THE EFFECT OF CHLORMEQUAT ON WHEAT CROPS WHERE LODGING IS INDUCED BY EYESPOT

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Summary

When chlormequat was applied to wheat crops affected by eyespot (*Cercospora herpotrichoides*), at a rate of 1 to 5 lb a.i. per acre and from the Feekes growth stage 3 to 9, lodging induced by eyespot was greatly reduced and harvested yields resultingly increased. A rate of 2 lb a.i. per acre is near optimum and, although time of application does not appear critical, there is an advantage of applying chlormequat at a stage of growth when its strengthening effect will be expressed on the base of the plant — that is, from the commencement of tillering to the appearance of the first internode. In the absence of lodging, chlormequat application does increase yield but the extent of this effect is variable.

INTRODUCTION

SINCE the development of chlormequat, many accounts of its effects on plant growth have been published (Humphries, 1968a, b). On wheat, its most notable effect has been to produce plants with thicker and more rigid stems and shorter individual internodes. This has resulted in markedly reduced lodging in wheat crops (Barrett *et al.*, 1967; Caldicott, 1966; Symme, 1968). Yield losses of 50 to 80% have been reported from lodging (Primost, 1964; Symme, 1968) and the writer has experienced complete yield loss under severe lodging conditions. In this later instance, eyespot (*Cercospora herpotrichoides*) which weakens basal internodes of the wheat plant was the cause. Chlormequat application effects a reduction in lodging, whether this results from eyespot or other causes, resulting in significant yield increases (Humphries, 1968a; Witchalls and Hawke, 1970).

This investigation evaluates chlormequat as an aid to wheat production in southern New Zealand where lodging induced by eyespot can be serious. It is recognized, however, that recommended cultural practices, if adhered to, will reduce lodging induced by this fungus (Witchalls and Hawke, 1970).

EXPERIMENTAL

The two major New Zealand wheat varieties, Aotea and Hilgendorf 61 (Hilg. 61), and these together with recent selections from the New Zealand Department of Scientific and Industrial Research (DSIR) were tested in factorial combination with chlormequat — applied at different growth stages as measured by the Feekes scale (Large, 1953) — and nitrogen, as sulphate of ammonia (S/A), in randomized blocks in experi-

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TABLE 1: TRIAL TREATMENTS AND DESIGN

Trial	Varieties	Seeding Rate (lb/acre)	Chlormequat Feekes Stage of Application		Nitrogen (cwt S/A)	Control Treatments	No. Treatments No. Replicates
			Rate (lb)	Application			
A 3 × 3 × 2 + 2	Aotea	133	1, 2, 4	5, 7, 10	nil	Aotea	20
	Hilg. 61					Hilg. 61	2
B 2 × 3 × 2 × 2	Aotea	101, 220, 294	0, 2, 5	6	0, 4	N.A.	24
	Hilg. 61	103, 190, 294					2
C 6 × 2	Aotea						
	1020.01						
	1169-01						
	1178.01						
	1178.02						
D 3 × 3 × 2 + 2	1351.01	133	0, 2, 5	6	nil	N.A.	12
	Aotea	133	1, 2, 5	3, 6, 9	0, 2	Aotea no N	4
						No chlormequat	20
						Aotea + N	3
						No chlormequat	

E As for Trial A apart from chlormequat applied to Feekes stage 2 to 3, 6 to 7, and 9.

F As for Trial B except seeding rate of Aotea (96, 192, 234 lb) and Hilg. 61 (101, 192, 220 lb).

G As for Trial C.

ments laid out in areas expected to show either severe or minimal eyespot infection. In all, there were seven trials (Table 1) sown in September 1968 and harvested in March 1969.

Trials A, B and C were sown at Waimatuku on a Drummond silt loam and E, F and G at Browns on an Otapiri silt loam as third wheat crops following swedes after an extended period in pasture. Both areas were severely infested with eyespot. Trial D, at Winton on an Otapiri silt loam, was a first wheat crop following swedes after pasture. There was no history of eyespot.

All trials received a basal application of 2 cwt of superphosphate and were sprayed with MCPA/dicamba for weed control. Weed control was only partially effective as apparently resistant basal weeds, chickweed (*Stellaria media*) and spurrey (*Spergulla arvensis*), were unaffected.

All rates of chlormequat are expressed as lb a.i. per acre.

MEASUREMENTS

- (1) *Lodging* was assessed visually on a 0 to 5 scale (0 = no lodging; 5 = 100% lodging); and by assessing percentage lodged tillers in ten 15 in. row lengths in each plot.
- (2) *Height*: Tiller height was assessed by collecting 25 tillers from each plot and measuring the distance from the crown of the plant to the base of the ear.
- (3) *White ears* (undeveloped ears prematurely ripening) were assessed visually on a percentage basis in Trials C and G. These were associated with severe eyespot lesions at the base of stem. There was no evidence of "take all" (*Ophiobolus graminis*).
- (4) *Yield* was assessed following direct heading by a commercial harvester. (Yield corrected to 15% moisture.)
- (5) *1,000 grain weight* was calculated for each treatment in all trials from samples taken during harvest.
- (6) *Grain weight per ear* was assessed by collecting at random 40 ears from each plot which were threshed by hand and grain weight calculated.

RESULTS

Results of Trials E, F and G at Browns were identical with those from Trials A, B and C, respectively, except for minor variations in degree of reaction, and as a result are not presented here.

LODGING

Assessments for Trials A, B and C are presented in Tables 2, 3 and 4. There was no lodging in Trial D in the absence of eyespot. In Trials A, B and C, Aotea was markedly more resistant to lodging than other varieties. In Trial A, Aotea plots scored 0 on the 0 to 5 scale; lodging averaged 4% in Aotea control plots. In Trial B, the result was similar, only 5% of the Aotea plot lodging at the highest seeding rate in the absence of chlormequat. As a result, the chlormequat reaction on Hilg. 61 is alone presented for Trials A and B.

TABLE 2: TRIAL A
The main effects of rate and time of application of chlormequat on lodging, yield, and tiller height of Hilg. 61 and on yield of Aotea sown under conditions of severe eyespot infection.

Chlormequat (lb)	Time of Application (Weeks)	Lodging 0-5	Hilg. 61 Tiller Assessment % Lodged	Height	Hilg. 61	Yield (Centals/acre)	Aotea
1		1.3 aA	16		38.2 bA	54.6 a	
2		0.6 bB	11		38.6 bA	55.9 a	
4		0.3 bB	7		42.7 aA	54.2 a	
	5	0.9 aA	8	28.1 aA	41.6 a	52.8 bA	
	7	0.4 bA	7	26.4 bAB	40.0 a	57.4 aA	
	10	0.8 abA	18	25.5 bB	38.0 a	54.5 abA	
Control		3.5	35	30.5	33.1	50.6	
CV%				7.0	7.5	6.1	

TABLE 3: TRIAL B
The main effects of chlormequat, seeding rate, and nitrogen on lodging and yield of Hilg. 61, and on yield of Aotea sown under conditions of severe eyespot infection.

Seeding Rate Aotea	Hilg. 61	Nitrogen (cwt S/A)	chlormequat (lb)	Lodging Hilg. 61 0-5	% Lodged	Yield (Centals/acre)	Hilg. 61	Aotea
101	103			1.4 bB	14	35.5 a	45.2 bB	
220	190			1.8 bB	25	35.6 a	49.5 aAB	
294	294			3.1 aA	55	35.3 a	53.0 aA	
		nil		2.2 a	32	34.0 a	45.5 bB	
		2		2.0 a	31	37.0 a	53.0 aA	
			nil	3.5 aA	55	30.4 bB	47.8 a	
			2.5	0.7 bB	8	40.6 aA	50.7 a	
				36		15.1	7.8	
CV%								
101	103			2.8	26	32.3	44.4	
220	190			3.0	48	30.9	46.5	
294	294			4.8	91	27.9	52.3	
		in absence of chlormequat						
101	103			0.1	3	38.8	46.0	
		in presence of chlormequat		0.2	7	40.7	52.5	

WHITE EARS

This assessment is presented for Trial C only (Table 4) with results suggesting chlormequat has some fungicidal action.

YIELD

Assessments for Trials A, B, C and D are presented in Tables 2, 3, 4 and 5, respectively. Note the increases in yield resultant from chlormequat application, particularly where there was no lodging (Trial D, Table 5).

1,000 GRAIN WEIGHT AND WEIGHT OF GRAIN PER EAR

These were assessed in an effort to explain yield increases from chlormequat application, particularly in the absence of lodging. In Trial D (Table 5), increased rate and delay in time of application of chlormequat *decreased* 1,000 grain weight. Results from other trials were extremely variable and did not help to explain yield increases either. Where eyespot was severe, as in Hilg. 61, chlormequat substantially increased 1,000 grain weight and grain weight per ear. This was to be expected as chlormequat prevented straws from breaking and allowed grain to reach fuller maturity.

This only partially affected yield, however, as lodging reduction had by far the most significant effect on harvested yield.

DISCUSSION AND CONCLUSIONS

Results demonstrate that, where eyespot is serious in southern New Zealand and lodging is imminent, chlormequat has a place in wheat production. Varieties differ in susceptibility to lodging and response to chlormequat, an effect also shown elsewhere (Humphries, 1968a). Aotea shows resistance to lodging and can be sown with little risk of yield loss under conditions conducive to severe lodging in Hilg. 61. It has been demonstrated, however, that conditions do prevail which will induce severe lodging in Aotea (Witchalls and Hawke, 1970). Recommended cultural practices, in relation to weed control, stubble management and seeding rates will, however, reduce these instances (Manning, 1967; Witchalls and Hawke, 1970). For example, Hilg. 61 has been sown as a third crop in this study only to demonstrate the effect of chlormequat. As eyespot is likely to be more prevalent in crops subsequent to a first crop, Hilg. 61 because of its susceptibility to lodging is not recommended other than as a first crop in southern New Zealand.

Although yield increases resulted from chlormequat application, in the absence of lodging, the components of yield through which this resulted were not isolated. Previous workers have shown an increase in grains per ear and number of fertile tillers per unit area are responsible (Humphries, 1968a).

Despite reports of increased lodging with nitrogen application (Humphries, 1968a), this did not occur here.

The difference in yields from Aotea and Hilg. 61 are due in part to their different reactions to eyespot and chlormequat, but also to the higher natural yield potential of Aotea (L. G. L. Copp, pers comm.).

Many efforts have been directed to finding the best time to apply chlormequat (Humphries, 1968a), but it appears the range of time over which it can be applied is wide, and enables application to coincide with

TABLE 4: TRIAL C
The effect of chlormequat on lodging, percentage white ears and yield of DSIR selections compared against the standard variety Aotea.

Variety (Selection)	Lodging 0-5 chlormequat (lb)		% White Ears chlormequat (lb)		Yield (centals/acre) chlormequat (lb)	
	0	2.5	0	2.5	0	2.5
Aotea	0.3 cdB	0.0 dB	3 bcdB	0 dB	56.0 bAB	58.0 abAB
1020.01	2.8 aA	0.3 cdB	25 aA	10 bB	49.0 cC	55.9 bAB
1169.01	2.3 bB	0.0 dB	28 aA	8 bcB	58.7 abAB	61.1 aAB
1178.01	0.4 cdB	0.0 dB	7 bcdB	0 dB	55.0 bB	60.9 aAB
1178.02	0.6 cB	0.0 dB	7 bcdB	3 bcdB	55.5 bAB	61.6 aA
1351.01	0.6 cB	0.0 dB	5 bcdB	1 cdB	57.1 abAB	56.2 bAB
CV%						4.3

TABLE 5: TRIAL D
Main effects of rates and times of application of chlormequat on yield and 1,000 grain weight of Aotea in the absence of lodging.

lb	Chlormequat Time of Application Feekes		Nitrogen (cwt S/A)	Yield (Centals/acre)	1,000 Grain Weight (g)
	0	3			
0				59.4 cC	46.54
1				64.4 bB	46.09 aA
2				64.1 bB	45.43 abA
5				68.6 aA	45.18 bA
	3			62.7 bB	46.23 aA
	6			68.1 aA	45.30 bAB
	9			66.3 aAB	45.13 bB
			0	62.6 a	45.35 a
			2	62.5 a	45.75 a
CV%				6.6	

spraying for weed control. It is agreed, however, and supported from these trials, that application to strengthen lower internodes gives best lodging resistance (Sturm and Jung, 1964). The ability of treated plants to withstand lodging depends *partly* on their reduced height so that the weight of ears exerts less force on the base of stems. Height reduction is only obtained by later application, but the effect of chlormequat on height does not follow, to the best advantage, its effect on lodging or yield (Table 2).

With increased rate of chlormequat, lodging is further reduced, the optimum being a question of economics in relation to yield increases.

Reduction in white ear percentage from chlormequat application suggests a fungicidal effect (Humphries, 1968a). This effect, however, is not complete enough to allow the full expression of yield from 1020.01, as normally, under eyespot-free conditions it will outyield Aotea (Witchalls and Hawke, 1970). In more recent trials of the 1969-70 season the fungicide benomyl was investigated against eyespot (Witchalls and Close, 1970). It completely obliterated eyespot, prevented lodging and produced a yield increase over control of 20 bushels per acre and over chlormequat-treated areas of 13 bushels per acre.

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