The uptake of potassium and phosphorus in oats infested with the cereal cyst nematode, *Heterodera avenae* Woll.

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Summary

The uptake of phosphorus and potassium by the roots of oats infested by the cereal cyst nematode, *H. avenae*, was studied using radio-labelling. The presence of nematodes in the roots did not impede uptake or transport of nutrients and roots compensated for reduced and altered root growth by increasing rates of uptake of phosphorus and potassium.

Résumé

Absorption du potassium et du phosphore par l'avoine infestée par Heterodera avenae *Woll.*

L'absorption du phosphore et du potassium par les racines d'avoine infestées par *Heterodera avenae* a été étudiée par marquage des éléments. La présence de nématodes dans les racines ne gêne pas l'absorption ni le transport d'éléments nutritifs et les racines compensent les effets de la réduction et de l'altération de leur croissance en augmentant le taux d'absorption du potassium et du phosphore.

Symptoms of nutrient deficiency are a common feature of nematode parasitized plants. Endoparasitic nematodes usually develop giant cells or syncytia in close association with the vascular tissues and there is an implied, if rarely stated, assumption that nematodes "block" the "uptake" of nutrients by the plant (Shepherd, 1965 ; Seinhorst & Den Ouden, 1971). However experimental details are contradictory ; Shaffie and Jenkins (1963) reported increased concentrations of potassium and phosphorus in the roots of *Capsicum frutescens* infected by *Meloidogyne incognita acrita* but there were no significant differences in the amounts of the two chemicals in shoots of infested and uninfested plants. Jenkins and Malek (1966) testing four nematode species, including *Meloidogyne hapla* on vetch (*Vicia villosa* Roth.) concluded "that nematodes in some way alter the plant mechanisms of absorption, translocation and accumulation of mineral constituents". Slightly greater amounts of ^{32}P were taken up by tomato infected by *Meloidogyne javanica* (Oteifa, Barrada & Elgindi, 1958) but Hunter (1958) suggested that *Meloidogyne incognita acrita* caused no interference with the absorption or translocation of minerals including phosphorus labelled with ^{32}P, in tomato.

This paper presents two experiments in which the absorption and transport of potassium and phosphorus by oat plants (*Avena sativa*) infested with the cereal cyst nematode (*Heterodera avenae* Woll.) was investigated using radioactive tracers in hydroponic culture.

Materials and methods

Preparation of infested plants

Cysts of *H. avenae* extracted from infested field soil were placed on a Whitehead tray (Whitehead & Hemming, 1965) and the hatched second stage juveniles added to pots containing oat plants growing in sand.

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In the first experiment 30 oat seeds of the susceptible cultivar Maris Osprey were sown individually into 7.5 cm pots filled with sand. After germination three days later, fifteen pots received a total of 1100 juveniles per pot over five days. On the eighth day all seedlings were washed from the sand and transferred to hydroponic culture. Three infested seedlings were retained, stained in lactophenol acid fuchsin and the number of nematodes invading the roots counted.

In the second experiment oat seeds of the susceptible cultivar Maris Tabard, were germinated on damp

Four root samples were dried and weighed, four processed to assess radio-labelling and four preserved in F.A. 4 : 1 (Southey, 1970) for estimating nematode invasion.

Dry weights of shoots and roots were done after oven drying for a minimum of 48 hours. Samples to be counted for $^{32}P^{-}$ were wet-ashed which involves dissolving the plant material in nitric acid and reducing the volume of this solution by evaporation on a hotplate. Concentrated solutions were transferred to planchettes (aluminium saucers approximately

Table 1

First Experiment : The effect of *H. avenae* on growth and potassium uptake in young oat seedlings, cv. Maris Osprey ($\pm$ S.E.)

	Uninfested	*Infested*	*Significance*
Fresh Weight of Shoot (mg)	127 $\pm$ 10	117 $\pm$ 3	N.S.
Fresh Weight of Root (mg)	131 $\pm$ 12	62 $\pm$ 6	< 0.001
Ratio : shoot/root	0.96	1.89	
Mean length of seminal axes (cm)	10.23 $\pm$ 0.48	2.72 $\pm$ 0.21	< 0.001
Number of Laterals cm^{-1} axis	0.42 $\pm$ 0.05	1.26 $\pm$ 0.08	< 0.001
Potassium ($^{86}Rb^+$) uptake			
Concentration of potassium in shoots (μ mole K^+ g^{-1} F.W.)	23.02 $\pm$ 1.02	16.01 $\pm$ 0.05	< 0.001
Concentration of potassium in roots (μ mole K^+ g^{-1} F.W.)	25.00 $\pm$ 1.04	27.00 $\pm$ 0.04	N.S.
Total uptake of potassium (μ mole K^+ g^{-1} F.W. Root)	47.08 $\pm$ 2.09	58.03 $\pm$ 2.00	< 0.005

Table 2

Second Experiment : Distribution within the root system, and development stage of, *H. avenae* in four week old oat plants cv. Maris Tabard ($\pm$ S.E.)

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Table 3
Second Experiment : The effect of *H. avenae* on plant weight, root system morphology and phosphorus uptake in four week old Maris Tabard oats ($\pm$ S.E.)

	Uninfested	*Infested*	*Significance*
Plant Weight (gms)			
Fresh Weight of Shoots	1.7 ± 0.1	1.4 ± 0.1	N.S.
Dry Weight of Shoots	0.2 ± 0.01	0.13 ± 0.01	< 0.05
Fresh Weight of Roots	1.9 ± 0.13	1.7 ± 0.13	N.S.
Dry Weight of Roots	0.13 ± 0.01	0.16 ± 0.03	N.S.
Mean length of root axes	18.3 ± 1.4	9.7 ± 0.8	< 0.001
Mean length of primary laterals	2.5 ± 0.2	2.9 ± 0.5	N.S.
Mean no. laterals per plant	207.0 ± 7.7	83.2 ± 11.0	< 0.001
Mean no. of laterals cm^{-1} root axis	1.8 ± 0.1	1.8 ± 0.2	N.S.
Mean total length (axes + laterals) per plant	$640.4 + 17.4$	310.7 ± 53.0	< 0.001
Total uptake H_2PO_4 (μ moles)			
Shoots	4.3 ± 0.8	4.0 ± 0.6	N.S.
Roots	3.2 ± 0.5	5.9 ± 1.7	N.S.
Conc. H_2PO_4 (μ moles g^{-1} F.W.)			
Shoots	2.8 ± 0.5	2.6 ± 0.2	N.S.
Roots	1.9 ± 0.1	3.5 ± 0.7	< 0.05

The total amount of potassium taken up by the infested plants (Experiment 1) was reduced, but this was due to the reduced size of the root system. Potassium uptake (total K^+ μ moles gm^{-1} fresh weight of root, Tabl. 1) was increased which is in agreement with other research (Drew & Nye, 1969 ; Drew, Nye & Vaidyanathan, 1969).

In the second experiment the amounts and the total concentration of labelled phosphorus in shoots

Other work suggests that root absorption and transport is unimpaired by root-knot and cyst nematode parasitism. O'Bannon and Reynolds (1965) found that roots of cotton severely damaged by *Meloidogyne incognita acrita* could transmit sufficient water when water was available, and Hanounik and Osborne (1975) found no impedence in nicotine (synthesized near the root tip) translocation to the leaves of tobacco infested with *Meloidogyne incognita*. Evans, Trudgill and Brown (1977) concluded that

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