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A Comparison of the Effects of the Growth Retardants Paclobutrazol (PP333) and Flurprimidol (EL500) on the Growth, Development and Yield of *Lolium perenne* Grown for Seed[1]

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ABSTRACT

Application of the growth retardants paclobutrazol (PP333) and flurprimidol (EL500) to perennial ryegrass (*Lolium perenne* L.) seed crops at spikelet initiation can substantially increase ryegrass seed yields. The mode of action of these two products is similar, both being gibberellin inhibitors, which results in stem internode retardation.

A comparison of the effects of these two growth retardants demonstrated that at the same rate of active ingredient, plots treated with PP333 outyielded plots treated with EL500, primarily because of a greater retention of seeds per spikelet. The greater activity of PP333 allowed less lodging, and prolonged reproductive photosynthetic leaf area. For comparable effects on perennial ryegrass plant growth and seed yield, EL500 had to be applied at double the active ingredient rate of that required for PP333.

Additional index words: **perennial ryegrass, seed production, growth retardants, seed abortion.**

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INTRODUCTION

The use of growth retardants to increase seed yield in perennial ryegrass crops through the prevention of lodging has been investigated for over 10 years. Recent attention has focused on two products, paclobutrazol (PP333) and flurprimidol (EL500), both of which have significantly increased ryegrass seed yields by increasing fertile tiller production and reducing seed abortion (Hampton and Hebblethwaite, 1985a;b Hebblethwaite et al., 1985).

Both retardants are root active with some foliar activity, and both are inhibitors of gibberellin biosynthesis which results in prolonged stem retardation and internode compression (Shearing and Batch, 1982; Anon., 1983). In this paper we compare the effects of PP333 and El500 on perennial ryegrass growth and seed yield.

MATERIALS AND METHODS

Experiments were carried out at the University of Nottingham experimental farm, Sutton Bonington, Loughborough, Leics., on soil of the Astley Hall series. Certified basic seed of perennial ryegrass cv. S24 was sown on 18 August 1981 and 23 August 1982 at 12 kg ha-1 with a row width of 15 cm and in plots 1.5 x 12 m. Details of experimental management have been previously described (Hampton and Hebblethwaite, 1985a; Hebblethwaite et al., 1985).

PP333 and EL500 were applied at spikelet initiation (25 March 1982; 29 March 1983) at active ingredient rates of 1.0 and 2.0 kg ha-1 for both products in 1982, and 1.0 kg a.i. ha-1 for PP333 and 2.0 kg a.i. ha-1 for EL500 in 1983. Growth retardant treatments plus an unsprayed control were replicated four times in a randomized complete block design.

Growth analyses were carried out at regular intervals; techniques used for data accumulation have been previously published (Hampton and Hebblethwaite, 1985a). Seed was harvested at 40% seed moisture content in both years by cutting 5.5 m^2 per plot in 1982 and 2.8 m^2 per plot in 1983 with a reciprocating knife mower (Mayfield). The cut material was placed in cloth bags and cool air dried to 12-15% straw moisture content before the seed was threshed, cleaned and weighed. Yield results are expressed at 0% moisture content.

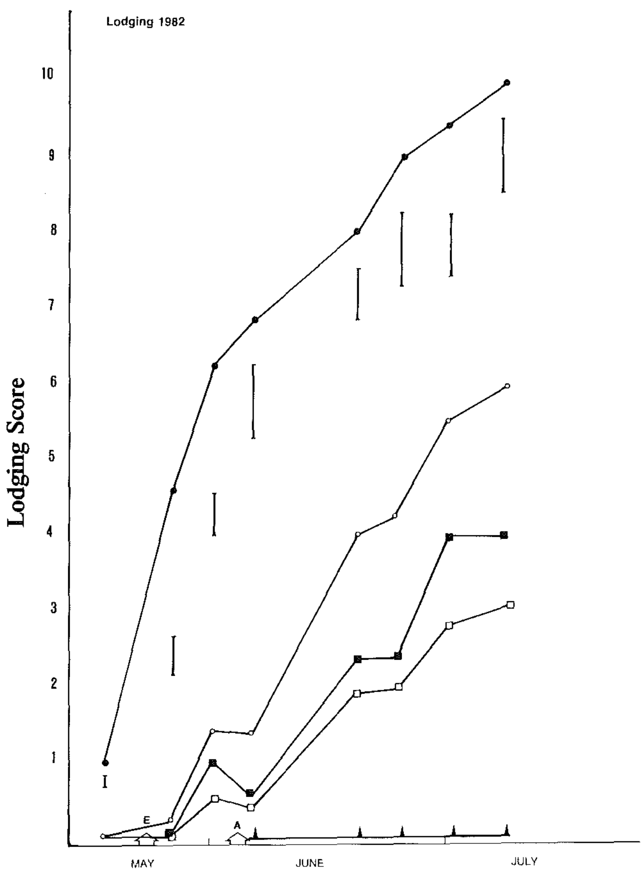

Figure 1. The effect of growth retardants on lodging, 1982. (● = nil; ■ = PP333, 1.0 kg a.i. ha-1; ▲ = PP333 2.0 kg a.i. ha-1; ○ = EL500 1.0 kg a.i. ha-1; □ = EL500. 2.0 kg a.i. ha-1; E = peak ear emergence; A = peak anthesis; I = S.E. diff.

RESULTS

Lodging and Stem Length

In untreated plots, lodging began at ear emergence in both years, and was severe by anthesis. Growth retardant application delayed the onset of lodging until after anthesis in 1982 (Figure 1), with PP333 at 2.0 kg a.i. ha-1 preventing lodging completely. In 1982 (Figure 1) and 1983, lodging in plots which had received EL500 at 2.0 kg a.i. ha-1 was not significantly different from that for plots which had received PP333 at 1.0 kg a.i. ha-1.

PP333 and EL500 reduced stem length in both years. In 1982, the stem length of plants treated with PP333 at 2.0 kg a.i. ha-1 was significantly less than that of plants treated with EL500 at the same rate of active ingredient by 56 days after application (Table 1). Greater retardation occurred at internodes three and four (base of stem = one) in PP333 treated plants. In 1983, the pattern of internode length reduction was similar for PP333 at 1.0 kg a.i. ha-1 and EL500 at 2.0 kg a.i. ha-1.

Table 1. The effect of growth retardants on stem length, 1982.

Treatment 1982 kg a.i. ha-1	Days after growth retardant application, 34	56	69	99
	Stem length			
	(cm)			
nil	28.5	49.5	53.7	60.2
EL500 2.0	11.3	29.8	40.7	51.6
PP333 2.0	9.2	21.6	24.6	33.1
S.E. diff. [1]	1.53	2.61	3.73	3.16
LSD .05	3.75	6.39	9.14	7.74

[1]6 d.f.

Table 2. The effect of growth retardants on tiller numbers, 1982 and 1983.

Treatment and rate a.i. ha^{-1}	Tiller number m^{-2}						Fertile tiller survival (%)
	Peak ear emergence		Peak anthesis		Final harvest		
	Vegetative	Fertile	Vegetative	Fertile	Vegetative	Fertile	
1982							
nil	3487	2387	3044	3206	5984	2468	76.9
EL500 2.0	6674	2526	1681	4406	5184	3048	69.2
PP333 2.0	8298	2204	4128	3478	6197	3285	86.4
S.E. diff. (6 d.f.)	1011.6	331.4	306.9	403.7	1381.6	234.6	
LSD .05	2478.4	811.9	751.9	989.1	3384.9	574.8	
1983							
nil	4239	1761	1384	2816	2454	3146	80.0
EL500 2.0	7301	1899	4498	2802	65	3735	88.9
PP333 1.0	6099	1901	3988	2412	353	4147	92.3
S.E. diff. (6 d.f.)	1008.6	116.7	301.6	246.2	612.8	439.9	
LSD .05	2471.1	N.S.	738.9	N.S.	1501.4	N.S.	

Tiller Production

In both years, growth retardant application increased the total number of tillers present at ear emergence by increasing the production of vegetative tillers (Table 2). At anthesis in 1982, vegetative tiller numbers in PP333 treated plots were significantly greater than those of EL500 treated plots, but fertile tiller numbers did not differ either at anthesis or final harvest. In 1983, tiller numbers in plots treated with PP333 at 1.0 kg a.i. ha^{-1} did not differ from those plots treated with EL500 at 2.0 kg a.i. ha^{-1}. At final harvest, vegetative tiller numbers in both PP333 and EL500 treated plots were significantly reduced (Table 2).

Dry Matter Accumulation and Distribution

Both growth retardants reduced fertile tiller stem dry matter (DM) in both years, had no effect on fertile tiller leaf DM and increased ear DM, although differences from the untreated check were not always significant. Vegetative tiller DM at final harvest was reduced in 1983.

Differences in DM accumulation and distribution between PP333 and EL500 were not significant in either year.

Table 3. The effect of growth retardants on the photosynthetic area index of fertile tillers, 1982 and 1983.

Treatment and rate a.i. ha^{-1}	Photosynthetic area index					
	Ear		Stem		Leaf	
	Anthesis	Final harvest	Anthesis	Final harvest	Anthesis	Final harvest
1982						
nil	1.0	0.9	2.3	1.6	2.1	0.2
EL500 2.0	1.1	1.0	1.5	1.6	2.2	0.4
PP333 2.0	1.2	1.4	1.1	1.5	2.8	1.0
S.E. diff. (6 d.f.)	0.26	0.18	0.31	0.27	0.22	0.02
LSD .05	N.S.	0.44	0.76	N.S.	0.54	0.05
1983						
nil	0.6	0.8	2.4	2.2	2.2	0.1
EL500 2.0	0.7	1.1	1.1	1.5	1.9	0.4
PP333 1.0	0.7	1.1	0.9	1.5	2.2	0.4
S.E. diff. (6 d.f.)	0.21	0.18	0.20	0.21	0.41	0.11
LSD .05	N.S.	N.S.	0.49	0.51	N.S.	0.27

Photosynthetic Area Index

Total reproductive photosynthetic area index (PAI) was decreased by growth retardant application prior to anthesis in both years because of a reduction in stem PAI (Table 3). By final harvest in both years, fertile tiller leaf PAI was increased by EL500 and PP333. However in 1982, the difference between PP333 at 2.0 kg a.i. ha^{-1} and EL500 at the same rate was significant (Table 3). In 1983, the fertile tiller leaf PAI of plants treated with EL500 at 2.0 kg a.i. ha^{-1} did not differ from that of plots treated with PP333 at 1.0 kg a.i. ha^{-1}.

Table 4. Effect of growth retardants on florets per basal, middle and penultimate spikelet and spikelets per tiller at anthesis, 1982.

Treatment kg a.i. ha^{-1}	Florets per spikelet			Spikelets per tiller
	basal	middle	penultimate	
nil	8.1	8.7	5.7	22.3
EL500 2.0	7.8	8.5	5.4	21.7
PP333 2.0	8.3	8.9	5.4	21.9
S.E. diff.[1]	0.28	0.24	0.44	0.56
LSD .05	N.S.	N.S.	N.S.	N.S.

[1]6 d.f.

Seed Yield--Potential, Actual and Components

At anthesis, potential seed yield was similar for all treatments, as no differences were recorded in the number of florets per spikelet and spikelets per tiller (Table 4), or fertile tillers (Table 2). However, actual seed yield was significantly increased by growth retardant application in both years as a result of increased fertile tiller numbers and a significant increase in the number of seeds per spikelet (Table 5). Other yield components did not differ. In 1982, plots treated with PP333 at 1.0 and 2.0 kg a.i. ha^{-1} significantly out-yielded plots treated with EL500 at 1.0 and 2.0 kg a.i. ha^{-1} respectively, because of an increase in the number of seeds per spikelet. The seed yield of plots treated with PP333 at 1.0 kg a.i. ha^{-1} and EL500 at 2.0 kg a.i. ha^{-1} did not differ in either year.

DISCUSSION

In 1982, seed yield from plots treated with PP333 at 1.0 kg a.i. ha^{-1} was 36.5 g m^{-2} (20%) greater than that of plots treated with EL500 at the same rate of active ingredient. Similarly, for plots treated with PP333 at 2.0 kg a.i. ha^{-1} seed yield was increased by 42.5 g m^{-2} (20%) over those plots treated with EL500 at the same rate. In both 1982 and 1983, seed yields from plots which had received PP333 at 1.0 and EL500 at 2.0 kg a.i. ha^{-1} did not differ. Seed yield differences between the two growth retardants resulted primarily from a greater num-ber of seeds per spikelet.

Hampton and Hebblethwaite (1985b) showed that the greater retention of seeds per spikelet in non-lodged perennial ryegrass plots occurred because seed abortion was reduced. Seed abortion may occur because of an assimilate shortage due to competition from the enlongating stem (Clemence and Hebblethwaite, 1984), competition from vegetative tillers (Hampton and Hebblethwaite 1984a), and loss of photosynthetic tissue in a lodged canopy (Hampton and Hebblethwaite 1984b). At anthesis, yield potential did not differ between the growth retardants. However, while PP333 at 2.0 kg a.i. ha $^{-1}$ completely prevented lodging, EL500 at 2.0 kg a.i. ha^{-1} allowed some lodging after anthesis. Stem length was reduced more by PP333 than EL500, although the theory that reduced stem size may

Table 5. The effect of growth retardants on seed yield and yield components, 1982 and 1983.

Treatment kg a.i. ha^{-1}	yield g m^{-2} seed	yield g m^{-2} straw	harvest index	fertile tillers m^{-2}	spikelets per tiller	seeds per spikelet (calc.)	1000 seed weight (g)	seed number m^{-2} x 10^4
1982								
nil	111.3	749.1	0.13	2468	20.7	1.19	1.85	6.04
EL500 1.0	186.3	716.7	0.21	3228	20.3	1.67	1.73	10.76
EL500 2.0	213.8	643.7	0.25	3048	20.9	1.59	1.78	12.00
PP333 1.0	222.8	716.6	0.24	3096	20.6	1.89	1.77	12.63
PP333 2.0	256.3	612.2	0.30	3285	20.3	2.21	1.76	14.59
S.E. diff. (12 d.f.)	8.1	37.6	0.01	373.6	1.11	0.19	0.96	0.67
LSD .05	17.6	81.9	0.02	814.4	N.S.	0.41	N.S.	1.46
1983								
nil	148.4	994.7	0.13	3146	19.9	1.25	1.89	7.85
EL500 2.0	225.2	792.0	0.22	3735	19.9	1.76	1.72	13.09
PP333 1.0	229.6	694.7	0.25	4147	17.2	1.89	1.70	13.57
S.E. diff. (6 d.f.)	16.3	50.3	0.02	439.9	1.35	0.14	0.08	1.17
LSD .05	39.9	123.2	0.05	N.S.	N.S.	0.34	N.S.	2.87

reduce the stem sink capacity to the benefit of the ear (Hebblethwaite et al., 1982) has still to be confirmed (Hampton and Hebblethwaite, 1985a). Vegetative tiller numbers did not differ significantly between growth retardants after anthesis, but fertile tiller leaf photosynthetic area index was significantly greater in PP333 treated plots over the same period.

Both PP333 and EL500 can substantially increase perennial ryegrass seed yields (Hampton and Hebblethwaite, 1985a; Hebblethwaite et al., 1985). However, PP333 has greater activity in the perennial ryegrass plant than does EL500, and for comparable effects on plant growth and seed quality the latter retardant needs to be applied at double the rate of active ingredient.

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