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EXPERIMENTS ON COMPETITION AS A MEANS OF DETECTING POSSIBLE DAMAGE BY NEMATODES

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EXPERIMENTS ON COMPETITION AS A MEANS OF DETECTING POSSIBLE DAMAGE BY NEMATODES

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INTRODUCTION

VAN DOBBEN (1955) cultivated barley and oats in monoculture and in mixed culture on plots with different pH-values. Below a pH of about 4 the yield of barley was pH-dependent whereas the yield of oats was not. The yield of barley sown in a mixture with oats, however, was pH-dependent below a pH of 5. The adverse effect of low pH-values of the soil on the pH-sensitive barley is apparently increased by cultivating these plants in a mixture with non pH-sensitive oats.

DE WIT (1960) showed that a similar effect occurs in mixtures of healthy and diseased plants, provided the disease occurs at an early stage.

Hence, to enlarge the effect of a disease on growth it may be helpful to cultivate beside monocultures, mixtures of varieties that are resistant and not resistant to that disease.

Experiments were carried out to determine whether the effect of nematodes on the growth of sensitive plants is increased by cultivating these plants in a mixture with nematode resistant plants.

EXPERIMENTS WITH CEREAL ROOT EELWORM *(Heterodera avenae Woll.)* IN 1961, 1962 AND 1963

To exclude difficulties which might arise from using eelworm populations of unknown composition, a population of biotype A of the eelworm (KORT, DANTUMA and VAN ESSEN, 1964) was used in the experiments with oats (cultivar Marne) as a sensitive host and barley 191 of the International Barley Disease Nursery as non-host.

Plastic buckets of 5 liter capacity were filled with 7 kg of nematode-free soil obtained from a depth of 50 cm below a permanent pasture. In half the containers cysts were added to the soil which resulted in an infestation of 500–600 larvae per 200 ml of soil.

The infested and non-infested containers were planted with 10 barley and oat plants in relative frequencies of 0, 0.2, 0.4, 0.6, 0.8 and 1 in three replicates.

The containers were placed in an open shed with glass roofing to ensure natural synchronisation of the life cycles of plants and nematodes. Limited water was given by watering the plants from above (sub-optimal) or a contineous supply by providing a constant water table (optimal).

After ripening, the plants were harvested and the total dry matter weight, seed and number of seeds were determined from each species per container.

Since oats ripens about two weeks later than barley, the number of seeds is a better yield measure in competition studies than the dry-matter weight (DE WIT 1960).

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The number of cysts and eggs at the end of the experiments were determined according to KORT (1960).

TREATMENT OF THE RESULTS OF EXPERIMENTS ON COMPETITION BETWEEN SIMILAR SPECIES

The method of treating competition experiments will be illustrated by means of the results of the 1962 experiment with barley and oats presented in fig. 2a.

The number of barley and oat plants per container is given along the horizontal axis. The fraction of both varies between 0 and 1, but the total plant number is 10 per container, throughout. The yields of barley and oats grown in monoculture are 210 and 360 kernels/container, respectively. If the yield of each species in the mixtures should be proportional to the number of plants of that species, the observations should be formed on the straight, broken line through these points and the origins. It is seen that the yields for oats are higher and those for barley lower than by these lines.

DE WIT (1960) showed that yields of both cereals in such a replacement series can be represented by

$$O_o = \frac{k_{ob}Z_o}{k_{ob}Z_o + Z_b} M_o \qquad [1]$$

$$O_b = \frac{k_{bo}Z_b}{k_{bo}Z_b + Z_o} M_b$$

O_o and O_b are the yields of oats and barley at plant-numbers Z_o and Z_b ($Z_o + Z_b$ = constant) and M_o and M_b the yields of the monoculture. The constants k_{ob} and k_{bo} are the relative crowding coefficients of oats in barley and barley in oats. When the two species are sufficiently similar, they may crowd for the same space and then

$$k_{bo} \,.\, k_{ob} = 1 \qquad [2]$$

This is always the case with barley and oats (DE WIT 1960).

The curves that fit the observations in fig. 2a are drawn according to equation [1] with $k_{ob} = 1/k_{bo} = 6$.

RESULTS

Experiment in 1961

Sowing took place on March 30; after one week 1 g of ammonium nitrate (NH_4NO_3) was given and an optimal water supply was maintained throughout the growing period. Both, oats and barley showed a rapid development and were harvested at the end of September.

The yields in number of seeds per container are shown in fig. 1a for the non-infested soil and in fig. 1b for the infested soil. The values of the constants in equation [1] as calculated from the data are given in table 1.

TABLE 1. M_o, M_b and k_{ob} ($= 1/k_{bo}$) in 1961.

	non-infested	infested	
M_o	680	660	kernels per container
M_b	290	260	,, ,, ,,
k_{ob}	1.0	1.0	

Fig. 4 gives the number of eelworms per unit contents of soil for both treatments.

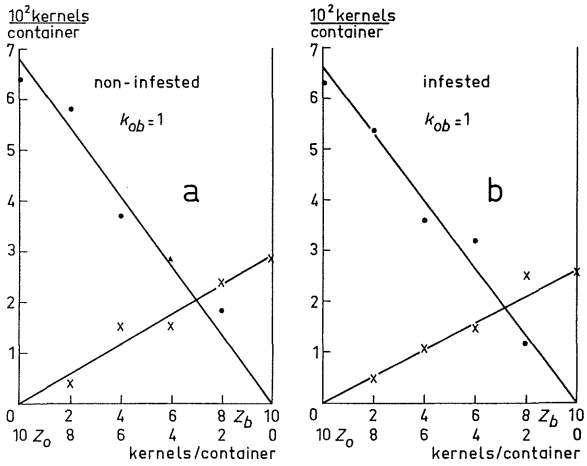


FIG. 1. Results of the experiment in 1961 with optimal supply, of water and nutrients and a succesful infestation.
• oats × barley

Experiment in 1962

Sowing was carried out on April 6; 1 g of ammonium nitrate was given 48 days later. A sub-optimal water supply was maintained throughout the growing period. Especially the early growth of both plant species was poor. The harvest took place in the middle of August. Yields are given in fig. 2a and 2b and the values of the constants in equation [1] are given in table 2.

TABLE 2. M_o, M_b and k_{ob} (= $1/k_{bo}$) in 1962.

	non-infested	infested	
M_o	350	385	kernels per container
M_b	210	185	,, ,, ,,
k_{ob}	6.0	1.3	

The number of eelworms is also given in fig. 4.

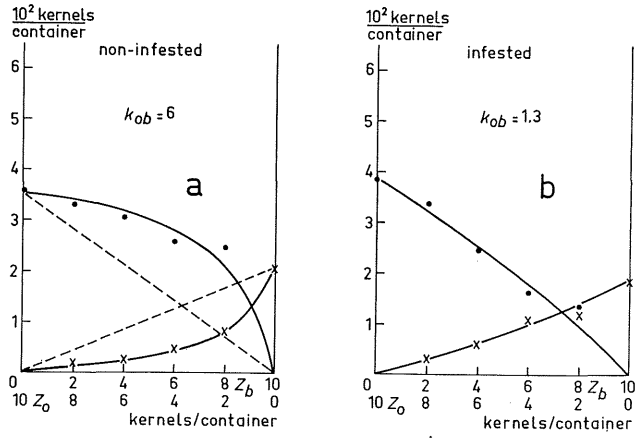


FIG. 2. Results of the experiment in 1962 with sub-optimal supply of water and a successful infestation. • oats × barley

Experiment in 1963

Sowing was carried out on April 5; 1 g of ammonium nitrate was applied 14 days later and the plants were harvested at the end of August.

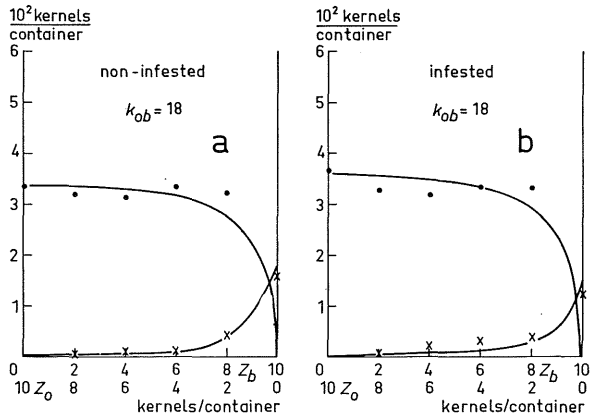


FIG. 3. Results of the experiment in 1963 with sub-optimal supply of water and an unsuccessful infestation. ● oats × barley

Half the containers were supplied with optimal and the other half with sub-optimal amounts of water. The yields of containers supplied with sub-optimal quantities of water are given in fig. 3a and 3b.

The constants in equation [1], as calculated for the sub-optimal and optimal water treatments are given in table 3.

TABLE 3. M_o, M_b, k_{ob} (= $1/k_{bo}$) in 1963.

	non-infested	infested	
sub-optimal water			
M_o	340	360	kernels/container
M_b	155	125	,, ,,
k_{ob}	18	18	
optimal water			
M_o	615	665	kernels/container
M_b	110	125	,, ,,
k_{ob}	18	18	

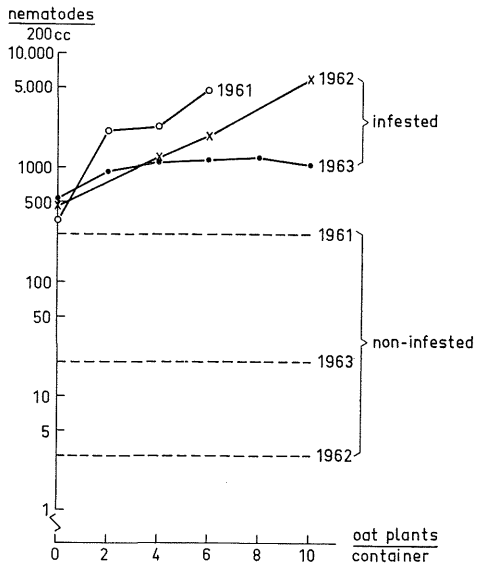
The number of nematodes at the time of harvest, averaged for both moisture regimes are given in fig. 4.

DISCUSSION

Fig. 4 shows that in 1962 nematodes were practically absent in the non-infested containers, but in the infested ones their number varied from 500 nematodes per 200 ml of soil for the monoculture of barley to 6000 nematodes per 200 ml for the monoculture of oats. The number of nematodes per oat plant increased with increasing relative frequency of oats in the containers. Hence the inoculation succeeded. In spite of a successful inoculation in 1962 the yields of oats as monoculture on infested and non-infested soil were the same (fig. 2). Experiments in which only monocultures on infested and non-infested soil are compared, will not show any differences in yield resulting from the presence of nematodes.

The absence of any influence of nematodes on yield in this kind of experiment may be due to the presence of sufficient roots to take up the limited amounts of water or nutrients or to the absence of damage by nematodes. These two possibilities can only be distinguished by comparing the yields of the mixed cultures.

FIG. 4. Density of the nematode population of infested and non-infested containers at the end of the experiment.



In the mixed culture on infested soil (fig. 2) the yield of oats is lower and that of barley higher in comparison to the non-infested soil. This effect of infestation is quantitatively accounted for by the value of the relative crowding coefficient k_{ob} which is 1.3 for the infested and 6 for the non-infested replacement series.

The effect on yield must be due to damage of the roots of oats by nematodes in an early stage. This damage prevented oats from occupying its share of the available soil and enabled barley to occupy more than its share.

Early activity of nematodes and a low supply of nutrients will enlarge the effect of infestation on the relative crowding coefficient.

In 1961 inoculation with nematodes succeeded (fig. 4) but in that year neither the yields in monoculture nor in mixed culture were affected. Supply with nutrients and water had been so liberal that even in the mixed cultures the yield of oats was not limited by a supply by the roots.

In 1963 there neither were differences between the replacement series with and without eelworms. This was true for both optimal and sub-optimal treatments. The data on the nematode numbers in fig. 4 show that the inoculation with nematodes for some reason was not successful.

The yield of oats with optimal water supply was twice that with sub-optimal water supply, but the yield of barley was the same for both. In spite of this, the relative crowding coefficient of oats was about the same in both cases (table 3). This is because the relative crowding coefficient is determined in an early stage and the effects of water supply on growth occur later.

The relative crowding coefficient of oats with respect to barley was 18 in the last year of experimentation. Since it is convenient to work with relative crowding coefficients closer to one, it would have been better if 1 seed of oats had been replaced by 2 seeds of barley, the mathematical treatment of a replacement series of this kind gives, of course, no difficulties (DE WIT, 1960).

SUMMARY

An experiment was designed to show whether the damage by eelworm infestation in oats could be enlarged by competition with a resistant barley variety.

Both cereals were grown in monoculture and as a mixed crop in containers filled with nematode-free soil and soil infested with cereal root eelworm. The infestation was successful in two out of three years, but the yield of oats in mixed culture was depressed by infestation.

In no case was the yield of oats affected, when grown in monoculture.

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