AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
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TITLE: **Plant Growth Regulator and Irrigation Effects on White Clover Seed Production**

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OBJECTIVES: The objective of this project was to determine the effect of PGRs and irrigation on seed yield and seed yield components in crimson clover and white clover seed crops.

PROCEDURES: Crimson Clover: Field trials were established at Hyslop Farm near Corvallis, Oregon. Crimson clover seed was planted in October 2014 and 2015 by using a Nordsten drill set at a 6-inch row spacing. The seeding rate was 17 lbs/acre. Clethodim and MCPA herbicides were applied at 12 oz/acre and 10 oz/acre, respectively, to control broadleaf and grass weeds in the crop.

The experimental design was a randomized block design with four replications; both Palisade EC (TE) PGR rate and timing treatments were evaluated. The two TE application timings were: stem elongation (BBCH 32 – late March), and bud emergence (BBCH 50 – mid April). Four TE rates were applied at each of the two timings: 1, 2, 3, and 4 pints/acre. These TE application timings and rates were compared to an untreated control (Figure 1).

Figure 1. Photo taken in early summer 2016 following crimson clover TE treatments.

White Clover: This trial was planted in early October, 2014 Hyslop Farm near Corvallis, Oregon and left in for two harvest seasons. The stand was seeded with a Nordsten drill at a seeding rate of 4.8 lbs/acre. Basagran herbicide was applied to control broadleaf weeds in both years. In the spring of both 2015 and 2016 the stand was flail mowed during the second week of April to simulate grazing and again during the first half of May to reduce biomass.

The experimental design was a randomized complete block with a split-plot arrangement of treatments and four replications. Main plots were irrigation and subplots were PGR and row spray applications. Once regrowth occurred 4 inches of irrigation was applied to main plots over a 2-d period at BBCH 51. PGR treatments, including TE and paclobutrazol (Bonzi), were applied to split plots in the spring of 2015 at BBCH 32 in both years (Figure 2). In 2015, TE rates were 4.3 and 5.7 pts/a. In 2016 Palisade rates were lowered to 2.15 and 3.4. Bonzi treatment rate was 0.89 lb ai/acre, both years. An additional row-spray treatment was added in 2016 to the second-year crop under both irrigated and non-irrigated conditions. This treatment included Rely 280 at 3 pints/acre plus Goal at 4 oz/acre on a broadcast basis. Approximately 3 inches of rows were left on 10 inch centers (approx. 70% spray out).

Figure 2. Photo taken in early summer 2015 following white clover TE treatments.

Both the crimson and white clover was swathed with a modified John Deere 2280 swather and was combined with a Hege 180 plot combine in June 2015 and June 2016. The seed was cleaned with a M2-B Clipper seed cleaner and 1000-seed weight was recorded after counting with an Old Mill Company Model 850-2 seed counter. Seed number was calculated based on seed yield, and 1000-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 were used to separate treatment means.

SIGNIFICANT ACCOMPLISHMENTS: Crimson Clover: The ANOVA revealed that most characteristics of crimson clover seed production were not affected by application of TE PGR. 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 2015-16 crop year, especially in fall 2015 (132% of normal) and March 2016 (183% of normal).

Seed yields were variable and lower than the ten-year average yield of 910 lbs/acre for the Willamette Valley as a result of extreme drought and high temperature conditions in 2015 (Table 1). There was no effect of TE PGR on seed yield at either application timing or for any of the four rates tested. These results were inconsistent with the preliminary on-farm trials in prior years, which showed a seed yield increase with TE. Seed weight was reduced with all TE application treatments. Overall, seed weight generally declined with increasing rate of TE and the 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 2015-16 crop year resulted in poor stands and low seed yields in 2016. 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 2-4 pints/acre TE at the BBCH 32 timing and by 3-4 pints/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 2). Biomass and harvest index were not affected by TE application in either year. The number of florets increased at the BBCH 32 application timing with 1 to 3 pints/acre rates, but not with 4 pints/acre in 2015. Only the 3 pint/acre rate increased floret production at the BBCH 50 timing. No effects of TE on stem number, inflorescence number, and floret number were found in 2016. Cleanout represents the quantity of non-seed material harvested. Cleanout increased with 3 and 4 pint/acre of TE at the BBCH 50 timing in 2015, but not in 2016.

White Clover: In the first year stand (2015), application of TE decreased seed yield and weight while Bonzi had no effect on either (Table 3). Reduced TE rates in the second year (2016) also had no effect on seed yield or weight (Table 4). Row spraying also had no effect on seed yield or weight. Cleanout was no affected by irrigation, PGR, or row-spray application in either year.

Irrigation and row-spraying had no effect on any of the seed yield components measured in either year (Table 5 and 6). In the first-year stand (2015) neither PGR affected dry weight or number of inflorescences m^2, however, TE increased florets/inflorescence (Bonzi had no effect). Irrigation had no effect on harvest index and PGRs had mixed effects. In the second-year stand (2016) Bonzi had no effect on any yield components but TE increased numbers of inflorescences/m^2. Unfortunately, this increase did not influence seed yield. PGRs had no effect on floret number in the second year stand.

Table 1. Effect of trinexapac-ethyl timing and rate on seed yield, seed weight, and seed number in crimson clover.

		Seed Yield		Seed Weight		Seed Number	
Timing	**Rate**	2015	2016	2015	2016	2015	2016
	pint/acre	lbs 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

*Means followed by the same letter are not different at LSD (0.05)

Table 2. Trinexapac-ethyl timing and rate effects on canopy height in crimson clover.

Treatment		**Canopy Height**	
Timing	**Rate**	2015	2016
	pint/acre	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

*Means followed by the same letter are not different at LSD (0.05)

Table 3. Effect of PGRs on white clover seed yield, % cleanout and seed weight following PGR applications applied at BBCH 32 in irrigated and non-irrigated environments, 2015.

		Yield lb/a	Cleanout %	Seed weight mg seed^{-1}
Irrigation				
Irrigated		487	9.8	0.57 b
Non-irrigated		494	10.4	0.54 a
Treatment				
Control		557 b*	10.8	0.59 c
Palisade	4.3 pt/a	424 a	10.6	0.51 b
Palisade	5.7 pt/a	400 a	11.1	0.50 a
Bonzi	0.89 lb ai/a	560 b	8.7	0.59 c

*Means followed by the same letter are not different at LSD (0.05)

Table 4. Effect of PGRs on white clover seed yield, % cleanout and seed weight following PGR applications applied at stem elongation in irrigated and non-irrigated environments, 2015.

		Yield lb/a	Cleanout %	Seed weight mg seed^{-1}
Irrigation				
Irrigated		481	8.0	0.593 b
Non-irrigated		458	6.2	0.565 a
Treatment				
Control		494	7.2	0.601 c
Palisade	2.15 pt/a	474	7.4	0.569 b
Palisade	4.3 pt/a	443	7.2	0.538 a
Bonzi	0.89 lb ai/a	449	6.4	0.599 c
Row-spray		488	7.4	0.589 c

*Means followed by the same letter are not different at LSD (0.05)

Table 5. White clover seed yield component measurements following PGR applications applied at stem elongation in irrigated and non-irrigated environments, 2015.

		Dry Wt.	Inflorescences	Florets	Harvest Index
		g m^{-2}	no m^{-2}	no/inflor.	%
Irrigation					
Irrigated		748.3	636.7	84.7	7.5
Non-irrigated		651.6	607.7	85.4	8.8
Treatment					
Control		760.2	605.3	80 a*	8.6 bc
Palisade	4.3 pt/a	666.9	616.0	92 b	7.4 ab
Palisade	5.7 pt/a	694.7	632.8	89 b	6.6 a
Bonzi	0.89 lb ai/a	694.2	623.4	82 a	9.5 c

*Means followed by the same letter are not different at LSD (0.05)

Table 6. White clover seed yield component measurements following PGR and row-spray applications applied at stem elongation in irrigated and non-irrigated environments, 2016.

		Dry Wt.	Inflorescences	Florets	Harvest Index
		g m^{-2}	no m^{-2}	no/inflor.	%
Irrigation					
Irrigated		783.1	741	74	7.1
Non-irrigated		672.8	742	77	8.7
Treatment					
Control		747.0	699 ab	75	8.6 b
Palisade	2.15 pt/a	771.5	845 c	75	6.6 a
Palisade	4.3 pt/a	723.5	800 bc	80	6.3 a
Bonzi	0.89 lb ai/a	717.4	689 ab	75	9.1 b
Row-spray		680.2	676 a	73	8.7 b

*Means followed by the same letter are not different at LSD (0.05)

BENEFITS & IMPACT: There were several important outcomes to this work. First, we now have a better understanding of the roles of PGRs in Oregon clover seed crops. We have generated data showing that TE has a positive effect on red clover, a mixed-effect on crimson clover (based on on-farm and Hyslop trials), and no effect on white clover seed yields. This information is important as we work with Syngenta to refine the product label for Palisade. It also allows us to make technical recommendations to growers and fieldmen who are interested in using PGRs in clover seed crops. We were also able to rule out any potential use of Bonzi on white clover crops in the Oregon environment. There is economic advantage to growers who use TE on red clover and crimson clover at recommended rates and timings. White clover growers will save money by not utilizing PGRs.

Second, we now have a firm understanding of the role of irrigation in white clover seed production. Data from both years shows us that irrigation does not improve seed yield, even under very dry conditions. This means that the crop is at least somewhat tolerant to drought conditions. This data is being presented at industry meetings and will be included in OSU irrigation recommendations. We also know that even when water is applied and more biomass is produced, PGRs and row spraying do not influence seed yield under high growth situations. Growers will now be equipped with information that will hopefully encourage them to not irrigate white clover crops, rather focus their water resources on other crops where yield increases can be measured from irrigation applications.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM: A total of $20,000 was awarded by the Oregon Clover Commission to support this work over a two year period. Syngenta provided Palisade EC and Bonzi PGR product at no cost.

FUTURE FUNDING POSSIBILITIES: Plant growth regulator work on clover seed crops has concluded at this time.