FACTORS INCREASING ROOT ROT AND AFFECTING PERSISTENCE OF CLOVER

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Summary

Evidence is given to suggest that fungal root rots of white clover (*Trifolium repens*) are limiting pasture production in New Zealand. Defoliation, temperature, moisture, soil and genetic factors that affect the dynamics of tissue death and vegetative renewal, are described and their effects on productivity and survival of white clover in pastures is discussed. Possible control measures are discussed including management and selection methods and the necessity of further studies to determine root rot distribution and define factors effecting severity is emphasised.

INTRODUCTION

ROOT rot is widespread on clovers (*Trifolium* spp.) in New Zealand. The effect it has on pasture production, its importance, and the identity and significance of the organisms involved, are far from being fully understood.

It has been found that carrying capacity of pastures in some parts of the North Island cannot be raised, by standard methods of pasture improvement. Responses to nitrogen, indicate a clover inadequacy. High levels of root rot are present in most of these problem areas that have so far been examined.

ROOT ROTTING FUNGI

Certain fungi have been found regularly associated with extensive root rot. One species, *Codinaea fertilis*, recorded only in New Zealand, has been isolated from white clover, red clover, sub clover and lucerne, and shown to be a primary pathogen. *C. fertilis* is widespread on clover in parts of the North Island, and in samples taken from the Wairoa area it has been found to occur in up to 60% of rotted roots (Menzies, 1973).

Fusarium spp., present on clover roots in most parts of New Zealand, have been found to be the main factor in root rot and yield reductions in all the important legumes in some areas overseas (Leath *et al*, 1971) A complex of fungi therefore appear to be capable of causing root rot on a number of legumes.

Some evidence for the effect of nematodes on white clover was reported by Healy *et al* (1973). In many areas, however, *Codinaea* and *Fusarium* root rots and nematode infestations occur on the same plants. In these cases it has not yet been possible to apportion the effect of each on plant growth.

Fungous Diseases of Pastures

There are various reasons why little attention has been focused on root rots in New Zealand pastures. Unlike leaf diseases, root rots are not particularly obvious to the casual observer. Often their effects are not evident until there are periods of stress, such as drought, and then unthrifty growth may be attributed entirely to the stress condition. Then there is the problem of separating rots caused by primary pathogens from those in which mild pathogens are following naturally occurring tissue senescence. Many of the fungi involved can act both as pathogens and as saprophytes, depending on the environmental conditions.

DYNAMICS OF PLANT GROWTH AND ROOT ROT

Survival of white clover and its productivity in a permanent pasture is governed by the state of balance between death and renewal of plant tissue. Thus the development of the root system will depend not only on rate of new root growth and rate of infection, but also on susceptibility of the host and virulence of the various pathogens. A variety of factors interact to affect this relationship between clover plants and their pathogens.

Effect of defoliation

In a grazed pasture the major factor affecting white clover is the continual defoliation. Frequency and severity of defoliation have both been shown to have a marked effect in increasing root rot in clover (Moody *et al.*, 1967; Siddiqui *et al.*, 1968). It has recently been shown by Evans (1973) that defoliation of young white clover plants could depress root elongation to 5% of that of undefoliated plants. Increased root rot and decreased root growth following defoliation would therefore have a combined effect in reducing the effectiveness of the root system. In experiments at Plant Diseases Division using soil from Wairoa infested with *C. fertilis* and *Fusarium* spp., root infection occurred on undefoliated clover plants, but there was little observable difference between growth in sterilised and in unsterilised soils. With defoliated plants fewer plants survived in unsterilised soil, the amount of healthy root remaining was less, and the weight of foliage of survivors was less than 26% of that of plants in sterilised soil (Menzies, 1973).

Effect of temperature

There is evidence to suggest that in the northern areas of New Zealand higher temperatures may be adversely affecting white clover by depressing root growth and increasing root rot. Temperature is known to affect root to shoot ratio. Mitchell (1956) grew white clover, subterranean clover and lotus plants at 22.2° and 11.7°C. He found that with defoliated plants the root to shoot ratio was considerably lower at the higher temperature. In U.S.A. root rot of red clover (*Trifolium pratense*) caused by *Fusarium* spp. was more severe at higher temperatures (Fulton and Hanson, 1960; Siddiqui and Halisky, 1968).

Infection studies at a range of temperatures are in progress at Plant Diseases Division. There is, however, already circumstantial evidence to show that *C. fertilis* causes more damage at high temperatures. Optimum temperature for growth of the fungus in culture is about 26°C, the greatest proportions of *C. fertilis* have been isolated from rotted roots during the warmer months of summer and autumn and from only the northern half of the North Island (Menzies, 1973).

Fungous Diseases of Pastures

Effect of moisture and soils

Although no detailed survey has yet been done in New Zealand, observations in problem areas show that lack of persistency appears to be more severe on light soils that dry rapidly. Two areas where this problem is known to be severe over a wide area are on Mairoa ash soils in the King Country, and soils derived from Taupo and Gisborne ash near Wairoa, Hawke's Bay. The root system of plants from these areas have been found to consist of a shallow layer of young roots that have not yet become infected, the older roots having been rotted off. Nodal roots on stolons do not penetrate as deeply into the soil as tap roots. Thus with rapid destruction of the tap root, plants soon lose the ability to utilise moisture from the lower levels, and thus become drought sensitive.

Genetic factors.

Within the clovers there is a diversity of genetically controlled growth types. In the white clover type there is a constant process of death and replacement of both roots and stolons. Some white clover plants act as annuals (Crowder and Craigmiles, 1960). Others survive vegetatively for long periods. Of those measured at one site by Harberd (1963), most were estimated to be about 20 years old, and one was considered to be 60 to 100 years old, or more. Within the range of genetic diversity of white clover, there are also differences in response to other factors, such as defoliation and temperature, that could be used in making selections for tolerance to root rots.

DISCUSSION AND CONCLUSIONS

In this paper most attention has been directed toward factors considered important in the root rot problem of white clover, although other factors are also known to have an effect on root rot, and other clovers are known to react differently from white clover.

Direct evidence of yield reduction caused by root rot is not easily obtainable. At present there are no methods to effectively control root rot in permanent pastures that would enable a comparison to be made between those with and those without root rot. However, circumstantial evidence indicates that it may be an important problem. Pathogenic fungi, widespread on clover roots, have been shown in glasshouse experiments to be capable of causing considerable root rot and growth reduction under some conditions. Under other conditions they have no effect. Growth conditions play an important part and make it impossible at present to use glasshouse results in assessing yield reductions in the field, where little is known about such conditions.

Chemical control of clover root rot on the farm scale would probably be economically impractical even if technically feasible. Other methods of control may prove more effective. Heavy grazing under set stocking conditions probably has the severest effect on clover in areas conducive to root rot. Therefore altering management towards a rotational system may reduce root rot and improve clover survival and persistency. In the long term, however, the most satisfactory method of control may lie in selection of clovers or other legumes for improved performance. In this case, testing and selection of plant material in the problem areas will be particularly important. Evaluation of performance should be made in the presence of organisms and growing condition which may be peculiar to these areas.

Fungous Diseases of Pastures

Further information on the distribution and importance of root rotting organisms, and further study of factors affecting severity of root rot, are required, to understand which organisms and which factors should receive most attention in developing control measures.

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