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Growth Regulator Effects on Seed Production of *Bromus willdenowii* Kunth. cv. Grasslands Matua¹

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ABSTRACT

The theoretical potential seed yield of prairie grass (*Bromus willdenowii* Kunth) cv. Grasslands Matua is 7 to 9 t ha⁻¹, but commercial seed yields are usually between 1.5 and 1.8 t ha⁻¹. Lodging, seed abortion, seed shedding and seed losses during harvest may all contribute to reducing seed yield.

The effects of three plant growth regulators (paclobutrazol, flurprimidol, chlormequat chloride) on seed yield of G. Matua were investigated in four trials at two sites in two seasons. All three products significantly increased seed yield, with the magnitude of the responses (0 to 42%) varying with different application rates. Paclobutrazol responses increased as application rate increased from 0.375 to 1.0 kg. a.i. ha⁻¹, but did not increase further at 2.0 kg. a.i. ha⁻¹. The maximum response to flurprimidol application occurred at 0.5 kg. a.i. ha⁻¹

and yield was decreased at 2.0 kg. a.i. ha⁻¹. There were no yield differences with chlormequat chloride application rates between 0.75 and 3.0 kg. a.i. ha⁻¹.

Seed yield increases were associated primarily with increased seed number per spikelet, as other yield components did not differ. All three products shortened stem internode length and prevented lodging, which may have contributed to the reduction in seed abortion. However, data recorded for paclobutrazol and chlormequat chloride showed that both significantly delayed leaf tissue senescence, which may also have assisted in the retention of more seeds per spikelet.

Growth regulator application allowed direct combine harvesting of an erect crop which on a dry matter basis had 20% less plant material to pass through the threshing process.

Additional index words: rescue grass; seed yield; paclobutrazol; flurprimidol; chlormequat chloride; lodging; seed abortion; leaf senescence.

INTRODUCTION

Prairie grass (also known as rescue grass) (*Bromus willdenowii* Kunth) cv. Grasslands Matua, described by Rumball (1974), is recommended for use in New Zealand dairy, sheep and cattle farming systems because of its potential to produce high quality feed, particularly in autumn and winter, and to persist under dry conditions

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(Clark, 1985). The cultivar was first certified in New Zealand in 1973, and seed for commercial use became available in 1975 (Hampton, 1986a).

Seed yields of over 2 t ha⁻¹ have been recorded (Brown and Rolston, 1985), and two seed harvests in one season are possible (Lancashire et al., 1980). For autumn sown crops, first harvest yields of 1.6 to 1.8 t ha⁻¹ and second harvest yields of 0.6 to 0.8 t ha⁻¹ can be expected, while spring sown crops yield 0.5 to 1.0 t ha⁻¹ (Hampton, 1985). However, using the floret data of Brown and Archie (1986), the theoretical potential seed yield for the cultivar is from 7 to 9 t ha⁻¹.

Seed yields increase with increasing rates of nitrogen up to 120 kg. ha⁻¹ (Brown and Archie, 1986), but lodging may occur before anthesis, reducing seed yield and increasing the proportion of light seed (low thousand seed weight) in the seed lot (Brown and Rolston, 1985). Further yield losses may occur at harvest, because the seed sheds readily (Lancashire et al., 1980) and threshing efficiency is impaired by the large herbage bulk required to be passed through the combine harvester (Brown and Archie, 1986).

Plant growth regulators (PGR's) may be used to prevent lodging and reduce dry matter production in herbage seed crops (Hampton et al., 1985). In 1985 and 1986 we investigated the effects of PGR's on seed production of prairie grass cv. Grasslands Matua.

METHODS AND MATERIALS

The experiments were carried out in 1985 and 1986 at two sites near Palmerston North (latitude 40°S), Aorangi, recently described by Rolston and Gomez (1986) and Hauorongo, recently described by Hampton (1986b). Both sites are temperate with warm summers and mild winters (annual mean temperature 13 C), with evenly spread annual rainfall averaging 900 mm. At both sites and in both years, either basic or first generation certified seed of Grasslands Matua was autumn sown. Subsequent management details are presented in Table 1.

Hauorongo: plots were cut to 12 cm on 6 August 1985 and 15 August 1986 prior to nitrogen and PGR application. Growth regulators were applied at spikelet initiation each year (Table 1). In each year a randomized complete block design with four replicates of each treatment was used.

Aorangi: plots were grazed by sheep until 6 August 1985 and 4 August 1986 prior to nitrogen and PGR application (Table 1). In each year a randomized complete block design with three replicates of each treatment was used.

Crop apical development stages were determined by microscopic dissection of tiller apices at frequent intervals (Hampton, 1986b) while ear emergence and anthesis

were recorded by observation. Growth analysis and lodging assessments were carried out at regular intervals, but green leaf area was assessed once, just prior to harvest, each year. Techniques used for data accumulation have been previously published (Hampton, 1986a; 1986b).

Plots were direct harvested by a single pass of a 1.5 m cut combine along each plot. Seed was then dried to 10 to 12% moisture content, cleaned and weighed. Results are expressed at 0% moisture content. Germination and thousand seed weight (TSW) were determined using international rules for seed testing (ISTA, 1985).

RESULTS

All three PGR's significantly ($P < 0.05$, 0.01) increased seed yield, and although yields differed between sites and seasons (Table 2), the magnitude of the responses was constant. For example, at the 0.75 kg. a.i. ha⁻¹ application rate, chlormequat chloride increased yield by 14% at Aorangi in both seasons and by 18% at Hauorongo in 1986. Applications at rates greater than 0.75 kg. a.i. ha⁻¹ did not further increase seed yield in either season. The greatest seed yield response (a 42% increase) was provided by paclobutrazol applied at 1.0 kg. a.i. ha⁻¹ at Hauorongo, but doubling this rate did not produce a further increase. The only significant increase following flurprimidol application was recorded at the lowest rate (0.5 kg. a.i. ha⁻¹), and at 2.0 kg. a.i. ha⁻¹, seed yield was reduced ($P < 0.01$).

Fertile tiller number (range 545 to 650 m⁻²), spikelets per tiller (range 39.6 to 42.4) and TSW (range 9.81 to 12.64 g) differed between sites and seasons, but were not significantly changed by PGR application in any of the four trials. However, seed numbers per spikelet were increased ($P < 0.01$) at both sites by paclobutrazol, and at both sites and in both seasons ($P < 0.05$) by chlormequat chloride (Table 1).

While fertile tiller numbers were not significantly increased by PGR application, treatment effects on vegetative tiller numbers were recorded. Both paclobutrazol and flurprimidol increased the number of vegetative tillers present at final harvest, although the differences were only significant at the highest application rate of each chemical. Chlormequat chloride consistently inhibited vegetative tiller formation (Table 3) and at final harvest vegetative tiller numbers were reduced by 25 to 40%, the responses differing slightly with site and season.

Lodging began in untreated plots prior to anthesis at Hauorongo in 1985, at both sites in 1986, and within one week of peak anthesis at Aorangi in 1985. By harvest in both seasons, over 50% of the seed heads in these plots were less than 30 cm from the ground. No lodging occurred in plots treated with PGR's, as the reduction in

Table 1. Details of experimental treatment.

	Hauorongo		Aorangi	
	1985	1986	1985	1986
Previous crop	wheat	fallow	fallow	fallow
Plot size (m)	12 x 2.5	10 x 2.5	6 x 1.5	15 x 3
Sowing date	20 March	14 March	21 March	20 March
rate (kg ha ⁻¹)	20	20	7.5	7.5
Row spacing (cm)	26	30	60	60
Herbicide	methabenzthiazuron + MCPA	methabenzthiazuron + MCPA	2,4-D + bentazone	methabenzthiazuron
Appl. date	30 April	30 May	29 April	2 May
Appl. rate ¹	2 + 0.4	2 + 0.4	1.1 + 0.3	2
Nitrogen				
Appl. date	3. Sept.	10 Sept.	27 April & 27 Sept.	25 Sept.
Appl. rate ²	100	120	30 + 78	80
P.G.R.				
Appl. date	2 Sept.	14 Sept.	2 Oct.	7 Oct.
Harvest				
Date	12 Dec.	16 Dec.	20 Dec.	16 Dec.
SMC (%)	45	42	42	44

¹kg a.i. ha⁻¹

²kg N ha⁻¹

Table 2. Effect of growth regulators on seed yield and number of seeds per spikelet¹ at Hauorongo and Aorangi in two seasons.

Treatment	Hauorongo			Aorangi		
	Rate (kg a.i.)	Seed yield (g m ⁻²)	Seeds per spikelet	Rate (kg a.i.)	Seed (g m ⁻²)	Seeds per spikelet
1985						
Nil	0	180	0.77	0	300	1.14
Paclobutrazol	1.0	255	1.15	0.375	355	1.47
	2.0	239	1.01	0.75	367	1.43
Flurprimidol	1.00	189	0.83	0.5	358	1.28
	2.0	115	0.43	0.75	312	1.16
				1.5	318	1.18
Chlormequat chloride	3.0	210	0.98	0.75	342	1.44
				1.5	332	1.40
S.E.D. (23 d.f.)		9.7	0.08		13.2	0.10
1986						
Nil	0	232	1.08	0	392	1.51
Chlormequat Chloride	0.75	274	1.24	0.75	445	1.84
	1.5	258	1.19			
S.E.D. (12 d.f.)		10.5	0.05		8.2	0.07

¹Other yield components did not differ significantly from the check.

Table 3. Effect of chlormequat chloride on fertile and vegetative tillers m⁻² at final harvest.

	Hauorongo			Aorangi		
	Rate (kg a.i.)	Fertile Tillers	Veg.	Rate (kg a.i.)	Fertile Tillers	Veg.
1985	0	545	1033	0	494	540
	3.0	550	665	0.375	467	227
				0.75	506	295
S.E.D. (7 d.f.)		39.6	51.3	(8 d.f.)	31.8	61.6
1986	0	612	863	0	562	746
	0.75	638	527	0.75	576	546
	1.5	647	501			
S.E.D. (11 d.f.)		27.7	62.9	(5 d.f.)	18.9	71.3

Table 4. Effect of growth regulators on fertile tiller stem length and total dry matter at harvest, 1975.

Treatment	Hauorongo			Aorangi		
	Rate (kg a.i.)	Fertile tiller length (cm)	Dry matter (t ha ⁻¹)	Rate (kg a.i.)	Fertile tiller length (cm)	Dry matter (t ha ⁻¹)
Nil	0	199	19.6	0	120	13.0
Paclobutrazol	1.0	121	16.0	0.375	98	11.1
	2.0	99	14.1	0.75	88	11.3
Flurprimidol	1.0	108	16.2	0.5	80	10.3
	2.0	89	10.9	0.75	78	10.5
				1.5	63	9.4
Chlormequat chloride	3.0	99	13.1	0.375	73	10.2
				0.75	61	10.2
S.E.D. (23 d.f.)		23.4	0.81		11.1	0.73

Table 5. Effect of paclobutrazol and chlormequat chloride on percentage green leaf area.

Assessment date	Leaf assessed	Paclobutrazol rate ¹		S.E.D. (7 d.f.)
		Nil	1.0	
10 Dec. 1985	Flag	52.8	84.3	10.6
	Leaf 2 ²	24.2	60.5	13.2
	Leaf 3 ²	7.5	26.7	7.1
<hr/>				
	Leaf assessed	Chlormequat chloride rate ¹		S.E.D. (5 d.f.)
		Nil	0.75	
16 Dec. 1986	Flag	31.8	56.4	8.0
	Leaf 2 ²	8.8	16.4	4.7
	Leaf 3 ²	0.3	13.4	3.2

¹kg a.i. ha⁻¹

²Leaves subtending the flag leaf

stem length ($P < 0.01$, Table 4) allowed plants to remain upright. No differences were recorded in leaf or ear dry matter, but because of reductions in stem dry matter, total dry matter at harvest was reduced at least 20% at both sites (Table 4).

Both paclobutrazol (1.0 kg a.i. ha⁻¹) and chlormequat chloride (0.75 kg a.i. ha⁻¹) delayed leaf senescence (Table 5). Data were not recorded for all treatments, but immediately prior to harvest at Aorangi in 1985 and Hauorongo in 1986, PGR application had resulted in over 50% more green leaf area remaining on the flag leaf and the two leaves subtending it. The germination of seed harvested did not differ significantly between treatments at either site in either year.

DISCUSSION

Bromus willdenowii can now be added to the number of herbage grass species where plant growth regulators have been successfully used to shorten stem internode length, increase lodging resistance and often increase seed yield. Chlormequat chloride has been previously used successfully on *Agrostis gigantea*, *Bromus inermis*, *Dactylis glomerata*, *Lolium perenne* and *Phleum pratense* (Hampton, 1986; 1988a), paclobutrazol on *Festuca arundinacea*, *F. rubra* and *L. perenne* (Hampton, 1988a) and flurprimidol on *L. perenne* (Hebblethwaite et al., 1985). Seed yield responses have been associated with modified tillering patterns and improved seed site utilization (Hampton et al., 1985).

Both paclobutrazol and flurprimidol increased total tiller numbers in *B. willdenowii*, but unlike the response in *L. perenne* (Hampton, 1986a) did not increase fertile

tiller numbers. At flurprimidol application rates above 0.5 kg a.i. ha⁻¹, vegetative tiller production was such that fertile tiller growth was checked and at the 2.0 kg a.i. ha⁻¹ rate, many tillers failed to set seed. This result was unexpected, as both PGRs have similar modes of action (Hebblethwaite et al., 1985) and produce similar growth retarding effects in *L. perenne*. Chlormequat chloride application did not increase tiller numbers, and in both seasons and at both sites, vegetative tiller numbers were reduced. Why this occurred is not clear, but it is possible that by allowing the crop to remain upright until harvest, vegetative tiller production after anthesis, which is encouraged by lodging allowing light into the base of the stand (Hampton, 1988a), was prevented. This does not explain why vegetative tiller numbers in the paclobutrazol and flurprimidol plots were increased after anthesis. However, it is known that both these PGRs are strongly soil residual (Hampton, 1988b), respond quickly to water, reduce apical dominance and strongly promote tillering (Hampton et al., 1985; Hebblethwaite et al., 1985), and rain in late November 1985 would have encouraged this to occur.

Seed yield increases were associated with increases in seed number per spikelet, a result similar to that previously reported for these PGR's in *L. perenne* (Hampton, 1986b). Seed numbers per spikelet depend primarily on the ability of a crop to sustain the number of seeds set, and assimilate shortage through crop lodging and/or competition from other sinks (particularly the stem and re-growth tillering) have been proposed as explanations for seed abortion in *L. perenne* (Hampton, 1988a). In *B. willdenowii*, prevention of lodging decreased the rate of

senescence of photosynthetic leaf tissue. What is not known is whether the reduction in size of fertile tiller stems also reduced their assimilate sink strength, or in the case of chlormequat chloride, whether a reduction in the number of vegetative tillers correspondingly reduced competition for assimilate from this source. Further work is required.

Paclobutrazol and flurprimidol are unlikely to become available for widespread use in arable farming in New Zealand because of cost and soil residual properties (Hampton, 1988b). However, chlormequat chloride is readily available and relatively inexpensive, and its use in *B. willdenowii* seed crops can be recommended for two reasons. Firstly, at an application rate of 0.75 kg a.i. ha⁻¹, consistent seed yield increases (420 - 570 kg ha⁻¹) were recorded in two seasons. Secondly, and perhaps just as important, an upright crop allows direct combine harvesting (rather than swathing and harvesting), and the reduced herbage bulk allows for greater efficiency in the threshing process (Brown and Archie, 1986). Both these factors are known to be associated with high harvest losses in *B. willdenowii* (Brown and Rolston, 1985).

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