IRRIGATION AND PGR EFFECTS ON RED CLOVER SEED PRODUCTION

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Introduction

Red clover is the most widely grown legume seed crop in the Willamette Valley. Red clover seed yields have roughly doubled since the mid-1970s and our recent work on use of plant growth regulators (PGRs) in red clover seed crops suggests that further improvement in seed yield is possible.

Oliva et al. (1994) showed that irrigation strategically timed to coincide with flowering increased seed yield over non-irrigated red clover. Foliar applied PGRs have been widely used on grass seed crops in Oregon and other parts of the world because of well documented seed yield increases and reduction in lodging (Zapiola et al., 2006). Two acylcyclohexanedione PGRs are registered for use as lodging control agents in grass seed crops in Oregon - trinexapac-ethyl (TE) and prohexamide-calcium (PC).

Very little research has been conducted on the use of PGRs on legume seed crops. In Norway, red clover seed yield was increased when TE was applied at stem elongation (Øverland and Aamlid, 2007). Anderson et al. (2012) conducted three years of on-farm investigations that revealed that TE applications increased seed yield of red clover seed crops in Oregon. There is nothing in the literature regarding the application of PC PGR on red clover seed crops. Furthermore, it is unclear what the combination of irrigation and PGR application might have on seed yield, yield components, and lodging control in red clover.

The objective of this study is to quantify the impact of irrigation and its potential interaction with PGR use on red clover seed production under Willamette Valley conditions.

Methods

Two plantings (2011 and 2012) of red clover seed crops were established in the fall at Hyslop Crop Science Research Farm near Corvallis and each will be followed over a two-year period to examine the effects of irrigation and PGR use. PGR treatment subplots (11 ft x 50 ft) were randomly allocated within irrigated and non-irrigated main plots in a split-plot arrangement of treatments in randomized block experimental design. Trials were replicated in four blocks. The following PGR treatments were made on the subplots:

1. Untreated Control
2. Trinexapac-ethyl (TE) PGR applied at 1 pint/acre at stem elongation
3. TE PGR applied at 2 pints/acre at stem elongation
4. TE PGR applied at 3 pints/acre at stem elongation
5. TE PGR applied at 4 pints/acre at stem elongation
6. TE PGR applied at 1 pint/acre at bud emergence
7. TE PGR applied at 2 pints/acre at bud emergence
8. TE PGR applied at 3 pints/acre at bud emergence
9. TE PGR applied at 4 pints/acre at bud emergence
10. Prohexamide-calcium (PC) PGR applied at 7.4 oz/acre at stem elongation
11. PC applied at 14.8oz/acre at stem elongation

The red clover seed crop was flailed in mid-May (prior to bud emergence) and residue was left on the field. Once regrowth occurred, approximately four inches of irrigation water was applied to the main plots at late bud emergence (BBCH growth stage 55) by using a custom-designed Pierce AcreMaster linear system equipped with minimum-drift Nelson sprinklers. This single irrigation was strategically timed to coincide with first flowering (BBCH 60 growth stage). TE and PC PGRs were applied at the rates listed above to subplots at stem elongation (BBCH growth stage 32) and bud emergence (BBCH growth stage 50). Seed was harvested with a small-plot swather (modified JD 2280) and threshed with a Hege 180 small-plot combine. Harvested seed was processed with a M2-B Clipper cleaner and clean seed yield was determined.

Plots were sampled at peak bloom (BBCH growth stage 65) to determine the number of heads (inflorescences) and florets within the heads, primary stems, and above-ground biomass. Harvest index was determined for each plot based on harvested seed yield and above-ground biomass. Seed weight was measured by counting two 1000 seed samples from harvested, cleaned seed and determining the weight. Seed number was calculated based on seed yield and 1000-seed weight values obtained from each plot.

Results and Discussion

Rainfall for the July through September period was 37% of the average. Only 10 of the past 123 years have been this dry or drier during summer in the Willamette Valley. These dry conditions were preceded by a very wet and cool spring, so soil moisture was greater than normal as summer approached.

Above-ground biomass, stem number, and harvest index were not influenced by either irrigation or PGR treatment, nor by the interaction of the two (Table 1). There were no interactions of irrigation and PGR for any of the seed production characteristics presented in this report.

Irrigation had significant effects on seed yield, seed weight, and several other characteristics (Table 1). Seed yield was increased by 10% in the 1st-year stand by irrigation over the non-irrigated crop (Table 2). The most likely reasons for the increase in seed yield attributable to irrigation were increased seed weight and a greater number of seeds/floret than the non-irrigated red clover. This increase in yield was evident despite the reduction in heads/ft^2 and florets/ft^2 by irrigation. While not significant, there was a trend for increased vegetative plant growth with irrigation and this might have altered the resource partitioning of the crop so that there were fewer flowers and more vegetation.

There was a trend for increased seed yield when TE was applied at stem elongation. However, unlike our previous work (Anderson et al., 2012), the PGR treatments did not significantly increase seed yield in 2012 (Table 3). There were several possible explanations for this observation. TE applications reduced seed weight over the untreated control regardless of rate of application or the timing of the application, and this reduction was greater than previously noted in our on-farm trials. The largest reductions in seed weight were found among the higher TE application rates and were more pronounced with the bud emergence timing. On the other hand, TE mostly increased the number of seeds produced but was not sufficient to offset the reduced seed weight and thus seed yield was not increased by TE. PC did not reduce seed weight like TE but also did not increase seed number and so seed yield was also not increased. The florets/head tended to be increased by some applications of TE at the stem elongation timing while PC had no effect on florets/head. Anderson et al. (2012) found some minor reductions in seed weight by using certain TE treatment application timings but not to the degree observed in this 1st-year stand of red clover. Moreover, the prior trials results showed that heads/ft^2 were increased by TE, a phenomenon not evident in the present work.

This is the first of a series of reports on irrigation and PGR effects in red clover seed production. Future updates will continue to follow the results of the two experimental red clover seed fields as they age as well as research on effect of PGR on seed quality and crop maturity.

References

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Table 1. Analysis of variance for effects of irrigation and PGR on red clover seed production 2012.

Characteristic	Source of variation		
	Irrigation (I)	PGR (P)	I x P
Above-ground biomass	NS	NS	NS
Stem number	NS	NS	NS
Harvest index	NS	NS	NS
Seed yield	*	NS	NS
Seed weight	**	***	NS
Heads/ft^2	*	NS	NS
Florets/head	NS	*	NS
Florets/ft^2	*	NS	NS
Seeds/ft^2	NS	***	NS
Seeds/floret	*	NS	NS

* $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

Table 2. Irrigation effects on a 1st-year red clover seed crop in 2012.

Characteristic	Treatment	
	Irrigated	Non-Irrigated
Seed yield (lbs/acre)	867 b†	786 a
Seed weight (mg)	1.73 b	1.64 a
Heads/ft^2	65 a	80 b
Florets/ft^2	7752 a	9635 b
Seeds/floret	0.80 b	0.59 a

†Means in rows followed by the same letter are not significantly different (P = 0.05).

Table 3. Effects of trinexapac-ethyl (TE) and prohexamide-calcium (PC) PGR treatments on red clover seed production characteristics in a 1st-year stand in 2012.

PGR	PGR rate and timing	Seed yield	Seed weight	Florets/head	Seeds/m^2
	pts/A (TE) or oz/A (PC)	lbs/acre	mg	no.	no. x 10^4
Control		818	1.77 a†	113 ab	5.18 a
TE	1 Stem elongation	829	1.71 b	125 d	5.43 ab
	2 Stem elongation	860	1.69 b	121 bcd	5.70 b
	3 Stem elongation	852	1.69 b	122 cd	5.64 b
	4 Stem elongation	844	1.66 c	120 bcd	5.73 bc
TE	1 Bud emergence	795	1.69 b	115 abc	5.25 a
	2 Bud emergence	831	1.64 cd	119 bcd	5.69 b
	3 Bud emergence	815	1.61 d	121 bcd	5.69 b
	4 Bud emergence	829	1.54 e	119bcd	6.04 c
PC	7.4 Stem elongation	812	1.76 a	110 a	5.17 a
	14.8 Stem elongation	807	1.75 a	114 ab	5.16 a

†Means in columns followed by the same letter are not significantly different (*P* = 0.05).