Effects of Chemical Dwarfing Application Under Different Nitrogen Levels on Seed Yield of Fine Fescue (*Festuca rubra*) cv. Cascade [1]

D. W. Albeke, D. O. Chilcote and H. W. Youngberg [2]

ABSTRACT

Application of spring nitrogen often causes lodging in fine fescue well before anthesis. Early lodging results in poor pollen dispersal, poor light interception and facilitates pathogen development.

An experimental growth retardant, Imperial Chemical Industries PP 333, was applied to *Festuca rubra* cv. Cascade fertilized in the spring with several nitrogen rates to determine effect on lodging factors related to seed yield.

PP 333 reduced lodging at all nitrogen (N) rates in this experiment. The high rate (0.8 kg ai ha^{-1}) chemical treatment reduced the culm length and both rates reduced the distance between the top and second node irrespective of N rate. More fertile tillers were present at anthesis in plots treated with 0.8 kg ai ha^{-1} at all rates of N application. The growth retardant application increased potential yield at the two higher N rates and increased harvested seed yield at all N rates.

Additional key words: **lodging, growth retardant, harvest index, seed yield components.**

INTRODUCTION

Application of nitrogen fertilizer in the spring is a common practice in attempting to maximize seed yield (Hebblethwaite, 1980). High fertile tiller mortality and relatively low number of seeds per spikelet in ryegrass has been attributed to the fact that crops receiving nitrogen in amounts that maximize seed yield have a dense closed canopy which can become severely lodged (Hebblethwaite, 1977). Higher rates of nitrogen fertilization accentuate the lodging problem (Hebblethwaite and Ivins, 1977).

A new experimental growth retardant, ICI's (Imperial Chemical Industries) PP 333 [(2RS,2RS)-1(4-chlorophenyl) -4,4-dimethyl-2-1,2,-4-triazol-l-yl)pentan-3-01] has shown promise for lodging control in grasses. PP 333 is a soil active chemical which must be taken up by the root system to exhibit growth retardant properties (personal communication, ICI). PP 333 appears to be more reliable and predictable in its response, as long as the chemical is present in the root zone (Hebblethwaite and Burbidge, 1976).

In experiments conducted in Great Britain, applications of PP 333 on perennial ryegrass delayed lodging, increased seed yields up to 50%, and substantially increased Harvest Index (Hebblethwaite et al., 1981).

The objective of this experiment was to study the interaction of growth retardant application with spring nitrogen rate as it affects seed yield of fine fescue, *Festuca rubra*. In this research, the effects of PP 333 on lodging, plant morphological characteristics, potential seed yield and actual seed yield were examined under several spring nitrogen application rates.

MATERIALS AND METHODS

The experiment on a nine-year-old stand of fine fescue cv. Cascade was a factorial arrangement of treatments with a split plot design. Nitrogen rates were treated as main plots and growth retardant, PP 333, treatments as subplots. The experiment was replicated five times. Plot size was 3.7 x 4.5 m. No autumn nitrogen was applied. In February, 1980, 30 kg ai ha^{-1} of nitrogen as amonium sulfate was applied uniformly to all plots. On 3 April, the spring nitrogen and the growth retardant PP 333 treatments were applied. A 2% granular formulation PP 333 was applied at 0.4 and 0.8 kg ai ha^{-1} using a lawn spreader. Supplemental nitrogen fertilizer was applied at 60, 90, and 120 kg ai ha^{-1} N in the form of ammonium sulfate. With the 30 kg applied earlier, this gave total nitrogen treatments of 90, 120, and 150 kg ha^{-1} and were designated as N_{90}, N_{120} and N_{150} treatments, respectively.

Morphological characteristics were measured on 20 fully emerged fertile tillers prior to anthesis in order to quantify treatment effect on panicle length, culm length, distance between the bottom spikelet and the first node, and the length between the first and second nodes at the top of the plant.

At completion of anthesis, four 929 cm^2 samples were taken from each plot to determine the potential yield. The fertile tillers were counted. Ten tillers were selected at random from each sample and spikelets per panicle and florets per spikelet, selected at random, on 10 spikelets were counted. Results were combined giving one yield component value per sample. Fertile florets per unit area were determined from the function: fertile tillers per meter square x spikelets per panicle x florets per spikelet = florets per unit area.

Seed was cut at 25% moisture content and air dried for 15 days. Seed and straw were placed in a heated forced air drier for 24 hours at 50 C before threshing. Weight of above-ground biomass was determined. Seed was threshed,

[1] A contribution of the Crop Science Department, Oregon State University. Received for publication 1 June, 1983.

[2] Formerly Graduate Assistant, Professor Crop Physiology, and Professor of Crop Science, respectively, Department of Crop Science, Oregon State University, Corvallis, Oregon 97331, USA.

cleaned, and weighed. Mean seed weight was determined by weighing 400 seeds. Harvest Index was calculated by dividing clean seed weight by weight of total above-ground biomass.

Lodging scores were obtained by visual inspection of the plots with a score of 1 indicating an upright canopy and 10 a totally flat canopy. Intermediate scores were based on the degree of flatness of the canopy as well as the lodged area. For conciseness, the sampling date values were combined and a mean lodging score is presented.

Analyses of variance were performed on all parameters measured. A significant F value at p × .05 was used to determine significant differences among treatments. The least significant difference (L.S.D.) at p × .05 was used to compare means.

RESULTS AND DISCUSSION

Application of PP 333 at the rate of 0.8 kg ai ha^{-1} reduced the culm length of developing fertile tillers at all nitrogen application rates (Table 1). The 0.4 kg ai ha^{-1} rate did not significantly reduce the total culm length, but did reduce the second internode length. The reduction of culm length is due primarily to shortening the second internode in both rates of PP 333. Nitrogen rate had no effect on culm or internode length. Panicle length and the distance between the lowest spikelet and the first node were not affected by either nitrogen level or growth retardant application.

Table 1. Morphological characteristics of Cascade fine fescue as affected by PP 333 and nitrogen treatments (1980).

Treatment	Length		Distance between:	
	Culm	Panicle	lowest spikelet and 1st node	1st and 2nd nodes
(kg ha^{-1})	----------	----------	(cm)	----------
Nitrogen[1]				
Low	71.1	9.7	46.4	14.8
Medium	70.1	9.5	44.4	15.2
High	73.2	10.2	45.3	15.9
L.S.D.$_{.05}$	NS	NS	NS	NS
PP 333[2]				
0	75.9	9.8	46.1	17.8
0.4	72.9	9.9	46.3	15.9
0.8	65.7	9.6	44.9	12.2
L.S.D.$_{.05}$	3.7	NS	NS	1.9

[1]Across three growth retardant treatments x five replications.
[2]Across three nitrogen treatments x five replications.

Fertile tiller number m^{-2} after anthesis was increased with application of PP 333 at 0.8 kg ai ha^{-1} (Table 2) over all nitrogen treatments. Spikelets per panicle were not affected by either growth retardant or nitrogen treatments. However, the number of florets per spikelet was increased at N_{150}. There was significant nitrogen by growth regulator interaction for this characteristic (Table 3). PP 333 application increased the number of florets per spikelet only at N_{150}.

Florets m^{-2} was affected both by growth retardant and nitrogen treatment (Table 4). Both rates of PP 333 increased potential yield significantly over the control (Table 2), while N_{150} increased potential yield significantly over N_{90} and N_{120}. There was significant growth retardant by nitrogen interaction for potential yield. Application of 0.8 kg ai ha^{-1} PP 333 at N_{90} decreased potential yield while applications of the growth retardant at N_{150} increased potential yield significantly (Table 4).

Table 2. Potential yield characteristics of Cascade fine fescue as affected by PP 333 and nitrogen treatments (1980).

Treatment	Fertile tillers m^{-2}	Spikelets per panicle	Florets per spikelet	Total potential fertile florets (10^3) m^{-2}
(kg ha^{-1})				
Nitrogen[1]				
Low	859	25.1	5.48	118.3
Medium	963	23.9	5.68	128.1
High	960	24.6	5.99	141.5
L.S.D.$_{.05}$	NS	NS	0.38	15.6
PP 333[2]				
0	862	24.7	5.64	120.0
0.4	945	24.8	5.73	134.5
0.8	974	24.1	5.77	133.3
L.S.D.$_{.05}$	101	NS	NS	11.7

[1]Across three growth retardant treatments x five replications.
[2]Across three nitrogen treatments x five replications.

Table 3. Florets per spikelet of Cascade fine fescue as affected by PP 333 and nitrogen treatments (1980).

PP 333 Rate (kg ha^{-1})	Nitrogen level		
	Low	Medium	High
0	5.7	5.7	5.6
0.4	5.4	5.7	6.1
0.8	5.4	5.6	6.3
L.S.D.$_{.05}$	NS	NS	0.4

Table 4. Total florets (x 10^3) m^{-2} of Cascade fine fescue as affected by PP 333 and nitrogen treatments (1980).

PP 333 Rate (kg ha^{-1})	Nitrogen level		
	Low	Medium	High
0	116.8	122.1	121.2
0.4	129.8	129.7	144.1
0.8	108.3	132.6	159.1
L.S.D.$_{.05}$	16.3	NS	16.3

Clean seed yield was increased significantly by application of PP 333 only at 0.8 kg ai ha^{-1} (Table 5). Optimum seed yield was obtained with N_{120}; however, there was no nitrogen x PP 333 interaction for harvested seed yield. Mean seed weight was not affected by any treatment in this experiment.

The efficiency of the seed production process as measured by Harvest Index, (HI), was altered by both PP 333 and nitrogen levels. Application of 0.4 kg ai ha^{-1} and 0.8 kg ai ha^{-1} significantly increased the HI. N_{150}, however, lowered

Table 5. Actual yield components and harvest index of Cascade fine fescue as affected by PP 333 and nitrogen treatments (1980).

Treatment	Seed yield	Seed wt.	Harvest index	Seeds/ spikelet
(kg ha^{-1})	(g m^{-2})	(mg)		
Nitrogen[1]				
Low	72.7	1.24	0.150	2.34
Medium	79.8	1.26	0.135	2.72
High	74.4	1.27	0.126	2.48
L.S.D.$_{.05}$	16.1	NS	0.021	0.23
PP 333[2]				
0	63.2	1.27	0.118	2.33
0.4	71.1	1.27	0.142	2.50
0.8	78.9	1.24	0.151	2.72
L.S.D.$_{.05}$	9.5	NS	0.013	0.16

[1]Across three growth retardant treatments x five replications.
[2]Across three nitrogen treatments x five replications.

HI significantly when compared to N_{90} and N_{120}. There was no interaction for HI and N level.

Both growth retardant and nitrogen level inceased seed filling. Applications of PP 333 at 0.4 and 0.8 kg ai ha^{-1} increased seeds per spikelet. N_{120} also increased seeds per spikelet. There was no nitrogen by PP 333 interaction for seeds per spikelet.

Application of PP 333 reduced lodging significantly over the control. Higher nitrogen levels caused more lodging even with retardant treatment (Table 6). However, there was no significant PP 333 by nitrogen interaction.

Table 6. Cascade fine fescue mean lodging scores[1] as affected by PP 333 and nitrogen treatments (1980).[2]

Rate (kg ha^{-1})	Low N	Medium N	High N	Mean
0	4.4	6.8	7.6	6.3
0.4	1.8	3.0	3.6	2.8
0.8	1.0	1.6	3.0	1.9
Mean	2.4	3.8	4.7	
L.S.D.$_{.05}$ nitrogen means -1.3				
L.S.D.$_{.05}$ growth retardant means -1.1				

[1]1 = no lodging; 10 = completely lodged.
[2]Across six observation dates.

CONCLUSIONS

Nitrogen rates had no significant effect on plant morphology or tiller number. Florets per spikelet was the only characteristic affected and by the high nitrogen rate only. However, only spring nitrogen rates were studied. Application of growth retardant at low nitrogen levels lowered potential yield, while high nitrogen levels accompanied by a growth retardant treatment showed an increased number of florets per unit area. Fertile tiller number was increased at the 0.8 kg ai ha^{-1} rate of PP 333. Significant culm height reduction was observed only at the high rate of PP 333 application, although the distance between the first and second nodes was reduced by both rates. No effect on the uppermost internode was observed. Lodging scores suggest that the stem is strengthened by the shortened lower internode,even though total culm height may not be reduced.

Growth retardant application increased seed yield at all spring nitrogen levels in this experiment. The optimum nitrogen rate was 120 kg ai ha^{-1} at all growth retardant rates. There was a greater number of seeds at the medium nitrogen rate when compared to the high or the low rates. Even though there was a growth retardant by nitrogen interaction for potential seed yield, there was no interaction for harvested seed yield. Higher rates of nitrogen and application at different plant growth stages in conjunction with growth retardant treatment need to be investigated.

REFERENCES

1. Hebblethwaite, P. D. 1977. Irrigation and nitrogen studies in S.23 ryegrass grown for seed. I. Growth, development, seed yield components and seed yield. J. Agric. Sci. Camb. 88:605-614.
2. Hebblethwaite, P. D., and J. D. Ivins. 1977. Nitrogen studies in *Lolium perenne* grown for seed. I. Level of application. J. British Grassland Society 32:195-204.
3. Hebblethwaite, P. D. 1980. Some physiological aspects of seed yield in *Lolium perrene* L. In: Seed Production, edited by P. D. Hebblethwaite. Butterworths. London.
4. Hebblethwaite, P. D., J. G. Hampton, and J. S. McLaren. 1981. The chemical control of growth, development and yield of *Lolium perenne* grown for seed. In: Chemical Manipulation of Crop Growth and Development. J. S. McLaren (ed.). Butterworths, London.

ACKNOWLEDGEMENTS

We would like to acknowledge the support of Imperial Chemical Industries in the conduct of this work. Thanks are also exended to C. Moon, W. Young, and D. Ehrensing for their assistance in the collection and summarization of data.