Arizona Grain Research and Promotion Council
2007 Final Progress Report

Project Title: Evaluating the plant growth regulator, Trinexapac-ethyl, for lodging resistance in spring wheat.

Principal Investigators: Dr. Kurt D. Nolte, Dr. Jorge M. Fonseca

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Location of Study: The Yuma Agricultural Research Center and Grower-Cooperator Fields in and around Yuma, Arizona.

Project Rationale

Significance of Study: In wheat, straw strength has been shown to be an important agronomic characteristic as it is closely correlated with potential crop yield. The process by which straw is displaced vertically is known as lodging which results in a crop with a permanent lean or which lies horizontally on the ground. It has been shown that in some cases, the potential wheat yield is reduced by 5% for every 10% of the field area that lodges early. Lodging is not a new agricultural phenomenon, but can be a serious problem that limits wheat productivity and directly affects the profitability and harvest of Desert Durum grown in Yuma County, the highest ranking wheat producing county in the state.

Immediate Objectives: This work provides for a direct means of mediating the severity of lodging and its subsequent adverse affects on grain yield and quality in irrigated Desert Durum production systems. More specifically, however, this study intends to answer whether trinexapac-ethyl (Palisade®, Syngenta Crop Protection USA), a gibberellin biosynthesis inhibitor, is a suitable antilodging agent for existing commercial wheat varieties for future use by Yuma County growers.

Research Method and Results

2007 Field Trial and Design. The 2006 results from the small plot studies were extended to a more large scale effort in 2007. Although it seems clear that split applications of Palisade® provides lodging protection and potential yield enhancement in wheat varieties which are prone to lodging, we wanted to determine the most grower efficient application rate and method. Thus, the goal of the 2007 effort is to evaluate the benefit of using Palisade® in typical producer settings using representative practices, equipment and methods. As a single Palisade® application rate of 128 g ai/ha (2 oz. ai/a) at GS30 proved equally as effective as split applications in 2006 (Fig. 6), we introduced the PGR in single application schemes within a series of replicated (RCBD) 5 acre experimental wheat (variety Kofa) plots (Table 1) in the North Gila Valley, South Yuma County (Arizona) and in the Winterhaven/Bard area of California. In this light, our goal was to also evaluate Palisade® in combination with the herbicide, Bronate Advanced® (560 ai/ha [8.5 oz. ai/a], Bayer Crop Science) and the fungicide, Tilt® (125 ai/ha [2 oz. ai/a], Syngenta Crop Protection USA) in small replicated (RCBD) plots (5 ft. x 30 ft., Table 2).

2006 Field Trial Design. Trinexapac-ethyl was tested at 2 locations within the Yuma, AZ area namely, San Luis, AZ and Winterhaven, CA in the Spring of 2006. Both trials were conducted at grower-cooperator fields in 400 square foot treatment plots embedded within existing stands of Desert Durum wheat (variety Kofa). Palisade® was tested as single (384 g ai/ha, 5.8 oz. ai/a) or split (128 g ai/a, 2 oz. ai/a) applications at GS30 (jointing), 7 days after application #1 and at GS37 (flag leaf just visible). Ethryl®, a generator of ethylene gas, has been shown to decrease stem elongation, resulting in shorter plants with increased rigidity, was also tested in this study at a single labeled rate of 280 g ai/ha (4.2 oz. ai/a). As the persistence of ethylene in the plant is very short, the timing of PGR application is critical and often produces somewhat variable results. Previous work has shown that the optimum timing for Ethryl® is at GS37 for lodging protection, which was used in this study. Applications were made with a calibrated backpack sprayer; an untreated control completed the experimental plan. Each trial was replicated 4 times using a randomized complete block statistical design and subsamples taken for evaluation. In addition to straw strength, plant height, grain yield, 1000-grain weights, phytotoxicity and stem diameter/stem wall thickness ratio were used as indicators of Palisade® effectiveness.

Measuring Stem Bending Resistance. Rather than evaluating the severity of lodging under field conditions with observation or an index, lodging risk assessment was performed using a field-based device that measures the force required to bend wheat stems past vertical. Briefly, the manually operated device does not require skilled operators, is adjustable, repeatable, portable, and is constructed from relatively inexpensive materials (Figure 1). The instrument is operated by adjusting a pushing plate (Fig. 1, A) against an isolated row of approximately 60 wheat stems, at 50% crop height, and displace them ~70º past vertical. Lodging resistance is recorded by a load cell which is attached to the pushing plate (Fig. 1, inset, B) which rapidly quantifies the force required for stem and anchorage failure. This method allowed for an objective and repeatable estimate of lodging risk where no natural lodging was required to adequately evaluate the effectiveness of the treatments involved. The force (Newtons, N) recorded from the load sensor was readily converted into a torque (Nm) measurement based on the height (m) at which the resistance reading was taken. Torque was used as the indicator for establishing wheat stem bending resistance in this study.

Fig. 1. Operation of field-based stem strength measuring device. A pushing plate (A) is placed against an isolated row of approximately 60 wheat stems, at 50% crop height, and are displace ~70º past vertical. Lodging resistance is recorded by a load cell (inset, B) which rapidly quantifies the force required for stem or anchorage failure.

Plant Growth Characteristics. Plant phytotoxicity was observed to be a negligible treatment characteristic 1 week following application of plant growth regulators to all experimental plots. In fact, these minimal effects could no longer be detected 2 weeks following the initial application. Plant height and internode measurements were made during grain filling (GS70). An approximate 16% reduction in stem height, relative to control plots, was observed in the split Palisade® treatments (Fig. 2). A slight reduction in plant height (~6%) was also noted in single applications of both Palisade® and Ethryl® when compared to the untreated control plots (Fig. 2).

Fig. 2. The effect of growth regulator application on Desert Durum wheat height. Trinexapac-ethyl applied at 128 g/ha 3 times during GS30-GS38 reduced the height of wheat stems relative to single applications of triexapac-ethyl or Ethryl®.

The use of the stem-strength metering device (Fig. 1) proved to be a valuable tool in assessing field lodging susceptibility, particularly in the Winterhaven trial since little or no lodging was observed at this location. Trinexapac-ethyl improved straw strength relative to Ethryl® or untreated plots (Fig 3.). The improvement in straw strength was particularly evident in the split Palisade® applications where a 35% increase in stem bending resistance was observed. Straw strength did not improve in plots treated with Ethryl®. We were particularly interested in the effects of Palisade® on stem rigidity and its influence on the development of the stem wall. Since, previous reports suggested that straw strength is strongly correlated to the composition and width of the stem wall (Rajala and Peltonen-Sainio, 2001), we investigated the morphology of the wheat stem following PGR treatments. Initial work shows that Palisade® can influence the development of wheat stems through an apparent enhancement of the stem wall thickness (Fig. 4). In a preliminary survey of wheat stems exposed to PGR treatments, it appears that the stem wall:stem diameter is greatest with split applications of Palisade®. Although the mechanism behind this observation is not fully understood, it may be due, in part, to carbohydrate partitioning during the period of stem growth and elongation. Equiza et. al. (2001) has shown a similar response in shortened wheat stems grown at low temperatures. The

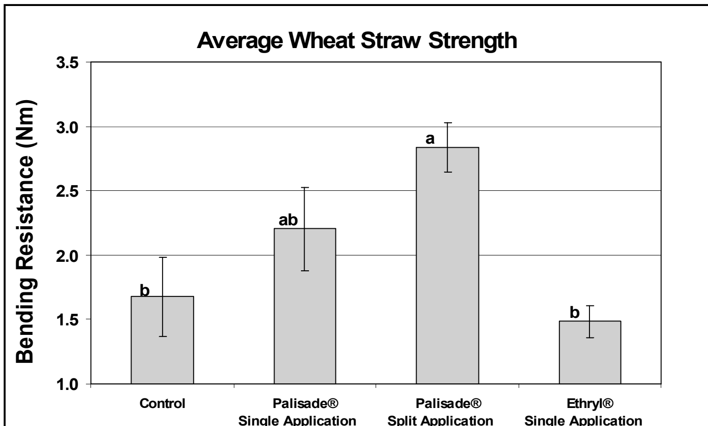

Fig. 3. Relative wheat stem bending resistance measured as torque (Nm) by an in-field stem strength measuring device. Split applications (128 g ai/ha) of trinexapac-ethyl demonstrated enhanced stem strength relative to single applications of Trinexapac-ethyl (384 g ai/ha) or Ethryl® (280 g ai/ha).

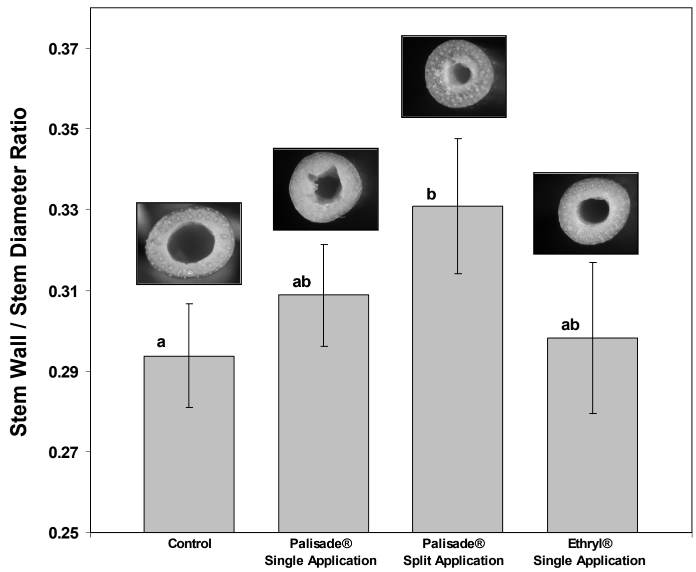

Fig. 4. Wheat stems exposed to either split or single applications of plant growth regulators.

overarching effect of Palisade®, however, was observed visually in the treatment plots at San Luis, AZ. At this location, a significant lodging event occurred during the critical period of grain fill where over 97% of the field was severely lodged. In treated plots, and particularly those treated with Palisade®, the reduced level of lodging was markedly striking (Fig. 5).

Fig. 5. The effects of Trinexapac-ethyl on Desert Durum wheat grown in San Luis, Arizona during Spring, 2006. Significant lodging is observed in control plots (A) without Trinexapac-ethyl relative to experimental plots (B) with a split application (128 g ai/ha applied 3 times during GS30–GS38) of the growth regulator.

Final Yield Determination and Conclusions. The improvement in straw strength did not have any apparent affect on final yield where lodging did not occur (Fig. 6, B). When individual grain weight (as determined by a 1000-grain count) and final yields were determined, no significant difference among treatments was observed in plots that had little or no lodging. Thus, it appears that the products tested have little effect on final grain yield in the absence of lodging. However, in the presence of a severe lodging event, as observed in the 2006 San Luis plots (Fig. 6, A), it seems that PGR's can have a positive effect on yield. Although split applications of Palisade® in 2006 appeared to result in greater 1000-grain weights and greater yield determinations relative to a single application and untreated checks some growers expressed interest in exploring the likelihood that single applications of the product would be more efficient within a grower operation. Although, in 2007, neither of the 3 test locations displayed a significant lodging event, an overall rating percentage of lodging incidence, as influenced by the PGR, was reduced at all locations (Table 1) as a result of PGR applications. Also, as shown in 2006, a single application of Palisade® was shown to be effective in enhancing lodging resistance and height reduction of wheat stems (Table 1). The effects of the PGR in combination with the Bronate Advanced® herbicide and Tilt® fungicide (Table 2, Fig. 7) suggested that Trinexapac-ethyl can be effectively mixed with other materials labeled for wheat production without a reduction in effectiveness.

It appears that the PGR, Palisade®, is a strong candidate for enhancing wheat production where lodging is an issue for producers within the state.

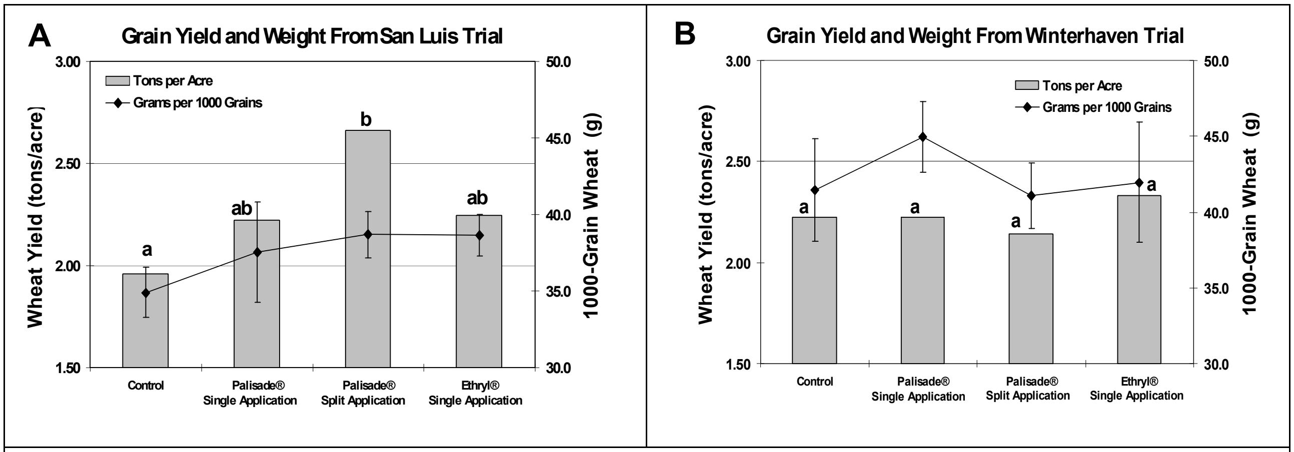

Fig. 6. The effects of Trinexapac-ethyl on Desert Durum wheat yield and grain size grown in 2 grower-cooperator locations. Trials conducted in San Luis, AZ (A), exposed to a significant lodging event during stem elongation, resulted in a significant increase in grain size and yield with split applications of Trinexapac-ethyl (128 g ai/ha, 3 applications) and intermediate results were obtained with a single application (280 g ai/ha) of Ethryl®. Winterhaven, CA plots (B) that showed little or no lodging events during growth, demonstrated no significant yield or grain size effects from growth regulator treatments.

Table 1. The effect of the growth regulator, Tirexapac-ethyl at GS30 on Desert Durum wheat evaluated in the spring of 2007 at 3 grower cooperator field locations.

Location	Treatment	Height (in)	Lodging (%)	Moisture (%)	Yield (tons/acre)
South Yuma Valley	Untreated Check	25.45 a	37.5 a	13.4 a	2.4 a
South Yuma Valley	Palisade 2 oz./acre	20.90 b	12.0 b	13.3 a	3.1 b
North Gila Valley	Untreated Check	24.75 a	15.4 a	12.5 a	2.9 a
North Gila Valley	Palisade 2 oz./acre	22.23 b	5.2 a	11.9 a	3.3 a
Bard/Winterhaven, CA	Untreated Check	26.65 a	22.3 a	12.8 a	3.2 a
Bard/Winterhaven, CA	Palisade 2 oz./acre	23.43 b	11.4 b	12.4 a	3.5 a

Table 2. The effects of Trinexapac-ethyl in combination with Bronate Advanced® herbicide and Tilt® fungicide on wheat quality and yield

Treatment	Lodging (%)	Height (cm)	Moisture (%)	Phytotoxicity at Harvest (%)	Yield (tons/acre)
Untreated Check, GS30	37.5 a	63.89 a	13.47 ab	0.0 b	3.67 a
Palisade 2 oz./acre, GS30	0.0 c	54.60 b	12.20 b	3.0 a	3.26 a
Palisade 2 oz./acre, GS30 Bronate Adv. 8.5 oz/acre, GS30	0.0 c	54.25 b	13.07 ab	0.0 b	3.09 a
Palisade 2 oz./acre, GS30 Bronate Adv. 8.5 oz/acre, GS30 Tilt 2 oz./acre, GS30	0.0 c	56.48 b	12.67 ab	2.8 a	3.01 a
Palisade 1 oz./acre, GS30 Palisade 1 oz./acre, GS37	0.0 c	54.41 b	13.52 ab	1.0 b	3.28 a
Ethryl® 4.2 oz./acre, GS37	13.8 c	58.42 b	13.72 a	0.0 b	3.26 a

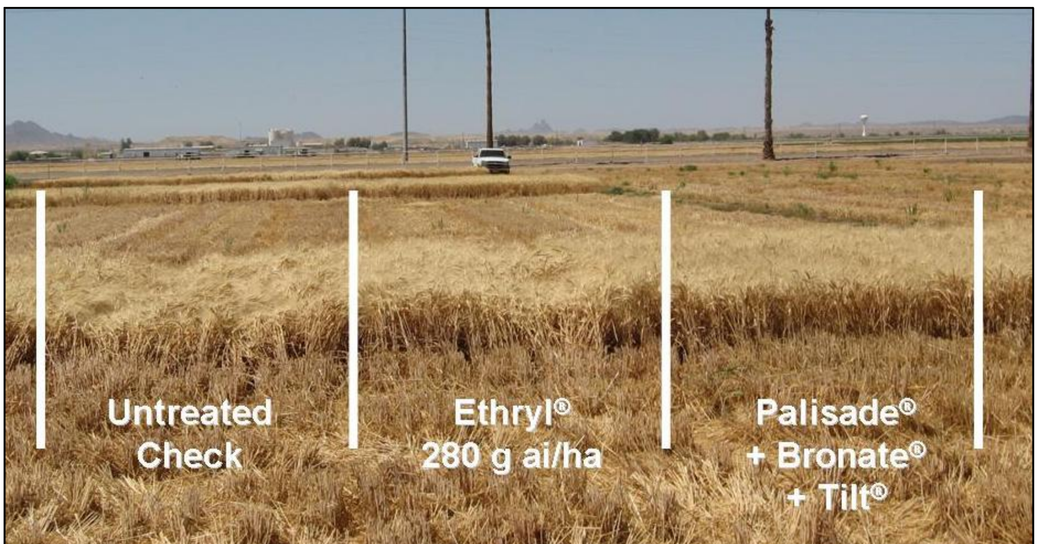

Fig. 7. Palisade® in tank mix combinations with Bronate Advanced® and Tilt® showed little or no response in effectiveness and continued to demonstrate enhanced lodging resistance.

References Cited

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