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THE ION UPTAKE OF RICE PLANTS AT DIFFERENT pH VALUES

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The different requirements of the several rice sorts for nutritives are well known, concerning their physiological causes, however, we haven't any data at all. The utilization of the nutritives being, in high degree, a function of external factors (pH, light relations, temperature, etc.), therefore, e.g., if a chemical fertilizing procedure is introduced, we must take into account their physiological effect, as well.

Among the external factors the actual pH relation of the soil (water culture) plays a very important role. This, namely, affects, as known from the examinations of a lot of authors, in high degree the intensity of uptake of some nutritives (ions) (Sutcliffe, 1962; Jennings, 1963; Kürten, 1954; Fried et al., 1965; Wallace, 1963). As Hungary, too, is getting on with growing different rice sorts in several soil types, the examination of that and of similar problems seems to be reasonable.

Material and method

At our examinations there have been used the rice sorts Dunghan Shali *(Oryza sativa* var. *japonica)*, Dubovsky—129 *(Oryza sativa* var. *japonica)*, and Nhang Mon S—4 *(Oryza sativa* var. *indica)*. The test plants were grown in greenhouses (by 5.500 Lux), in water culture. Composition and method of the nutritive solution were discussed in details already earlier (Zsoldos, 1966).

For a continuous control of the pH of the nutritive solution, a measuring instrument with recording apparatus has been employed, by the help of which the so-called rhythm-change was measured, too. The setting of pH and its correction from time to time was performed with the aid of 0,1 n HCl or 0,1 n NaOH. For isotopic tracing P—32 and Rb—86 were used. The absorption solution, in which uptake and pH change was measured, was a saline solution of 5×10^{-4} M. During the investigations the activity of the different organs was measured directly and the results are expressed related to dry material (μmol/g). The roots were rinsed in distilled water three times (in a minute) after being taken out of the active solution. In the course of our experiments, there were applied at each occasion fifty 10—12 days old rice plants grown

under similar conditions (in three repetitions). The stabil isotopes have been determined by mass spectrometer as described by Fried and co-workers (1965). The results are expressed in relation to dry material ($\mu g/g$).

Experimental results

During the examination of our water cultures it was ascertained that in a nutritive solution the change of pH took very quickly place, influenced, of course, in a high degree by the ration of roots and fluid. The data

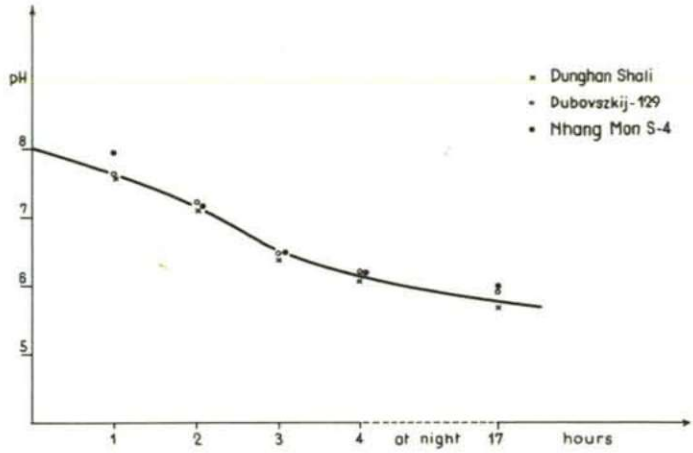

Figure 1. Examination of the change of pH-values by rice plants in a water culture.

of Fig. 1 are demonstrating well, that in an alkaline solution (pH = 8), a considerable decrease of pH can be observed in a short time after the beginning of the experiment. In case of acid or weakly acid nutritive solutions (pH = 4 and 6 resp.) a pH dislocation can be observed but after a longer time in the direction of the acid side, just as in case of an alkaline soluition.

The change of pH during the night is demonstrated similarly in Fig. 1. In this case, too, it keeps on decreasing getting to the minimal value in the morning following the beginning of the experiment. After that a minor pH increase can be observed.

In the course of our sort-comparing examinations, under the conditions investigated, there couldn't be found any major differences concerning the single rice sorts (Fig. 2). We have observed, anyhow, although demonstrated but a little by the graph, that the change of pH is slower in case of rice of indica type than at the other sorts.

We may consider interesting the experimental results in case of which the changes of pH of different absorption solutions were compared with one another at rice sorts of indica and japonica types. The obtained results are partially in harmony with the data of Fig. 1 as, at an

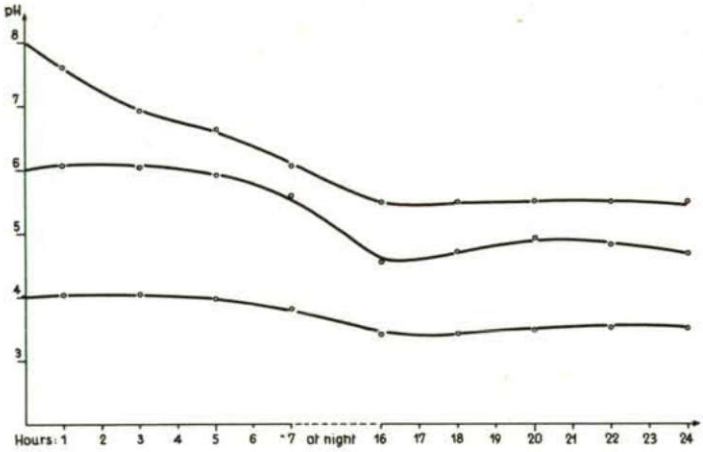

Figure 2. Change of pH-values by different rice sorts in a water culture.

examination of short duration, a major change of pH can be observed only if an alkaline solution has been applied (Table 1). It can be observed, as well, that the change of pH is more considerable at RbCl than in case of KH_2PO_4. This may be explained obviously by a different intensity of the anion-cation uptake. Among the different sorts there haven't been observed any considerable differences.

TABLE 1. Change of pH-values of the nutrition solution using different salts.

Rice sort resp. type	pH value at the beginning of the experiment	pH value after 120 minutes	
		RbCl	KH_2PO_4
Indica	4	4.05	4.10
"	6	5.85	5.90
"	8	6.70	7.25
Japonica	4	4.00	5.85
"	6	5.85	4.00
"	8	6.50	7.60

Concerning the intensity of the anion and cation uptake, as it was to be expected, considerable differences can be established in case of young rice plants, as well. Our results are demonstrated in Table 2. The data of the Table demonstrate also that in an acid medium both the uptake of phosphorus and that of rubidium are more favourable.

We hold as very remarkable the change of activity in the shoot of the single rice sorts, making possible a conclusion concerning the rate of ion transportation. It is interesting from that point of view to compare the intensities of root and shoot elongation of some two days old rice sorts

TABLE 2. Effect of pH on uptake and transport of Rb and P-ions (Uptake time: 60 minutes).

Rice sort	pH	Rb-uptake in μM/g D. W.		P-uptake in μM/g D. W.	
		root	shoot	root	shoot
Dunghan S.	4	107.2	4.28	28.8	0.81
"	6	101.3	4.83	18.7	0.78
"	8	72.0	3.99	15.5	0.29
Dubovsky	4	104.6	3.75	27.9	0.56
"	6	102.2	3.74	21.8	0.33
"	8	100.9	4.37	17.9	0.71

(Fig. 3). First of all Dunghan Shali differs from the others in growth rate of the shoot. The data of Table 2 call our attention also to the fact that, after an experimental time of one hour, a considerable part of the ions uptaken is accumulated in the roots since but a small part of the tracing isotopes got to the shoot.

Table 3 is demonstrating the uptake of nitrate and ammonium nitrogen at different pH values. The data of Table correspond thoroughly to the results of the experiments already made known and to other literary data referring hereto, as well.

TABLE 3. Effect of pH on uptake and transport of different N-compounds. (Uptake time: 90 minutes).

pH	NO_3-N uptake in μg/g D. W.		NH_4-N uptake μg/g D. W.	
	root	shoot	root	shoot
4	80.9	8.1	242.0	19.2
6	69.4	7.1	362.0	18.4
8	47.4	10.5	369.8	20.4

Discussion of results

The very important physiological role of pH is generally known. But there are comparatively few experiments concerning intact higher plants. An explanation of that may possibly be the fact that it is considerably easier to work with excised roots or micro-organisms than e.g. with intact plants. Our first and important ascertainment is that the change of pH in the nutritive solution takes place very fast, in fact in a few minutes. This is, of course, affected supposedly in a high degree by the ratio between the mass of root and the amonunt of the nutritive solution, as well. The change, as seen in Fig. 1, is particularly obvious in an alkaline medium. The close connection between the hydrogen ion concentration of the nutritive solution and the ion uptake may have different causes. Thus e.g., in the ion absorption of phosphate the pH

plays a particularly important role as, apart from the physiological effect, there follows here a considerable change in the ion form, as well. As the pH value rises the monovalent form ($H_2PO_4^-$) becomes divalent (HPO_4^{--}) and finally, the solution becoming strongly alkali, there exists only trivalent phosphate (PO_4^{---}). The latter one can, however, not be utilized by plants.

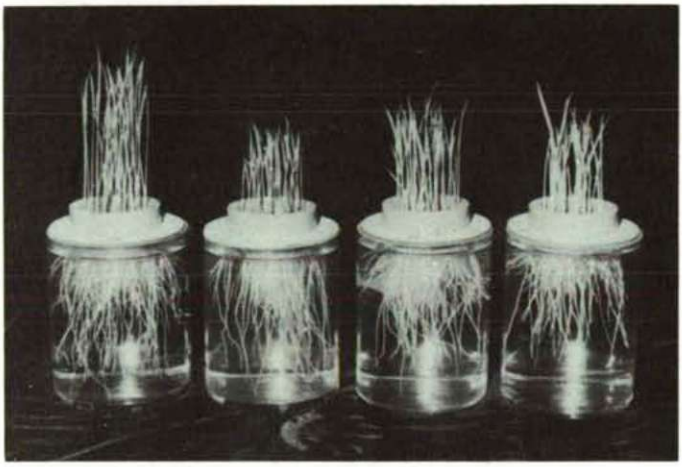

Figure 3. Rice sorts growing in nutrient solution. From left to right: Dunghan Shali, Dubovsky—129, Uzros—17, Nhang Mon S—4.

The considerable difference observed between the intensities of the anion and cation uptake is not surprising if we realize that the exchange capacity of cations is usually multiple of that of the anions, as demonstrated by several literary data.

It was demonstrated already in the course of earlier experiments by the help of stabil isotopes, too, that at experiments of short duration the optimum of pH of nitrate-N uptake is 4,0—4,5 while in case of ammonium-N the optimal pH is about 8 (Fried et al., 1965). This statement is supported repeatedly by our own experiments and it appears from the data that the acid, resp. the weakly acid medium (pH 5,5—6,5) may generally be considered optimal for rice. This, anyway, entirely agrees also with the practical observations (Kürten, 1954). We want to notice that the more intensive uptake of NH_4-N, observed in alkali solution, may not at all be considered really optimal as in that case we have already to reckon with some free NH_3 well-known as a cell-poison and a substance troubling the growth (Vines and Wedding, 1960; Varga and Zsoldos, 1963).

An important part of our experimental results is a comparison of the amounts of ions transported into the shoots in case of different rice sorts (Table 2). It is obvious that at the sort Dunghan Shali the ion content of shoot is considerably higher although the rate of root growth

is similar to that of sort Dubovsky. Although the ion uptake may be affected by the endosperm content of germinating plants, as well, nevertheless in this case where we have worked with isotopes it cannot be considered a methodical mistake. In fact, taking into consideration the physiological qualities of Dunghan Shali and the way how it utilizes the nutrients, by all that our opinion is supported that we are facing here a sort-peculiarity. Accordingly, some sort-peculiaritites can be demonstrated by such and similar methods.

Summary

In case of a few rice sorts the pH change that takes place in the nutritive solution has been examined during experiments of short and longer durations. It has been ascertained that, particularly in alkalic media, a considerable change of the pH occurs into acid direction even if examined but for a very short duration. At night the pH value got to its lowest level in the course of which we have measured a pH value of 3,8. The uptake of different ions is affected in a different way by the pH of the nutritive solution. Generally an acid medium (5,5—6,5 pH) may be considered optimal for rice, NH_4-N making, however, an exception. Concerning the amount of ions transported into the shoots we have observed considerable differences at the different sorts. Among the sorts examined by us, the shoot of Dunghan Shali contained the most isotopes from which an intensive metabolism can be concluded showing well also the vitality of this sort.

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