EFFECT OF CHLORMEQUAT CHLORIDE PLANT GROWTH REGULATOR WITH AND WITHOUT SPRING MOWING IN ANNUAL RYEGRASS SEED CROPS

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Introduction

Forage grass seed crops, including annual ryegrass (*Lolium multiflorum* L.), are a vital part of seed production enterprises in Oregon. Like other cool-season grasses, annual ryegrass produces only 15 to 33% of its potential seed yield. Lodging of the crop during flowering and seed shattering are two of the major factors limiting maximum seed yield. Seed yield is reduced by lodging during anthesis and early seed fill as a result of self-shading in the canopy and reductions in pollination. Making better use of management practices that reduce stem length, decrease lodging, and/or reduce seed shatter are areas that should be further explored to address seed yield potential.

Plant growth regulators (PGRs) are widely used to reduce lodging and increase seed yield in many of Oregon's cool-season grass seed crops. One species widely grown in Oregon without use of PGRs is annual ryegrass. This has been a result of low seed prices and lack of previous research. However, recent work with trinexapac-ethyl (TE; tradename: Palisade EC) has shown that 400–600 g TE ha^{-1}, combined with spring defoliation (mowing), can increase seed yields by 150% or more (Anderson et al., 2020, 2021).

A federal registration for a different PGR, chlormequat chloride (CCC), is being sought, but research is needed to evaluate its effect on annual ryegrass seed crops. Early work by Hebblethwaite et al. (1978) examined the effect of CCC on perennial ryegrass and found that it had little effect on tiller length or lodging. However, seed yield was increased in some years, likely due to improved assimilate transfer to the seed. Hampton (1986) also evaluated effects of CCC on perennial ryegrass and found that neither tiller length nor lodging was reduced, but seed yield increases resulted from improved survival of tillers. More recent work showed no effect on seed yield from CCC applications in dryland turf-type perennial ryegrass (Anderson and Maliszewski, 2021). The aim of this work was to determine whether CCC and tank mixes of TE + CCC can be used to further increase annual ryegrass seed yield under western Oregon conditions.

Materials and Methods

Field trials were conducted on 'Gulf' annual ryegrass at Oregon State University's Hyslop Research Farm over two harvest years, 2021 to 2022. Plot size was approximately 14.5 m x 3.5 m. Spring defoliation by sheep grazing was simulated using a flail mower. The experimental design was a randomized complete block with a split-plot arrangement of treatments and four replications.

Main plots were spring defoliation, and subplots were PGR treatments. Subplots were randomly allocated within defoliation main plots. Defoliation treatments included an untreated control (no mowing) and mowing (2x) at the two-node stage (BBCH 32). Subplots included TE (0, 400 g ha^{-1}), CCC (0, 600, 1,200, and 1,800 g ha^{-1}), and TE + CCC tank mixes (600 g CCC ha^{-1} + 400 g TE ha^{-1}, 1,200 g CCC ha^{-1} + 400 g TE ha^{-1}, 1,800 g CCC ha^{-1} + 400 g TE ha^{-1}). All PGR applications were made at BBCH 31–32, except for a single CCC treatment, which was split over two timings (1,200 g CCC ha^{-1} at BBCH 32 + 600 g CCC ha^{-1} at BBCH 51).

At peak flowering (BBCH 65), two 0.1 m^{-2} samples of above-ground biomass were collected from each plot near crop maturity to determine total dry matter and seed yield components. Samples were placed in a dryer at 65°C for approximately 48 hours to determine above-ground biomass. Lodging ratings were recorded just prior to harvest on a scale of 0–100%.

Plots were swathed with a modified John Deere 2280 swather and combined with a Hege 180 plot combine. Subsamples of harvested seed were collected from each plot and cleaned using a Clipper M2B cleaner to determine clean seed yield. Seed weight was determined by counting two 1,000-seed samples with an electronic seed counter and weighing these samples on a laboratory balance.

Analysis of variance was conducted to test spring defoliation and PGR treatment effects and their interaction on seed yield, seed weight, seed number, and other characteristics for each trial. Spring defoliation and PGR treatment means for each trial were separated by Fisher's protected LSD values at 5% level of significance.

Results and Discussion

There was a significant interaction between spring mowing and PGR for seed yield, seed number, harvest index (HI), and final lodging in both years (Tables 1 and 2). Most PGR treatments containing TE resulted in increased seed yield in both years. Applications of CCC alone had no effect on seed yield in either year, with or without spring mowing at BBCH 32. The combination of TE + CCC did not result in additional increases over TE alone.

In both years, there was a significant interaction for seed number. However, seed weight was affected by the interaction only in 2022. Lodging was affected by TE and TE + CCC when plots were mowed, but not when they were left unmowed. Similar results occurred for HI. It is likely that any seed yield increases resulted from an increase in seed number that more than offset the decrease in seed weight, most likely caused by improved pollination conditions resulting from a reduction in lodging.

These results provide additional confirmation that annual ryegrass seed yields in Oregon are able to respond to more intensive spring crop management, including the use of TE PGR and spring mowing. However, application of CCC alone, or in a tank-mix with TE, is not likely to provide additional benefit to annual ryegrass seed crops grown in western Oregon. We recommend that spring mowing and TE continue to be utilized together to maximize annual ryegrass seed yields.

Table 1. Interaction effects of chlormequat chloride (CCC) and trinexapac-ethyl (TE) plant growth regulators on seed yield, yield components, harvest index, and lodging in 'Gulf' annual ryegrass with and without spring mowing, 2021.

Treatment	Yield		Seed weight	Seed number		Harvest index[1]	Lodging[1]
	(kg ha^{-1})		(mg seed^{-1})	(no m^{-2})		(%)	(%)
No mow							
Untreated control	1,536	a	2.966	51,968	a	12.0	100
400 g TE ha^{-1}	2,399	bcd	2.843	84,936	bcdef	11.5	94
600 g CCC ha^{-1}	1,531	a	3.091	50,000	a	7.6	99
1,200 g CCC ha^{-1}	1,423	a	3.132	45,751	a	7.8	99
1,800 g CCC ha^{-1}	1,297	a	3.024	43,038	a	8.0	96
600 g CCC ha^{-1} + 400 g TE ha^{-1}	2,541	cdefg	2.777	92,050	defg	14.1	93
1,200 g CCC ha^{-1} + 400 g TE ha^{-1}	2,453	cde	2.744	89,395	cdef	14.3	91
1,800 g CCC ha^{-1} + 400 g TE ha^{-1}	2,471	cdef	2.636	94,343	efg	17.4	88
1,200 g CCC ha^{-1} + 600 g CCC ha^{-1}	1,638	a	3.136	52,295	a	10.9	96
2x mow							
Untreated control	1,670	ab	2.953	56,698	ab	17.3	96
400 g TE ha^{-1}	2,944	defg	2.676	109,908	fg	28.8	73
600 g CCC ha^{-1}	1,856	abc	2.932	63,639	abcde	17.4	90
1,200 g CCC ha^{-1}	1,564	a	2.925	53,748	ab	15.4	90
1,800 g CCC ha^{-1}	1,796	abc	2.981	60,261	abc	15.3	93
600 g CCC ha^{-1} + 400 g TE ha^{-1}	3,229	efg	2.617	123,392	gh	32.1	74
1,200 g CCC ha^{-1} + 400 g TE ha^{-1}	3,247	fg	2.570	126,645	h	25.4	66
1,800 g CCC ha^{-1} + 400 g TE ha^{-1}	3,282	g	2.559	128,693	h	28.2	61
1,200 g CCC ha^{-1} + 600 g CCC ha^{-1}	1,803	abc	2.892	62,312	abcd	15.0	89
LSD = 0.05	*P* = 0.0294		0.2319	0.0066		0.0006	0.0003

[1]Homogenous group format cannot be used because of pattern of significant differences.

Table 2. Interaction effects of chlormequat chloride (CCC) and trinexapac-ethyl (TE) plant growth regulators on seed yield, yield components, harvest index, and lodging in 'Gulf' annual ryegrass with and without spring mowing, 2022.

Treatment	Yield	Seed weight	Seed number	Harvest index[1]	Lodging
	($kg\ ha^{-1}$)	($mg\ seed^{-1}$)	($no\ m^{-2}$)	(%)	(%)
No mow					
Untreated control	1,397 bc	2.851 f	49,401 bc	9.0	93 c
400 g TE ha^{-1}	1,823 e	2.723 cde	66,958 efg	10.0	90 c
600 g CCC ha^{-1}	1,379 bc	2.824 ef	48,801 bc	7.4	91 c
1,200 g CCC ha^{-1}	1,579 cd	2.840 ef	55,722 cd	9.2	95 c
1,800 g CCC ha^{-1}	1,557 cd	2.846 f	54,758 cd	8.8	94 c
600 g CCC ha^{-1} + 400 g TE ha^{-1}	1,693 de	2.661 c	63,838 def	9.8	93 c
1,200 g CCC ha^{-1} + 400 g TE ha^{-1}	1,576 cd	2.688 cd	59,192 de	8.7	91 c
1,800 g CCC ha^{-1} + 400 g TE ha^{-1}	1,577 cd	2.755 cde	57,584 cd	8.8	91 c
1,200 g CCC ha^{-1} + 600 g CCC ha^{-1}	1,213 ab	2.827 ef	43,003 ab	8.1	90 c
2X mow					
Untreated control	1,251 ab	2.788 cdef	44,883 ab	14.8	95 c
400 g TE ha^{-1}	1,858 ef	2.501 b	74,470 gh	17.0	75 b
600 g CCC ha^{-1}	1,179 ab	2.794 def	42,240 ab	8.9	89 c
1,200 g CCC ha^{-1}	1,154 ab	2.840 ef	40,842 ab	9.8	95 c
1,800 g CCC ha^{-1}	1,066 a	2.759 cdef	38,715 a	8.1	94 c
600 g CCC ha^{-1} + 400 g TE ha^{-1}	1,745 de	2.445 ab	71,307 fgh	18.6	58 a
1,200 g CCC ha^{-1} + 400 g TE ha^{-1}	1,880 ef	2.412 a	78,068 h	15.6	61 a
1,800 g CCC ha^{-1} + 400 g TE ha^{-1}	2,087 f	2.384 a	87,693 i	19.7	61 a
1,200 g CCC ha^{-1} + 600 g CCC ha^{-1}	1,217 ab	2.772 cdef	44,042 ab	10.5	93 c
LSD = 0.05	P = 0.0000	0.0000	0.0305	0.0014	0.0000

[1]Homogenous group format cannot be used because of pattern of significant differences.

References

Anderson, N.P., T.G. Chastain, and C.J. Garbacik. 2019. Are higher yields possible in annual ryegrass seed crops? (Year 1). In N.P. Anderson, A.G. Hulting, and D.L. Walenta (eds.). *2018 Seed Production Research Report*. Oregon State University, Ext/CrS 160.

Anderson, N.P., T.G. Chastain, C.J. Garbacik, and B.C. Donovan. 2020. Are higher yields possible in annual ryegrass seed crops? (Year 2). In N.P. Anderson, A.G. Hulting, D.L. Walenta, and C.A. Mallory-Smith (eds.). *2019 Seed Production Research Report*. Oregon State University, Ext/CrS 162.

Anderson, N.P. and D.J. Maliszewski. 2022. Evaluation of chlormequat chloride plant growth regulator on dryland perennial ryegrass seed crops. In N.P. Anderson, A.G. Hulting, D.L. Walenta, and C.A. Mallory-Smith (eds.). *2021 Seed Production Research Report*. Oregon State University, Ext/CrS 166.

Hampton, J.G. 1986. The effect of chlormequat chloride application on seed yield in perennial ryegrass (*Lolium perenne* L.). J. Appl. Seed Prod. 4:9–13.

Hebblethwaite, P.D., A. Burbidge, and A.D. Wright. 1978. Lodging studies in *Lolium perenne* grown for seed. 1. Seed yield and seed yield components. J. Agric. Sci. (Camb.) 90:61–267.