.

In the case of an ill-drained boggy soil, an oily film of iron can be observed at the surface of the field.

2. Diagnosis by Crop Characteristics

(1) Growth and morphological characteristics of the rice plant

Plants which have been affected by " akiochi " have the following growth and morphological characteristics :

(*a*) Their growth at the early stages is normal or rather vigorous, and their leaves hang down in most cases. At the later stages, retardation in growth becomes conspicuous, and non-fertile tillers increase in number. In a boggy field, they may not show satisfactory growth at the early stages.

(*b*) They have short stalks and ears. The upper internodes are also short. Panicle exertion from the leaf sheath is poor.

(*c*) The number of spikelets per ear decreases, and there is also increase in sterility.

(*d*) The grain-weight leaf and stalk-weight ratio is small.

(*e*) Generally the paddy grains lose their lustre and dark brown spots developed on them.

(*f*) The grains, both hulled and unhulled, are inferior in quality and possess a lower thousand-grain weight.

(*g*) The lower leaves of the affected plants die off at a very early stage. At harvest time, only one or two active upper leaves remain on each stalk.

(2) Root

The diagnosis of the roots should be carried out by the comparison of affected and non-affected plants. For such comparison, plants which are of the same variety and of the same time of sowing or transplanting should be chosen. Generally speaking, roots begin to rot after the

formation of ear primordia, and rotting increases in severity after booting. Sometimes the rotting of roots begins only after heading, depending on the type of the field. During both *yala* and *maha* seasons, the investigations should be conducted to determine the stage when the root-rot begins.

The roots of a healthy plant are reddish-brown in colour, due to the coating of colloidal iron hydroxide. Healthy plants are difficult to uproot, owing to their elastic roots.

On the other hand, the roots of plants affected by " akiochi " are white or black. Plants so affected can be easily uprooted as their roots are decayed. The black coloration is caused by the adherence of black colloidal iron sulphide. The existence of the black roots indicates the generation of hydrogen sulphide in the soil.

In a boggy field, the intensity of red coloration of roots is deeper in comparison to that in a sandy field, owing to the abundance of iron in the soil, but, nevertheless, black or decayed roots are produced due to the generation of hydrogen sulphide in the soil. This is because the generation of hydrogen sulphide is governed by the quantity of decomposable organic matter, iron, and sulphur, in the soil. When the quantities of decomposable organic matter and sulphur are greater in comparison to that of iron, hydrogen sulphide is produced.

On diagnosing " akiochi ", those places which have once been affected by drought should be avoided; drought-affected plants, in spite of the whiteness of the roots, have only a few black or rotted roots.

(3) DISEASES

Helminthosporium leaf-spot is most likely to occur. In Japan the occurrence of this disease is taken as an index of " akiochi ", for it is almost always found whenever " akiochi " occurs. In Ceylon, other than Helminthosporium leaf-spot, diseases such as sheath blight, leaf blast, neck-rot, and stem-rot are observed to occur.

LITERATURE

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