BIOLOGIA PLANTARUM (PRAHA)

9 (1) : 56—60, 1967

Metabolic Disturbances in *Nicotiana glauca*, a Symptomless Carrier of Potato Witches' Broom

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Received February 24, 1966

Abstract. Metabolic disturbances in *Nicotiana glauca*, a symptomless carrier of potato witches' broom were studied. The dry weight content of leaves of diseased plants was slightly decreased, that of the stems increased. The ash content in the dry weight of the whole diseased plant was decreased by 11%. Contrary to tomato plants which had shown considerable disproportions in the distribution of metabolites among the individual organs investigated (ULRYCHOVÁ, LIMBERK 1964), the content of the total nitrogen and of the individual nitrogen fractions of both leaves and stems of diseased *Nicotiana glauca* were decreased. The content of glutamine was increased in both organs in spite of the decrease of ammonia nitrogen by nearly 30% in both cases. The most striking disturbance found in the diseased plants of *Nicotiana glauca* was the 67% increase of a low-molecular phosphorus fraction (P extractable with 0·2N $HClO_4$) in the leaves. This result agrees with that found in diseased tomato plants and may be primarily associated with the virus infection. The content of all other phosphorus fractions of both leaves and stems was decreased.

In our previous work (ULRYCHOVÁ, LIMBERK 1964) we found considerable disproportions in the distribution of metabolites among the individual organs investigated in tomato plants infected with potato witches' broom. The physiological picture corresponded roughly to the morphological picture of the disease. The leaves of the diseased plant, markedly inhibited in growth and development, were actually starving and the content of all nitrogen and phosphorus fractions were decreased, except for the low-molecular phosphorus fraction soluble in 0·2N $HClO_4$ which was increased by 23%. On the other hand, the stems strongly thickened with many rootlets and sprouts along their entire length forming the characteristic brooms were overflowing especially with nitrogenous metabolites. The content of the total nitrogen was increased by 61%, that of ammonia N was raised 7-times and that of non-protein N 3·5-times. An accumulation of both glutamine and proline in stems of diseased plants was found. The content of the total phosphorus in stems was slightly lowered, but the fraction of P soluble in 0·2N $HClO_4$ and that of both RNA and DNA were increased.

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The aim of the present work was to obtain information which of the metabolic changes were directly associated with the disease. For this purpose we studied the pathophysiology of *Nicotiana glauca*, a symptomless carrier of potato witches' broom (VALENTA 1958). The symptoms of the disease were manifested only in flowers which are virescent and sterile.

Material and Methods

Seedlings of *Nicotiana glauca* were grafted early in spring with scions from diseased plants of *N. glauca*. The infectivity of all plants used for analyses was verified by regrafting on tomato plants. All analyses were carried out at least four months after grafting. In some experiments plants infected last year were used. Both infected and control plants were cut off several times during this period to form new sprouts.

The determination of dry weight, ash content and different phosphorus and nitrogen fractions was carried out according to the methods described in detail previously (ULRYCHOVÁ, LIMBERK 1964).

Results

The results of all analyses are summarized in Tables 1, 2 and 3.

As follows from Table 1, the dry weight content of leaves of diseased plants is slightly but significantly decreased, that of the stems increased. The ash content in dry weight of the whole diseased plant is decreased by 11%. These results agree with those found for tomato plants.

Table 1. Dry weight and ash content

Dry weight and ash content	Healthy plants $\bar{x}$	Diseased plants		Mean difference d	Standard deviation s	n	P
		$\bar{x}$	in % of healthy ones				
Leaves Dry weight in %	10·47	9·99	95·4	0·48	0·69	13	$P > 0{\cdot}05$
Stems Dry weight in %	8·43	8·79	104·2	0·36	0·74	8	$P > 0{\cdot}30$
Ash content in dry weight in % of the whole plant	9·87	8·77	88·8	1·10	0·70	3	$P > 0{\cdot}20$

The results of the phosphorus fractionation are summarized in Table 2. It may be seen that there are great differences in the content of individual phosphorus fractions between the leaves and the stems of diseased plants. In the stems the level of all fractions examined is lower. On the other hand, the content of the total phosphorus in the leaves is slightly increased. This increase is mostly due to a 22% increase of the inorganic phosphorus fraction and especially to the highly significant increase of the phosphorus fraction soluble in 0·2N $HClO_4$ (67%).

Table 2. Amount of different phosphorus fractions (in mg P/g of dry matter)

Fraction	Healthy plants $\bar{x}$	Diseased plants		Mean difference d	Standard deviation s	n	P
		$\bar{x}$	in % of healthy ones				
Leaves							
Inorganic P	1·47	1·80	122·4	0·33	0·56	7	$P > 0·20$
P extractable with 0,2 N $HClO_4$	0·53	0·89	167·3	0·36	0·14	7	$P > 0·001$
Lipid P	0·96	0·79	82·6	0·17	0·17	4	$P > 0·20$
RNA P	0·97	0·89	91·4	0·08	0·06	3	$P > 0·20$
DNA P	0·33	0·29	88·6	0·04	0·02	4	$P > 0·05$
Total P theoret.	4·26	4·66	109·3				
Total P	4·01	4·19	104·7	0·18	0·27	5	$P > 0·30$
Stems							
Inorganic P	1·60	1·22	76·0	0·38	0·17	5	$P > 0·01$
P exctractable with 0,2 N $HClO_4$	0·65	0·61	94·1	0·04	0·16	5	$P > 0·70$
Lipid P	0·68	0·65	94·4	0·03	0·16	4	$P > 0·70$
RNA P	0·62	0·50	81·0	0·12	0·11	4	$P > 0·20$
DNA P	0·18	0·16	87·2	0·02	0·01	4	$P > 0·05$
Total P theoret.	3·37	3·14	84·1				
Total P	3·69	3·30	89·6	0·38	0·35	4	$P > 0·20$

Table 3 summarizes the changes in the individual nitrogen fractions. The leaves and the stems of diseased plants show a lowered content of all nitrogen fractions. In spite of the decrease of ammonia N by nearly 30% it was found by paper chromatography that the glutamine content in extracts of both organs was higher, similarly to the diseased tomato plants. The glutamine content in the leaves quantitatively determined after the chro-

Table 3. Amount of different nitrogen fractions (in mg N/100 mg of dry matter)

Fraction	Healthy plants $\bar{x}$	Diseased plants		Mean difference d	Standard deviation s	n	P
		$\bar{x}$	in % of healthy ones				
Leaves							
Ammonia N	0·11	0·08	72·7	0·025	0·03	3	$P > 0·30$
Non-protein N	0·97	0·91	93·8	0·06	0·10	3	$P > 0·50$
Protein N	3·27	3·14	96·0	0·13	0·06	3	$P > 0·10$
Total N	4·35	4·13	94·9	0·23	0·14	3	$P > 0·20$
Stems							
Ammonia N	0·074	0·050	71·4	0·023	0·022	3	$P > 0·20$
Non-protein N	0·79	0·61	77·2	0·19	0·17	3	$P > 0·20$
Protein N	1·31	1·29	98·4	0·013	0·26	3	$P > 0·50$
Total N	2·18	1·95	89·4	0·23	0·19	3	$P > 0·20$

matographic separation and elution was increased by 31% (FISCHER, DÖRFEL 1953).

Discussion

When the results of the present work are compared with those previously published, the following conclusions could be drawn: Great disturbances in nitrogen metabolism, found in tomato plants, represent in our opinion consequent changes leading to striking morphological alterations. On the other hand, *Nicotiana glauca* does not show any morphological alterations due to the infection and the changes in the content of the individual nitrogen fractions being not essential, though there is a general decrease. The latter result agrees with the former findings (DUNLOP 1930), viz. that the content of the total nitrogen decreases in host plants which were infected with yellows.

The most striking finding is the 67% rise of the low-molecular phosphorus fraction soluble in 0·2N $HClO_4$. This fraction was also the only one which was increased in the leaves of tomato plants infected with potato witches' broom, where the content of total phosphorus was significantly lowered. Thus, we can suppose that this disturbance is primarily associated with this virus infection. The above-mentioned fraction involves mostly the phosphorylated sugars and nucleotides, including the ATP/ADP system, which has not only the role of the energy capture, transfer and supply, but also the regulating function between the exergonic and endergonic reactions. For the present we have no experimental data enabling us to presume a disturbance in the regulating function of the system ATP/ADP due to virus infection. But the foregoing findings of the increase in the respiratory rate after the infection summarized by WYND (1943), and the high sugar content especially of saccharose in the plants suffering from yellows and leafroll (PERDRISED, MACQAIRE 1963) and the findings of an increased glutamine level in potato witches' broom and in leaf-roll (ALLISON 1953) are facts that can be correlated with our presumption.

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M. Ulrychová, J. Limberk, Ústav experimentální botaniky ČSAV, Praha: **Metabolické poruchy u *Nicotiana glauca*, latentního hostitele metlovitosti bramboru.**—Biol. Plant. **9** : 56—60, 1967.

Byly studovány metabolické poruchy u *Nicotiana glauca*, latentního hostitele metlovitosti bramboru (potato withes' broom). Sušina listů nemocných rostlin byla mírně snížena, zatímco sušina os byla vyšší. Obsah popelu v celých rostlinách byl u nemocných rostlin snížen o 11 %. Na rozdíl od rostlin rajčat, kde byly nalezeny výrazné disproporce v rozložení metabolitů mezi jednotlivými orgány (Ulrychová, Limberk 1964), byl obsah celkového dusíku i jednotlivých dusíkatých frakcí snížen jak v listech, tak v osách. V obou orgánech byl výrazně zvýšen obsah glutaminu, přestože amoniakální dusík byl v obou případech téměř o 30 % nižší. Nejvýraznější změnou u infikovaných rostlin *Nicotiana glauca* bylo zvýšení fosforové frakce, extrahovatelné 0,2N-$HClO_4$ v listech o 67 % statisticky vysoce průkazně. Tento výsledek je v souhlasu s nálezem u rostlin rajčat. Obsah ostatních frakcí fosforu v listech a všech frakcí fosforu v osách byl snížen.

М. Ульрихова, Я. Лимберк, Институт экспериментальной ботаники ЧСАН, Прага **Нарушения обмена веществ у *Nicotiana glauca*, латентного хозяина вируса метельчатости картофеля.** — Biol. Plant. 9 : 56—60, 1967.

Исследовались нарушения обмена веществ у *Nicotiana glauca*, латентного хозяина вируса метельчатости картофеля (potato witches' broom). Сухое вещество больных растений понижено, между тем как сухое вещество стеблей было повышенным. Содержание золы в целом растении было у больных растений понижено на 11%. В отличие от томатов, где были найдены большие диспропорции в распределении метаболитов между отдельными органами (Ульрихова, Лимберк 1964), общий азот и азот отдельных фракций оказался пониженным как в листьях, так и в стеблях. В обоих органах резко повышено содержание глютамина, несмотря на то, что в обоих случаях аммиачный азот был понижен почти на 30%. Самым выразительным изменением инфицированных растений *Nicotiana glauca* было повышение фракции фосфора, экстрагируемого 0,2 N — $HClO_4$ в листьях на 67%, статистически высоко достоверное. Этот результат является сходным с результатом полученным при анализе томатов. Содержание остальных фракций фосфора в листьях и всех фракций фосфора в стеблях было пониженным.