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Some energetical aspects of plant viral diseases

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In the field of relationships between viruses and virus infected plants, due to characters specific to this pathogen, research works carried out at molecular level are older than those made with other pathogenic agents. Many contributions to the knowledge of the viral infection mechanism have been made by biochemical and biophysical investigations. Nevertheless, the energetic point of view was not systematically considered; it was only in the sixties that it became a direction of research, in the field of plant virology.

The gathered evidence, shows clearly that viral infection strongly affects cellular metabolism. As far as phosphorus metabolism is concerned, which is closely connected with the energy changes, it was shown, that in the case of systemic infection of tobacco with TMV, both the relationship of concentrations of different phosphorus compounds, and the activity of certain enzymes which participate in the regulation of these relationhips, are strongly modified already at very early stages of the incubation period [1-5, 10-16]. Such influence, was likewise detected, in certain metabolic processes and physico-chemical properties of some enzymatic proteins closely connected with energy metabolism. It has, thus, been shown that the P/O ratio, in the stage of symptom development is significantly diminished in the case of *Nicotiana tabacum* plants infected with TMV; this indicates to a deterioration of the storage and distribution mechanisms of the energy liberated in energogenous processes [8]. Ladygina and Rubin made similar observations on the variety Trapesond infected with TMV [9]. We found this deterioration also in the roots of the same plants infected which the same virus [7, 8]. One of its effects is that of inhibiting the capacity of these roots to take up mineral phosphorus from their nutritional environment. This is undoubtedly one of the main causes of phosphorus deficiency but also its continuous increase, as the incubation period proceeds.

Considering that macromolecular and cellular structures are maintained at the expense of energy, furnished metabolically, it was to be expected that energy losses, consequent to an imbalance in the oxydative-phosphorylation process, should induce their denaturation. These denaturations must be reflected in biological properties. In case of enzyme proteins, modifications in kinetics of the reactions they catalyse, must be produced. Our research confirmed these assumptions. Taking reaction rate and activating energy as criteria, we recorded in both cases important modifications [2-4, 6]. It should be noted that the variation curve of activating energy, both in the case of phosphatase, as well as of apyrase, follows the variation curve of both the activity of enzymes, as well as differences between these, respectively, between diseased and healthy tissues. We have some still unpublished data, according to which we could discern these phenomena, also by modification of Michaelis-Menten constant. We likewise have experimental indications that the activity of enzyme proteins in extracts from diseased tissues changes during storage, in other proportions than that of enzyme proteins from control extracts, stored in the same conditions.

Starting from the idea that coordination of enzymatic activity is one of the essential factors of maintaining cellular metabolism within normal limits, we attempted to explain the disease conditions from point of view of the energy metabolism, in conformity with scheme (Fig. 1).

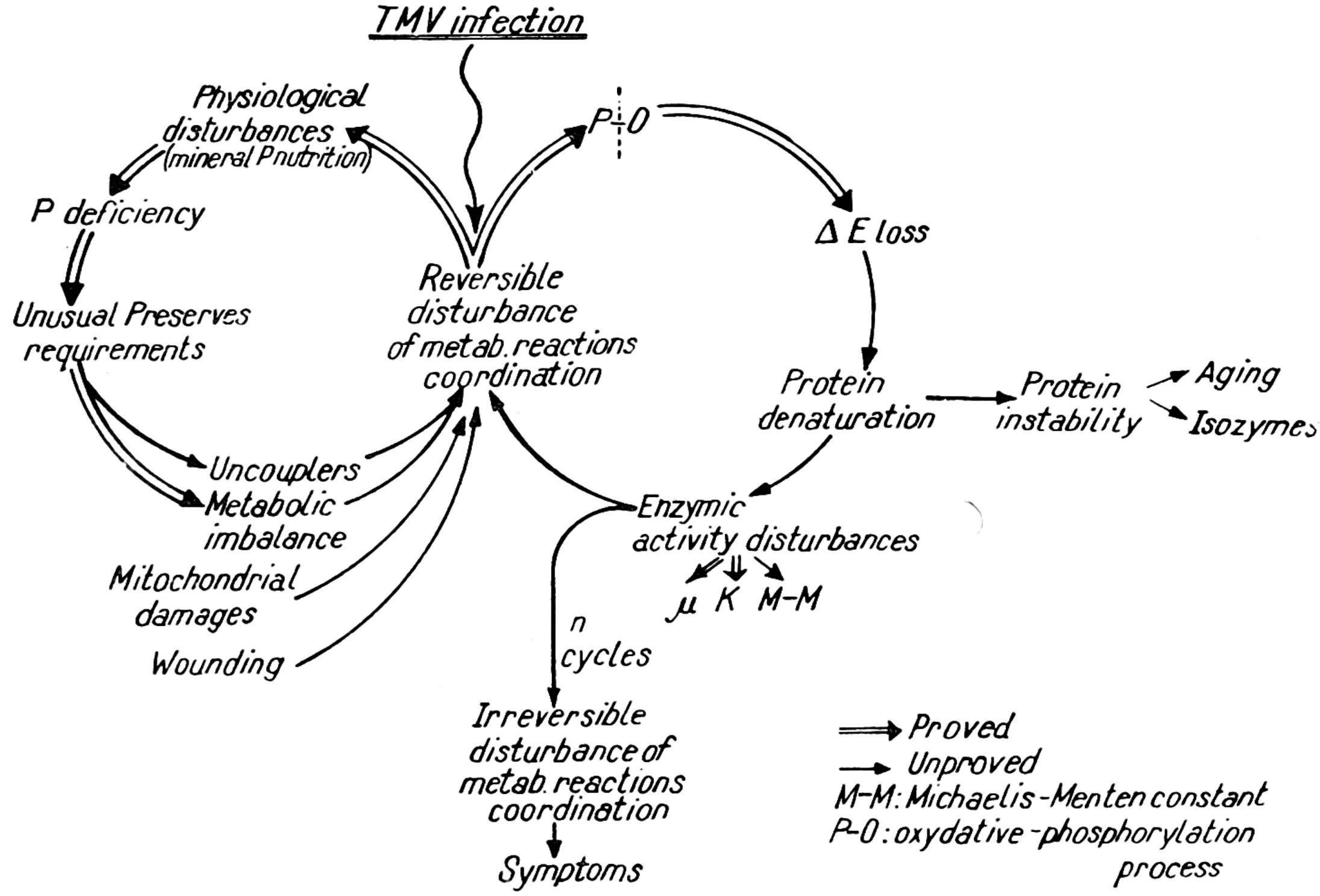

Fig. 1. Energy metabolism — TMV infection process interrelations.

According to this scheme, the decoordination of the activity of enzymes appears as result, on the one hand, of energy losses and their respective consequences, and on the other, of the metabolical imbalance due to both the unusual requirements of phosphorus reserves and the liberation of certain compounds with an uncoupling effect and with direct effects on enzymes. Thus the biochemical and biophysical events of one cycle have their causes in events of the same nature of the other cycle and the reverse. What occurs in one is an effect of the other, but likewise a cause of the phenomena of this cycle. The common point respectively, the main effect, is represented by the decoordination of the enzymes activity. To begin with, this is reversible, but after occurrence of a certain "number of cycles", decoordination becomes irreversible, which, from a biological point of view, means a final establishing of disease and appearence of its symptoms.

This hypothetical scheme is still incomplete. For instance, functional and causal connections with the other metabolic processes are not shown and it cannot be specified which is the primary sign of viral infection. At the same, time it presents, however, a logical image, based on original data, of joining up certain main links of energy metabolism; it shows connection of the latter with phosphorus metabolism and offers suggestions both for finding necessary additional proofs to be brought in its support, as well as for the development of connections between the energy metabolism and the cellular one, in which protein metabolism occupies a central place. The scheme likewise suggests, at the same time, an explanation, on biochemical and biophysical level, of existence of incubation periods, conceived as the time necessary for accumulation of effects of each "cycle", up to the exceeding of compensable limits, when symptoms appear. This is likewise the point of tangency with the problem of different degrees of resistance to the same parasite, of the different species and varieties. Here the connection is made with the self-regulating biochemical mechanisms and their role in the resistance to the attack of parasites. We hope that, to a large extent, the solution of all these problems will possibly be found by the investigation of the host's metabolism in the light of connections between the transfer of energy and the coordination of the activity of the enzymes, as well as that of biological and biochemical mechanisms which control these processes.

SUMMARY

The viral infection induces a disturbance of the energy metabolism evidenced by the decrease of oxydative and respiratory phosphorylation capacity (*Nicotiana tabacum* infected with TMV). The decrease of energy dificiency is, partly due to the disturbance of phosphorus metabolism, by decreasing the level and changing the ratios between different phosphorylated compounds, including the macroenergic ones, in leaves as well as in the roots of diseased plants.

The energy dificiency induced by the presence of TMV determines a reversible denaturation of the cellular organelles, as well as of the macromolecules, especially the proteic ones. The modifications of some physico-chemical properties of enzymatic proteins and, especially of their activity, are induced.

Since these modifications seem to be independent of external and internal conditions of the plant host, one can consider them as specific for the pathological processes.

These effects are different for different enzymes, and thus, the coordination of cellular enzymatic activities is in some extent disturbed. Above a certain level of this disturbance the disease appeares.

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