MYCORRHIZAL SUPPRESSION AS A POSSIBLE MECHANISM OF WEED COMPETITION

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Summary: Mycorrhizal infection was low in seven of sixteen weeds examined, although two had a substantial mycorrhizal root weight due to extensive root systems. All the families (except the Oxalidaceae) to which these weeds belonged, have been previously reported as not forming mycorrhizas.

V-A endophyte spore numbers declined following the growth of fumitory and doublegee together with clover in pots. When clover was grown following fumitory, wild turnip or doublegee in the same pots, it had reduced infection intensity, root dry weight and mycorrhizal root weight.

The shoot dry weight of clover grown as a second crop was weakly related to the number of V-A endophyte spore numbers present at germination. Phosphorus availability to the second crop was probably low, therefore mycorrhiza formation might be important to its nutrition.

INTRODUCTION

The majority of higher plants are normally mycorrhizal (Maeda 1954). However, there are a few exceptions mainly in the *Cruciferae*, *Polygonaceae*, *Urticaceae* and *Fumariaceae* (Hirrel et.al. 1978). A number of reports suggest that non-mycorrhizal plants may reduce the incidence of mycorrhizas in companion plants (Hayman et. al. 1975, Iqbal and Qureshi 1976, Morley and Mosse 1976).

This experiment was designed to investigate whether mycorrhiza suppression is one mechanism by which non-mycorrhizal weeds compete with other plants.

MATERIAL AND METHODS

Experiment 1. Single seedlings of sixteen species were collected and potted. Four replicate pots and controls (no weeds) were grown for 88 days in a glasshouse. They were then allowed to dry out. Roots were extracted and assessed for infection intensity (Phillips and Hayman 1970). Vesicular arbuscular (V-A) endophytes spores in the soil were counted (Smith 1979). Roots were dried and mycorrhizal root weight calculated as the product of dry root weight and infection intensity.

Experiment 2. Four seedlings each of five species of weeds, corkscrew, fumitory, wild radish, doublegee, wild turnip and control (no weeds) were planted in pots. In half the pots these were surrounded by four pre-germinated clover seedlings. Four replicates were grown for 88 days; the tops were then harvested (H 1). Soil samples were taken for V-A endophyte spore counting. Subterranean clover was grown in each pot for 80 days. The shoots were harvested (H 2), and the phosphorus content determined (Colwell 1965). A further set of soil cores was then taken. V-A endophytes were counted and the roots extracted. Mycorrhizal root weight was calculated as previously.

RESULTS

Experiment 1. V-A endophyte spore numbers (mainly *Acaulospora laevis*) increased under capeweed and decreased under nettle, Cape tulip, Guildford grass and wild turnip. Infection was low in soursob, wireweed, chickweed, wild radish, flatweed,

fumitory and wild turnip. Flatweed had high root weights, therefore its mycorrhizal root weight was similar to the mycorrhizal species examined. Mycorrhizal root weights of less than 0.02g were found in soursob, wireweed, wild radish, Cape tulip, fumitory and wild turnip (Table 1.).

Experiment 2. V-A endophyte spore numbers were unaffected by the plant species grown in the absence of clover, however they decreased when clover was grown together with fumitory or doublegee. Clover alone had no effect on spore abundance (Table 2). At harvest 2 spore numbers were reduced in the pots previously cropped with wild radish plus clover or doublegee alone, but otherwise no differences in V-A endophyte spore numbers were observed. Total V-A endophyte spore numbers at harvest 1 were weakly correlated with numbers at harvest 2 ($r = 0.36^{**}$). Both root weight and mycorrhizal root weight of clover at harvest 2 were depressed following wild turnip and fumitory (Table 2). Mycorrhizal root weight of clover at harvest 2 was strongly correlated ($r = 0.94^{***}$) with root dry weight and only weakly ($r = 0.38^{**}$) with infection intensity. This suggests clover plants differ more in their ability to grow roots than in their susceptibility to V-A endophyte infection. The biomass at harvest 2 was weakly related to that at harvest 1 ($r = 0.26^{*}$) and V-A endophyte spore abundance at harvest 1 ($r = 0.31^{*}$). The phosphorus content of the clover shoots at harvest 2 was also related to the shoot dry weight at harvest 1 ($r = 0.45^{*}$). Corkscrew shoot phosphorus content was reduced when clover was also present, but clover phosphorus concentrations appeared unaffected by competition (Table 2).

DISCUSSION

V-A endophyte spore numbers within the root zone of a non-mycorrhizal plant change due to death and abortive germination because sporulation cannot take place. Total V-A endophyte spore numbers in the presence of wild turnip declined in Experiment 1; they were unchanged in Experiment 2. This may be due to different environments or sampling times. Another crucifer, *Arabidopsis thaliana* inhibited germination and hence maintained numbers of white reticulate spores, but had no effect on *G. araucareae* spores (Bevege and Bowen 1975).

There were low levels of infection in wild radish and wild turnip Experiment 1. This is consistent with the findings of other workers that most members of the Cruciferae are normally non-mycorrhizal (Bevege and Bowen 1975, Read, Koucheki and Hodgson 1976). However, some exceptions have been reported (Saif and Iffat 1975). The results of this experiment are consistent with the hypothesis that only dead and moribund roots of the Chenopodiaceae and the Cruciferae become infected with V-A endophytes and then only in the presence of companion plants (Hirrel et al. 1978).

Infection intensity of fumitory was less than 5% in Experiment 1, but spore numbers under fumitory fell only when grown with clover. Possibly fumitory roots inhibit germination of the V-A endophyte spores; an inhibition which is nullified by the presence of clover roots. The few members of the Fumariaceae previously examined have been found to be non-mycorrhizal (McDougal and Liebtag 1928). Doublegee roots were heavily infected, but wireweed was not. Wireweed roots were difficult to clear, therefore this species was not utilised in Experiment 2. Doublegee and clover grown together led to a decrease in V-A endophyte spore numbers. This may be due to spore germination being stimulated by the clover roots, which were ineffective hosts because they suffered from the competition of the doublegee plants. Plants of the Polygonaceae are usually non-mycorrhizal (Read et al. 1976) but with some exceptions (Saif and Iffat 1975).

Where clover was grown after wild turnip, fumitory and doublegee root infection was reduced. Similarly infection in onions was reduced when grown with swedes (Hayman et al. 1975). Growth of clover was inhibited even after removal of

the weeds. This may be due to allelopathy, nutrient depletion or loss of suitable endophyte propagules. The correlation between V-A endophyte spores at harvest 1 and clover biomass at harvest 2 suggests that endophyte depletion may be one reason for the decreased growth of clover. At the same time, the depletion of soil phosphorus by the first crop would make the second crop more dependent on V-A mycorrhizas.

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Table 1. Root parameters of weeds and their effect on total V-A endophyte spore numbers in the soil.

	Total V-A endophyte spores/100g soils mean ± s.e.	% infection intensity mean ± s.e.	Root dry wt.g mean ± s.e.	Mycorrhizal root weight g mean ± s.e.
Cape tulip *(Homeria miniata)*	10 ± 2	41 ± 24	0.04 ± 0.01	0.009 ± -
Capeweed *(Arctotheca calendula)*	66 ± 20	45 ± 6	0.48 ± 0.06	0.20 ± 0.02
Chickweed *(Stellaria media)*	26 ± 6	5 ± 2	0.48 ± 0.18	0.04 ± 0.03
Corkscrew *(Erodium botrys)*	40 ± 8	45 ± 3	0.55 ± 0.05	0.25 ± 0.04
Crowfoot *(Erodium moschatum)*	26 ± 2	15 ± 6	0.48 ± 0.06	0.06 ± 0.02
Doublegee *(Emex australis)*	30 ± 2	29 ± 9	0.31 ± 0.03	0.09 ± 0.03
Flatweed *(Hypochoeris spp.)*	24 ± 4	6 ± 0.5	2.00 ± 0.46	0.13 ± 0.04
Fumitory *(Fumaria muralis)*	22 ± 6	3 ± 0.6	0.10 ± 0.03	0.003 ± -
Guildford grass *(Romulea rosea)*	12 ± 2	37 ± 14	0.10 ± 0.28	0.04 ± 0.01
Paterson's curse *(Echium plantagineum)*	30 ± 6	37 ± 9	0.51 ± 0.05	0.19 ± 0.06
Soursob *(Oxalis pes-caprae)*	24 ± 2	1 ± 0.2	0.25 ± 0.07	0.003 ± 0.001

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Stinging nettle (*Urtica urens*)	12 ± 1	31 ± 114	0.32 ± 0.07	0.13 ± 0.08
Subterranean clover (*Trifolium subterraneum*)	26 ± 6	23 ± 5	0.42 ± 0.06	0.09 ± 0.02
Wild radish (*Raphanus raphanistrum*)	34 ± 6	5 ± 0.6	0.35 ± 0.09	0.02 ± 0.005
Wild turnip (*Brassica tournefortii*)	10 ± 2	1 ± 0.1	0.20 ± 0.05	0.002 ± -
Wireweed (*Polygonum aviculare*)	28 ± 6	2 ± 0.5	1.30 ± 0.42	0.02 ± 0.008

Table 2. Root and shoot parameters of some weeds and clover grown together or separately and their effect on the abundance of V-A endophyte spores in the soil. Harvest 1.

	Total V-A endophyte spores / 100g soil	Weeds shoot dry mean s.e.	Clover shoot dry mean s.e.	Weed shoot % P mean s.e.	Clover shoot % P mean s.e.
Without CLOVER					
Control	66 ± 14		4.4 ± 1.3		0.27 ± 0.04
Corkscrew	62 ± 10	8.2 ± 0.	1.2 ± 0.4	0.16 ± 0.06	0.27 ± 0.00
Doublegee	72 ± 6	5.6 ± 1.5	1.6 ± 0.7	0.20 ± 0.07	0.34 ± 0.04
Fumitory	60 ± 8	3.7 ± 1.2	1.5 ± 0.1	0.13 ± 0.07	0.31 ± 0.03
Wild radish	58 ± 12	3.8 ± 1.4	1.3 ± 0.6	0.16 ± 0.05	0.34 ± 0.06
Wild turnip	66 ± 6	4.9 ± 1.6	1.4 ± 1.2	0.13 ± 0.05	0.27 ± 0.00
With CLOVER					
Control	78 ± 8				
Corkscrew	74 ± 18		7.7 ± 0.7		0.27 ± 0.04
Doublegee	48 ± 8		10.5 ± 1.5		0.17 ± 0.06
Fumitory	44 ± 10		4.5 ± 1.2		0.15 ± 0.04
Wild radish	90 ± 4		6.7 ± 1.9		0.18 ± 0.06
Wild turnip	62 ± 4		6.0 ± 0.7		0.13 ± 0.04

Harvest 2 - Clover

Previous crop	Endophyte spores/ 100g soil	root dry weight	root infection intensity	mycorrhizal root wt.	shoot dry weight	% P in shoot
With CLOVER						
Control	70 ± 12	4.2 ± 0.2	58 ± 4	2.4 ± 0.1	5.7 ± 0.5	0.20 ± 0.03
Corkscrew	52 ± 18	2.4 ± 1.0	62 ± 9	1.2 ± 0.3	4.2 ± 0.6	0.15 ± 0.05
Doublegee	68 ± 16	2.6 ± 0.4	50 ± 5	1.3 ± 0.2	4.6 ± 1.1	0.21 ± 0.09
Fumitory	54 ± 16	1.7 ± 0.1	47 ± 2	0.8 ± 0.0	5.6 ± 0.6	0.16 ± 0.05
Wild radish	42 ± 14	1.8 ± 0.4	52 ± 9	1.0 ± 0.3	6.3 ± 0.8	0.16 ± 0.05
Wild turnip	78 ± 18	1.0 ± 0.4	42 ± 7	0.3 ± 0.1	3.8 ± 0.9	0.14 ± 0.06
Without CLOVER						
Control	58 ± 8	2.6 ± 0.9	60 ± 6	1.6 ± 0.6	7.3 ± 2.1	0.28 ± 0.06
Corkscrew	68 ± 22	2.6 ± 0.5	60 ± 3	1.6 ± 0.3	6.4 ± 1.5	0.16 ± 0.05
Doublegee	40 ± 6	1.9 ± 0.4	45 ± 10	0.9 ± 0.4	3.7 ± 1.1	0.14 ± 0.07
Fumitory	62 ± 14	2.3 ± 0.4	61 ± 9	1.4 ± 0.3	6.4 ± 0.6	0.21 ± 0.06
Wild radish	74 ± 4	4.3 ± 2.0	55 ± 6	2.7 ± 1.5	6.5 ± 0.8	0.13 ± 0.05
Wild turnip	74 ± 24	3.5 ± 1.0	53 ± 4	1.8 ± 0.5	7.2 ± 0.8	0.16 ± 0.02