# EFFECT OF FOLIAR APPLICATIONS OF TRINEXAPAC-ETHYL PLANT GROWTH REGULATOR ON RED CLOVER SEED CROPS

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## Introduction

The use of foliar applied plant growth regulators (PGRs) has become commonplace on temperate grass crops grown for seed in Oregon and other parts of the world in the last decade. This practice has been adopted due to well documented seed yield increases and reduction in lodging (Chastain et al., 2003; Rolston et al., 2004). Little research has been conducted on the use of PGRs on legumes in Oregon, though some work conducted on red clover during the late 1980s showed reduced stem length and lodging and improved seed yields with soil applications of uniconazal and paclobutrazol (Silberstein et al., 1996). The soil applied products are not currently available for commercial application in seed crops due to issues with longevity in the soil and residual activity on subsequent crops.

Excessive growth of red clover interferes with maximum seed production and harvest. Lodging can also result in increased problems from disease and can reduce the number of inflorescences available for pollination. Stem elongation and flowering of red clover are long-day responses mediated by the plant hormone gibberellic acid (Lunnan, 1989). Trinexapac-ethyl (TE), commercially known as Palisade® EC or Moddus®, is a plant growth regulator that inhibits gibberellic acid biosynthesis which has resulted in a positive effect in controlling plant height and improved yield in grass and other seed crops.

Data from a study conducted in Norway reports a 21% seed yield increase in red clover crops when trinexapac-ethyl was applied at stem elongation (Øverland and Aamlid, 2007). In 2004, Moddus was registered for use on red clover seed crops in Norway. In this article we summarize the results from six on-farm trials designed to measure the effect of TE in western Oregon.

## Materials and Methods

Large scale, on-farm trials were established on six commercial red clover seed fields in Washington and Clackamas counties in 2010 and 2011. The experimental design for the on-farm trials was a split-plot with treatments arranged in randomized complete blocks. Main-plots were farm research sites and sub-plots were PGR rate and timing treatments and an untreated control. Individual plots were 20 to 25 ft. wide by 300 ft. long. Treatments were applied with an ATV mounted boom sprayer equipped with TeeJet 11002 VS nozzles at 30 psi applying a spray volume of 14 gpa. No surfactant was used. Early applications were made when the crop was initiating stem elongation (BBCH scale 32), late applications were made when the crop in the bud emergence stage (BBCH scale 50), and split applications were made at these timings at a 1.7 pt/acre rate.

Plots were sampled at peak bloom for fertile head counts, stem counts, canopy height measurements, lodging scores, and above ground biomass dry weights. Plots were swathed and combined using grower equipment. A weigh wagon was used to determine seed yields harvested from each plot. Sub-samples of the harvested seed were collected to determine thousand seed weight, percent cleanout, and calculate total clean seed weight.

## Results

No interactions of farm research site and TE treatments were evident in 2010; however, interactions were observed in seed yield, heads per square foot, canopy height and lodging score in 2011 (Table 1). Examination of the interaction effects suggested that the TE was more effective in seed yield modification and other aspects of plant performance at some farm sites than at others in 2011 (from analyzed data, but not presented here). Significant differences were observed in seed yield among farms in 2010, and for seed yield and several other characteristics in 2011. Seed yield and seed weight were affected by TE treatments in both years (Table 1). Heads per square foot and canopy height were also influenced by the application of TE in 2011. Trinexapac-ethyl did not affect lodging score, the above-ground dry weight or the number of primary stems in the red clover seed crop.

In 2010, TE treatments increased red clover seed yields by 15 to 34 percent above the untreated control (Table 2). Seed yield was significantly increased by TE when applied late at 1.7 pt/acre or when 3.4 pt/acre was split between early and late timings.

Table 1. Analysis of variance for TE treatment in on-farm trials with red clover seed crops in 2010 and 2011. On-farm trials were conducted at 2 farms in 2010 and 4 farms in 2011.

| Source of variation | Clean seed yield | Seed weight | Head number | Canopy height | Lodging score | Dry weight | Primary stems |
|---|---|---|---|---|---|---|---|
| *2010* | | | | | | | |
| Farm (A) | *** | NS† | -- | -- | -- | -- | -- |
| TE (B) | * | * | -- | -- | -- | -- | -- |
| A X B | NS | NS | -- | -- | -- | -- | -- |
| *2011* | | | | | | | |
| Farm (A) | *** | *** | *** | NS | ** | NS | * |
| TE (B) | *** | *** | *** | * | NS | NS | NS |
| A X B | * | NS | * | * | *** | NS | NS |

*$P \leq 0.05$.
**$P \leq 0.01$.
***$P \leq 0.001$.
†Not significant.

Table 2. Effect of TE timing and application rates on red clover clean seed yield and thousand seed weight in 2010.

| TE timing and rate | Clean seed yield | Seed weight |
|---|---|---|
| (pts/acre) | (lbs/acre) | (mg/1000) |
| Control | 308 a† | 1.61 ab |
| Early 1.7 | 353 ab | 1.70 b |
| Early 3.4 | 374 ab | 1.63 ab |
| Late 1.7 | 414 b | 1.59 ab |
| Split 1.7 | 414 b | 1.53 a |

† Means followed by the same letter are not different.
$P \leq 0.05$.

In 2011, TE increased seed yield by 5 to 13 percent above the untreated control (Table 3). Three of the four TE treatments significantly increased red clover seed yield. In both years, the split 1.7 pt/acre treatment ranked among the best for increasing seed yield. Thousand seed weight was inversely related to seed yield; treatments producing highest seed yield had the lowest seed weight. Heads per square foot were increased by all TE treatments. The early 3.4 pt/acre treatment reduced canopy height, and that tendency was evident but not significant in other TE treatments.

Table 3. Effect of TE timing and application rate treatments on red clover clean seed yield, thousand seed weight, heads/ft$^2$, and canopy height in 2011.

| TE timing and rate | Clean seed yield | Seed weight | Heads$^2$ | Canopy height |
|---|---|---|---|---|
| (pts/acre) | (lbs/acre) | (mg/1000) | (no./sq ft) | (cm) |
| Control | 991 a† | 1.88 c | 90 a | 54.0 b |
| Early 1.7 | 1059 b | 1.85 bc | 114 b | 51.2 ab |
| Early 3.4 | 1080 bc | 1.81 ab | 133 b | 48.1 a |
| Late 1.7 | 1036 ab | 1.82 ab | 114 b | 49.3 ab |
| Split 1.7 | 1117 c | 1.79 a | 121 b | 48.5 ab |

† Means followed by the same letter are not different.
$P \leq 0.05$.

**Discussion**

In both years of this study, red clover grown for seed was responsive to TE applications. The cause of the seed yield increase seems to come from several factors including increased production of seed heads and reduction of canopy height. Field observations over the two years of on-farm trials indicate that in addition to increasing seed yield, TE treatments also promoted earlier maturation of the crop thereby allowing more timely harvest operations.

An important part of using this compound will be identifying the optimum rate and stage of crop development to apply TE for maximum effect. Additional studies are needed to determine such information. However, it appears that TE shows considerable promise for beneficial modification of the canopy of the red clover seed crop and for increasing seed yield under Oregon conditions.

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