VIVOTOXINS AND UPTAKE OF IONS BY PLANTS

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PRIMARY loss in permeability of tissues with the onset of toxæmia in cotton (with susceptible variety—K 2) produced by *Fusarium vasinfectum*, resulting in deranged selective absorption of the key metabolite potassium was reported in a general way from this laboratory.[1] Further work in this field of enquiry, using the Lundegårdh air-acetylene spark-in-flame technique (only Ilford Zenith plates were used) on ash samples (leaves) of 18-days-old cotton plants of the susceptible (K 2) and resistant (Cambodia) varieties grown in sterilized garden soil, with and without *F. vasinfectum* inoculum, revealed some new and interesting results, permitting of more elaborate analysis of this intricate imbalance in uptake due to plasmolytic changes brought about in root tissues in the presence of vivotoxins. The technique used was essentially as detailed before[1] except that the ash samples were derived by a wet ashing method[2] and not by dry ashing at high temperatures which is known to produce some loss in metals, as, for instance, potassium.[3]

Since it is a common observation in pot trials that certain plants of the susceptible variety of cotton growing in inoculated soil apparently escape the disease and remain healthy while others show the characteristic vein-clearing symptoms and are wilting, leaves from such plants were also included in this study. The samples thus were: (1) resistant, control; (2) resistant, grown in inoculated soil; (3) susceptible, healthy control; (4) susceptible, grown in inoculated soil, but apparently healthy; and (5) susceptible, wilting plants. The results presented in Fig. 1 clearly indicate that there is a derangement in ionic uptake by plants of both varieties consequent on the presence of the pathogen in the root region, although in the normally resistant variety it is not so pronounced as to upset its normal metabolic functions to any appreciable extent. On the other hand, despite the apparently healthy condition of certain plants of K 2 grown in inoculated soil, a considerable degree of imbalance in the uptake as well as accumulation of the elements studied was noted.

The net percentage loss or gain in the elements due to infection in the soil is given in Table I. Although the resistant variety showed a slight loss in the three major elements, their ratios remained practically unchanged (Table II). The manganese content registered no change and the fall in ratio between Mn and the major elements was negligible. On the contrary, the ratios between all the elements

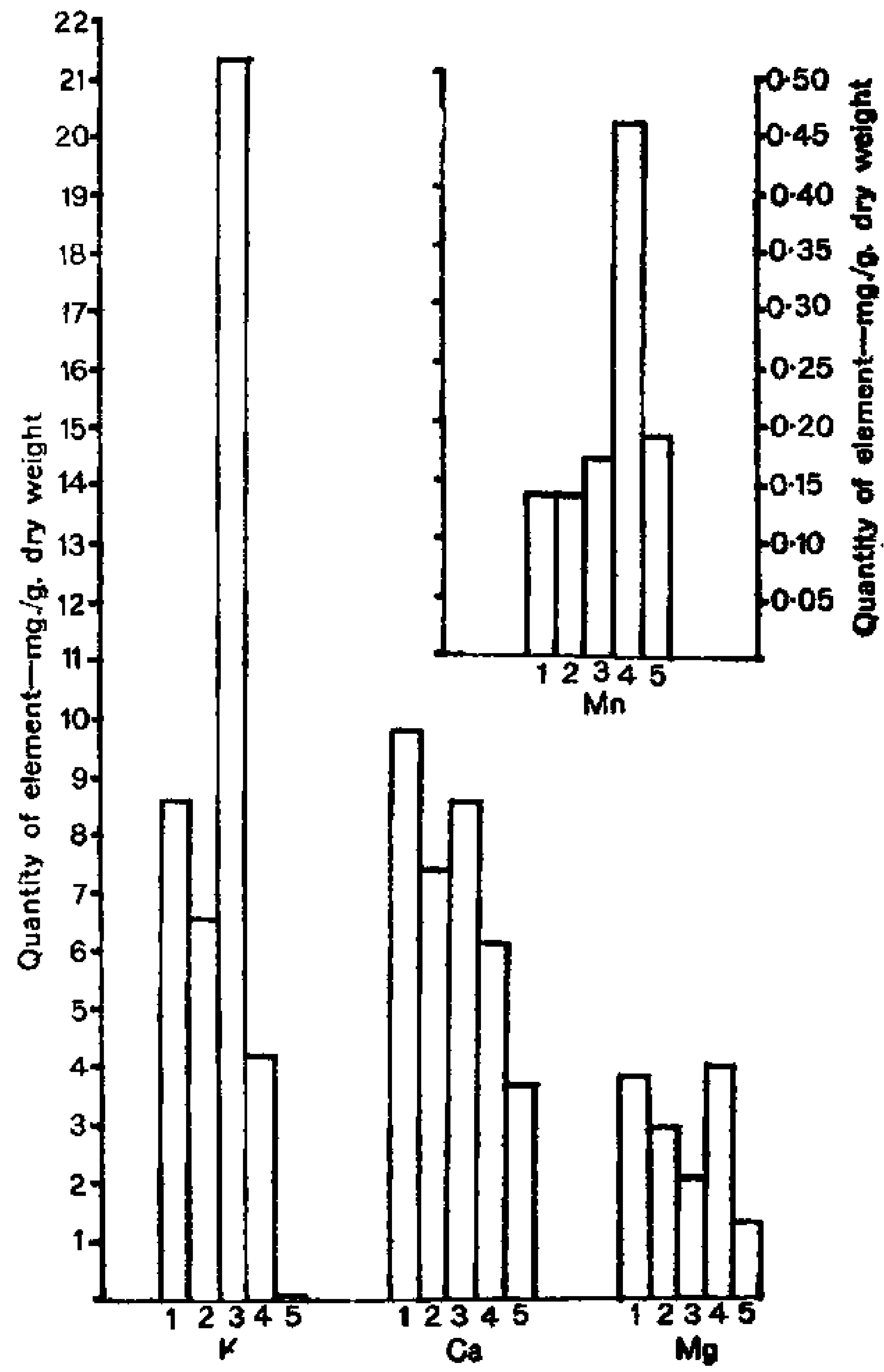

FIG. 1. The quanta of K, Ca, Mg and Mn in Cotton leaves. (1, 2, 3, 4 and 5 in X-axis refer to the samples as given in the text.)

showed a considerable fall in the two infected series of the susceptible variety. Table I shows

TABLE I

Percentage loss or gain in elements due to infection in soil

Element	Resistant	Susceptible	
		Apparently healthy	Wilting
K ..	23·3 (−)	80·3 (−)	99·5 (−)
Ca ..	24·5 (−)	29·1 (−)	57·0 (−)
Mg ..	23·7 (−)	95·0 (+)	38·1 (−)
Mn ..	0	170·6 (+)	11·8 (+)

TABLE II
Ratios between elements

Samples		Resistant		Susceptible		
		1	2	3	4	5
K : Ca	..	0·9	0·9	2·5	0·7	0·03
K : Mg	..	2·3	2·3	10·1	1·1	0·8
Ca : Mg	..	2·6	2·6	4·1	1·5	2·9
K : Mn	..	61·4	47·6	125·3	9·1	0·5
Ca : Mn	..	70·0	52·9	50·6	13·3	19·5
Mg : Mn	..	27·1	20·7	12·4	8·7	6·8

a varied accumulation of the different elements in these infected plants. There was an enormous rise in the amount of magnesium as well as manganese in the infected but apparently healthy plants. In the wilting plants also manganese level was higher than in the healthy control plants. But the key metabolite K registered a great loss in the susceptible plants following infection and a look at the ratios between the elements in these plants, as compared to that in the healthy, shows the thorough imbalance in ionic uptake. It is very interesting to note that the apparently healthy plants of the susceptible variety growing in inoculated soil suffer from a gross derangement in metallic uptake while their counterparts in the resistant variety do not, to any significant extent. In the case of the former, a clear loss in the semi-permeability of the cells is strongly indicated which may be due to the action of vivotoxins, although, for some reason or other, the toxin may not as yet be in sufficient amounts to produce visual symptoms and hence their apparently healthy condition. Perhaps with increase in age these may also succumb to toxic action. On the other hand, the slight disturbance in the normally resistant plants grown in infected soil may only be the result of its response to the presence of the pathogen in the root region, but which is unable to establish itself in this host. It is strongly doubted that toxin production itself is prevented in the root region of the resistant host. This point is under investigation and is expected to give much valuable clue to this disease mechanism.

There seems to be a strong case for following up these changes in more cotton varieties, both susceptible and resistant, as indeed, this study has opened up new vistas into the genetic nature of the control of the uptake of these metals by root systems, for primarily the pattern of uptake of the quanta of different metallic ions seems to be so different in the two varieties of cotton studied [an *arboreum* (K 2) and a *hirsutum* (Cambodia)], even without the complicating factor of the presence of the toxin in the region of the rhizosphere.

The question uppermost in our minds is whether the damage to the semi-permeability of the tissues due to toxæmia is permanent or whether at all the antidoting of the toxin *in vivo* in the region of the root plasma membrane (presumably by a process akin to chelation) is possible so as to register a partial or a complete recovery of the wilting plant.

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