Cereal root disease constraints to developing conservation tillage in southern Australia

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Summary. Soil-borne root diseases impose serious constraints on cereal production. The damage to roots and the subsequent yield losses from some diseases is increased by direct drilling and some herbicides. It is essential that rotations and management practices which reduce disease levels in soil are part of conservation tillage farming.

Introduction

Cultivation has been considered an essential part of agriculture for millenia and in Australia four or five workings prior to sowing is not uncommon. Why does cultivation persist, despite the advent of herbicides which can replace the plough? One of the advantages of cultivation is that plant residues colonized by pathogens are broken up which reduces the propagule size. The significance of root diseases in wheat production has been demonstrated by soil fumigation, which gave yield responses of 0.3-2.4 t/ha (7).

The major soil-borne root diseases of wheat and barley in southern Australia are take-all, *Gaeumannomyces graminis* var. *tritici, Rhizoctonia* bare patch, *Rhizoctonia solani,* and cereal cyst nematode or eelworm, *fleterodera avenae.*

The take-all fungus invades the phloem and xylem and interferes with movement of assimilates, nutrients and water. This results in reduced lateral root growth and water stress which may cause premature ripening and whiteheads. The narrow host range of the take-all fungus confines it to wheat, barley, some triticales and grasses, thus facilitating control by rotation or reduction of grasses in the annual pasture.

Rhizoctonia bare patch is of more limited occurrance than take-all, but with the introduction of direct drill (no-till) farming, it has become a problem in Australian cereal crops (5). Rhizoctonia has a wide host range and cannot be controlled by rotation but its effects can be ameliorated by improved nitrogen and phosphorus nutrition, grass-free legume pastures, and grain legumes in the year preceding cereals.

Cereal cyst nematode (CCN), is confined to cereals and grasses; rotation with non-host crops is one form of control along with nematicides, resistant cultivars, and direct drilling (8).

In this paper we summarize data obtained from field trials conducted over 15 years which demonstrate the significance of root diseases in cereal production and the effect of tillage and herbicide interactions on the incidence of these diseases.

Methods

Field trials were conducted at several sites in South Australia in calcareous Mallee soils and red brown earths with annual average rainfall ranging from 350 to 500 mm.

All trials were of a random block design with at least four replicates and plots ranging from 40 to 100 m length by 1.8 m wide.

`Conventional cultivation' consisted of three cultivations to a depth of 7-10 cm with a scarifier cultivator between the opening autumn rains and sowing. 'Direct drilling' involved treatment of the naturally regenerated pasture with desiccant herbicide prior to direct drilling. In trials prior to 1984 the herbicide treatment occurred one to two days before sowing with the SIRODRILL - a drill with front fluted coulter discs followed by narrow ('Janke') points and press wheels. Post 1984 the pasture was sprayed three to four weeks before sowing with a conventional seed drill with narrow sowing points.

Disease assessments were made on washed roots of plants sampled 10 to 12 weeks after sowing. Plant top dry weights were obtained from the plants used for disease assessment. Grain yields were obtained by mechanical harvesting the entire plots at maturity.

Impact of diseases on root development of wheat

In Figure 1 we have represented diagramatically the effects of the three root diseases on root length and morphology. These diagrams evolved from the many studies which we conducted and indicate how rooting depth and soil exploration are affected by root disease.

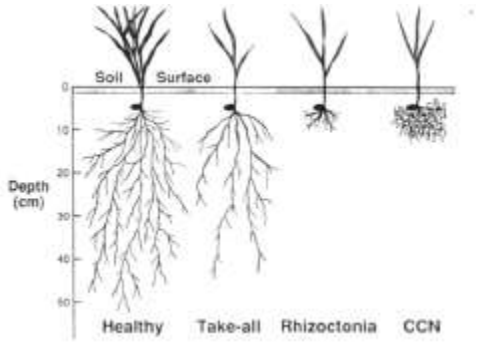

Figure 1. Diagrammatic representation of the effects of three root diseases on wheat roots.

Results and discussion

Effect of rotation and tillage

Take-all. Long-term field trials in South Australia demonstrated the importance of grasses in building up the levels of the take-all fungus in soil, increasing the damage to roots and reducing yields of wheat (Figs 2 and 4).

Levels of barley grass, *Hordeum* spp. and annual ryegrass, *Lolium rigidum* were higher in the phase alternating with direct drilled wheat than with wheat sown following cultivation (Fig. 3) which explains the higher levels of take-all and lower yields with direct drilling. Development of herbicides to remove grasses in pasture and grain legume crops has remedied this problem.

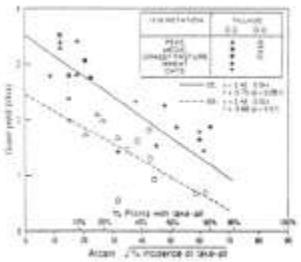

Figure 2.Relationship between the incidence of take-all on roots and grain yield of wheat sown with cultivation (CC) and by direct drill (DD) following different rotations at Avon, SA in 1979.

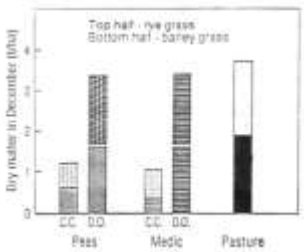

Figure 3.Levels of ryegrass and barley grass in peas and medic sown with cultivation and by direct drilling and in naturally regenerated annual pasure at Avon, SA, in 1978.

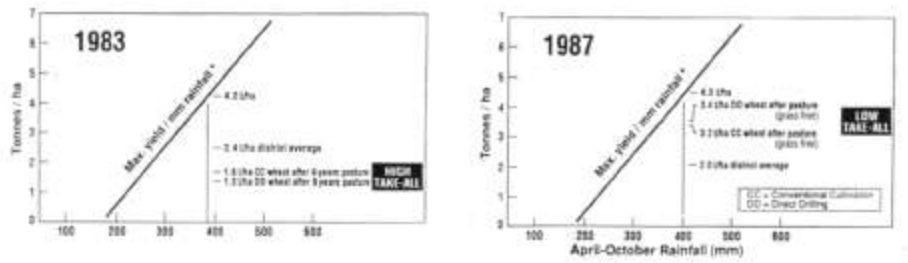

Figure 4. Effect of take-all on the yield of wheat in relation to potential yield (2), at Kapunda, SA in 1983 and 1987.

Figure 5 demonstrates that cultivation reduces Rhizoctonia root rot (5). Subsequent research demonstrated that spraying the pasture 3-4 weeks prior to sowing (`chemical fallowing') reduced the damage caused by Rhizoctonia in direct drilled wheat (4) and led to yields equal to those obtained with cultivation.

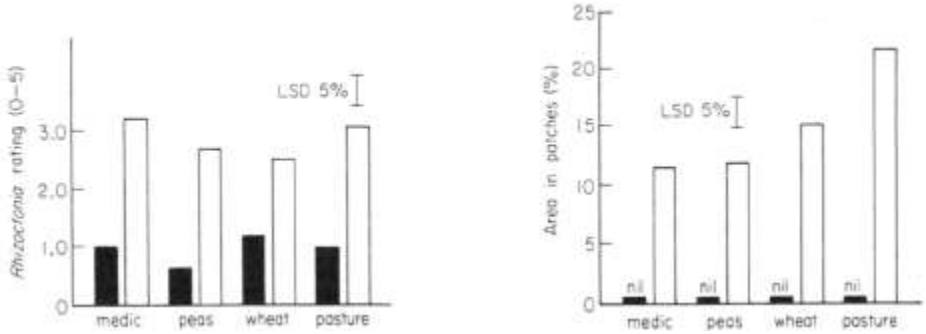

Figure 5. Effect of cultivation and rotation on root damage caused by *Rhizoctonia* and on the area of patches in wheat at Avon, SA, in 1983.

Rhizoctonia bare patch. The strong competitive saprophytic ability of *Rhizoctonia* allows it to colonise particulate organic matter near the surface (3), and farming practices which conserve organic matter on or near the surface favour this pathogen and account for this disease being a serious problem in direct drilled crops in southern Australia (5).

Cereal cyst nematode. Control of this disease by rotation with non-host crops and resistant varieties of wheat and barley is now well established (8). In contrast with take-all and Rhizoctonia bare patch, cultivation increases the damage to roots by CCN and results in lower yields (Table 1). This is attributed largely to the mixing of the nematode cysts and nematodes through the soil with cultivation. The lower number of cysts of CCN that are produced on the cereal crop sown with direct-drilling compared with cultivation will reduce the build up of the disease.

Table 1. Effects of cultivation on the damage to wheat roots by CCN, on the numbers of `white cysts' at anthesis and on grain yield at Calomba, SA in 1980.

Tillage	Disease rating[a]	Number of 'white cysts' per plant	Grain yield (t/ha)
Cultivated	3.5	59	0.85
Direct drilled	1.7	23	1.23
l.s.d. (P=0.05)	0.7	29	0.27

[a] Disease rating: 0 = no damage to 5 = maximum damage.

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Herbicide - root disease interactions

Conservation tillage depends upon herbicides replacing cultivation, so the reports of increased damage from a number of root diseases in the presence of herbicides (1) is cause for concern. Although the sulfonyl urea herbicides are effective at extremely low concentrations, their slow rate of decline in alkaline soils presents problems. Glean (chlorsulfuron) increases damage by Rhizoctonia root rot causing yield losses (6). Subsequent research has shown that the presence in soil of sulfonyl ureas (Glean (chlorsulfuron), Ally (metsulfuron methyl) and Logran (triasulfuron)) increased damage by the take-all fungus, while the foliar-applied herbicides MCPA (a 'phenoxyalkanoic acid') and Dicamba (3,6-Dichloro-o-anisic acid) used to control broadleaf weeds in crop also increase damage caused by the take-all fungus (Rovira and Neate, unpublished).

Conclusions

In this paper we have shown that the three major diseases of cereals have major effects on yield and that the detrimental effects of two of these diseases are increased in direct drilling and when certain herbicides are used *as* part of conservation farming systems. These results demonstrate that in the Mediterranean region of southern Australia correct rotations to minimize disease levels in soil must precede the application of conservation tillage if yield losses are to be avoided.

References

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