THE NPK CONTENT OF THE EXUDATION SAP OF RICE PLANTS GROWN IN ALKALINE SOILS OF DIFFERENT TYPES

by

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Introduction

In Hungary the weather certainly plays a considerable part in giving rise to rice disease, viz. brusone (braun disease). In strongly bound, uncalcarous (acidic) alkaline soils, characteristic of the region beyond the river Tisza or likewise in loamy limeless soils the sudden,, intensively destructive appearance of the rice diseases had repeatedly occurred (1949, 1954, 1955). Whereas in the calciferous-sodic alcaline soils of the Danube valley no intensive occurrence of the brusone was noted even under unfavourable weather conditions. So the conclusion can be drawn that the chemical differences in the soil may also have a role in the appearance of the disease.

According to HARMATI et al. (3) there is no fear of brusone in the strongly calciferous soils of the Danube valley, nor in unfavourable conditions as the damage, at the worst, amounted to 5—10 per cent.

PONNAMPERUMA (13) describing the chemical characteristics of rice-soils states that the brusone (brown disease) appears in Ceylon almost exclusively in poorly drainaged limeless (acidic) soils.

In VÁMOS' opinion (18), beside the susceptible regions, there are such areas where no damage occurs despite the presence of the predisposing factors (heat, fall in temperature etc.).

NEHÉZ (7) attributes the origin of brusone to the interaction of the metabolism and of the environmental factors.

On the basis of the literary data enumerated above it is obvious that the examination of the environmental factors of the rice plants, including that of the mineral nutrients, may give important results. Our experiments had the aim to determine the nitrogen, phosphorus and potassium up-take of the rice plants on the basis of the analysis of the exudation sap at different phases in soils making susceptible, viz. non susceptible to brusone.

Material and Method

The determination of the upward-streamed nutrients at the different phases of development of the plants was carried out by analysing the exudation sap. The basic principles and detailed description of the method were described by us (8, 9, 10, 11) and by others (2, 4, 5, 12, 14, 15, 16) too.

The sap was collected from four consecutive treatments so that the pipes were fixed in the evening and taken off next morning about 12 hours later. In every case equally developed plants were used for exudation. The sap obtained from 100 shoots of the varieties was mixed and measured. The weights were referred to the atomic weights of the nutrients also in the case of phosphorus and potassium. The concentrations obtained from the analyses were multiplied by the quantity of the sap obtained from 100 shoots and so received the nutritive content of the sap of each variety.

N, P and K concentrations were determined during the analysis. The ammonium-N was determined together with the organically bound nitrogen. During the analysis the mean error was below 0,02. This was calculated with $S = \pm \sqrt{\frac{\Sigma v^2}{n-1}}$, where v denotes the deviation from the mean value and n denotes the number of repetitions.

The experiments were made in the limeless alkalic soils of Sándorfalva (near Szeged) making susceptible to the brusone and in the calciferous sodic soils of Szúnyog (near Kiskunlacháza) not making susceptible in 1955. In the soil of Sándorfalva where practically no calcium could be demonstrated in the upper 40 cm layer of the experimental plots, the intensively devastating form the brusone appeared in 1955. In Szúnyog, however, it did. not.

The variations of soil-improvement and fertilization were:

In Szúnyog (soil not-making-susceptible to the disease).

Plot „A": calciferous sodic alkalic, improved with calcium phosphate, 346 q. per cad. acre for 4 years, received 312 kg salt of Pét and 312 kg superphosphate per acre before sowing. Mark: corrected + NP.

Plot „B": calciferous-sodic, alkalic, the soil-improvement as in plot „A", however, without fertilizer. Mark: corrected + ∅.

Plot „C": not-improved calciferous-sodic, alkalic. Mark: not-improved.

In Sándorfalva (soil making susceptible to the disease).

Plot „A": limeless alkalic, improved with calcium phosphate, 180 q per cad. acre for 3 years, received 178 kg salt of Pét and 178 kg superphosphate per acre before sowing. Mark: corrected + NP.

Plot „B": limeless alkalic, soil-improvement identical with plot „B" without fertilizer. Mark: corrected + ∅.

Plot „C": not-improved limeless alkalic. Mark: not-improved.

Data concerning the soil-improvement and fertilization were made available for us by I. HARMATI's kindness.

For experiments Dunghan shali (ÖMIRT 39) susceptible to brusone was used. During the breeding season, exudation sap was five times collected and analysed at the phases of development as follows:

I. 18. July bolting
II. 29. July after bolting
III. 10. Aug flowering
IV. 17. Aug ripening
V. 24. Aug ripening

Results

The vertical axis of the graphs resulting from the chemical analyses shows the N, P or K content of the exudate of 100 rice plants for 12 hours in mg, whereas the (Roman) numbers on the horizontal axis shows the exudation time mentioned above, viz. the phases of development. The columnar graphs found on the right side of the figures illustrate the amount of the quantities resulting from the quintiple analyses, namely, which variant had a better up-take from the proper nutrient during the examination (5 times 12 hours). Fig. 1 shows the N content of the saps.

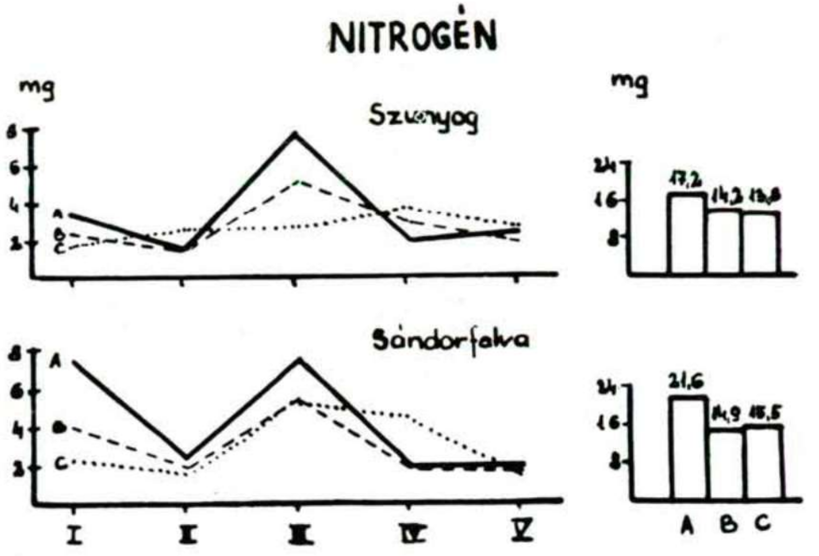

Fig. 1. The nitrogen content of the exudation sap of 100 rice plants grown in the calciferous-alkalic soil of Szunyog and in the limeless-alkalic soil of Sándorfalva.

„A" improved + NP
„B" „ ∅
„C" not-improved

I. Bolting
II. At the end of bolting
III. At flowering
IV. At ripening
V. „ „

The nitrate-N in the sap of water-logged rice-plants could be demonstrated neither in the present nor in our earlier experiments, only in the sap of rice grown in dry condition (8, 9).

Water-logged rice-plants take up the nitrogen in form of ammonium-ion, however, from the exudation-sap, a very slight quantity, a few μg, can be demonstrated. It follows that the root system, immediately after the up-take, converts it into an organic binding. Similar conclusion was drawn by Zsoldos (19) too.

It is evident that the change of the N up-take of the rice-plants grown in the limy sodic alkalic soils of Szunyog and in the limeless alkalic soils of Sándorfalva in the phases of development, as illustrated by the curves, is very much alike. The flowering maximum is also in agreement.

Taking into consideration the N content of the differently treated plots, it appears that the sap of the plants of the improved and NP-fertilized plots („A") contained the highest quantity of N in both soils. This is well discernible on the columnar graph. This graph shows further that the difference between „A" and „B" treatment (Szunyog) is 21 per cent whereas between „A" and

„B" (Sándorfalva) is 45 per cent. According to the graphs of Fig. 1. the N content of the saps collected in Sándorfalva, considering the three kinds of the treatment, is higher than that of the saps of identically treated plants in Szunyog, though the difference is slight.

Fig. 2. presents the phosphorus up-take. This figure – as it is seen – is fourfold magnified, compared with the previous one, in order to be able to indicate the slight difference of the curves. Namely, the phosphorus content of the rice-plant sap 3 to times lower than the N content.

Considering the running of the curves of Fig. 2. it is obvious that in the non-making-susceptible soil of Szunyog the change of the stream of the phosphorus is very much like that of the nitrogen (Fig. 1.). The maximum is to be found also in the flowering with the curves of Szunyog. The direction of the curves of the rice-plants grown in soils making susceptible to the disease (Sándorfalva) is significantly differing from that of Szunyog; the maximum of the flowering period is missing. On the columnar graphs of the phosphorus can be noted that the amount of the quintuple analyses resulted also in a significant difference. The phosphorus stream of the rice-plant grown in soils non-making-susceptible to the disease is, in all the three treatments, more intensive than that of the rice-plants grown in soils making susceptible to the disease. The difference in „A" treatment is 42 per cent, in „B" 43 per cent and in „C" 27 per cent taking for basis that of Sándorfalva. The next, viz. the ratio of the graph of Fig. 3. is four times lower than that of the phosphorus, that is, it is identical with that of the N graph.

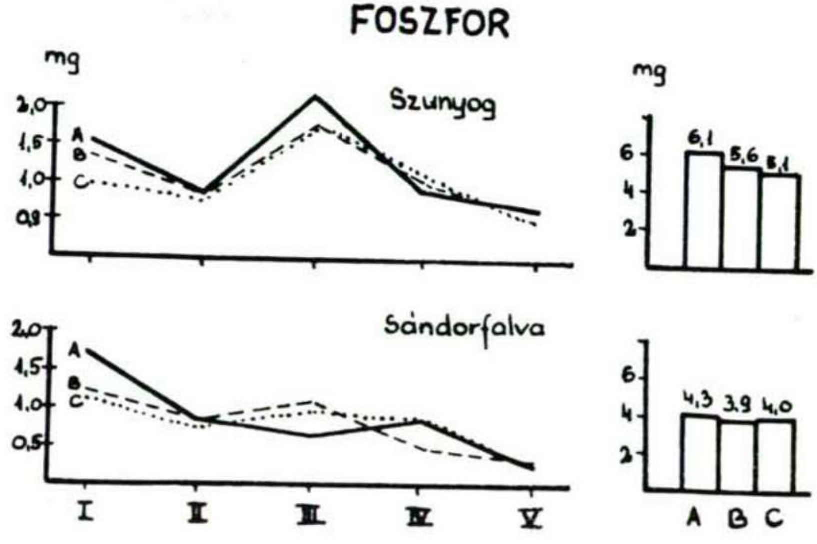

Fig. 2. Phosphorus content of the exudation sap of 100 rice plants grown in the calciferous-alkalic soil of Szunyog and in the limeless-alkalic soil of Sándorfalva.

„A" improved + NP
„B" „ Ø
„C" not-improved

I. At bolting
II. Atthe end of bolting
III. At flowering
IV. At ripening
V. „ „

The curves obtained from the K contents those of Szunyog, viz. curves of the rice-plants grown in non-making-susceptible soils are again identical with those of the nitrogen, those of Sándorfalva, however, are quite different. Taking into consideration the columnar graphs obtained from the amount of the quintuple analyses it turns out that the K streaming of the rice plants (Szu-

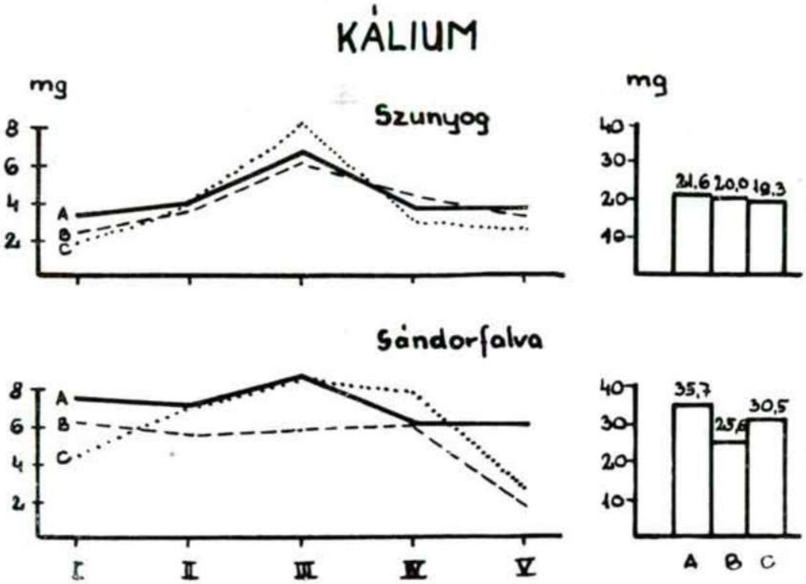

Fig. 3. Potassium content of the exudation sap of 100 rice plants grown in the calciferous-alkalic soil of Szunyog and in the limeleess-alkalic soil of Sándorfalva.

„A" improved + NP
„B" „ Ø
„C" not-improved

I. Bolting
II. At the end of bolting
III. Flowering
IV. Ripening
V. „

nyog) treated differently, hardly shows any difference from one another (21,6; 20,0 and 19,3 mg). There again considerable difference is shown in the plants grown in Sándorfalva (35,7; 25,6 and 30,5 mg). The data of the colummar graphs indicate further that the K content of the sap of the rice-plants grown in Sándorfalva, in all the three treatments, is significantly higher than that of the plants grown in Szunyog. The difference in „A" is 65 per cent, in „B" 28 per cent and in „C" 58 per cent.

The graphs, so far described, present the extent of the stream of the single nutrients and the change of the up-take in the phases of the development. From these, however, the relation of the nutrients to one another can not be proved as regards to the different soil-treatments and the two kinds of soil-type. Therefore the single nutrients are found in equal proportion on the graphs of Fig. 4 — summarizing the results of the quintuple analyses.

Fig. 4. shows that potassium in the sap of rice-plants can be found in the largest quantity in both type of soils. In this respect the various ways of soil-improvements and fertilizers showed no difference.

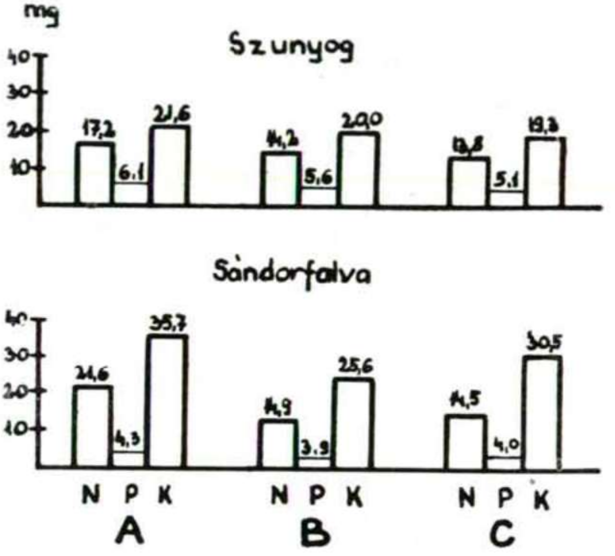

Fig. 4. The total nitrogen, phosphorus and potassium content of the sap — exudated five times in 12 hours — of 100 rice-plants grown in the calciferous-alcalic soil of Szunyog and in the limeless-alkalic soil of Sándorfalva.

Comparing the sap of rice-plants grown in the soils of Szunyog and Sándorfalva results that the sap of the plant — free from brusone — grown in Szunyog contains less nitrogen and potassium but more phosphorus than that of the plants grown in the soils of Sándorfalva, making susceptible to brusone; on the contrary the rice, harvested in Sándorfalva, with a higher content of nitrogen and potassium streams up phosphorus only in a lesser quantity. This phenomenon seems to be common and as Fig. 4 shows, it is manifested in all the three treatments.

For information, here are the harvest results:

	Szunyog	Sándorfalva
Plot „A" (improved + NP)	21,5	19,6 q/kh
„ „B" (improved ∅)	15,6	16,6 „
„ „C" (not-improved)	13,6	14,0 „

As regards the yields, a correlation can be found between the nitrogen, phosphorus and potassium up-take (Fig. 4) and the quantity of the crop; the yield of the plants with a better nutrient up-take is in general higher. Naturally, comparing the treatment of the plots with the up-take as demonstrated by us, it can be noted that the better up-take is correlated with the fertilization, i.e. with the soil-improvement. However it should be remarked that the efficacy is presumably more considerable vowadays than a few years earlier as the fresh broken grass plot or the virgin soil of the rice-growing stations were still rich in nutrients. In these soils, namely as a rule rice-monoculture was made for years (in Szunyog and Sándorfalva). Such farming, of course, simply exhausted the soils. To avoid such exploitation the crop-rolation system has been introduced.

Discussion

From the runing in connection with the phases of plant development (Fig. 1) may be stated that the change of the N up-take of the rice plants grown in the calciferous-sodic and in the limeless soil, viz. the tendency of the curves is very much alike. This follows naturally from the fact that there is no significant difference between the examined phases of development. Thus the difference between the N nutrition of the rice-plants of the two stations is hardly presumable to be a factor of susceptibility to disease. Further may be concluded from the data that the N fertilizer, in limeless soils, proved to be more effective. It is easily understood if we take into consideration that in Sándorfalva (limeless alkalic soil) the soil is strongly bound and compact; the soil is not leached out by the flood-water. In Szunyog (limy alkalic soil) the upper bound alkalic layer, however, is only 60—100 cm thick and beneath there is very permeable sand. The lower part of the bound layer is not alkalic everywhere or it is cemented with $CaCO_3$, consequently the nutrients can be easily washed out.

From the curves of the phosphorus up-take (Fig. 2) is distinctly discernible that there is a considerable difference between both the course of the single phases of the development and the total results of the five examinations. The tendency of the P curves of the rice-plants grown in the calciferous-sodic alkalic soil in Szunyog bears resemblance to the N curves whereas that of Sándorfalva differs from them. The difference is mainly attributable to the absence of the flowering maximum (III). It should be noted that the brusone on large scale appears, in the susceptible fields, just about this time. It is remarkable that the better up-take of P in the soils of Szunyog — despite the leaching out — was shown. We, ad well as other authors (6,17) had stated that the increase of the up-stream and infiltration of N is followed by a similar increase of P. In the present case this could not be realized. It may be assumed that the binding of P, in an impossible condition of up-take, is favoured by the anaerobic condition forming in the strongly bound limeless alkalic soils. Whereas in the soil of Szunyog being constantly washed by the fresh flood water rich in O_2 no anaerobic condition can be formed. Similar results were obtained by Dzubay (1) too, carrying out P fertilization experiments also in limeless alkalic soils, viz. in strounlgy bound acidic grass fields. On the basis of the author's results no significant crop-increasing effect could be demonstrated in consequence of the phosphatic manures of different quantity and quality in the two-year period rotation of rice-crop (waterlogged, anaerobic conditions).

The curves of K up-take prove that the K content of the exudation sap is considerably higher in the bounded, limeless alkalic soils making susceptible to the disease than in the calciferous — sodic alkali soils. The tendency in the phases of the development is also different, though the maximum of the flowering period can be found in both places.

In our earlier experiments, made on rice-plants (8,9), has already been stated that the streaming of the monovalent cations is considerably higher in limeless alkaline soils than in those non-making-susceptible to the disease.

Finally it was determined that the largest quantity of K is to be found in the sap of the rice-plants grown in both soils. In this respect the various fertilizations and soilimprovements did not show any difference. The quantity of N is only slightly less than that of K but the P content of the upward streaming sap is 3 to 4 times less than this. Bearing in mind these ratios it follows that the rice grown in the alkalic soil making susceptible to the disease causes somewhat more of N and significantly more of K stream, i.e. when it contains considerably less of P than the rice grown in non-making-susceptible soil.

Summary

The nitrogen, phosphorus and potassium up-take of rice-plants grown in soils making susceptible and non-susceptible to brusone was examined with the method of analysis of the exudation sap. The analysis were made in the different phases of development — five times in both lots — on the Dunghan Shali variety extremely susceptible to brusone. Investigations have been carried in both places in improved, not-improved and fertilized plots. The up-take has been always compared with plants of identical development and was stated:

1. The change of N up-take in the different phases of development of the rice-plants grown in alkaline soils making susceptible to the brusone is much alike to that of the rice-plants grown in non-making-susceptible alkaline soils (curves of Fig. 1). Out of the five phases of the development the highest nitrogen content was obtained at the flowering. Summarizing the results obtained from the different phases of development, in all the three cases, the nitrogen up-take of the rice-plants grown in soils making susceptible to the brusone is the higher one, though not much (columnar graphs of Fig 1).

2. The change of phosphorus up-take of the rice-plants grown in soils non-making-susceptible to the brusone in the different phases of the development is similar to that of the nitrogen while that of the rice-plants grown in soils making susceptible to the brusone considerably differs (Fig. 2).

3. The change of potassium up-take of the rice-plants in the different phases of the development is much the same as that of the nitrogen in soils not-making-susceptible to the brusone; in the other soil, viz. making susceptible to the brusone is strongly differing (Fig. 3).

4. The largest quantity of potassium can be found (Fig. 4) in the sap of the rice-plants grown in both making susceptible and non-making-susceptible soils. As regards quantity the nitrogen is the highest, the phosphorus content is the lowest in every sap, it is about one third or a quarter of the N content.

5. As to the quantity of nitrogen, phosphorus and potassium content of the saps — despite the considerably differing soils, viz. the various soil-improvements and fertizations — was not changed (Fig. 4).

6. The sap of the rice-plants grown in soils free from the brusone contains less nitrogen but more phosphorus than the plants grown in soils making susceptible to the brusone and vice versa; the rice-plants grown in making susceptible soil with higher nitrogen and potassium content causes the phosphorus stream in considerably less quantity.

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