

EVALUATION OF PACLOBUTRAZOL IN PECAN NUT TREES: GROWTH, YIELD AND RESIDUES

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INTRODUCTION

Paclobutrazol is a triazole, generally applied as a fungicide, but with said growth inhibiting characteristics when applied to fruit and nut trees. The growth retardance effect of paclobutrazol on pecan nuts is well studied (Wood 1988; Andersen 1988; Worley et al 1996), however its effects on yield and other parameters remains understudied (Zhu & Stafne 2019), while evidence of yield decline after paclobutrazol application exists (Andersen 1988; Worley et al 1996). Paclobutrazol is registered for use on many tree crops, including pecan nuts, as a growth regulator. One of the registered products, containing 250 g / L paclobutrazol, is Cultar. In this research trial, this product was used to evaluate the effect of different application rates, as per label recommendation, on shoot growth, stem circumference, yield, quality, and for paclobutrazol residues in the pecan nuts and residence in the soil.

METHODS

The Cultar label stipulates different dosages should be applied to different tree ages. Here young (8-10 years old) and mature (15-20 years) trees were evaluated. The dosages evaluated on young trees were: 0, 5, and 10 ml / tree while the dosages evaluated on mature trees were 0, 20 and 40 ml / tree. Each treatment was applied on 10 data trees, replicated on three farms, on the cultivar “Wichita” in the Hartswater production region, Northern Cape, South Africa.

Applications of Cultar were done as a soil drench, diluted in 5 L water per data tree, around the base of uniform, healthy trees after removing all organic material from the application area (Picture 1). Applications were done in October 2020 on three farms. Growth length of the summer flush was evaluated during February 2021 and February 2022. During the 2021 measurements of growth, 5 replicates were measured per data tree (N = 860) and during the 2022 growth measurements, four replicates were evaluated per wind direction per data tree on the top and bottom of each data tree from vegetative and reproductive branches (N = 11 456). Stem circumferences were measured during February 2022. Yield information were evaluated for the 2021 and 2022 seasons during May-June. The weight of dropped nuts per tree (in kg), total number of sticktights per tree (count) and weight of sticktights per tree (kg) were measured (N = 180 per yield outcome per season). Paclobutrazol residue analysis included 54 replicated pecan nut samples and 6 replicated soil samples (two samples from the 40 ml / tree treatments per farm) during the 2021 harvesting season and 42 pecan nut samples and 10 soil samples in the 2022 season. Yield quality parameters were evaluated at a processor from three grouped samples per treatment, age group and farm (N = 54 samples per season). Kernel quality parameters evaluated against paclobutrazol treatment outcomes included sound edible kernel and kernel sizes: J, XL, L, M, S.



Picture 1. Soil drench around a mature pecan nut tree.

Statistical analysis

Results of this study were analyzed in RStudio: R Core Team (2015), v 4.2.1. Outliers were removed prior to statistical analysis using the Interquartile Range (IQR) method. The IQR is the central 50 % of the dataset, between the 75th and 25th percentile of the data distribution. Outliers were identified as points 1.5 times smaller or larger than the IQR. Data were presented per treatment with significant differences indicated as different letters, based on post-hoc tests. Significance of treatments were evaluated using Dunn's post-hoc test for pairwise multiple comparisons of the ranked data in the package: rstatix (Kassambara 2021). All statistical significance were determined on the alpha level = 0.05 (95% confidence limit). Data was subjected to Shapiro-Wilk tests of normality of model residuals and Levene's Test for Homogeneity of Variance prior to statistical analysis and plotting with the packages ggisgnif (Ahlmann-Eltze 2021), ggstatsplot (Patil 2021) and ggplot (Wichham 2016). Statistical results of each effect were summarized in a table format using the package: Rmisc (Hope 2022) giving the sample size (N), average (mean),

standard deviation (sd), standard error (se) and 95% confidence intervals (ci). Mean and std. error (se) plots were provided from these tables, using the package: ggpubr (Kassambara 2020).

RESULTS

Growth

Flush length

The results showed a significant treatment effect and reduction on the new growth (flush) lengths during the second season after application on young trees ($\chi^2_{\text{Kruskal-Wallis}}(2) = 144.83$, $p < 0.001$, Figure 1A) and both the 2021 and 2022 seasons on mature trees ($\chi^2_{\text{Kruskal-Wallis}}(2) = 21.59$, $p < 0.001$ and $\chi^2_{\text{Kruskal-Wallis}}(2) = 367.74$, $p < 0.001$ respectively, Figure 2A).

Stem circumference

The results showed a significant reduction in tree stem circumference of young ($F_{\text{fisher}}(2, 27) = 26.78$, $p < 0.001$, Figure 3A) and mature ($F_{\text{fisher}}(2, 22) = 6.95$, $p < 0.01$, Figure 3B) trees at one treatment site.

Yield

Natural drop

The harvested weight of the pecan nuts that dropped to the ground naturally did not show significant results across treatments and seasons on young or mature trees (Figure 1B & Figure 2B). Significant correlations (Table 1) were however observed between young tree yield and stem circumference (Figure 4A), and the number of young trees sticktights (Figure 4B). There was no significant correlation between the yield and the flush lengths (Figure 4C).

Sticktights

The number of sticktights counted in 2022 were significantly reduced with young tree paclobutrazol treatments ($\chi^2_{\text{Kruskal-Wallis}}(2) = 8.20$, $p = 0.02$, Figure 1C). Mature tree paclobutrazol treatments did not show overall significant effects on the sticktight counts (Figure 2C). Significant correlations (Table 1) were observed between young and mature tree sticktight counts and sticktight weights (Figure 5A), sticktights and flush lengths (Figure 5B) and sticktights and stem circumferences (Table 1).

Quality

The grading reports showed a significant increase in XL kernel after 40 ml / tree applications compared to the untreated control (54.74 ± 4.47 % and 41.47 ± 2.82 % respectively), and significant decrease of size L kernel after 20 and 40 ml / tree applications compared to the untreated control (28.86 ± 2.06 , 26.42 ± 2.66 and 36.69 ± 1.50 % respectively) in the 2021 harvest season. During the 2022 harvest season, the percentage edible kernel was significantly reduced after 40 ml / tree paclobutrazol treatments compared to the control (57.11 ± 0.68 and 59.00 ± 0.26 % respectively). The overall treatment effects across the two seasons did not show significant treatment differences (Figure 6).

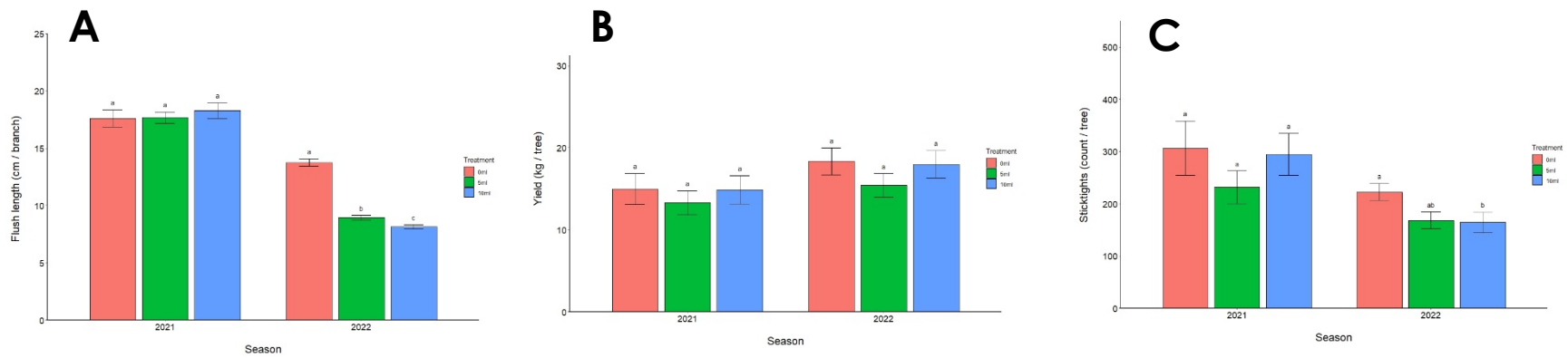


Figure 1. Observed young tree (A) February flush lengths, (B) May-June yield and (C) May-June sticktights after treatments were applied in October 2020.

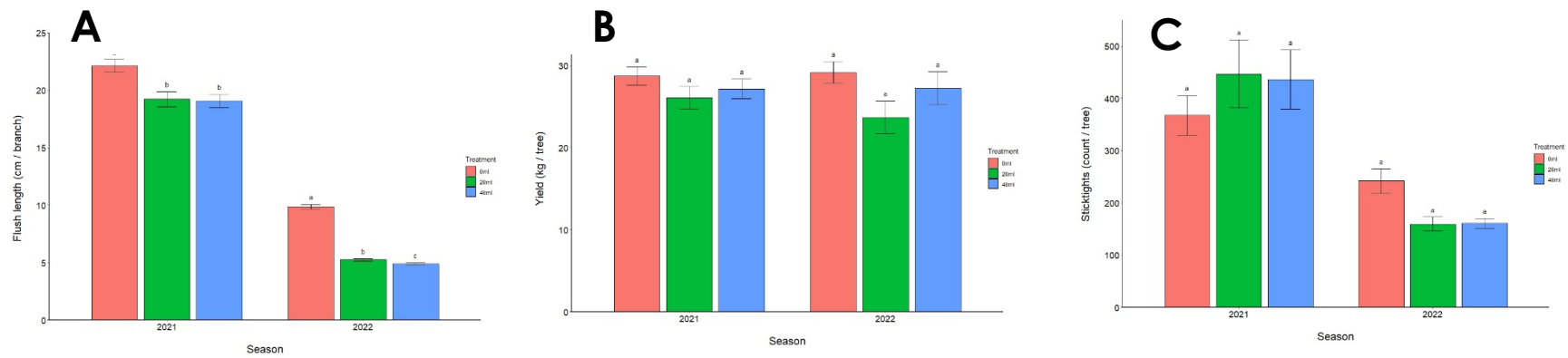


Figure 2. Observed mature tree (A) February flush lengths, (B) May-June yield and (C) May-June sticktights after treatments were applied in October 2020.

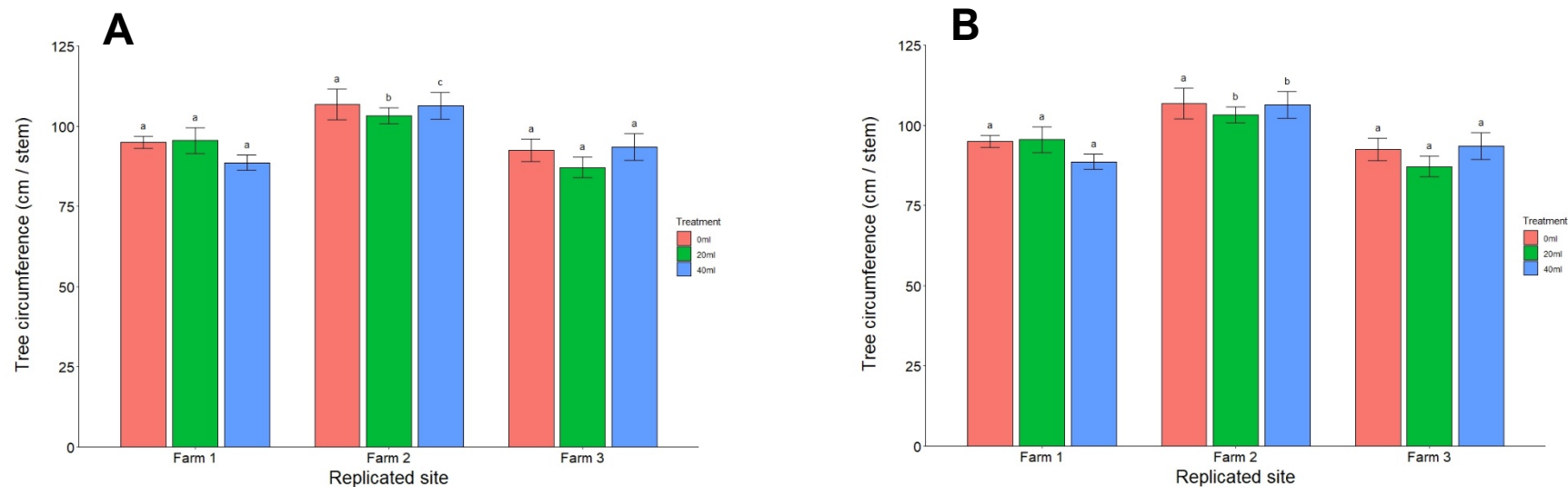


Figure 3. Stem circumference (mean $\pm$ se) results from measurements in February 2022 from (A) young and (B) mature trees on three replicated farms. Different letters annotate significant treatment effects.

Table 1. Significant Pearson's product-moment correlation statistics and linear model coefficients for young and mature tree yield and sticktights.

Dependent variable	Predictor variable	t	df	p-value	R ²	Intercept	Predictor multiplication factor
Young trees							
Yield (kg / tree)	Tree circumference (cm / stem)	12.84	88	<0.001	0.65	-12.87	0.46
Yield (kg / tree)	Sticktights (count / tree)	5.90	178	<0.001	0.16	11.15	0.02
Sticktights (kg / tree)	Sticktights (count / tree)	22.9	178	<0.001	0.75	0.82	0.01
Sticktights (count / tree)	New growth length (cm / branch)	7.53	143	<0.001	0.28	19.18	17.89
Sticktights (count / tree)	Tree circumference (cm / stem)	8.28	88	<0.001	0.44	-94.35	4.26
Mature trees							
Sticktights (kg / tree)	Sticktights (count / tree)	19.20	177	<0.001	0.68	1.39	0.01
Sticktights (count / tree)	New growth length (cm / branch)	10.29	153	<0.001	0.41	41.68	20.58
Sticktights (count / tree)	Tree circumference (cm / stem)	2.62	87	0.01	0.07	-6.58	2.00

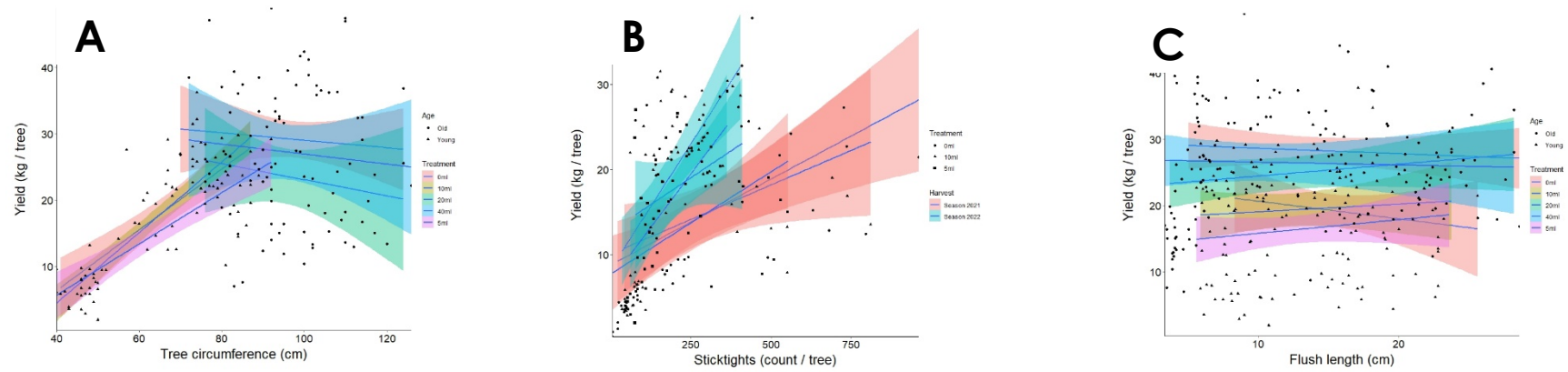


Figure 4. Significant correlations between yield and (A) tree circumference, (B) young tree sticktights and (C) flush lengths.

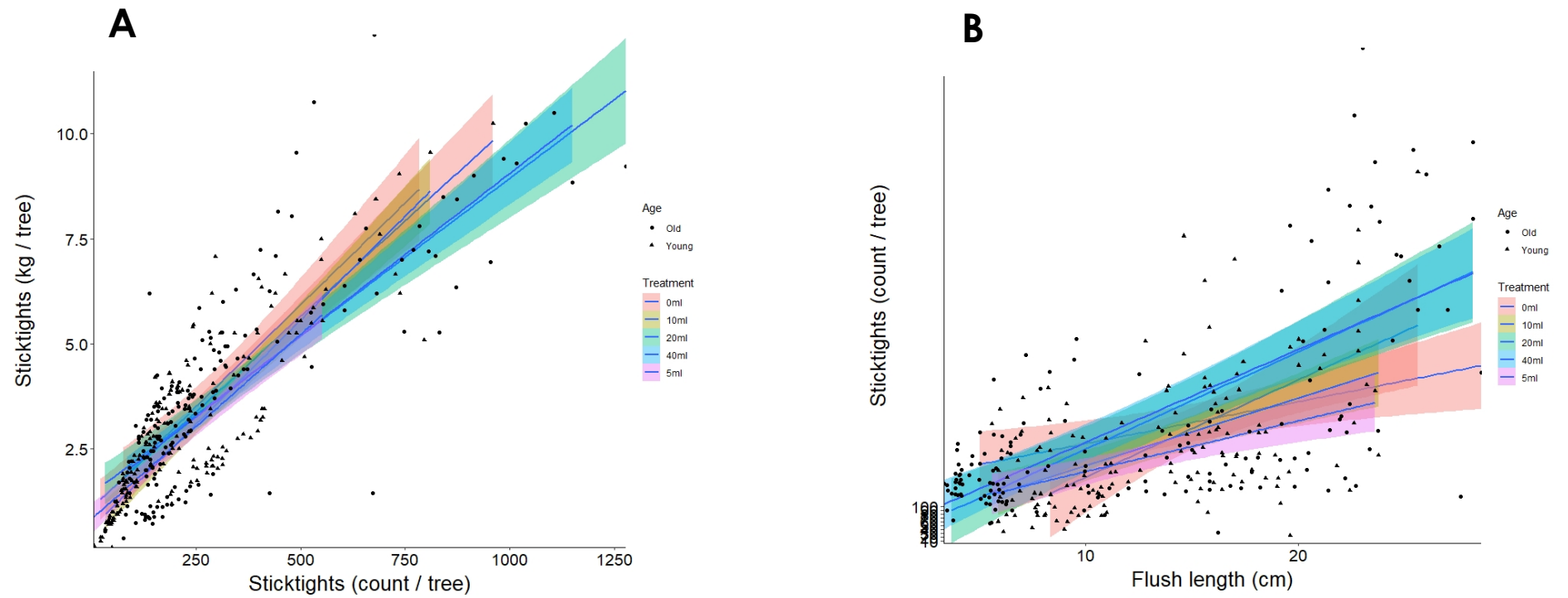


Figure 5. Correlations between sticktight counts and (A) sticktights weights and (B) flush lengths per treatment across seasons.

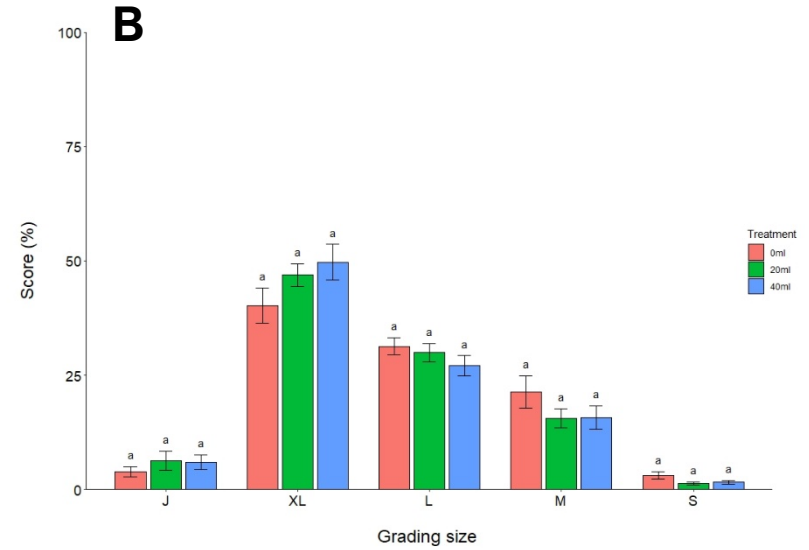
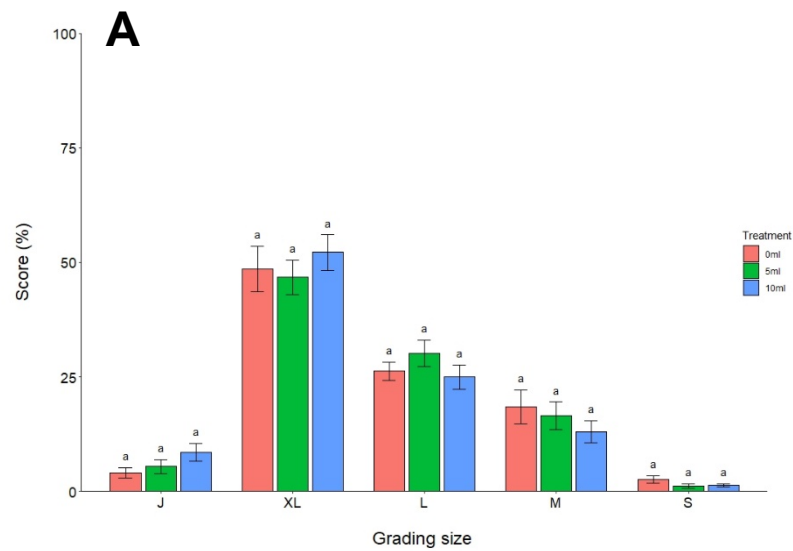


Figure 6. Grading report results for (A) young and (B) mature trees. Different letters annotate significant treatment differences.

Residues

Pecan kernel

During the 2021 harvest season, no paclobutrazol residues were detected in pecan nut kernel across all replicated treatment samples on all farms (N = 54). During the 2022 harvesting season, 42 residue samples were analyzed and again no residues were detected above the limit of quantification (Table 2).

Table 2. Residue analysis results from pecan nut and soil samples collected during May-June 2022.

Sample description	Paclobutrazol residue	Replicated residue samples (N)
Pecan nuts		42
Mature trees		
0ml	None detected	4
20ml	None detected	6
40ml	None detected	7
Young trees		
0ml	None detected	6
5ml	None detected	6
10ml	None detected	9
Soil		10
20ml	None detected	4
40ml	None detected	6

Soil

Paclobutrazol residues were detected from two of the six soil samples during the 2021 harvesting season. The residues detected were 0.37 ppm and 0.017 ppm paclobutrazol in soil collected from mature trees that received 40 ml / tree treatments. During the 2022 harvesting season, 10 residue samples were analyzed and no residues were detected above the limit of quantification (Table 2).

CONCLUSIONS

The results of this work with a single application of paclobutrazol showed significant evidence for reduced flush in young and mature trees for two consecutive seasons after application. The data showed no support for correlations between new growth lengths and yield and very few positive quality effects. Sticktights however correlated significantly positively with yields on young trees, and there were significant correlations between flush lengths and sticktights on young and mature trees. Sticktight counts on young trees were significantly reduced with paclobutrazol treatments. Stem circumferences correlated positively with young tree yields and were significantly reduced by paclobutrazol treatments on young and mature trees.

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