ECOLOGICAL GEOGRAPHIC FACTORS INFLUENCING „STRAIGHTHEAD" OF RICE PLANT

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Introduction

Large-scale farming of two plants has been introduced in Hungary after World War II. These two plants are rice and cotton.

Cotton farming has been definitely discontinued after a few years failure. Rice, on the contrary, is still grown and crops not only cover domestic consumption but there is an ample surplus for exports.

The success of rice farming was based on systematic research over fifteen years indefatigably pursued by our experts. The possibility of rice growing having been established we proceeded under systematic control to gradually increase the acreage affected to the cultivation of rice, which, at present, amounts to about 40 thousand hectares.

Having acclimatized the rice plant average yield in Hungary soon caught up with other rice producing countries. Drafting of the proper agrotechnique to ensure high average yields necessitated in this country too, the study of soil and climate, as well as of physiology and various diseases of the rice plant. Our results achieved in this particular field are by no means negligible.

Looking for the incentive of our success, i. e. the true motive of scientific and practical results achieved in rice farming and generally in the field of irrigation, the answer will be found in the specific conditions of our geographical situation.

From the successful acclimatization of rice in *Hungary* the rule is inferred that detailed research work in plant breeding and cultivation should be preceded by a survey of prevailing conditions. First of all it should be known what the region has to offer or can offer for satisfying the claims of the given plant. Next, according to the features ascertained, the plant breeder may choose among the available varieties trying to find the variety best suitable for the given soil and climatic conditions, i. e. ecological conditions of the region.

A detailed study of geographic conditions is a most important task with regard to the development of regional cultures. There is still much to be done in the field of rice production in this country — meaning in this context first of all the years when our rice fields are heavily damaged.

A significant part of agricultural plants cultivated today in *Hungary* originate from different parts of the globe. For a part of these plants acclimatization has not yet proceeded far enough for cultivation in this land to change significantly the climatic needs typical of the genus. Hence, as a consequence of unaccountable atmospheric variations, the years of dryness, of drought often lead to great deficits in agriculture. As a remedy, a field crop had to be introduced promising good yields after long, dry, warm and bright summer seasons, when potatoes requiring more precipitation and cooler weather, or corn requiring warmth but more rain, yield crops far below yearly averages. From this angle too, it has been a pudicious measure to introduce rice growing on the lowlands of the Hungarian *Great Plain* frequently exposed to drought and suitable for the cultivation of rice.

In this country rice is chiefly grown on calcareous or non calcareous alkali soils and on meadow soil. In addition to this variance of soils, climatic factors more than ordinarily influence the cultivation of rice. It is understandable with the given soil and climatic conditions that no agronomic pattern for ricegrowing to be adopted with success at all times and on all soils could develop here either. Moreover, there are a number of problems mainly relating to the question of successful culture; some of which problems are not of a general character, referring to one or the other specific landscape. To promote efficient farming we deal in this paper with a disease of rice occurring under certain ecological conditions in specific regions: the „straighthead" of rice plant.

Description of the Disease

The „straighthead" is a form of sterility of the rice plant in which the dry greyish green panicles are empty and erect. This characteristic gave the disease its English name adopted in international literature. In other cases of sterility the panicles generally droop. The first methodic description of the disease is due to TISDALE and JENKINS (18), it was taken over without modification by PADWICK (18). Plants susceptible to the disease have a luxuriant habitat, with deep green, broad and rugged leaves, also standing rigidly erect like lances. (Plate 1.) The appearance of the panicle lags behind normal plants. Roots of plants affected by this disease are relatively healthy, for it needs some strength to drag up the plant, in contrast to brusone which completely destroys the roots and the plants can be lifted without any effort. However, the roots are thick, brittle, scarcely ramifying and poor in root-hair. Injured plants with sterile panicles grow new shoots at the base of the stem, which naturally have no time to flower, still less to ripen.

Regional Spreading of the Disease

In connection with the incidence of the disease in this country, it is a known fact that „straighthead“ occurs on the same soils, on which blast (brusone, browning disease) also threatens the crop. On soil formed on the acidic

Plate. 1. Rice plants susceptible to „straighthead“.

deposits of the river *Tisza* and its tributaries in unfavourable weather the occurrence of the disease can always be reckoned with though to various extent.

In rice plantations, however, on the calcareous deposits of the *Danube*, where blast is also unknown, „straighthead“ does not occur nor did it even in years when damages have been heavy in the irrigated region of the *Tisza*, as, for example, in 1955. In 1955 typical „straighthead“ was more frequent on meadow soil, while brusone occurred more frequently on acidic alkali soils with a thin productive surface layer. „Straighthead“ is a major problem not only in *Hungary*, but also in other rice producing countries. Thus, in the *United States*, namely in *Louisiana* and *Texas*, it also occurs frequently, causing heavy damages. The „Pan-Sukh" in *India*, the „biancette" or „gentiluomo", „lussuria" in *Italy* are closely resembling the „straighthead". (6, 7, 8, 14, 18).

Hungarian farming experts have brought the disease in connection with fogs during florescence. This circumstance gave the disease its Hungarian name of „fog damage". The first assumption attributing a role to fog in rice damages is exactly 400 years old. AGOSTINO GALLO, in his „*Venti giornata dell' agricolture*" published in 1560, writes of a disease called „Fogging". According to CHIAPPELLI (7) this disease is identical with the „brusone". CHIAPPELLI also mentions popular belief in noxious emanations. According to GRIST (14) symptoms permit to conclude to climatic influences. He attributes a major role to sudden falls in temperature and to hail.

PADWICK (18) includes the „straighthead" among non-parasitic diseases. According to his views the occurrence of this disease is determined in a large measure by the absence of air in the soil during the early period of growth of the rice plant. Abundance of organic matters in the soil is another factor favourable to the disease (7, 8, 11, 22, 32). On freshly broken up virgin soil it is a phenomenon almost certain to occur under unfavourable weather conditions. (14, 18, 23). A typical instance was the damage experienced at *Cserebökény* in 1959.

OBERMAYER (15) and SOMORJAY (16, 23) attribute a significant role to sudden and marked fall in the temperature of the layer of air above the rice field. They consider as decisive that the influencing factors should occur simultaneously and the pathological picture also depends on the coincidence of the factors causing the disease.

Occurrence of the Disease

The disease attacks the rice plant during the period of fertilization. In fact, the disease is nothing else than an action to which the plant is exposed during florescence and the susceptible phase following upon the former, in consequence of which fertilization does not take place, or is discontinued in the earliest phase of grain formation.

A valuable clue in the identification of the disease has been furnished by the fact that in this country „straighthead" has occurred in the same years as brusone i. e. in 1949, 1954, 1955 and 1959. On the contrary, there were hardly any damages in 1950, 1951, 1952, 1956, 1957, 1958 and 1960.

We have made a comparative survey of weather conditions in the years of disease and free of disease respectively (31). In connection with the browning (blast) of rice WAGNER's (34) studies of microclimate offer a valuable footing for our research work.

We observed both in 1955 and 1959 that only rice plants flowering simultaneously have been attacked by the disease, while individual plants flowering earlier or later did not display this form of sterility. We also observed that while the panicles on the main shoot have been attacked in one field, in other fields it was the secondary and tertiary stem that have been injured.

Consequently the disease was not caused by an infecting micro-organism, but by the relatively short impact of a noxious outward influence.

Since this disease is causing considerable damages in this country too, we have collected data, made examinations and performed experiences to identify the immediate cause and the influencing factors of the disease. Our results achieved so far are published in the following.

We studied the case in the rice farms of the country, yet more in particular at *Cserebökény, Tiszasüly* and *Karcag,* tests have been performed at the *Palé* experimental station, liquidated since then, of the Kopáncs State Farm, as well as at the *Kopáncs* and *Szarvas* experimental stations of the ÖRKI. *(Research Institute for Irrigation and Rice-cultivation.)* Chemical and other properties of the soils used in our tests have been described in our previous papers, (32, 33). No special methods have been used for performing the tests.

Results

From the circumstance that the above described disease of the rice plant occurs only on certain soils and under certain weather conditions, it may be

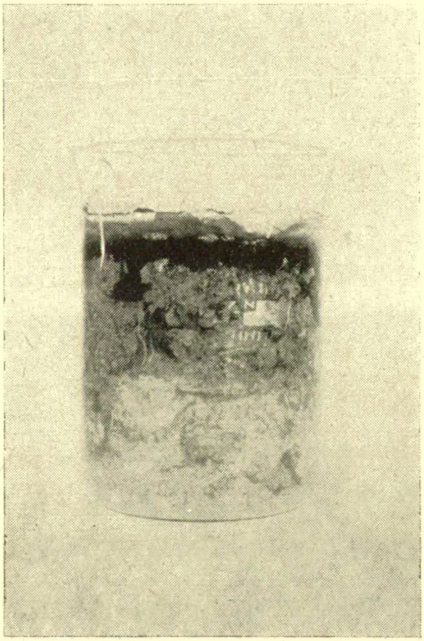

Plate. 2. Layer containing ferrous sulphide in waterlogged acidic alkali („szik“) soil.

inferred that the sterility is the result of the joint influence of unfavourable weather and of noxious processes taking place in the submerged soil. Since the same unfavourable climatic conditions do not cause similar damages in the rice fields along the *Danube*, it is obvious that the immediate influencing factor originates from the soil.

Processes taking place in submerged acid alkali („szik") and meadow soils have been systematically studied in the past years and the results have already been published in our previous papers (32, 33).

It is known that in soils covered with water, hydrogen sulphide or ferrous sulphide are formed as a result of complex microbiologic processes (14, 20, 21, 29, 33). (Plate 2.) The zone containing ferrous sulphide is immediately beneath the surface and is covered with an extremely thin: 0,5 to 2,0 mm thick layer of rusty brown oxidized mud. Laboratory tests have established that large bacterial populations may form a film acting like a perfect oxygen filter under which the reducing bacteria can also multiply without a mud cover. We have established that the formation of ferrous sulphide is far more vigorous along the roots of the rice plant than anywhere else, meaning that root respiration and the decomposition of dead roots play an important role in the formation of ferrous sulphide. Studying the root tract of rice in submerged soil we have established that a low oxydation-reduction potential — 300 to 400 mV — by itself does not impede the biological processes of rice. In fact, deficiency of air causes no disease, since, according to results arrived at by ALESIN (2) rice possesses enzymes capable of utilizing a minimum of oxygen. Desoxidation, however, accompanying root respiration and the decomposition of dead roots, creates conditions favourable to sulphate reducing bacteria and thus reduction is more vigorous there. Moreover, CO_2 and organic acids resulting from the above processes facilitate the formation of molecular hydrogen sulphide from sulphides:

$$NaSH + H_2CO_3 \rightarrow NaHCO_3 + H_2S$$

Hydrogen sulphide will unite with iron ions to form ferrous sulphide. This is a harmless compound becoming noxious only if molecular hydrogen sulphide is again released.

Until recently we have not given due attention to the presence of hydrogen sulphide formed in submerged soils. We rather concentrated our studies upon the redox state of the soil, though low redox values in themselves do not cause rice diseases. We have established, for example, that the soil of rice fields along the *Danube* do not differ as regards to redox properties from rice fields beyond the *Tisza*, and despite this fact no lesion of the roots has been observed on the former even with low redox values.

The released hydrogen sulphide blocks the heavy metals through which it affects the environing plants as a poison attacking the cells and respiration (10, 17, 20, 35). Besides, reduction and oxydation of sulphur plays an important role in the degradation of temporarily submerged soils (9, 12, 24, 25, 26). Research of the metabolic conditions of the rice plant became therefore synonymous with studying the degradation of alkali soils (3, 4, 24, 25).

Dissociation of hydrogen sulphide is a function of the pH-value of water. In neutral and acidic environments the molecular form predominates and it is more toxic than SH-ions. RUBENTSIK (21) has proved that even a feeble acidity of the water is enough to increase H_2S (Fig. 1). It has also been established that the pH-value of water increases in early summer. This increase, of the pH-value i. e. alkalinity favorizes the growth of hydrosulphide. Yet when pH-values decline in late summer, the acidic condition releases the poisonous molecular H_2S. If water acidity increases in a continuous process, the low concentration of released H_2S is not dangerous oxydation being continuous.

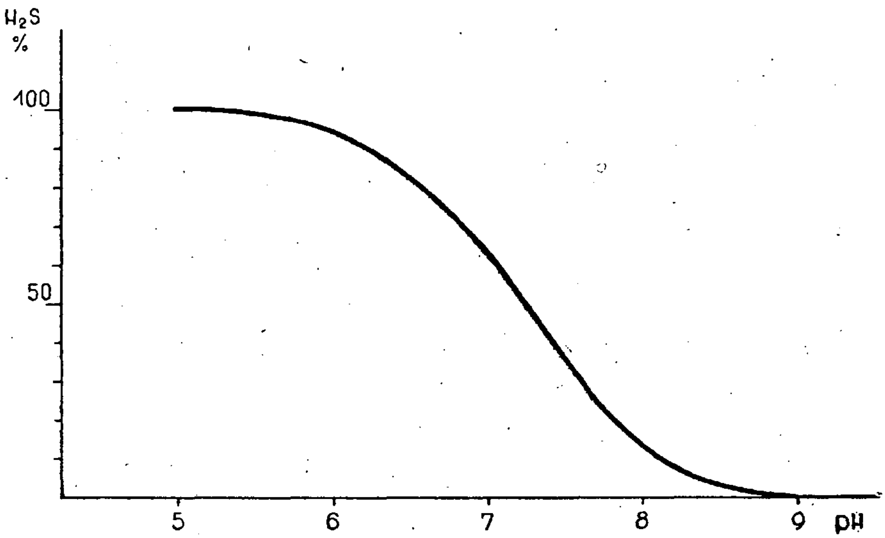

Fig. 1. Dissociation of H_2S according to pH-value (Rubentsik 1947)

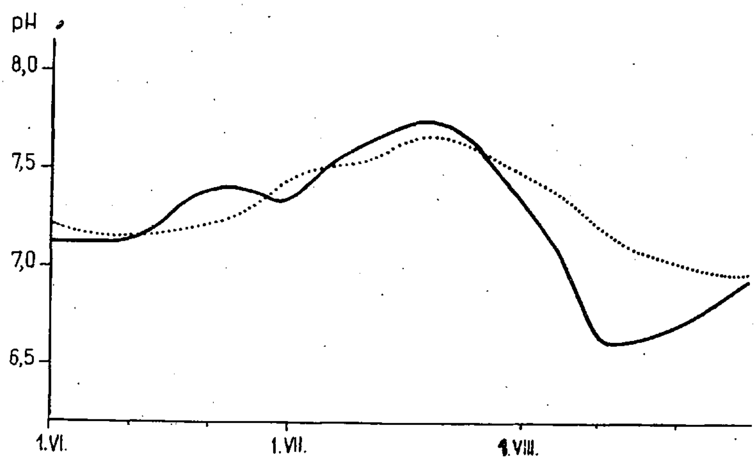

Fig. 2. The changes of the pH value in Kopáncs in 1956 (...... ——) and 1959

The danger of damages will arise when as a consequence of being released at a rapid pace, H_2S attains a greater concentration. The pH-values of submerging waters are plotted in a diagram on Fig. 2. The pH-value is influenced, besides the temperature, by organic matter contained in the soil, the height of the submerging water table, the exposition of the soil, the depth of the impermeable layer, previous soil management, etc. This explains that pH-values may vary, even on one and the same farm, within wide limits.

The Influence of Climatic Factors

From the incidence of the disease in some years — 1949, 1954, 1955, 1959 — and its complete absence in others — 1950, 1951, 1952, 1956, 1957, 1958, 1960 — it seemed a likely presumption that favourable weather protects the plant against the noxious influence or possibly prevents the formation of the agent causing the disease. The obvious course to be taken was therefore the closer examination of weather conditions prevailing in damaged and disease-free years respectively, particularly in the critical period. This critical period begins with the elongation of the stem, when oxygen supply through the roots declines (1). As already stated in our previous papers weather conditions in years free of disease differ chiefly in the abundance of sunshine from years of great damage when weather has been cloudy (31). In gloomy weather the rice plant susceptible to the disease translocates little or no oxygen to its roots (31). The roots uptake oxygen from their environs, thereby furthering reductive processes and incidentally the formation of their own toxic agents. As a result there is a rapid decay of roots. On the contrary, in fair weather the plant has a large reserve of healthy roots, as replacement is continuous. The distribution of sunshine during the months of July and August of the years 1955 and 1959 when there have been severe damages, as against 1956 and 1960, years free from disease, is recorded in Figs. 3. and 4. From the data available we established that in 1955 and 1959, during the period preceding the setting-on of the disease there have been much larger quantities of ferrous sulphide in the root zone than e. g. in 1956 and 1957 when no or very small quantities of ferrous sulphide have been found in the root zone.

The quantities of sulphides found in the soil of the experimental fields are shown in the below table.

Table 1.

The quantitative change of the S^{--} in paddy soils.

Depth cm	S^{--} mg/100 g			
	Kopáncs Palé 1955	Kopáncs Ökröstó 1955	Gencshát I. 1958	Gencshát II. 1958
0— 5	6,2	7,7	4,6	5,4
10—15	0,5	2,1	0,4	1,0
20—25	trace	0,5	trace	trace

The quantities of sulphides shown in the above table and light conditions by themselves do not explain the sudden appearance of the disease. As a further approach to solve the problem we made a closer survey of weather conditions at the onset of the disease. According to our own observations, in

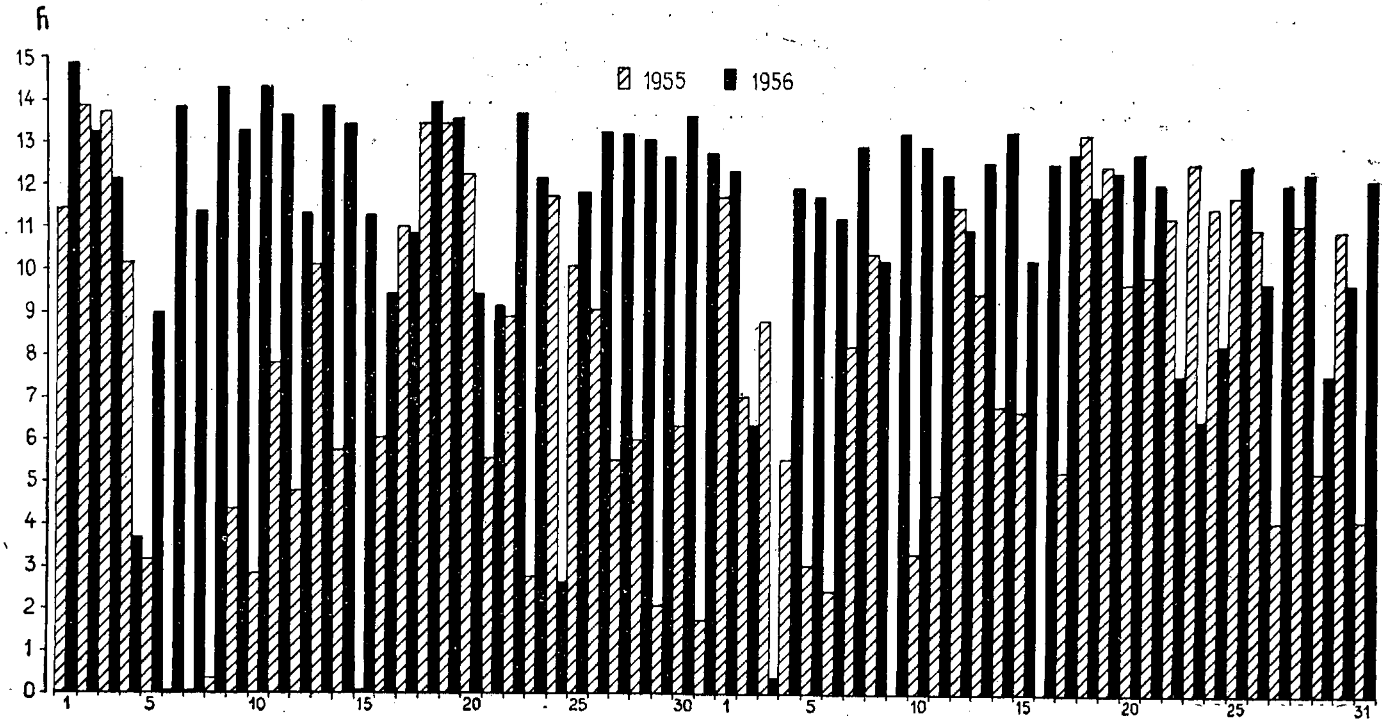

Fig. 3. Solar radiation in July and August in 1955 and 1956.
(1955 damaged and 1956 no damage.)

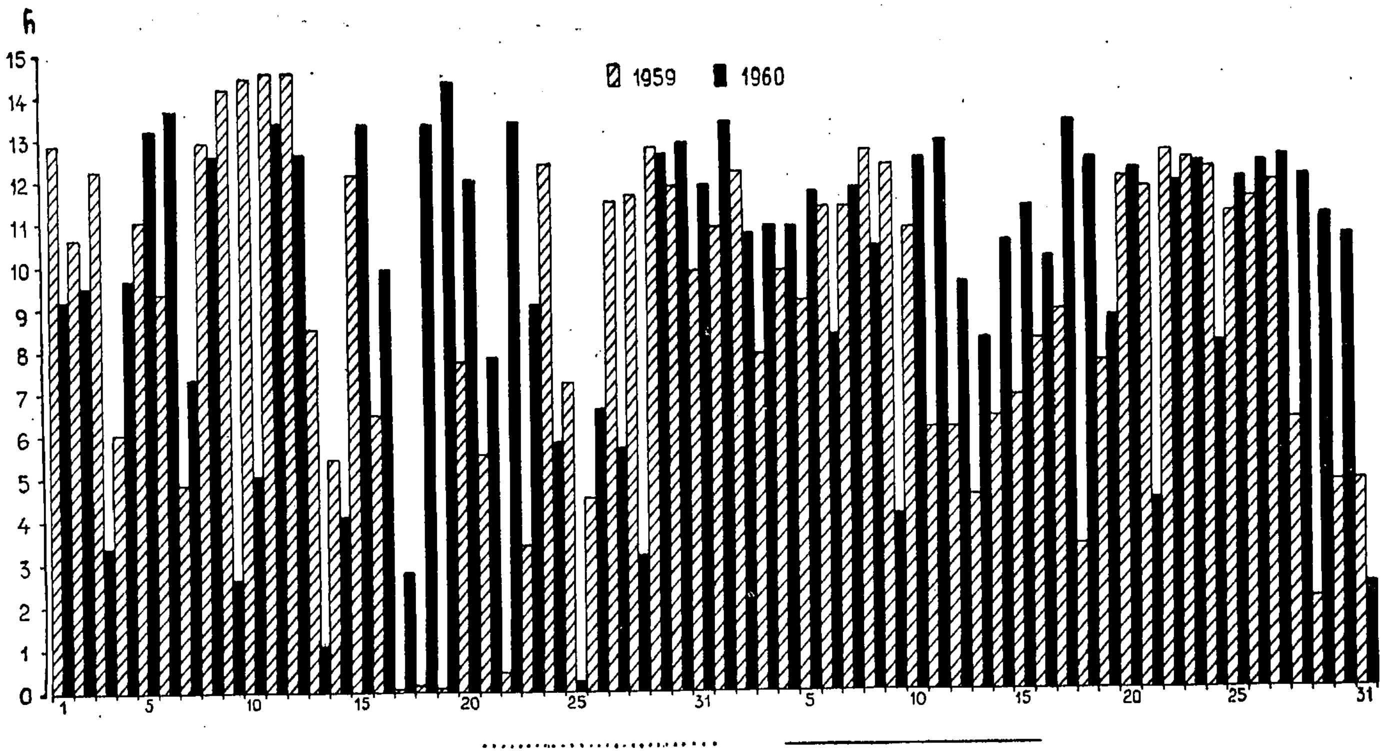

Fig. 4. Solar radiation in July and August in 1959 and 1960. — (1959 damaged and 1960 no damage) Time of flowering in 1959 .... and time of flowering in 1960 ______.

1955 and 1959 there was heavy fog during florescence above the damaged fields at *Tiszasüly*, *Karcag*, *Kopáncs* and *Deszk*. It is characteristic of fog forming above rice fields that it broods over the field. However, in the course of years we have observed that even the greatest fogs do not cause such damages in the rice fields situated along the *Danube*. Our own observations have further proved that even extreme fogging has failed to cause damages

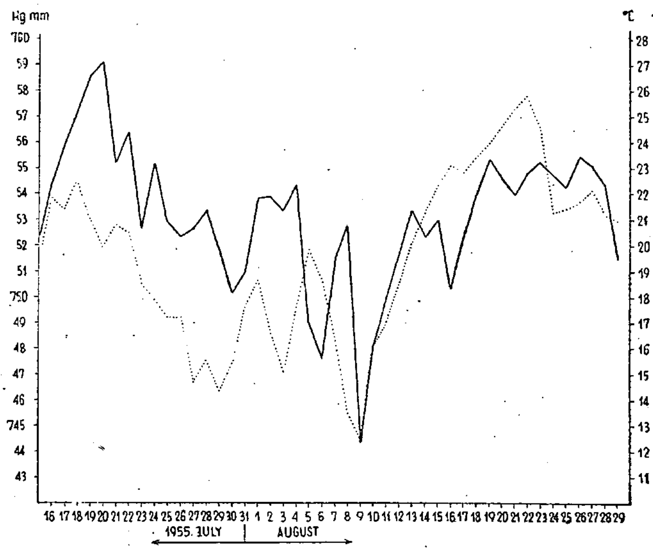

Fig. 5. Changes of temperature and atmospheric pressure from July 15 — to August 31 in 1955 Szeged University .... atm. pressure ——— temperature.

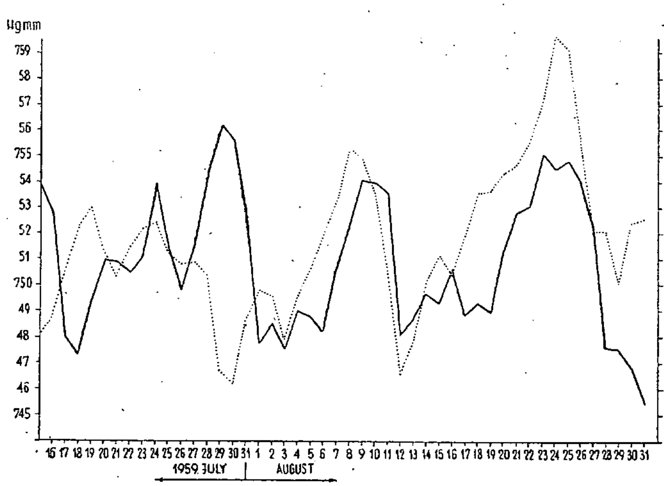

Fig. 6. Changes of temperature and atmospheric pressure from July 15. to August. 31. in 1959. Szeged University..................... atm. pressure, ——— temperature.

in the rice farms belonging to the Irrigation System of River *Tisza* during the years 1956, 1957 and 1958. Hence, fog alone cannot cause sterility.

To test this assumption we have made experiments with susceptible variety *Dunghan Shali.* Flowering rice plants grown in pots have been re-

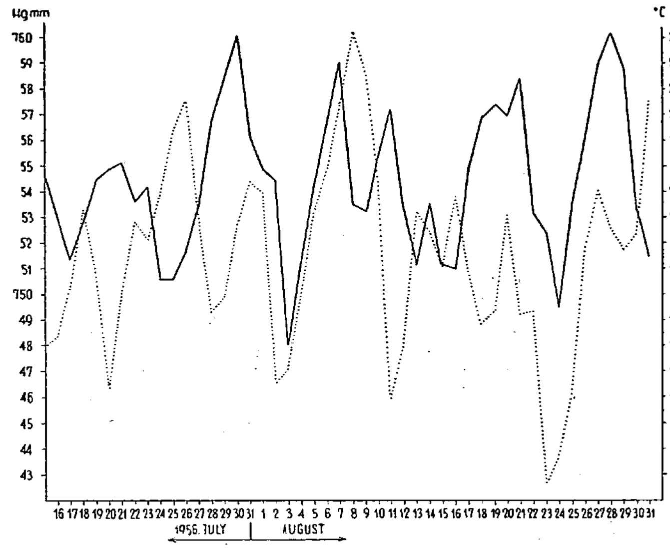

Fig. 7. Changes of temperature and atmospherie pressure from July.15. to August 31. in 1956. Szeged University .... atm. pressure ______ temperature.

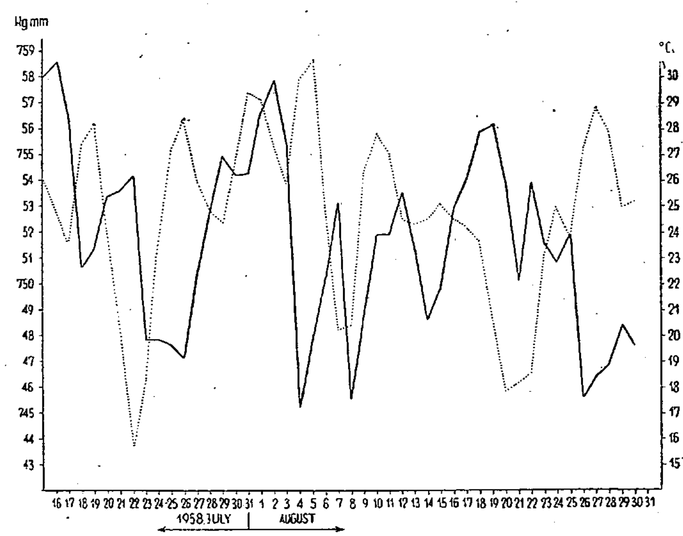

Fig. 8. Changes of temperature and atmospheric pressure from July 15. to August 31. in 1958. Szeged University .... atm. pressure, ______ temperature.

peatedly sprayed with 4 °C water, while other plants have been repeatedly submerged. We have been able to establish from these informatory experiments that cold water and vapour did not prevent the fertilization of rice. Accordingly, fog alone does not bring forth the disease, yet it may become a significant factor.

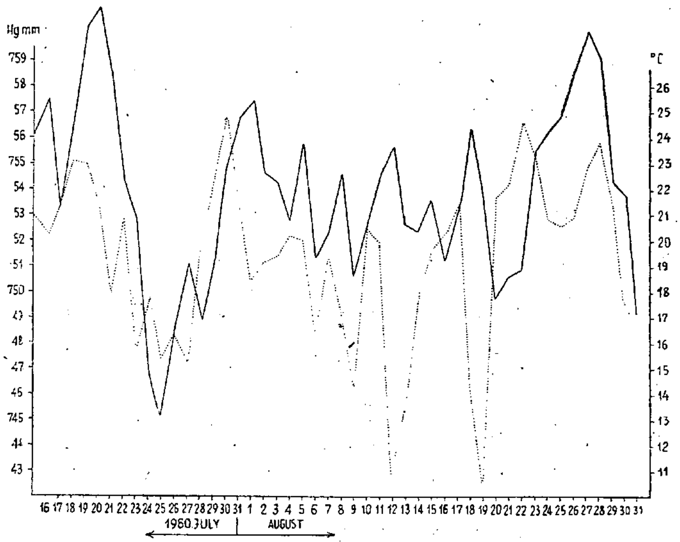

Fig. 9. Changes of temperature and atmospheric pressure from July 15. to August 31. in 1960. Szeged University .... atm. pressure ——— temperature.

We have further observed that in every instance the disease in accompanied by atmospheric depression. Fig. 5. and 6. below show barometric pressures and temperatures in the damaged years 1955 and 1959, as against barometric pressures and temperatures between *July 15* and *August 31* in the years 1956 and 1958 when no disease has been recorded. (Fig. 7 and Fig. 8.). The onset of „straighthead“ has been observed on the *1st*, the *3rd* and after the *9th of August 1955*, on *July 30* and *August 11* in 1959, but blast broke out at the same time. It can be seen from the proceding figures that in every instance there was a heavy depression in the atmosphere. In 1955 there was moreover an unusual fall in temperature.

In 1959 the sky was cloudy from *July 16* for 9 days on and this was followed by the atmospheric depression shown in the figure, after which the disease broke out for the first time, to reappear again after *August 12*. Fig. 9. shows atmospheric and temperature conditions during the unusually cool year 1960. Given the abundance of sunshine shown in fig. 4. the rice plants have easily withostood the detrimental effect of cool weather. The question is to establish the role played in the disease by sudden fall in temperature, depression and fog. The next step was to elucidate the way in which fog might further the detrimental effect of H_2S.

Atmospheric Depression

The bulk of the hydrogen sulphide, collects in a way similar to other marsh gases contained in the mud, in the cavities kept together by the rice root system. We have observed that soils susceptible to „straighthead" are particularly sludgy and contain a large portion of organic matter in decomposition. When the pressure acting on the water surface decreases, gases accumulated in the mud escape first into the water and then into the atomsphere. This is when H_2S escaping into the air can be smelled.

It is frequent, particularly with heavy soils, for the roots of the rice plant to spread on the surface, i. e. horizontally. Such horizontal growth of the roots may be caused e. g. by abundance of nitrogen, thin upper layer, deep water cover, etc. The roots spread in the surface layer are partly or fully destroyed by hydrogen sulphides formed under the said climatic conditions in the same layer. Even small quantities of hydrogen sulphide impede root respiration, assimilation of water and nutritive material; should the plant be exposed to such influence in the period of florescence, ensuing lack of water in itself may cause the sterility of the panicle. That is the disease called „brusone". The lesion is accompanied by the appearance of more or less fungi of the species *Piricularia oryzae* Cav. Yet sterility may occur without the lesion of the roots and the characteristic browning of the nodes, and this is the typical „straighthead".

In the rice fields there is a specific microclimate. Above the layer of water rise in temperature by day is less, while fall in temperature by night is more marked than above the neighbouring dry lands. Hence fogging is frequent above rice fields. Fog is formed at dawn after cloudless, calm nights following the drop in temperature. We have records covering several years showing that fog formed in the rice fields hangs at an approximate height of 80 to 120 cm at the so-called *„panicle level"*. WAGNER (34) has proved by microclimatic measurements that the lowest air temperature is found at this level and this is the reason why the fog spreads at panicle level above the submerging water having a higher temperature than the air. As a consequence of increased water acidity and atmospheric depression, the H_2S escaping from the relatively warm water again dissolved in the cold damp may reach the embryonic seeds and kill them. Since fertilization and the entire generative phase require large amounts of oxygen, it is easy to see that a relatively small amount of hydrogen sulphide is sufficient to sterilize the panicle. We have not yet been able to determine the smallest quantity of H_2S causing complete sterility. The possibility for the lesions to be caused by H_2S escaping into the air and condensing again in the cold damp (fog) has been suggested by the following observations.

(1) In 1955 we have observed at the *Palé* experimental station of the *Kopáncs* State Farm that the plants growing on the dam slope and not continuously submerged have been attacked by the disease in the same way as the plants permanently under water. Note, that all plants flowered at the same time.

(2) In August 1955 we have observed at the *Tiszasüly* State Farm that the leaves of willow plants on the dam running across several hundreds of yokes planted with heavily damaged rice showed a curious lesion at the time of the disease. The lower part of the shrubs was yellow, while the

upper part retained its normal green colour. According to the workers the shrubs turned yellow up to the level of fog observed the previous days. In both cases the plants have been attacked through the air and not through the roots.

(3) BERTALAN DÉNES, chief agronomist, told us about his having observed that in the smaller rice fields located in the river loops about *Tiszasüly* there was no incidence of „straighthead“ in 1955. MR. DÉNES further observed

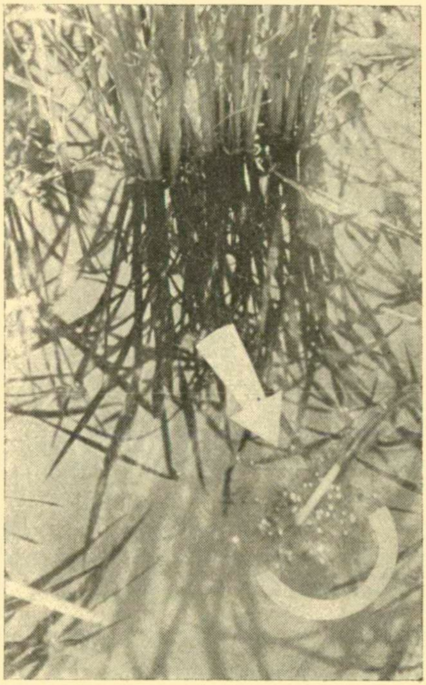

Plate. 3. Bubbles due to fall of the atmospherical pressure.

that above these fields protected by the woods in the flood area there was no fog and no fall in the temperature of the air, and he attributes the absence of disease to this circumstance, considering that fields a few kilometres farther off have suffered 100 per cent. damage.

On these observations we have made laboratory test to study the effects of vapour saturated with H_2S.

These informatory tests have yielded the following results:

(1) In dry atmosphere H_2S gas (100 mg/cu. m) does not cause sterility.

(2) Vapour of room temperature containing 100 mg/cu. m H_2S completely sterilizes the flowering rice plant. The lesion brought about in the laboratory was similar also in outward appearance to the lesion occurring in the field.

(3) Vapour containing hydrogen sulphide did not attack rice leaves, but willow leaves proved particularly susceptible and turned yellow in the same way as open air plants at *Tiszasüly*. In the years 1956, 1957 and 1958, despite repeated fogs, fall in temperature and depressions occurring during the critical time of florescence, there has been no disease because in the favourable sunny weather the metabolism and respiration of the rice plants went on undisturbed, hence no sufficient amount of H_2S could form and accumulate in the root zone to cause lesions by escaping.

Role of the temperature fall

On the basis of many experiences may be said that the mud contains considerable sulphide, and the rapid drop in the temperature promotes the appearance of both the „brusone" and the „straighthead". Cansequently the temperature fall has to favour the release of H_2S. Namely, the cold increases the oxigen content of the water. Owing to this fact the surface of the sulphide-layer is

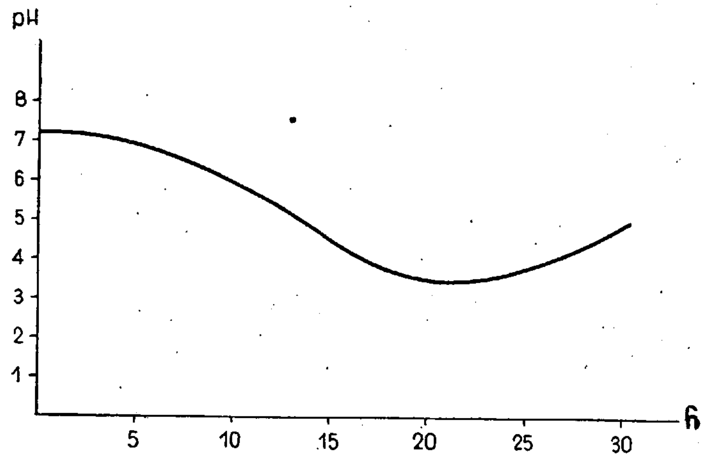

Fig. 10. Changes of pH value in reduced layer in aerobic condition.

oxidized to sulphuric acid. Thus in such cases an extremely low pH-value, about 3,5 may be measured. (Fig. 10). Under such conditions the H_2S is suddenly released, whereby a considerable reduction is shown in the sulphide content of the mud while an increse is noted in the sulfate content in the water. Fig. 11. denotes the pattern of liberation of H_2S and the way of the damage of the rice plant done by it.

The Problem of Resistance

It is a known fact that certain rice varieties show definite resistance against the disease (18). According to TISDALE and JENKINS (18) rice varieties with short seeds are more resistant against the disease. Experience accumulated in this country up to date supports this opinion. Such resistant varieties are the following:

Uz Rosz 17, Uz Rosz 72, Linia 45, Precocce (Allorio, Dubovszkij 129. Resistance to „brusone“ and to „straighthead“ are fully identical. These observations support our assumption that the agents directly responsible for the

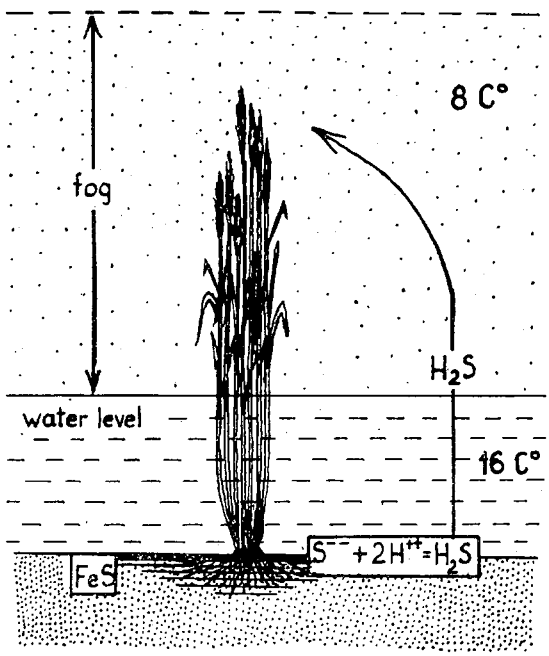

Fig. 11. Pattern of the release H_2S and lesion of the rice plant done by it.

diseases called „brusone“ and „straighthead“ are identical. With the difference, however, that in brusone the H_2S gas attacks the root, hindering its function or blocking certain elements prevents uptake of the nutrients, while in case of the „straighthead“ it is the flowers of the rice that are attacked.

Thus the metabolic processes are not influenced nor are they disturbed. Consequently, with this lesion fungi *(Piricularia oryzae, Helminthosporium oryzae)* appearing on the leaves mainly as a result of disturbances in the nitrogen metabolism are not observed. Japanese researchers have proved that hydrogen sulphide acting on the root is a factor favourable to fungi. (5).

A further problem is the correct interpretation of the resistance of certain varieties. In the case of brusone the resistance of some varieties can be explained by their demanding less light or having more vigourously developed roots and hence a higher oxidizing capacity. Variety *Uz Rosz 17* has a far better developed and more vigourous root system than the *Dunghan Shali* variety of the same age.

In the case of „straighthead", in our opinion, resistance should be attributed similarly to the higher oxydizing capacity of the root system. In fact, as a result of better oxygen supply less sulphides are formed about the roots of the resistant varieties, thus, a smaller amount of hydrogen sulphide escaping, no lesion takes place.

The further question is when and where do „brusone" and straighthead occur? In our opinion „brusone" attacks the plant in places where the root system, as a result of the above said causes inherent in the soil, spreads horizontally immediately below the surface, i. e. in the zone where H_2S is generated, where H_2S can fully exert its toxic effect. This was the case e. g. of the brusone at *Kopáncs—Ökröstó* in 1957. „Straighthead", on the other hand, appears where the root system growing in depth avoids the immediate damaging influence of hydrogen sulphide, but enough H_2S dissolves in the vapour situated at panicle level during florescence to cause sterility.

Since in both cases we have to deal with the same noxious agent, it is comprehensible that both diseases are favoured by the same soil and climatic factors. The influence of these factors has been described by several authors (7, 11, 13, 14, 15, 18, 22).

Histological Examination

In general we have not detected browning on the nodal cross-sections of plants attacked by straighthead. Colouring typical of „brusone" may happen to be detected at the base of the stem and in the cross-section of the roots (18, 27, 28).

Artificially produced „Straighthead"

Several authors have recorded that „straighthead" could be produced by overdoses of ammonium sulphate (6, 18). In our own experiments we have also employed ammonium sulphate to produce this lesion. We have utilized quantities varying from 1 to 10 q. per cadastral yoke. Experiences performed during a period of several years permit the assumption that spreading on the surface favours „brusone", while administering at the roots rather produces „straighthead". Experiments with „straighthead" have been successful in 1955 and 1959 only, when weather conditions have been appropriate. Experiments did not yield any results in other years, since sunshine was abundant. Similar results have been reported by BALDACCI, CIFFERRI and FABRIS (6), who have been unable to produce rice sterility even with tenfold doses of ammonium sulphate and dry blood. However, in the year they made their experiments there have been no disease in this country either, since weather was warm and sunny throughout Europe.

What precedes gives a pointer to the two methods of protection, namely breeding of resistant varieties or preventing the formation of hydrogen sulphide.

Summary

The „straighthead“ of rice is a complex problem in which the immediate cause and the favourable factors are in causal relation, research work meant therefore the simultaneous elucidation of the immediate cause of several factors and of the correlation between symptoms. The damage is incident on the acidic deposit of the river *Tisza* and its tributaries, i. e. on the soil produced in these areas, in unfavourable weather conditions. In rice fields along the *Danube* „straighthead“ is unknown even in bad weather, consequently the noxious agent originates from the soil. Since the root system of the rice plant is not or only slightly attacked by this disease, ecological factors play also a significant role in the noxious influence.

In soils where „straighthead“ is incident large quantities of hydrogene sulphide are generated as a result of microbiological activity. The lesion occurs during the florescence of rice, when due to the acidity of the flood water and to atmospheric depression the H_2S is released from the mud and from the water into the air. Namely, when the plants are attacked, atmospheric pression and temperature drop and there is a marked formation of fogs. In such cases H_2S releasing from the relatively warmer water is again dissolved in the fog at panicle level and causes sterility.

Soil and climatic factors of this disease are identical with those of „brusone“, yet while „brusone“ kills the roots and the sterile panicles droop, the root system of „straighthead“ rice remain healthy and the empty panicle stands erect. In the former case H_2S attacks the root system, prevents the uptake of water, oxygen and nutritive agents, and thereby causes sterility, in the latter case, with „straighthead“, sterility is a consequence of H_2S directly attacking the flower.

References

1. *Alberda, Th.:* Growth and root development of lowland rice and its relation to oxygen supply. Plant and Soil **5**, 11—29. 1953.
2. *Alesin. I. P.:* Vlijanie uszlorij prorasztaniaja na oxidazii i katalazii risza. Fiz. Raszt. **5**, 4. 1958.
3. *Antipov—Karatajev, I. N.:* Szolonyecek melioraciója a Szovjetunióban, Szovjet Tud. Akadémia. Moszkva—Leningrad. 1953.
4. *Arany S.:* A szikes talaj és javítása. Mezőgazdasági Kiadó. 1956.
5. *Baba, O., J. Takahashi, J. Iwata:* Nutrients absorbtion of rice as affected by H_2S added to culture solution. Proc. Crop. Sci. Soc. Japan al. 98—99. 1952.
6. *Baldacci, E.: Cifferi, R. Fabris, A.:* Ricerche ed esperienze sulle malattie del riso. VII° La concimazione azotata in relazione alla patologia del riso e alla sindrome indicata come lussuria. Atti Ist. Bot. Pavia V, 8 (5), 202. 1951.
7. *Chiappelli, R.:* A rizs gombabetegségei. Önt. Közl. 2. 233—245. 1940.
8. *Corbetta G., De Rege, F.:* L'analisi del Rapporto azotosostanze organiche, Il Riso. reprint. 1957.
9. *Darab, K.:* A vetésforgó néhány növényének hatása tiszántúli talajaink szerkezeti viszonyaira. Agrokémia és Talajtan. 4. 305—312. 1955.
10. *Erigin, P. Sz.:* Fiziologicseszkie osznovi orosenija prorosztkov risza. Moszkva—Leningrad. 1950.

11. *Frank, M.:* A rizs bruzone betegsége. Agrártudomány. 1. 298—303. 1949.
12. *Gerei, L.:* Adatok hazai talajtípusaink könnyen oldható vas és alumínium tartalmának vizsgálatához és jelentőségéhez. Agrókémia és Talajtan. 5. 171—182. 1956.
13. *Goto, L., Tai, K.:* On the differences of oxidizing power of paddy rice seedling roots among some varietes. Soil and Plant Food. 2, 198—200. 1957.
14. *Grist, D. H.:* Rice. Longmans Green and Co. London. 1959.
15. *Obermayer, E.:* A hazai rizstermesztés kilátásai a legújabb kísérletek és tapasztalatok alapján. Közlemények a szegedi M. kir. Növénytermesztési Kísérleti Állomásról. 1940.
16. *Obermayer, E., Somorjai F.:* Újabb két év tapasztalatai a magyar rizstermesztés körül. Közlemény a szegedi M. kir. Növénytermesztési és Növénynemesítő Kísérleti Intézetből. 1942.
17. *Okajima, H., Takagi, S.:* Physiological behavior of hydrogen sulfide in the rice plant. II. Effect of hydrogen sulfide on the content of nutrients in the rice plant. Sci. Rep. Res. Inst. Tokohu Univ. 89—99. 1955.
18. *Padwick, G. W.:* Manual of rice diseases. The Commonwealth Mycological Insitute Kew. 1950.
19. *Pearsall, W. A., Mortimer, C. H.:* Oxidation-reduction potentials in waterlogged soils, natural waters and muds. J. Ecol. 27. 483—501. (1939).
20. *Ponnamperuma,* F. N.: The chemistry of submerged soils in relation to the growth and yield of rice. Thesis. Cornell Univ. 1955.
21. *Rubentsik, L.:* Sulfatreducijusnije bakterii. Moszkva—Leningrád. 1947.
22. *Sik, K.:* A rizs barnulásos megbetegedésének oka és megelőzése. Hidr. Közl. 3—4, 106—110. 1949.
23. *Somorjai, F., Járányi, Gy.:* Rizstermelés. Mezőgazdasági Kiadó. Budapest, 1954.
24. *Szabolcs, I. Máté, F.:* A hortobágyi szikes talajok genetikájának kérdéséhez. Agrókémia és talajtan. 9. 31—38. 1955.
25. *Szabolcs, I.:* Die Degradierung der Bewässerten Reisböden in Ungarn. Chemie der Erde. 20. 36—48. 1959.
26. *Szabolcs, I., Darab, K.:* Accumulation and dynamism of silicic acid in irrigated alkali („szik") soils. Acta Agronomica Hung. 8. 213—235. 1958.
27. *Szepes, J.:* Vizsgálatok a rizs barnulásos megbetegedésének korai felismerésére. Agrártudomány; 6. 72. 1954.
28. *Szepes, J.:* A brusonés szövetbarnulás mértéke különböző rizsfajtákban. Kísérletügyi Közlemények. Növénytermesztés. 1. 21—37. 1960.
29. *Takai, J., Koyama, T., Kamura, T.:* Microbial metabolism in reduction process of paddy soils. Soil and Plant Food 2. 63—68, 1956.
30. *Thomas, K. M.:* A new paddy disease in Madras. Madras agric. J. 29. 34—36. 1931.
31. *Vámos, R., Andó, M.:* Die Rolle des Sonnenlichtes in der Bekämpfung des in den Reisböden entstehenden H_2S. Acta Biol. Szeged, 5. 61—69. 1959.
32. *Vámos, R.:* The role of soil's excess nitrogen in the bruzone of the rice. Acta Biol. Szeged. 2. 103—110. 1956.
33. *Vámos, R.:* „Bruzone" disease of rice in Hungary. Plant and Soil. 11. 165—77. 1959.
34. *Wagner, R.:* Angaben zum Mikroklima der Reisfelder in Kopáncs. Acta Climatologica. 1. 3—27. 1959.
35. *Zsoldos, F.:* Changes in the free amino acids of the rice seedlings induced by low temperature and H_2S. Current Science. 3. 123—124. 1959.

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