EVALUATION OF CHLORMEQUAT CHLORIDE PLANT GROWTH REGULATOR ON DRYLAND PERENNIAL RYEGRASS SEED CROPS

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Introduction

Plant growth regulators (PGRs) have been an important management tool utilized by grass seed growers worldwide for several decades. They have been used successfully to reduce lodging and increase seed yield in several cool-season grass species, including perennial ryegrass (*Lolium perenne* L.).

In Oregon, perennial ryegrass seed crops are grown on approximately 63,000 acres, and production is valued at nearly $100 million. However, production acres of this important cool-season grass seed crop have decreased by approximately 31% over the past ten years (Anderson, 2022). This reduction in production area is a result of increased input costs, higher pest pressure, and decreased stand longevity compared to other cool-season grass species that can be grown in the same environment. Thus, it is important to look for new management practices that may help overcome the economic challenges and improve future production opportunities for this important grass seed crop in Oregon.

Stem elongation in grasses is promoted by gibberellic acid (GA), but this elongation can be counteracted by the application of PGRs (Rademacher, 2015). There are three different groups of GA-inhibiting PGRs, two of which are examined in this study. One of these groups of PGRs block GA metabolism by inhibiting cyclase activities in the early stages of GA biosynthesis (onium compounds), while another works in late stages of GA biosynthesis by inhibiting dioxygenase reaction in blocking 2-oxoglutaric acid as a catalyst (acylcyclohexanedione).

One onium PGR used in crop production is chlormequat chloride (CCC), and the most widely used acylcyclohexanedione PGR is trinexapac-ethyl (TE; Palisade EC, Syngenta) (Rademacher, 2015). Prior to the development of TE, CCC was used commercially in perennial ryegrass seed crops in New Zealand, where it was observed to increase grass seed yields (Hampton, 1986). The greater seed yield response to TE in comparison to CCC eventually resulted in rapid grower adoption of TE.

Plant growth regulators containing CCC have not previously been registered for use in grass seed crops in Oregon, but a federal registration is pending in the U.S. (Adjust, Eastman Chemical Company). 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. Application of CCC alone had no effect on turf-type or forage-type tall fescue in Oregon, but a 31–35% increase in seed yield was observed with 210 g TE ha^{-1} + 750 g CCC ha^{-1} over the untreated control (Hudgins, unpublished). More recently, Szczepanek et al. (2021) showed an increase in seed yield from the use of CCC and TE + CCC in both strong creeping red and Chewings fescue with two nitrogen fertilizer rates over two production years.

The objective of this study was to determine the effects of CCC and combinations of CCC + TE on seed yield and yield components in turf-type perennial ryegrass seed crops grown under dryland conditions in western Oregon.

Materials and Methods

The field trial was established at OSU's Hyslop Crop Science Research Laboratory in the fall of 2019 with 'Fastball' perennial ryegrass. The first- and second-year seed harvests occurred in 2020 and 2021, respectively. Plot size was 11 feet x 45 feet. The experimental design for this trial was a randomized complete block with four replications.

Routine herbicide, molluscicide, and insecticide treatments were applied to manage pests as needed. Spring nitrogen was applied to plots at a rate of 140 lb N/acre. The PGR treatments were applied with a bicycle-type boom sprayer operated at 138 kPa with XR Tee Jet 8003VS flat spray nozzles.

The following PGR treatments were included:

- Untreated control (No PGR)
- 2.8 pt/acre Palisade (TE) at BBCH 32 (two nodes)
- 1.3 lb/acre Adjust (CCC) at BBCH 32
- 2.6 lb/acre Adjust at BBCH 32
- 3.9 lb/acre Adjust at BBCH 32
- 1.3 lb/acre Adjust + 2.8 pt/acre Palisade at BBCH 32
- 2.6 lb/acre Adjust + 2.8 pt/acre Palisade at BBCH 32
- 3.9 lb/acre Adjust + 2.8 pt/acre Palisade at BBCH 32
- 2.6 lb/acre Adjust at BBCH 32 + 1.3 lb/acre Adjust at BBCH 51 (head emergence)

At peak flowering (BBCH 65), three 0.1 m^{-2} samples were harvested (cut to 2 cm above ground level) at random from each plot to determine fertile tillers m^{-2}, tiller length cm^{-2}, and above-ground biomass. Samples were placed in a dryer at 65°C for approximately 48 hours and were then weighed to determine the above-ground biomass. Tillers were then counted, and length was determined by measuring ten stems randomly chosen from each sample.

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 cleanout percentage and 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. Harvest index (HI), the ratio of seed yield to above-ground biomass, was also quantified.

Results and Discussion

Results from the first year of the study (2020) indicate that 2.8 pt/acre Palisade was the only PGR treatment that affected seed yield (Table 1). This treatment increased seed yield by 15.9% over the untreated control. Treatments containing CCC, either alone or in a tank-mix, had no effect on seed yield.

Percent cleanout increased with all CCC + TE treatments, compared to the untreated control. Seed number and biomass were not affected by any of the PGR treatments. Seed weight decreased by 5.8 and 6.2% with the 1.3 lb/acre Adjust + 2.8 pt/acre Palisade and 2.6 lb/acre Adjust + 2.8 pt/acre Palisade treatments, respectively. There were no differences in fertile tiller numbers among any of the PGR treatments; however, all treatments containing TE reduced tiller height compared to the untreated control and all CCC-alone treatments. There was no effect on HI from any of the PGR treatments.

In the second year of the study (2021), all PGR treatments containing Palisade decreased seed yield, while treatments containing only CCC were not different than the untreated control (Table 2). The 2.8 pt/acre Palisade treatment decreased seed yield by 22.4%, while the Adjust + Palisade tank-mixes resulted in seed yield decreases ranging from 30.8 to 36.4%.

Percent cleanout increased with all treatments containing TE but was not different with treatments containing CCC alone. There were no differences in seed weight, biomass, or fertile tiller number among treatments. All CCC + TE tank-mix treatments decreased seed number and tiller height compared to

Table 1. Plant growth regulator (PGR) effects on first-year 'Fastball' perennial ryegrass, 2020.[1]

	Yield	Cleanout	Seed weight	Seed number	Biomass	Fertile tillers	Tiller height	Harvest index
	(lb/a^{-1})	(%)	(mg $seed^{-1}$)	(no m^{-2})	(kg ha^{-1})	(no m^{-2})	(cm)	(%)
Untreated control	1,346 a	9.6 ab	1.529 cd	98,615	11,915	293	49.7 b	13.5
Palisade @ 2.8 pt/a	1,561 b	11.6 bcd	1.487 bc	117,693	8,616	237	31.9 a	20.3
Adjust @ 1.3 lb/a	1,346 a	10.6 abc	1.515 cd	99,570	9,676	252	48.0 b	15.9
Adjust @ 2.6 lb/a	1,385 a	10.7 abc	1.527 cd	101,763	8,923	231	47.9 b	18.2
Adjust @ 3.9 lb/a	1,328 a	10.8 abc	1.532 d	97,155	10,168	283	45.2 b	14.9
Adjust @ 1.3 lb/a + Palisade @ 2.8 pt/a	1,339 a	11.7 cd	1.455 ab	103,293	11,022	299	30.1 a	14.3
Adjust @ 2.6 lb/a + Palisade @ 2.8 pt/a	1,295 a	13.3 d	1.433 a	101,429	8,557	243	26.9 a	17.4
Adjust @ 3.9 lb/a + Palisade @ 2.8 pt/a	1,382 a	12.2 cd	1.488 bc	103,772	9,155	250	28.9 a	17.2
Adjust @ 2.6 lb/a + Adjust @ 1.3 lb/a	1,326 a	9.2 a	1.508 cd	98,635	10,538	266	48.2 b	14.6

[1]Numbers followed by the same letter are not significantly different at LSD ($P = 0.05$).

Table 2. Plant growth regulator (PGR) effects on second-year 'Fastball' perennial ryegrass, 2021.[1]

	Yield	Cleanout	Seed weight	Seed number	Biomass	Fertile tillers	Tiller height	Harvest index
	(lb/a^{-1})	(%)	(mg seed^{-1})	(no m^{-2})	(kg ha^{-1})	(no m^{-2})	(cm)	(%)
Untreated control	652 c	14.5 a	1.224	59,611 cd	12,971	480	44.6 bc	5.7 de
Palisade @ 2.8 pt/a	506 ab	18.7 b	1.084	52,529 bc	14,381	471	39.3 b	4.0 abc
Adjust @ 1.3 lb/a	648 c	14.7 a	1.223	59,354 cd	14,354	501	44.0 bc	5.3 de
Adjust @ 2.6 lb/a	655 c	14.8 a	1.208	60,865 d	15,768	518	47.0 c	4.7 bcd
Adjust @ 3.9 lb/a	608 c	15.2 a	1.107	61,713 d	14,182	491	43.3 bc	4.9 cde
Adjust @ 1.3 lb/a + Palisade @ 2.8 pt/a	417 a	20.6 b	1.115	42,414 a	13,297	454	30.3 a	3.6 ab
Adjust @ 2.6 lb/a + Palisade @ 2.8 pt/a	415 a	21.6 b	1.078	43,709 a	13,308	434	29.0 a	3.5 a
Adjust @ 3.9 lb/a + Palisade @ 2.8 pt/a	451 a	20.4 b	1.068	47,067 ab	13,016	429	31.5 a	3.9 abc
Adjust @ 2.6 lb/a + Adjust @ 1.3 lb/a	600 bc	13.4 a	1.104	61,008 d	11,728	415	44.8 bc	5.8 e

[1]Numbers followed by the same letter are not significantly different at LSD (P = 0.05).

the untreated control, TE alone, and CCC-alone PGR treatments. Harvest index was decreased with all PGR treatments containing TE.

The differences in seed yield response to PGR treatments between years can likely be attributed to differences in spring rainfall conditions. The long-term mean precipitation for March through June in the Willamette Valley is 10.34 inches. In 2020, the precipitation was slightly below the long-term mean at 9.17 inches. However, the precipitation during this same period in 2021 was only 5.17 inches. The dry conditions in 2021 resulted in lower seed yield, which likely was caused by lower seed weights and higher percent cleanout in the second-year stand.

The results of this study indicated that applications of CCC alone, or in a tank-mix with TE, should not be considered in western Oregon dryland perennial ryegrass seed crops at this time. However, more work is needed to evaluate CCC-containing PGRs on other varieties, under irrigation, and in other regions of Oregon where perennial ryegrass is grown in different environmental conditions. We recommend that TE continue to be used as an important management tool to increase seed yield in perennial ryegrass seed crops.

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