TRINEXAPAC-ETHYL TIMING AND RATE EFFECTS ON CRIMSON CLOVER SEED PRODUCTION

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Introduction

Crimson clover is one of the important forage legume seed crops grown in the Willamette Valley of Oregon. The Willamette Valley produces about 95% of the total U.S. crimson clover seed crop annually, with production valued at $20 million in 2014.

Crimson clover seed yields have more than doubled since the mid-1970s, and recent research with red clover seed crops suggests that further improvement of crimson clover seed yield may be possible. One reason for increased red clover seed yield is foliar application of the plant growth regulator (PGR) trinexapac-ethyl (TE), an anti-lodging agent (Øverland and Aamlid, 2007; Anderson et al., 2015; Anderson et al., 2016).

Research focused on application of TE or any other PGR to crimson clover seed crops has not previously been conducted. Preliminary on-farm trials have shown that TE can increase crimson clover seed yield by 10–24% over the untreated control (Anderson et al., unpublished). More information is needed to identify the optimum application rate and stage of crop development for TE application to achieve the best economic return in crimson clover seed production.

The objective of this 2-year study was to evaluate the effects of TE timing and application rate on crimson clover seed crops and to establish recommendations for timing of TE application to crimson clover in the Willamette Valley of Oregon.

Materials and Methods

Field trials were established at Hyslop Research Farm near Corvallis, OR, for the 2014–2015 and 2015–2016 crop years. Crop development stages and crop management timings were assessed using the BBCH scale. Crimson clover seed was planted in October 2014 and 2015 with a Nordsten drill set at a 6-inch row spacing. The seeding rate was 17 lb/acre. SelectMax (Clethodim) and MCP Amine 4 (MCPA) herbicides were applied at 12 oz/acre and 10 oz/acre, respectively, at BBCH 12 to control weeds in the crop. The crimson clover crop was mowed to a height of 5 inches at BBCH 40 to control a wild garlic (*Allium vineale*) infestation during the second year.

The experimental design was a randomized block design with four replications. TE was applied at two stages of crop development: stem elongation (BBCH 32, late March) and bud emergence (BBCH 50, mid-April). At each application timing, four TE rates were applied (1, 2, 3, and 4 pt product/acre). Visual evaluations were conducted on date1, date2, etc. to determine the effect of TE rate and application timing on crop growth and development compared to an untreated control.

Soil water content was determined by time domain reflectometry (TDR) in early May. Seed yield components, including numbers of stems, heads, and florets, were quantified on samples taken at peak bloom (BBCH 65, mid-May). Canopy characteristics, including above-ground biomass and canopy height, were also measured at peak bloom.

The crimson clover was swathed with a modified John Deere 2280 swather, and seed was harvested with a Hege 180 plot combine in June 2015 and June 2016, respectively. The seed was cleaned with a M2-B Clipper seed cleaner, and 1,000-seed weight was recorded after counting with an Old Mill Company Model 850-2 seed counter. Seed number/ft^2 was calculated based on seed yield and 1,000-seed weight values obtained from each plot. Analysis of variance (ANOVA) was used to test TE treatment effects, and Fisher's protected least significant difference (FPLSD) test was used to separate treatment means.

Results and Discussion

ANOVA revealed that crimson clover stem numbers, above-ground biomass, seed head numbers, seed number, and seed yield were not affected by application of TE PGR (Table 1). Very dry conditions prevailed in the spring of 2015, with only 58% of normal rainfall occurring April through June, and these dry conditions likely influenced the results. Extremely wet conditions were prevalent in the 2015–2016 crop year, especially in fall 2015 (132% of normal rainfall) and March 2016 (183% of normal rainfall).

In 2015, seed yields were variable and were lower than the 10-year average yield of 910 lb/acre for the Willamette Valley as a result of extreme drought and high temperatures during the 2014–2015 crop year

(Table 2). Neither timing of TE PGR application nor application rate affected seed yield. These results were inconsistent with the preliminary on-farm trials in prior years, which showed a seed yield increase with TE. Table 2 shows seed yield and the contributions of its two primary seed yield components, seed weight and seed number. Seed yield is the mathematical product of yield components and can be expressed as follows: seed yield/area = seed weight x seed number/area. Seed weight was reduced with all TE application treatments (Table 2). Overall, seed weight generally declined with increasing rate of TE and later application time. There was no effect of TE on seed number, which was the primary factor responsible for the seed yield increase by TE PGR in red clover (Anderson et al., 2015; Anderson et al., 2016).

Wet fall and late spring conditions in the 2015–2016 crop year resulted in poor stands and low seed yields in 2016 (Table 2). Seed yields were not influenced by TE in 2016. Nevertheless, seed weight was affected by TE in the same way in 2016 as in 2015, despite the lack of influence on seed yield. In general, seed weight was reduced by TE, and that effect was most pronounced at high TE rates. Unlike in 2015, seed number was affected by TE. Seed number was increased by TE with application rates of 2–4 pt/acre at the BBCH 32 timing and by 3-4 pt/acre TE at the BBCH 50 application timing. This increase in seed number was unable to offset the loss in seed weight, thereby resulting in no seed yield increases by TE.

Canopy height of the crop was consistently reduced with TE applications in 2015 and in 2016 (Table 3). Biomass and harvest index were not affected by TE application in either year (data not shown). The number of florets increased at the BBCH 32 application timing with 1–3 pt/acre, but not with 4 pt/acre in 2015. Only the 3 pt/acre rate increased floret production at the BBCH 50 timing. No effects of TE on stem number, inflorescence number, or floret number were quantified in 2016. Cleanout increased with 3 and 4 pt/acre of TE at the BBCH 50 timing in 2015, but not in 2016.

Table 1. ANOVA for trinexapac-ethyl treatment effects on crimson clover seed yield and seed yield components, 2015 and 2016.[1]

Characteristics	2015	2016
Seed yield	ns	ns
Seed weight	***	***
Seed number	ns	***
Cleanout	***	ns
Biomass	ns	ns
Stems/ft^2	ns	ns
Heads/ft^2	ns	ns
Florets/ft^2	*	ns
Canopy height	***	***
Soil water content	*	ns

[1]* $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$
ns = Not significant

Table 2. Effect of trinexapac-ethyl timing and rate on seed yield and primary seed yield components (seed weight and seed number) in crimson clover.[1]

---------- Treatment ----------		------ Seed yield ------		------ Seed weight ------		------ Seed number ------	
Timing	Rate	2015	2016	2015	2016	2015	2016
	(pt/a)	------- (lb acre^{-1}) -------		------- (mg seed^{-1}) -------		------- (seeds ft^{-2}) -------	
Untreated control	—	362 a	287 a	5.67 a	5.24 a	667 a	559 ab
BBCH 32	1	346 a	304 a	5.38 b	4.98 b	673 a	624 abc
	2	364 a	291 a	5.17 c	4.48 d	733 a	660 cd
	3	383 a	331 a	5.05 cd	4.42 de	792 a	763 e
	4	305 a	299 a	4.79 de	4.24 e	669 a	717 de
BBCH 50	1	278 a	267 a	5.11 c	4.98 b	566 a	547 a
	2	301 a	294 a	4.88 de	4.74 c	643 a	631 bc
	3	290 a	307 a	4.49 f	4.37 de	676 a	716 de
	4	278 a	289 a	4.38 f	4.36 de	660 a	675 cd

[1]Means followed by the same letter within each column are not significantly different by Fisher's protected LSD values ($P = 0.05$).

Table 3. Trinexapac-ethyl timing and rate effects on canopy height in crimson clover, 2015 and 2016.[1]

----------- Treatment ----------		----- Canopy height -----	
Timing	Rate	2015	2016
	(pt/a)	----------- (cm) -----------	
Untreated control	—	71.1 a	69.1 a
BBCH 32	1	61.1 bc	61.1 bc
	2	58.3 cd	54.1 de
	3	55.7 d	56.7 cd
	4	53.6 d	51.7 e
BBCH 50	1	65.2 b	63.1 b
	2	63.9 b	57.3 cd
	3	63.8 b	56.8 cd
	4	62.4 bc	53.4 de

[1]Means followed by the same letter within each column are not significantly different by Fisher's protected LSD values ($P = 0.05$).

Cleanout represents the quantity of nonseed material harvested.

The reduction in canopy height by TE most likely opened up the canopy, thereby allowing a greater loss of soil water through evaporation in 2015. Coupled with the abnormally dry and hot conditions in 2015, the reduction in canopy coverage with TE reduced the amount of soil water available for seed filling; as a result, seed weight was also reduced more than previously noted. With very wet conditions in March and April 2016, no effects of TE on soil water content were detected in early May 2016.

Poor weather and growing conditions in both years of the study resulted in lower-than-expected seed yields for crimson clover. Under these extreme conditions, TE consistently reduced height of the crimson clover seed crop canopy. Although seed yield was not affected, seed weight was reduced at all rates and timings.

References

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