NUTRITION CONDITIONS OF RICE AT THE TIME OF THE APPEARANCE OF THE BLAST (»BRUZONE«)

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Damage is being done by the extensive root rot to the rice plants in the limeless alkaline soils and the meadow clay East of the river *Tisza*. Such an extensive root rot, however, is not to be noted in the lime alkaline soils (»szik«) between the rivers Danube and Tisza. The roots are here healthy and of white colour. (*Fig. 1. 2.*) The cause of the root rot in limeless alkaline and meadow soils, is to be attributed primarily to the toxic effect of the hydrogen sulphide formed in the soil and the products of the butyric acid fermentation (4, 7, 9, 12) The root rot is one of the characteristic symptoms of the »bruzone«. The affected plants can be easily, almost without any resistance, removed from the soil whereas to pull out the healthy ones a considerable force is needed owing to their intact roots.

The roots of the injured plants serve merely to secure the fixation to the soil. Failure of root supply, the absence of root hair cause disturbances in the nutrition. The plant is in want of the beneficial activity of rhizosphere bacteria due to the absence of active root hair. To replace the dead roots adventitious roots develop even from the higher nodes (partly in the water, partly above the surface of water) (*Fig. 3*). The ears of such specimens are in general empty, the upper part of the leaves becomes dry and necrotic spots appear on the leaves still functioning. On the transsection of the nodes, mainly in the fascicles, in a more advanced condition on the whole transsection, brown-colored portion, so very characteristic of the disease, can be recognized. The adventitious roots presumably due to the shift of the redox-potential level connected with the deficiency of oxygen, are often negative geotropic. The flexibility and branching are characteristic of the thin roots. Yet in the soil owing to calcium deficiency thickened, fragile gelatinous branching and hairless roots are developed (8). The more injured the roots are, the more important becomes the role of the adventitious roots. The adventitious roots under water losing entirely every contact with the organic and inorganic nutrients in the soil are fully reduced to the salts solved in the water, i. e. to their ions.

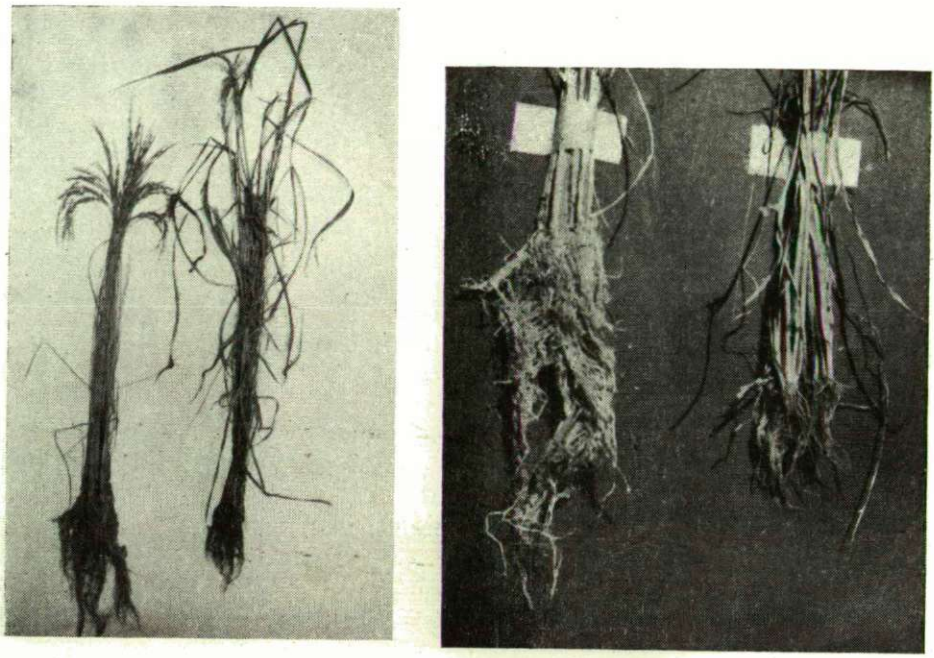

Fig. 1–2. Healthy and injured rice plants and their roots.

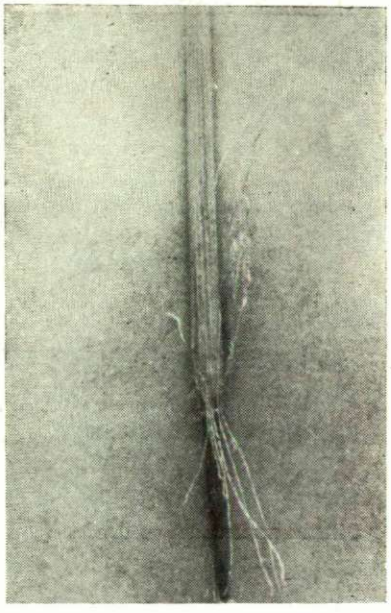

Fig. 3. Adventitious roots

Experimental

To elucidate the nutrition conditions of the adventitious roots examinations were carried out with the rice grown in the fields and waters of the region *Szeged—Hódmezővásárhely* between 1—15 August 1957. Results are shown in *Table 1.*

It is clear from the data that the water of the affected and healthy rice fields, as food source, shows no significant difference, yet plant of deep and heatlhy roots, compared with the injured ones, have much more favourable nutritive conditions because the chemicals of the soil are available.

The quantity of the available nutrients, total N and S^{--} in the soil of the affected fields at the time of the appearance of the disease is denoted below. *(Table 2.)*

Comparing the data of *Table 1.* and *2.* it is evident that the flooded water is considerably poorer in nutrients than the soil, consequently the plants of healthy roots and those dependent merely on the adventitious roots are living in very different conditions. A lower pH-value characterizes the water of root rot fields wherein the manganese-, nitrate-, sulphate- and phosphate-ions are deficient (see *Table, 1, colums 11, 14, 17* and *18).* Besides the iron as well as ammonium-ion are absent or in a very minimal quantity *(Table 1., columns 12* and *16).* In the water of healthy fields the phosphate-ion occurs sometimes in traces and somewhat more but still in a very slight quantity also ammonium-ion.

Discussion

N deficiency of the flooded water.

The NO_3-N disappears from the soil a few days after flooding. The N-source of the rice is the ammonia but this is adsorbed by the colloids in the soil. Thus it is absent or found only in a minimal quantity 0,1—0,2 mg/1, in the water of both the healthy and injured fields, while the ammonia is available for the plants of healthy roots from the soil in sufficient quantity, its quantity available from the water for the affected plants is slight. Beside the soil adsorption the microbiological bond plays also a role in the formation and development of the ammonia deficiency. The ammonia as a result of the decomposition of protein, not adsorbed by the soil, is mainly utilized by the algae as well as by other microorganisms, e. g. bacteria *(Desulfovibrio desulfuricans)* living in water and mud.

That sufficient quantity of nitrogen is available in the soil for the plant at the end of the vegetation, and during the critical period respectively, is shown in *Table 2.*

FÜLEKY, NAGYMIHÁLY *et al.* (2) stated that the injured rice is deficient in nitrogen even in soils rich in nitrogen and the protein synthesis stops in plants decidedly damaged by »bruzone«. The ammonia-nitrogen was accumulated and in every case was higher than the amid-nitrogen. The reason for the formation of the conditions afore-mentioned is explained by the nutri-

Table I.

Farms	Signs	Conditions	pH	Tot. solid residue	Alkalinity	Total hardness	Ca^{++}	Mg^{++}	K^{+}	Mn	Fe	^{-}Cl	$^{-}NO_3$	$^{-}NO_2$	NH_4^{+}	$=SO_4$	$\equiv PO_4$	SiO_2
							mg/l											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Kopáncs	V_{11}	healthy	7,7	378	4,6	12,4	45,7	21,7	4,9	—	—	50	—	—	—	—	—	2,0
Kopáncs	V_6	„	7,6	554	5,2	10,0	25,7	27,7	4,9	—	—	70	—	—	0,2	—	—	—
Kopáncs	V_4	„	7,5	408	5,2	9,9	42,3	23,4	5,3	—	—	54	—	—	0,1	—	—	—
Kopáncs	V_{12}	„	7,5	488	6,0	15,0	43,6	35,0	6,7	—	0,05	58	—	—	0,1	—	traces	—
Kopáncs	W	„	7,8	372	4,8	11,8	47,1	22,8	5,1	0,137	—	40	—	—	—	—	traces	4,2
Gencshát	G	„	7,6	370	3,0	11,2	51,4	17,3	6,0	0,06	0,05	84	—	—	—	—	—	—
Kopáncs	V_1	„	7,8	461	6,2	10,0	48,2	23,3	8,2	—	—	49	—	—	0,1	—	traces	—
Kopáncs	Ü	„	7,8	332	4,0	13,4	31,4	17,3	6,2	—	—	42	—	—	0,2	—	—	2,0
Vajhát	$Ö_{10}$	injured	7,2	398	3,2	9,6	35,5	10,4	4,3	—	—	26	—	—	0,05	—	—	6,6
Vajhát	$Ö_{14}$	„	7,15	424	3,4	10,0	45,7	13,8	7,1	—	0,1	28	—	—	0,1	—	—	7,2
Vajhát	$Ö_{10}$	„	7,2	322	4,0	10,2	47,3	10,2	5,9	—	0,15	29	—	—	—	—	—	8,0
Vajhát	$Ö_{13}$	„	7,3	267	3,0	8,4	44,3	9,5	4,6	—	—	30	—	—	-	—	—	6,0
Vajhát	$Ö_{10}$	„	7,3	304	3,3	9,1	39,0	12,7	6,1	—	0,05	26	—	—	0,1	—	traces	6,6
Palé	P_1	„	7,4	442	4,4	11,0	47,1	19,3	7,6	—	—	68		—	0,1	—	—	2,8
Palé	P_2	„	7,3	442	4,0	12	52,8	12,9	7,3	—	—	72	—	—	0,1	—	—	4,2
Palé	P_3	„	7,4	414	—	10,6	43,1	14,7	8,8	—	—	58	—	—	0,2	—	—	8,0
Fresh flood water (Tisza)	T	„	7,2	308	3,0	7,4	44,2	7,01	3,1	—	0,05	26	—	—	—	50,1	—	6,0

ment deficiencies, primarily that of phosphoric acid and of sulphur due to the changed nutritive conditions. Rice of healthy roots can utilize also considerable quantity of nitrogen beside sufficient uptake of phosphorus, sulphur and manganese. Our common experiments with TAKÁCS support the beneficial effect of ammonium suphate before earing (10).

Table II.

Soil samples	NO_3—N	NH_3—N	P_2O_5	K_2O	Total—N	S
	mg/100 g					
No. 1.	—	2,6	2,8	6,3	125	8,0
No. 2.	—	4,5	7,2	4,0	161	4,6
No. 3.	—	2,8	12,7	5,8	219	7,4
No. 4.	—	9,6	9,0	10,8	213	5,24

Deficiency of phosphorus in flooded water.

As the availability of phosphorus is not influenced directly by the hydrogen sulphide, there is always sufficient phosphorus in the soil, however, it is absent in the flooded water. The plants reduced merely to adventitious roots are manifestly deficient in phosphorus. Deficiency of phosphorus inhibits the synthetic reactions. In the case of complete deficiency the formation of carbon-chain, amino-acid and the development of seeds cease. When this is partial the ripening is delayed, the leaves are dark green, sometimes bluish (onion-like), even the seeds themselves keep their green colour (3). The slow ripening was particularly remarkable in 1957 in the fields affected with root rot.

Sulphate deficiency in flooded water.

The sulphur taken up in form of sulphate ion is essential for the protein synthesis. The deficiency of sulphur in dry cultivation is not a problem as our fields possess the S quantity needed. The water of the river *Tisza* used for flooding contains in general 30—40 mg/l sulphate ion on an average. This quantity, however, in constantly flooded fields may significantly be decreased in consequence of anion adsorbtion and of the sulphate reduction (7, 9, 12) as well as a result of the microbiological bond due to the microorganisms, (mainly algae) living in the water or — as it has been noted in the analitical examinations (*Table 1.*, column 17) — may totally disappear. To supply it is markedly beneficial. A remarkable effect of the top fertilization with ferrous sulphate was observed in the rice fields *Szeged—Baktó* in 1955. The clorotic plants regained their green colour after application. The sulphur requirement of the rice is secured by top fertilizing with ammonium sulphate. The American produced fertilizers (Ammo-Phos-Ko) used for top dressing to supply the sulphur deficiency contain 7—15% sulphur.

Deficiency of potassium in rice plants.

The appearance of the symptoms of this deficiency is presumably due to the cessation of the protein sythesis. Namely this results the accumulation of ammonia in the rice plant. The ammonia inhibits (1, 8) both the uptake and utilization of the potassium. As the synthetized N-compounds can not migrate any more in the dead seeds the ammonia-N increases in the damaged plant. Though both the soil and the water be rich in available potassium, the plant with empty ear often exhibits also symptoms of potassium deficiency.

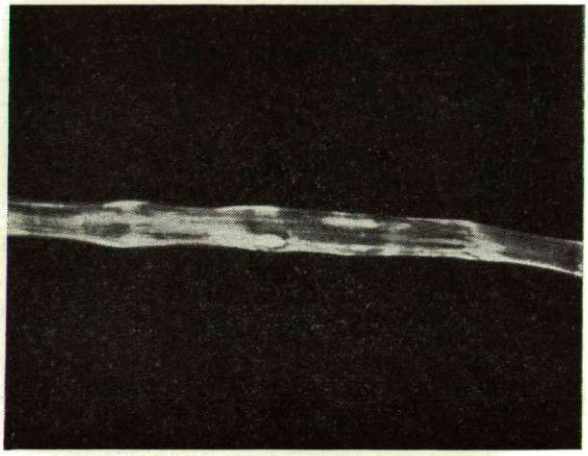

Fig. 4. Injured leaf.

Deficiency of manganese in flooded water.

In contrast to the soil the plant can not obtain Mn from the water because it is precipitated into MnO_2, whereas in the mud — due to absence of oxygen — it remains in solution as manganese ion. The manganese is an essential constituent for rice. When absent the very active Fe^{++} iron is accumulated in the cells exerting a toxic effect on the plant. The manganese deficiency may indirectly contribute to the cessation of the protein synthesis too.

Moreover such trace elements may be absent which are rendered unavailable by the hydrogen sulphide produced in the soil.

The results of the examinations regarding the »bruzone« disease of the rice deny the possibility of nitrite toxicity repeatedly suggested. The examinations reveal a complete deficiency of NO_2. Under the above-mentioned circumstances no nitrite can be produced either by nitrate reduction (absence of nitrate!) or nitrification (absence of oxygen!).

Consequently the activity of the dead soil roots can not be replaced by the adventitious roots. The rice gets its nutrients from the soil and not from the water wherein the essential elements are absent. After the destruction of the roots fungi *(Helminthosporium oryzae, Piricularia oryzae, P. grisea etc.)* (*Fig. 4.)* following deficiency diseases and metabolic disturbances produce the pa-

thological symptoms to which was given the name of *brown disease* (barnulásos betegség), *blast, »bruzone«, Aki-ochi, Brand* etc.

Summary

The root rot of the rice plants in the meadow clay and limeless alkaline soils is commonly known. The roots are affected by the H_2S and by the product of anaerobic fermentation (butyric acid fermentation). To replace the dead roots adventitious roots develop from the nodes. The flooded water is poor in nutrients wherein several essential elements are missing. The adventitious roots can utilize only the nutrients dissolved in the water in contrast to the deep soil roots of healthy plants.

The root rot, the deficiency diseases, the metabolic disturbances and fungi appearing on affected plants give symptoms that are called *brown disease* (barnulásos betegség), *blast, »bruzone«, Aki-ochi, Brand* etc.

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