CONTROL OF LODGING IN WHEAT CAUSED BY EYESPOT *(Cercosporella herpotrichoides* Fron.*)*

J.T. WITCHALLS
SHELL OIL NEW ZEALAND LTD

W.H. RISK AND M.F. HAWKE
FIELD RESEARCH SECTION, RESEARCH DIVISION
NEW ZEALAND DEPARTMENT OF AGRICULTURE

R.C. CLOSE
PLANT DISEASES DIVISION, D.S.I.R.

SUMMARY

Cultural practices of low seeding rate, weed control, corrective stubble management and the sowing of varieties resistant to lodging, decreased the severity of lodging caused by eyespot and led to increased yields. The growth regulating chemical C.C.C. and the systemic fungicide benomyl reduced lodging to low levels. The resulting yield increases from benomyl were 45% higher than that of the untreated crop.

INTRODUCTION

In cold wet climates lodging of wheat is often caused by the foot-rot or eyespot fungus Cercosporella herpotrichoides Fron. the importance of which has been reviewed by Blair (1954) Bruehl et.al. (1968). In New Zealand, eyespot was first recorded in 1941-42 on the Taieri Plains by Saxby (1943). In recent years, following large increases in wheat area in Southland (1963 5,265 hectares; 1968 20,250 hectares) the disease assumed severe proportions. The cold,damp and humid climate of this area is conducive to the disease, and severe infestations led to entire crop collapse and complete grain loss. In the past, control of eyespot was attempted by adopting agronomic practices which favour the crop and not the pathogen (Glynne 1965). In recent years growth regulating chemicals such as Chlormequat (C.C.C.) and systemic fungicides such as benomyl have been demonstrated as effective lodging control treatments (Slope et.al. 1969, Witchalls, 1970 and Witchalls and Close, 1971).

NEW ZEALAND RESEARCH 1943 - 1968

1. Cultural Methods of Control

(i) Some cultural practices exaggerate the cold, damp and humid climate of southern New Zealand and if these conditions are encouraged at the crop base, where the fungus occurs, lodging as a result of eyespot infection increases.

Two practices which exaggerate these effects are high seeding rates and lack of basal weed control.

(a) Seeding Rate

Where eyespot has been minimal, several trials have shown that seeding rates above 136 - 148 kg/ha per hectare are unnecessary to maximise yield (Witchalls,1970). Where eyespot is present higher seeding rates are at a distinct disadvantage as lodging is increased and yield drastically reduced.

(b) Weed Control

It has been difficult to demonstrate the significance of weed control owing to uneven weed infested sites and seasonal climatic variations that have led to variable weed growth. However, several crop surveys have demonstrated the significance of weeds, and substantiative proof was obtained in trials in the 1969 - 70 and 1970 - 71 seasons, results of which will be discussed below.

(ii) Varieties

Varietal susceptibility to lodging differs markedly (Witchalls, 1970).
In the 1966-67 season two trials compared the susceptibility of the varieties Aotea and Hilgendorf 61 to lodging. In the first, at seeding rates ranging from 139-270 kg per hectare, lodging in Aotea ranged from 2 - 16% and in Hilgendorf 26 - 91%. In the second trial at similar seeding rates there was 5% lodging in Aotea with 68 - 86% in Hilgendorf. In the 1967-68 and 1968-69 seasons similar results were also obtained. A recent Crop Research Division cultivar, Kopara is also many times more susceptible to eyespot than is Aotea.

(iii) Stubble Management

A ready source of the disease is stubble of an infected crop. If infected stubble is left standing over the winter the cold,,wet and humid conditions which prevail encourage pathogen development. It is therefore important to destroy all stubble before a subsequent wheat crop is sown. Burning is the most effective method. If burning is not possible as is often the case in Southland on account of dense weed growth, deep ploughing is the next most effective means, provided it is deep enough to prevent infected straw from being dragged to the surface with subsequent cultivations. Surface or skin ploughing is ineffective. (I.D. Blair - pers. comm.).

Winter stock management is equally important. A common practice in Southland is the wintering of the ewe flock on wheat stubble with hay feed out on the paddock and/or to use the paddock as a run-off from swedes. Blair (1954) has shown eyespot will survive and grow on ryegrass straw, so by feeding this on stubble eyespot is encoura This has been strikingly recorded over the past few seasons, with remarkable increases in lodging resulting. Also the practice of using stubble as a run-off from swedes is dangerous as there is the risk of spreading eyespot from the harvested wheat crop to the swede paddock which normally is subsequently sown in a wheat crop. In the last two seasons 1969-70, 1970-71, stubble management practices were studied.

2. Chemical Control

Since 1967 the use of C.C.C. has simplified the rather involved and demanding management practices for the control of this disease.

C.C.C. seems to have no direct effect on the fungus (Slope et. al., 1969); its main effect is to shorten and stiffen the straw of wheat and make the plants more resistant to straw break and straggle. The extensive work on C.C.C. has been reviewed by Humphries, 1968. In New Zealand similar responses have been obtained (Witchalls, 1970). In four trials C.C.C. increased the yield of Aotea (lodging being insignificant in untreated plots), by 203-470 kg/ha, while with Hilgendorf (70% lodging) the increase was 675-1210 kg/ha.

NEW ZEALAND RESEARCH 1969-1971

In the 1969-70, and 1970-71 seasons further trials were conducted on an area where eyespot had been allowed to build up in the previous wheat crops.

The aim of these trials was to evaluate the combined effects of winter stubble management, treatment with C.C.C., weed control, and the action of the systemic fungicide benomyl which had shown in *in vitro* tests to suppress eyespot growth.

Field trials were sown in the spring (September 1969 and October 1970). Trials were of split plot design with three replicates of main plot treatments:

1. Stock fed hay on stubble over the winter period.

2. Stubble not stocked, ploughed early and the area fallowed through the winter until sowing the following spring.

Trial 1. 1969-70

The six subplot treatments comprised the combinations given in Table 1. Plots were 40 metres long by 1 metre wide. All plots received two overall applications of dithioquinox (Morestan) sprays at the Feekes 5 and 7 growth stages, in an attempt to eliminate powdery mildew from the crop.

The herbicide mixture of bromoxynil/MCPA/MCPP was applied to appropriate plots just prior to dithioquinox sprays. C.C.C. was applied at Feekes 7 growth stage, and the benomyl at the Feekes 7 - 8 stage. Both were applied in water 225 l/ha.

Lodging assessments and yield measurements were made on each plot.

Unfortunately due to management, fencing and water supply problems the main plot treatments were not satisfactorily applied and this comparison had to be discarded and subplot treatment replications increased to 12.

One spray application of benomyl almost completely prevented lodging and produced an increase in yield of 1350 kilograms, or 45.6% more than that of control. This can be compared with C.C.C. where there was 9.8% lodging and an average yield 22% lower than that given by benomyl. The use of weedicides suppressed competitive weed growth, and treated plots yielded significantly more than control. Lodging, however, was not significantly reduced following weedkiller use and this lack of response can be attributed to the dense weed growth in control plots which supported some weakened tillers and prevented them from lodging completely. The increase in yield from use of weedicide could be attributed to two factors (a) a probable decrease in severity eyespot infection, and (b) more efficient threshing. Where weeds were eliminated some severely lodged tillers were collected by the threshing machine at harvest, but where weeds were present the weed canopy prevented lodged tillers lying beneath it from being collected. Nothing was gained by using C.C.C. in combination with either benomyl or weedkiller. Benomyl, because of its systemic properties, seems to have had a direct effect on the eyespot fungus and thus prevented lodging. The yield increase appears to have come mainly from the control of eyespot which resulted in little lodging in treated plots and plants being stronger and slightly later maturing.

TABLE I: Effect of Single Applications of Benomyl, Weedicides and C.C.C. on the Eyespot Lodging and Yield of Spring Wheat 1969/70.

Treatments	Feekes Growth Stage Applied	Lodged Tillers (a)(b) Mean Numbers per 4.6 m row	%		Yield (Kilograms per hectare)	
Control		155	38.6	eD	3950	cC
Benomyl (113 g.ai)	7-8	9	2.2	bB	4300	aA
Bromoxynil 113 g.ai. MCPA 113 g.ai. + MCPP 567 g.ai	4-7	112	27.7	eD	3400	bB
C.C.C. (568 g.ai)	7	40	9.8	cC	3520	bB
C.C.C. + Benomyl		3	0.8	aA	4240	aA
C.C.C. + Weedkiller		60	14.8	dC	3670	bB
		C.V.15.7%			C.V. 7.3%	

(a) Sample was 5 rows, each 0.914 metres long, 5 samples per plot, 12 plots per treatment.

(b) Based on 403.8 total number of tillers per sample - being a mean of 22 samples in benomyl and C.C.C. plots. For statistical analysis the original tiller counts were transformed to logs.

Trial 2 1970-71

In view of the failure to effectively apply main plot treatments in 1969-70 a similar trial was repeated in 1970-71. Treatments were as for Trial 1 except benomyl, C.C.C. and weedkiller were respectively applied at the ~~Feekes~~ 9-10, 9-10, and 5 growth stages following sowing on the 15.10.70. Dithioquinox was not applied, as the season was exceptionally hot and dry from November on and regular inspections detected only a few leaves and stems infected with powdery mildew.

Lodging assessments and yield measurements were completed for each plot and these are respectively recorded in Tables 2 and 3.

(a) Lodging:-

Lodging was more severe on the stock plus hay treatment plots. It is interesting to note that the mean number of tillers per sample area in the main plots differed considerably. Whether this was due to the main plot treatment effect on the eyespot fungus is possibly subject to some question, as it could equally result from possible changes in soil structure following stock wintering. This is a factor worthy of further attention.

It has been established that higher plant populations encourage lodging (Witchalls, 1970) and as a result the lodging trend should theoretically have been the opposite to that which occurred. However, crop residues left on the soil surface over the winter are a suitable media for eyespot to build up on, and following the sowing of wheat in the spring could be responsible for the mortality of seedling plants and infection of survivors. Higher soil nitrogen levels as a result of urine return may also assist eyespot build up (Glynne, 1965),

Subplot treatment effects on lodging were marked. The effect of benomyl was prounced, and the effect of weedkillers was much more marked than in 1969-70 being equal to that of C.C.C. and superior to control.

TABLE 2: Effect of Management and Single Spray Applications of Benomyl, Weedkiller and C.C.C. on the Eyespot Lodging (1970/71).

A. Main Plots

	Mean Number of Tillers Lodged per 7.3 metres of row. (a)	Mean Number of Tillers Lodged per 7.3 metres of row. (b)	Mea Per cen Lod
Not Stocked & Ploughed Early	837	23 aA	2.8
Stocked and Ploughed Late	522	28 bB	5.4

B. Sub Plots (Main Effects)

Treatments	Mean Number Tillers Lodged per 7.3 Metres row (b)
Control	103 dC
Benomyl	10 bA
Weedicide	39 cB
C.C.C.	29 cB
C.C.C. + Benomyl	4 aA
C.C.C. + Weedicide	11 bA

(a) Sample was 1.83 metres of drill row (7 coulters), 4 samples per plot. 36 plots per main plot.

(b) For statistical analysis the original tiller counts were transformed to square roots.

(b) Yield

Yield differences (Table 3) were marked. The main plot treatment caused a 920 kilogram or 20% yield increase in favour of not stocking stubble and burying it by early ploughing.

Subplot treatments benomyl and weedicides gave similar yield increases over control, with C.C.C. having no effect.

TABLE 3: Effect of Management and Single Applications of Benomyl, Weedicides and C.C.C. on Spring Wheat. Grain Yield kg/ha.

	Main Plot Treatment		
Sub Plots Treatments	Stock + Hay	No. Stock Plough	Main Effects of Sub-plot Treatments
Control	4130 cC bB	4940 bC	4530 bB
Benomyl	4770 ab AB bB	5870 aA aA	5320 aA
Weedkiller	4910 a AB bB	5680 aAB aA	5290 aA
C.C.C.	4350 bc BC bB	5170 bBC aA	4760 bB
C.C.C. + Benomyl	5030 aA bB	5890 aA aA	5460 aA
C.C.C. + Weed-Killer	4710 ab ABC bB	5870 aA aA	5290 aA
Main plot effect	4650 bA	5570 aA	CV% 8.1

DISCUSSION 1969-70, 1970-71 TRIALS

Some pertinent and interesting differences in results were obtained from virtually identical trials in the two seasons.

(a) Lodging

The major treatment difference between the two seasons was the greater effect of weedkiller in 1970/71. This was probably a reflection of the hot, dry summer in 1970-71 which led to the almost complete desiccation of weeds in untreated plots leading to a control of weeds equal to that on weedicide treated plots. Because of this, when lodging stresses became apparent there was no physical support by weeds to weakened stems in control treatment plots as occurred in 1969-70. Earlier in the season, October-November, when eyespot was in its destructive stage, climatic conditions encouraged weed growth and conditions inducive to eyespot infection in the non weedicide treated plots. Where weedicide was applied these conditions did not exist and plants were not weakened and lodging stresses in the late summer had less effect.

C.C.C. was not superior to weedicide in 1970-71, a reflection of either more effective eyespot control following weedicide application, or alternatively less severe conditions, which precipitate lodging, than occurred in 1969-70, not allowing the straw strengthening effect of C.C.C. to show up.

(b) Yield

Differences in subplot treatment effects on yield between the two seasons is interesting. In 1970-71 benomyl and weedkiller effects were overriding and of equivalent efficacy however, this was not the case in 1969-70 when benomyl was superior. C.C.C. had no effect in 1970-71, being no better than control, while in the 1969-70 season it caused significant results. These differences are probably a reflection of the hot dry season in 1970-71. In this season the yield increase from benomyl appeared to have come mainly from the control of the eyespot fungus, but the weedicide was as effective in increasing yield suggesting that the removal of weeds reduced eyespot to a 'no effect' level in terms of yield, altering basal crop conditions to the extent of preventing the eyespot fungus from developing. However, lodging differences in these plots were significant though on a percentage basis this difference was only 4% which in terms of yield was of no account. C.C.C. had no effect on yield, supporting the contention that it only effects straw strength and not the fungus (Humphries, 1968) which in the absence of benomyl or weed control, was severe enough to effect grain development. The lodging reduction over control is of little account when lodged tillers in control plots can be threshed, the drought desiccated weeds did not prevent the gathering of lodged tillers at harvest, a reversal of the situation in 1969-70.

CONCLUSIONS

It has been shown that cultural practices of reduced seeding rates, weed control, stubble management, and the sowing of more resistant or stronger strawed wheat varieties will decrease the severity of lodging caused by eyespot and lead to increased yields. Where proven cultural methods cannot be practiced, applications of C.C.C. or benomyl become useful and effective management tools with benomyl being the superior through its complete reduction in lodging by its control of the eyespot fungus.

ACKNOWLEDGEMENTS

The assistance of Mr C.B. Dyson with statistical analysis of data is gratefully acknowledged.

BIBLIOGRAPHY

Blair, I.D. 1954: Nutrition and survival of Cerçosporella herpotrichoides and aspects of the wheat eyespot disease. N.Z.J. Sci. Tech. 36A: 207-220.

Bruehl, G.W., et.al., 1968: Experiments with Cercosporella foot rot disease of winter wheat. Washington Ag. Exp. Sta. Bull. 1964: 1-14.

Dickens, L.E., 1964: Eyespot foot rot of winter wheat caused by Cercosporella herpotrichoides. Cornell Univ. Mem. 390: 1-39.

Glynne, M.D., 1965: Crop sequence in relation to soil borne pathogens. In Ecology of Soilborne Plant Pathogens, Prelude to Biological Control. Ed. K.K. Baker and W.C. Snyder, Univ. California Press, Berkeley, pp. 432-435.

Humphries, E.C., 1968: C.C.C. and Cereals. Field Crop Abst. 21: 91-99.

Saxby, S.H., 1943: Eyespot in Wheat, N.Z.J. Agric. 66: 257-261.

Slope, D.B., Humphries, E.C., Etheridge, J., 1969: Effect of C.C.C. on eyespot (Cercosporella herpotrichoides) of winter wheat. Plant Path. 18: 182-185.

Witchalls, J.T., 1970: The effect of chlormequat on wheat crops where lodging is induced by eyespot. Proc. 23rd N.Z. Weed and Pest Control Conference 1970: 17-23.

Witchalls, J.T. and Close R., 1971: Control of Eyespot lodging in wheat by benomyl. Plant Disease Reporter, 55, 45-47.

Witchalls, J.T. and Hawke, M.F., 1970: Eyespot in Wheat. N.Z.J. Agr. 66: 257-261.