CROWN RUST AND PASTURE PRODUCTION

J. A. LANCASHIRE
Grasslands Division, D.S.I.R., Palmerston North
G. C. M. LATCH
Plant Diseases Division, D.S.I.R., Palmerston North

INTRODUCTION

THERE is much information available on New Zealand's grasslands which indicates the vast difference between various theoretical plant (Mitchell, 1963) and animal (Hutton, 1963) production potentials and what is actually achieved in practice. Although these potentials are often regarded with scepticism, the fact remains that many research and demonstration farms and top farmers now produce quantities of animal products per acre which would have appeared ridiculously high a few years ago. Further, much grassland research is concerned with the identification of factors limiting the attainment of these potentials, as shown by work on treading (Edmond, 1966), nutrient cycling under grazing systems (Sears, 1953), and the optimum stage and intensity of defoliation of pasture plants (Brougham, 1961).

As more of these limitations have been demonstrated in recent years, many authors have predicted changes in the future pattern of use of New Zealand's grasslands. For example, Mitchell (1960, 1963, 1966) states that the present systems of pasture production are inherently self-limiting and that different types of vegetation should now be examined with a view to the eventual removal of much of the livestock from the land. On the other hand, Brougham (1966) suggests that it may be 40 years before the average national production of butterfat per acre equals that currently being obtained at the Ruakura No. 2 dairy unit. Another aspect of the future suggested by Rogers and Lazenby (1966) and Woodford (1966) is that maximum production and utilization of grasses will come only from single species grown for defined purposes under monocultural conditions. In other words, grass will be grown more like a cereal crop than the grazed multi-species pasture of today. No doubt the future will see some sort of compromise between such diverse ideas, but it is certain that some aspects of grassland research will receive greater emphasis than in the past.

One topic which has received scant attention is that of pasture plant diseases. There is little doubt that they already limit potential plant production in current systerns, but it is clear they will become increasingly important if uniform communities of plants are grown where the spread of disease in a population of closely related individuals will be much easier than in a mixed pasture (Jensen, 1952; Cooke, 1967; Bawden, 1968). An indication of the problem is given by Latch (1966a, 1966b) who has identified 19 fungous diseases of ryegrass in New Zealand and also found (unpublished) that at least 12 fungous diseases affect clover. In addition, there has been little work on viruses, although they are undoubtedly widespread in New Zealand (Smith, 1963; Latch and Procter, 1966), and overseas work (Catherall, 1966) suggests they may have severe effects on the growth of pasture species.

As a result of these observations and because there are very few quantitative data on the effects of plant diseases on pasture species, a study of some of these factors has recently started at the Grasslands Division and Plant Diseases Division of the D.S.I.R. at Palmerston North. The most intensive work to date has been on the parasitic fungus *Puccinia coronata* Corda or crown rust (Lancashire and Latch, 1966). This disease has been recorded on a wide range of grass species (Cunningham, 1931) and is the commonest rust on ryegrass in New Zealand (Latch, 1966a). It is found at all times of the year but is particularly obvious in summer and autumn when large numbers of rust spores turn many paddocks orange. Rvegrass varieties show a marked variation in susceptibility and Cruickshank (1957) showed that 'Grasslands Ruanui' perennial ryegrass was more severely affected than 'Grasslands Manawa' ryegrass. Thus, selection for resistance to crown rust was made in the breeding of 'Grasslands Ariki' ryegrass (Corkill, 1957, 1963), which has proved. more resistant than Ruanui perennial ryegrass (Barclay, 1963). This difference is probably one reason why Ariki ryegrass pastures contain more live and less dead material than similarly managed Ruanui pastures during summer (Lancashire and Keogh, 1964). However, although McAlpine (1906) in Australia, Sampson and Western (1954) in Britain, and Cruickshank (1957) in New Zealand observed that crown rust may reduce the growth of ryegrass, no quantitative measurements have been reported.

EXPERIMENTAL AND RESULTS

The experiments were based on the use of a spray "Dithane S-31" (a mixture of ⅓ nickel sulphate and ⅔ 80% maneb) which effectively controlled crown rust without causing leaf damage. It was therefore possible to compare the growth of plots having a high level of crown rust infection (unsprayed) with that of plots with a low level of infection (sprayed). As there was no evidence that the spray stimulated growth directly, and as other plant pathogens were virtually absent, it was assumed that differences in growth between sprayed and unsprayed plots were solely due to differences in the severity of crown rust. The technique was initially used in plots of 'Grasslands Ruanui' perennial ryegrass and 'Grasslands Ariki' ryegrass.

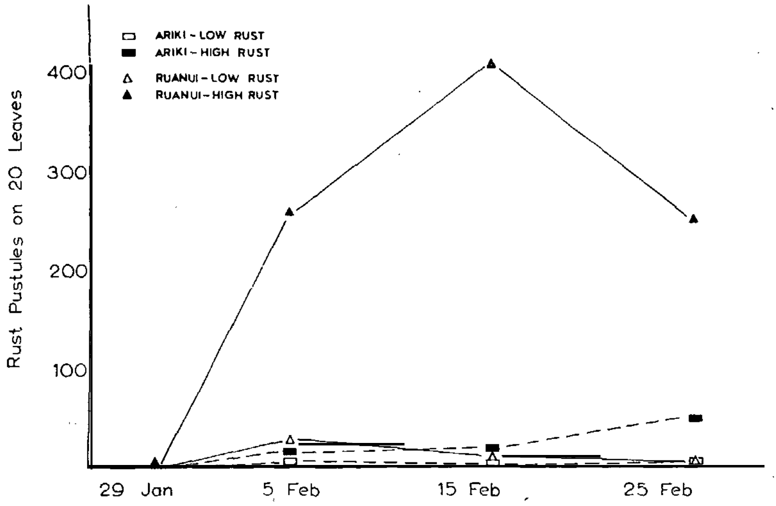

FIG. 1: *The incidence of crown rust on two ryegrass varieties.*

Figure 1 shows that the objective of high and low rust level treatments was achieved and also that Ariki was more resistant to the disease than Ruanui.

Figure 2 shows that the initial response of ryegrass to the rise in rust infection was an increase in the amount of yellow (senescent) material in the sward. Subsequently, the yields of green (live) and brown (dead) ryegrass were

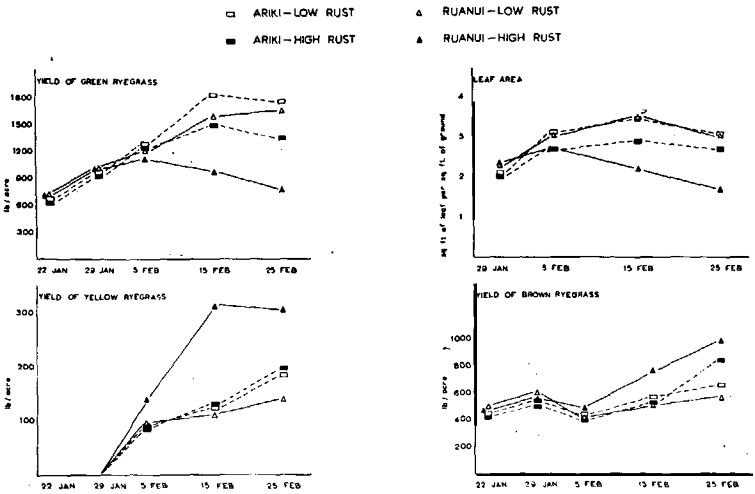

FIG. 2: *The effect of crown rust on two ryegrass varieties.*

affected so that by the end of the experiment crown rust had reduced the yield of green ryegrass by 53% in the Ruanui plots and **21%** in the Ariki plots. Conversely the disease had caused a 68% increase in brown ryegrass in Ruanui and a 27% increase in brown ryegrass in Ariki by the final harvest. Figure 2 also shows that there was a substantial reduction in leaf area and, as up to 70% of the yellow and brown fractions was leaf, it is clear that the disease caused widespread death of ryegrass leaves. Table **1** shows that this eventually led to the death of complete tillers and the opening up of the sward.

Prior to the start of the experiment all plots grew to four inches ("tall") and then half were cut to one inch ("short").

TABLE 1: MEAN NUMBER OF LIVE AND DEAD RYEGRASS TILLERS PER SQUARE FOOT ON MARCH 1
(Data combined for the two ryegrass varieties)

	Live	*Dead*
Low rust level	1,244	147
High rust level	996	209
S.E.	52 **	12 **

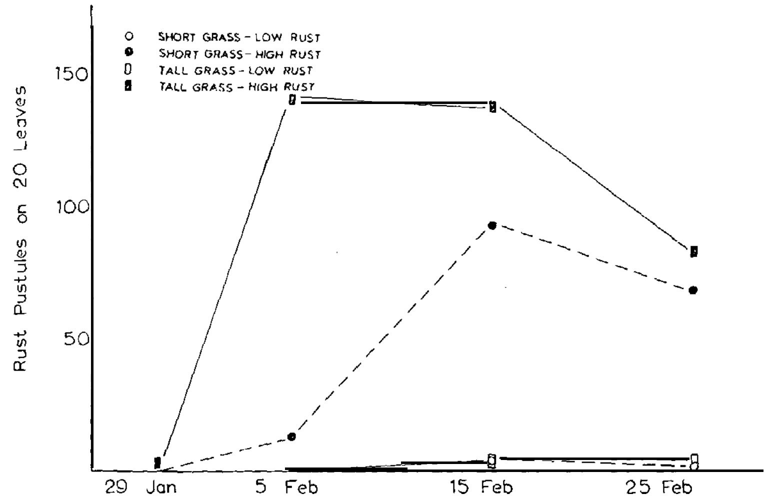

FIG. *3: The incidence of crown rusf on ryegrass af two mowing heighfs. (Data combined for the two ryegrass varieties.)*

Figure 3 shows that this defoliation delayed the rise in rust infestation and also reduced the level of the disease below that obtained in the "tall'! plots. As a result there was less effect from rust (Fig. 4) in the "short" defoliated plots than in the "tall" treatment. This effect probably occurred because the mowing treatment removed many infected ryegrass leaves and thus the cycle of infection: rust development in the leaf and spore production would have to begin again on the regrowth while continuing uninterrupted on the leaves in the undefoliated treatment.

TABLE 2: CROWN RUST IN LATE SUMMER AND AUTUMN

	Maximum Reduction in Yield caused by Crown Rust %	*Maximum Recorded Spore Numbers (per g dry, weigh t of herbage)*	*Mean Air Temperature (°F)*
Late summer:			
Ariki	22	5,688,000	67.3
Ruanui	64		
Autumn:			
Ariki	17	4,140,000	60.0
Ruanui	49		

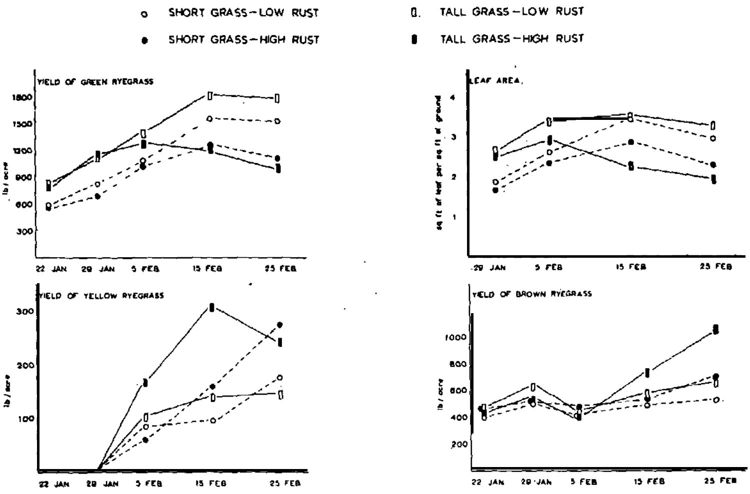

FIG. *4: The effect of crow11 rust on ryegrass at two mowing heigkts. (Data combined for the two ryegrass varieties.)*

These trials were repeated in the autumn from early March to early May and the same general pattern of results occurred except that, as shown in Table 2, the incidence of crown rust was less severe, probably because of lower, temperatures.

In order to reproduce the field situation more closely, a study was also made of the effect of crown rust on a mixed Ruanui perennial ryegrass/Huia white clover sward.

Figure 5 shows that by the end of the experiment the disease had caused an 84% reduction in ryegrass yield and an 87% increase in clover yield. Clearly the reduced growth and death of ryegrass in the diseased plots gave the clover a competitive advantage so that in a period of only 5 weeks the proportion of clover in the sward increased from 24% to 80%. A further point is that the loss of ryegrass yield through rust was considerably greater in this mixed sward than in the pure ryegrass swards discussed earlier. This appears to be a good example of a phenomenon observed by de Wit (1960) who showed that the effects of a disease on a susceptible species are increased if it is grown in a mixture with a resistant species.

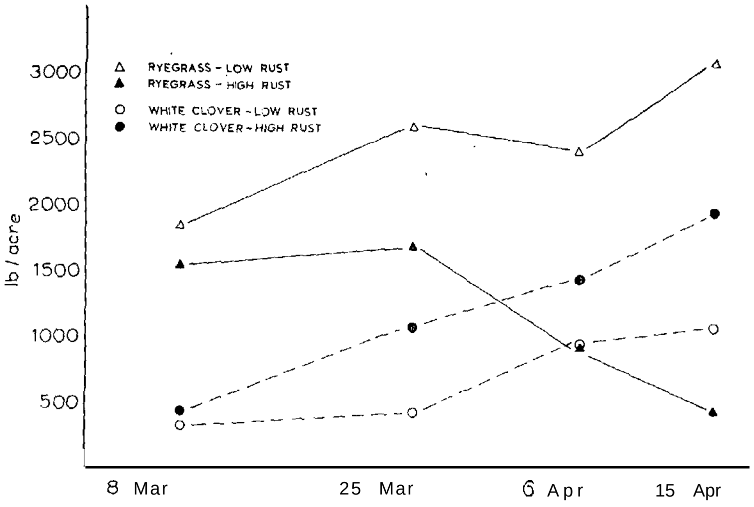

FIG. 5: *The effect of crown rust on a Ruanui perennial ryegrass/Huia white clover sward.*

DISCUSSION

It is concluded from these experiments that crown rust can be an important factor limiting pasture producton during the summer and autumn, especially when Ruanui ryegrass, which is widely used in New Zealand, is the major component of the sward. Ariki ryegrass has generally shown superior summer and autumn production to Ruanui and it appears from these experiments that its relative resistance to crown rust may be partly responsible for this improvement. However, it should also be noted that the yield of Ariki was reduced as much as 22% by crown rust and therefore further selection for resistance to the disease may be warranted in this variety. It also appears likely that the disease contributes to the generally higher proportion of clover found in Ruanui pastures than in Ariki pastures during summer and autumn. In addition, other grass species or weeds may invade Ruanui pastures as they are opened up by the disease.

The results of the mowing trial indicate that it may be possible to reduce the incidence of crown rust by variations in grazing management. The time which elapses between ‘spore germination on a leaf and the production of new spores is 7 to 12 days according to environmental conditions (Latch, unpubl.). It is possible, therefore, that successive grazings at this interval with consequent leaf removal would greatly reduce the incidence of the disease. However, this severe' grazing system is likely to have an adverse effect on ryegrass persistency during the summer (Brougham, 1960) and is therefore impractical. Observations in the field suggest that three-weekly grazings will check much of the very rapid spore multiplication which causes most of the damage to ryegrass plants, This grazing interval would be a more practical proposition except in areas subject to summer drought. However, more field work is required before definite recommendations can be made.

A further problem indicated by Corkill (1956) is that sheep will not graze heavily rusted single plants, although Butler and Rae (1957) found no deleterious effects on sheep which grazed severely infected pure stands of Ruanui ryegrass. It is possible, therefore, that to ensure success with a grazing control technique it would be necessary to mob-stock heavily in order to force the sheep to eat the rusted ryegrass.

In addition to reducing pasture yield, crown rust will probably reduce the "nutritive value" of the pasture. Rusted forages are generally unacceptable to stock (Demarquilly *et al.,* 1965) and also the increases in dead material in a' pasture will cause a fall in the digestibility of the herbage (Miles *et al.,* 1964). These factors probably account for the observation bv many dairy farmers in New Zealand that a fall in milk production occurs after cows have grazed a paddock infested with crown rust.

A more direct effect on stock health is provided by the large quantities of dead material which form an 'ideal substrate for *Pithomyces chartarum,* the fungus which causes facial eczema. As crown rust is active at the same period of the year as *Pithomyces chartarum,* any method which reduces the incidence of crown rust may indirectly reduce the incidence of facial eczema.

The relatively large effect of crown rust in the autumn presents an interesting control problem. Many farmers shut up pasture for autumn-saved feed in earlv April, and in some cases paddocks may not be grazed for 3 to 4 months. Meanwhile, rust may occur and probably contribute to the large quantities of dead material often seen in autumn-saved pastures. However, these effects could probably be substantially reduced by shutting up in late April or May when temperatures are well below the optimum for the development of crown rust, and by spelling for only 6 to 8 weeks as suggested by Brougham (1956). This reduced spelling period would also tend to reduce the severity of several other fungous diseases of ryegrass which are often troublesome in autumn-saved pasture (Latch, 1966a).

Finally, it should be pointed out that this paper has been concerned with only one disease — crown rust. Large effects have been demonstrated, but it is perhaps equally important to consider the effects on production potentials of the other 30 to 40 diseases of possible economic importance which are present in New Zealand pastures.

REFERENCES

Barclay, P. C., 1963: *Proc. N.Z. Grassl. Ass., 25: 128.*

Bawden, F. C., 1968: New *Scientist, 39: 136.*

Brougham, R. W., 1956: N.Z. *J.* Sci. *Tech. 38A: 78.*

———, 1960: *N.Z. J. agric. Res., 3: 125.*

———, 1961: *Proc. N.Z. Soc. Anim. Prod., 21: 33.*

———, *1966: N.Z. agric. Sci., 2: 19.*

Butler, G. W.; Rae, A. L., *1957: Sheepfmg Annu.: 181.*

Catherall, P. L., 1966: *J. Br. Grassl. Soc., 21: 116.*

Cooke, G. W., *1967:* In *The' Control of Soil Fertility,* Crosby Lockwood, London.

Corkill, L., 1956: *Sheepfmg Annu.: 47.*

———, *1957: Agric. Rev., 3 (6):* 31.

———, 1963: *Proc.* N.Z. *Grassl. Ass. 25:* 153.

Cruickshank, I. A. M., 1957: *N.Z. J. Sci. Tech. 37A: 539.*

Cunningham, G. H., 1931: In *The Rust Fungi of* New *Zealand,* Pub. by the author, Dunedin, N.Z.

Demarquilly, C.; Boissau, J. M.; Cuylie, G., 1965: *Proc. 9th inf. Grassl. Cong.: 877.*

Edmond, D. B., 1966: *Proc. 10th int. Grassl. Cong.: 453.*

Hutton, J. B., 1963: *Ruakura Fmrs' Conf. Proc.: 204.*

Jensen, N. F., *1952: Agron. J., 44: 30.*

Lancashire, J. A.; Keogh, R. G., 1964: *Proc. N.Z. Grassl. Ass., 26: 153.*

Lancashire, J. A.; Latch, G. C. M., 1966: N.Z. *J. agric. Res., 9: 628.*

Latch, G. C. M., 1966a: N.Z. *J. agric. Res., 9: 394.*

-----, 1966b: *Ibid., 9: 808.*

Latch, G. C. M.; Procter, C. H., 1966: *Ibid., 9: 726.*

McAlpine, D., *1906:* In *The Rusts of Australia,* Dep. Agric., Victoria, Australia.

Miles, D. G.; ap Griffith, G.; Walters, R. J. K., 1964: *J. Br. Grassl. Soc.,* 19: 75.

Mitchell, K. J., *1960: Proc. N.Z. Soc. Anirn. Prod., 20: 82.*

-----, 1963: *Proc. Inst. agric. Sci.: 80.*

-----, *1966: N.Z. agric. Sci., 2: 23*

Rogers, H. H.; Lazenby, A., 1966: *Proc. 10th int. Grassl. Cong.: 630.*

Sampson, K.; Western, J. H., 1934: In ***Discuses of British Grasses and Herbage Legumes.*** Cambridge University Press.
Sears, P. D., 1953: N.Z. ***J. Sci. Tech., 35A:*** Suppl. 1.
Smith, H. C., 1963: N.Z. ***J. agric. Res., 6: 229.***
de Wit, ***C.*** T., 1960: ***Versl. landbouwk. Onderz., 66: 8.***
Woodford, E. K., 1966: ***J. Br. Grassl. Soc., 21: 109.***

DISCUSSION

Different levels of rust infection were obtained by spraying with fungicides. Asked if crown rust and ryegrass staggers could be associated, Lancashire stated that there was no experimental evidence to support this. He thought pasture diseases were present in South Island pastures — *e.g.*, crown rust was an obvious one. It would be necessary to run similar trials to that reported to obtain a reliable measurement of the effects in the South Island.

A comment was made that fertility levels might have an effect on the incidence of rust — e.g., urine patches never seem to be badly affected. Lancashire agreed that there was a close tie-up. Trials had shown that the fungus tends to develop more rapidly under low fertility conditions. However, even a high fertility plot was affected if left undefoliated for more than three weeks.

As far as animals were concerned, no ill-effects had been observed. To a question on the susceptibility of grasses other than ryegrass to crown rust, Lancashire stated it affected a wide range of species. Other diseases might also be important. Trials at Palmerston North had shown that stem rust could reduce cocksfoot yields by as much as 40%. On being asked whether insect damage could have caused tiller deaths, he stated that other pathogens or insects had little, if any, effect on yield in this trial.