Determining the Effect of Acadian LSC Seaweed Extract on Pistachio Inflorescence Bud Abscission

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Summary:

The objective of this trial was to determine if a seaweed extracts could affect alternate bearing by decreasing bud abscission. The trial was conducted at the Strain Ranch (6859 Grime Arbuckle Rd, Arbuckle, CA 95912, Latitude 39.012868, Longitude -122.035319) during the 2016 pistachio growing season. The orchard was eight year-old Kerman scions on a PG1 rootstock. Eight single-tree replicates per treatment were selected for the 8 treatments, totaling 64 experimental trees. The treatments were Acadian A LSC®, Acadian B (an unregistered Acadian product), low-biuret urea, Acadian A LSC® + low-biuret urea, Acadian B LSC + low-biuret urea, Maxcell®, Maxcell® + low-biuret urea. The untreated control was water. Average tree yields across treatments were the same demonstrating all trees had an equivalent bearing status. Among the treatments the low-biuret urea and Acadian B treatments demonstrated the lowest and highest percentages of bud abscission, respectively. The percentage of bud abscission was significantly higher in shoots with clusters. The percentage of bud abscission on shoots with clusters was strongly and significantly positively correlated with embryo growth. There was a significant positive correlation between length, width and weight of new wood and 1 old wood with nut weight. Collectively the data supports the multiple theories in the literature that alternate bearing as manifested by bud abscission on current shoots is a function of crop load on the one-year old growth of the same shoot. Therefore, alternate bearing is a function of within shoot carbohydrate status, possibly regulated by a growth regulator signal that precipitates bud abscission. It has been suggested that bud abscission evolved as an adaptive mechanism that allowed the tree to survive and reproduce in harsh conditions with pest populations. The ability the shed crop on alternate years allowed the tree to restore carbohydrate reserves and intermittently denied pest populations a host.

Introduction:

Alternate bearing, is the ability of a shoot, or tree to alternate high and low crops on successive years. It has not been demonstrated to be harmful to the tree, but is disruptive to commercial farming operations and marketing. Attempts to alleviate alternate bearing by foliar nutritional and

growth regulator sprays have not been successful. Severe mechanical topping, on Kerman trees on Atlantica rootstocks, after a heavy crop, has successfully decreased alternate bearing for as long as 7 years (Ferguson et al. 1995). Alternate bearing appears to be correlated with crop load and is therefore probably related to carbohydrate limitations (Sajjadinia et al. 2010; Spann et al. 2008; Vemmos et al. 2012).

Within the inflorescences on 1-year–old wood, individual pistachio nuts begin growth by expanding only the nutshells (endocarp + exocarp = pericarp) in mid-April, reaching full size by mid to late May. The nutshells then begin to harden by thickening and changes in composition (Allan et al. 2015, unpublished data). In nut growth studies bud abscission in pistachio has been reported to be correlated with kernel (embryo) enlargement. New extension shoot growth precedes the abscission of the developing inflorescence buds on the current year's shoot growth (Spann et al. 2008). The basal inflorescence buds on the shoot growth beyond the nut clusters die and drop, or abscise, sequentially from the shoot's base to the tip. Generally, the heavier the current crop load the more severe the percentage bud abscission.

This finding, combined with multiple earlier studies demonstrating changes in shoot and leaf carbohydrate and plant hormone levels before and during inflorescence bud abscission, suggests, but does not prove, that a temporary competition for the stored carbohydrates in fruit-bearing shoots initiates a hormonal signal that causes the bud abscission on current year's shoot growth that results in alternate bearing (Caruso et al. 1992; Crane et al. 1971, 1972, 1976, 1977; Mara et al. 2009; Nzima et al. 1997; Takeda and Crane 1980; Takeda et al. 1980; Vemmos et al. 2012; Wolpert and Ferguson 1990).

Acadian's seaweed extracts are derived from *Ascophyllum nodosum.* Their suggested effect on decreasing alternate bearing is based on the premise that these products increase shoot nitrogen levels, and therefore chlorophyll development, resulting in higher photosynthetic rates and higher carbohydrate levels. These products also have cytokinin-like activity that protects chlorophyll and through enhanced photosynthesis again promote production of photosynthesis.

This study is a continuation of an earlier trial (Brar; 2014, 2015). Generally, his results were inconsistent. In 2014, the Acadian treatment was significantly different from the control while the other two treatments (low-biuret urea and Acadian LSC + low-biuret urea) were not statistically different from either the control or the Acadian LSC treatment. The data set from 2015 shows significant differences among treatment means. Acadian LSC® produced significantly lower bud abscission percentages than the Control and ALSC®+LB Urea treatments. The mean percentage bud abscission was highest with the Acadian LSC® + LB Urea treatment, even higher than the control.

Materials and Methods

This trial was conducted during 2016 growing season in 8-year-old pistachio orchard (6859 Grime Arbuckle Rd, Arbuckle, CA 95912, Latitude 39.012868, Longitude -122.035319). The experimental design was a randomized complete block with each of eight treatments, including a water sprayed control, repeated once in eight rows. The female cultivar was Kerman with a Peters male, both on

PG1 rootstocks. Treatments included foliar sprays of Acadian A LSC®, Acadian B (a new unregistered product), low-biuret urea, Acadian A LSC+ low-biuret urea, Acadian B LSC+ low-biuret urea, Maxcell®, Maxcell® + low-biuret urea(Table1). Spray applications were done with a hand gun sprayer at 300 GPA on May 20th and June 15th 2016(figure 1). In each tree 5 bearing and 5 nonbearing shoots were randomly selected. On each, from mid-June to mid-August the number of flower buds were counted biweekly. From mid-July to mid-August, a single randomly selected cluster per tree was collected and 5 tip nuts were weighed and measured (figure 2). Embryo fresh weight was collected 4 times, biweekly, as soon as growth was visible, to determine how closely bud abscission correlated with kernel weight. All 64 trees were harvested September 13th, 2016 and 25-pound samples from each tree sent to Wonderful company for quality grading. In all 5 bearing and 5 nonbearing branches of each tree, leaf dry weight, nut weight, length and width of one-year-old and new wood were measured. Data analyzed using SAS and R and graphed using R and Excel. Results presented as percentage of buds abscised {% bud abscission = (abscised buds/initial bud number) X 100}.

Discussion and Conclusions:

All the trees in the experiment had equal crop loads; ranging from 20-25 pounds of edible weight per tree (2300-2800 pounds per acre) (Figure 3). This demonstrates all the trees, across all treatments had equal cropping status. Therefore, tree cropping status had no effect on the bud abscission; abscission correlated with cropping status of the shoot. Also none of the treatments had any effect on the total edible yield percentage (Figure 4).

The percentage of bud drop in control water treatment on July 1, July 12, July 22, August 2, August 16, September 13, respectively was 15.35%, 23.23%, 40.51%, 50.37%, 54.64%, and 70% in branches with crop and 1.41%, 2.34%, 5.11%, 7.43%, 8.69% and 15.58% for non-crop branches. Branches with crop lost buds at a constant rate, not achieving an asymptote prior to harvest. (Figure 5). The mean percentage of bud drop for all the treatments in cropped shoots was 57-78% but always less than 18% percent for uncropped shoots. This demonstrates that bud abscission is a within shoot phenomenon, that shoots are generally synchronized within a tree, and often trees within an orchard, which produces the observed alternate bearing.

The percentage of bud abscission on shoots with clusters was strongly and significantly positively correlated with embryo weight (R^2 = 0.9403) (Figure 6) and less strongly but negatively correlated with length, width and dry weight of 1-year old shoot growth and dry leaf weight. There was a statistically significant linear regression (R^2) between the length, width and weight of new wood and one-year-old wood with nut weight (R^2 = 0.9, 0.84,0.78 for new wood and 0.88,0.83,0.75 for old wood (Figures 7-9). There was also a statistically significant correlation of leaf dry weight with nut weight (R^2 = 0.7677) (Figure 10). This data supports the theory that nut growth is a function of shoot carbohydrate status which in turn affects the subsequent season's production. The visible mechanism of alternate bearing is bud abscission which appears to be correlated with shoot cropping status. Specifically, how has not been determined.

The eight foliar spray treatments had no consistent, significant effect on abscission (Figure 11). The percentage of bud drop for Acadian A LSC®, Acadian B, low-biuret urea, Acadian A LSC+ low-

biuret urea, Acadian B + low-biuret urea, Maxcell®, Maxcell® + low-biuret urea and water was75%, 87%, 57%, 60%, 79%, 69%, 73%, 59% For branches with crop and 13%, 15%, 17%,12%, 10%, 10%, 18%,10% respectively for branches without crop.

There was no consistent significant difference among treatments in non-cropped branches (Figure 11). These results clearly demonstrate two things. First, shoots with crop drop their buds at a significantly higher percentage than shoots with no crop. Second, neither the MaxCell® nor any of the the seaweed extract products had any effect on bud drop. All the literature and evidence at this time supports the conclusion that the alternate bearing produced by bud drop is a result of the shoot's carbohydrate status. Therefore, foliar applications of nutrients and growth regulators applied prior to bud drop, with the objective preventing bud drop, are ineffective because preventing bud drop does not alleviate the situation that produced the bud drop.

Acknowledgements

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Figure 1. Spray applications with a hand gun sprayer at 300 GPA on May 20th and June 15th 2016

Figure 2. A single randomly selected cluster per tree was collected and 5 tip nuts were weighed and measured.

Table 1. Treatments applied May 20th and June 15th 2016 at 300 GPA with a hand gun sprayer

Treatment	Rate	Amount Per Tree
Acadian 1 LSC	128 oz./per acre	28 ml.
Acadian 2 LSC	128 oz./per acre	28 ml.
Low-biuret urea	40 lb/per acre	134 g
Acadian 1 LSC+ low-biuret urea	Above rates	Above rates
Acadian 2 LSC+ low-biuret urea	Above rates	Above rates
MaxCel	16 fl oz/per 100 gallon	10.5 ml.
MaxCel + low-biuret urea	Above rates	Above rates
Control untreated	Water spray	8.5 L

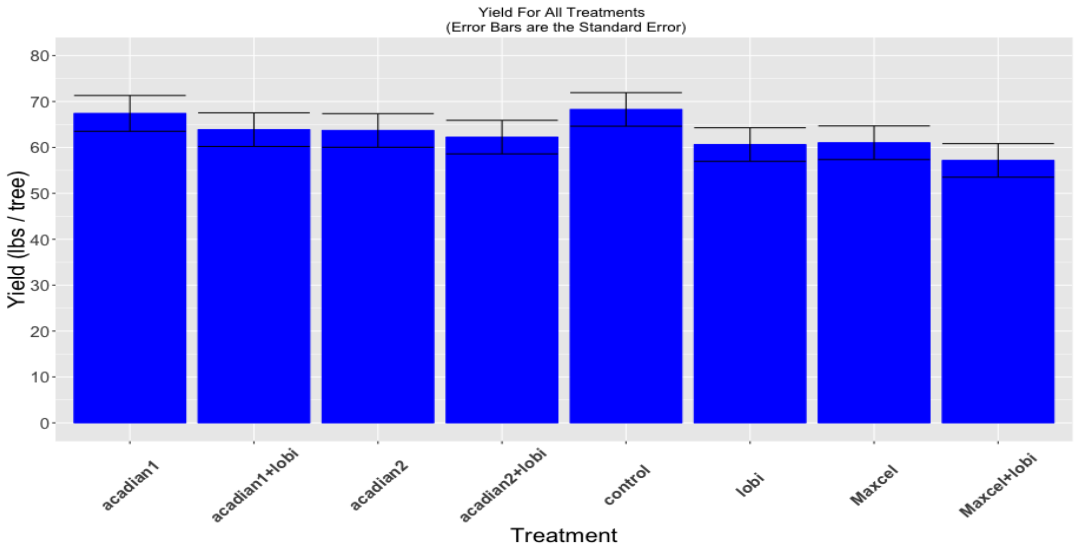

Figure 3: Average tree yield across treatments. There is No significant differences among treatments. all the trees, across all treatments had equal cropping status.

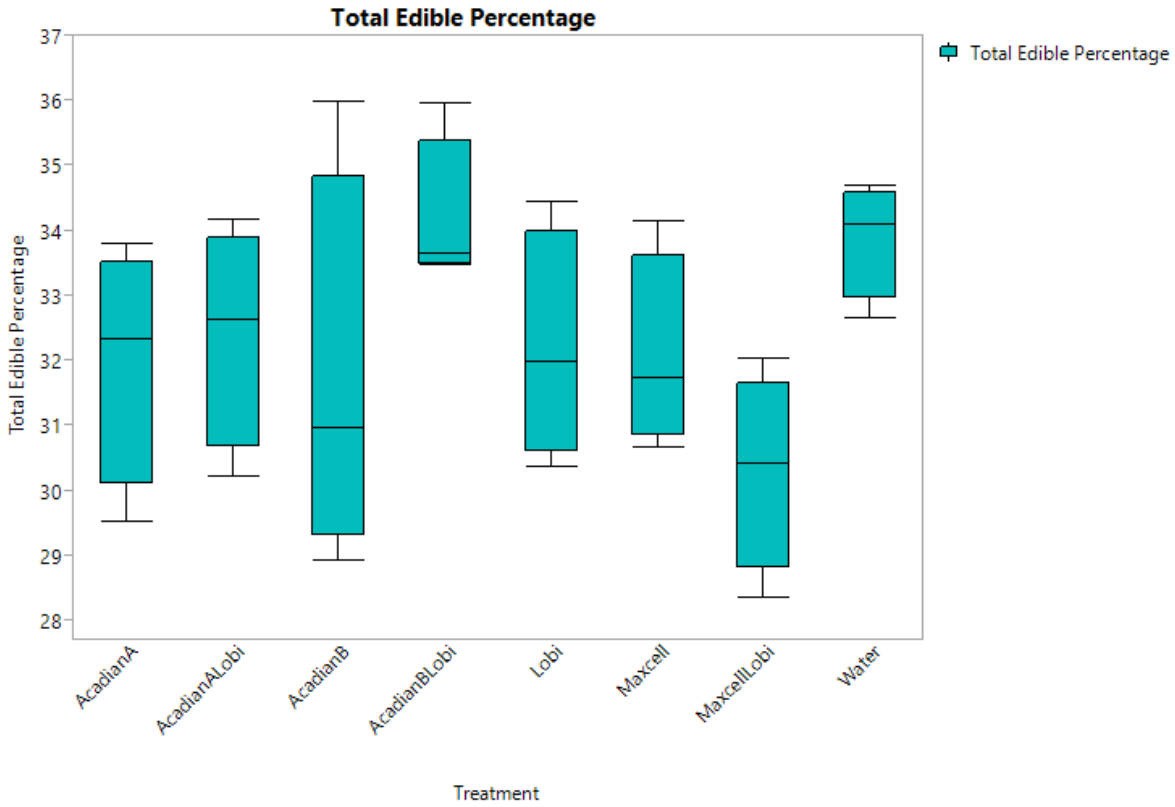

Figure 4. None of the treatments had any effect on the total edible percentage

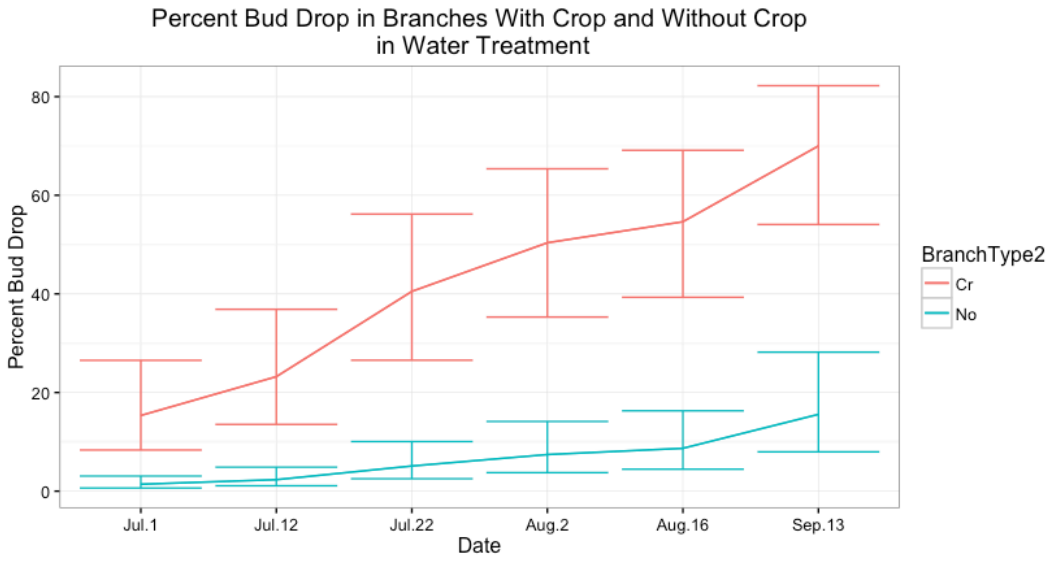

Figure 5. Percentage of bud drop in branches with (red line) and without crop (blue line). The percentage of bud abscission is significantly higher in shoots with clusters.

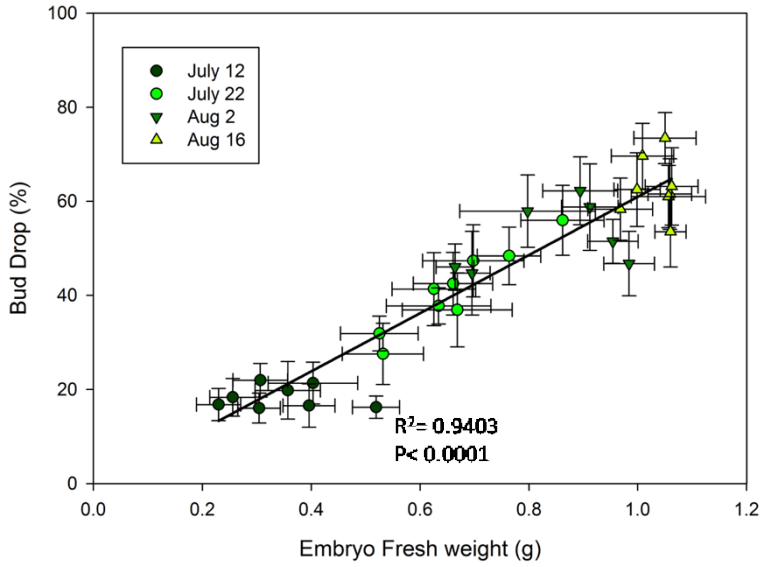

Figure 6: Relationship between percentage of bud drop and embryo fresh weight over a season. The percentage of bud abscission on shoots with clusters strongly and significantly correlates with embryo weight. There were no significant differences among treatments in % bud abscission as a function of embryo weight.

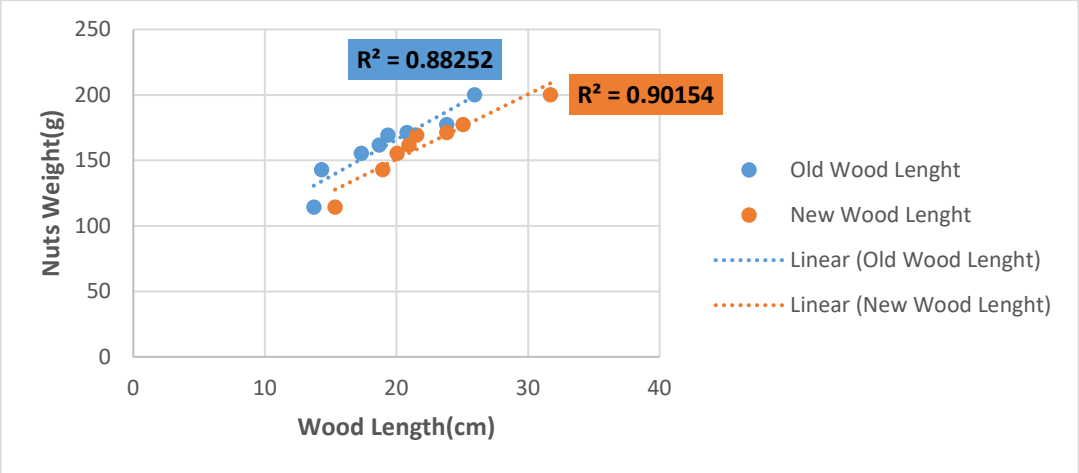

Figure 7. Regression between wood length and nuts weight. There is statically significant linear regression between wood length and nuts weight.

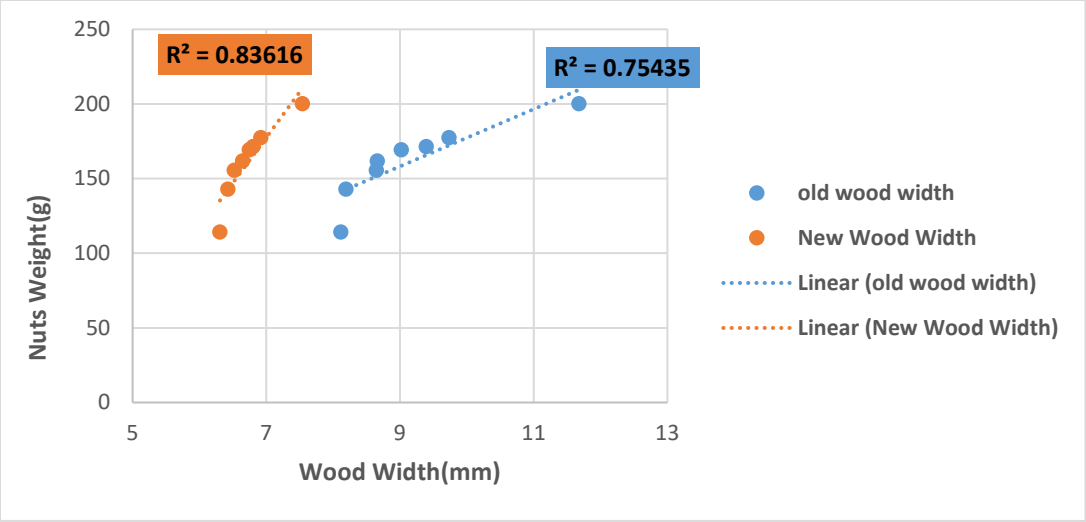

Figure 8. Regression between wood width and nut weight. There is statically significant linear regression between wood weight and nut weight.

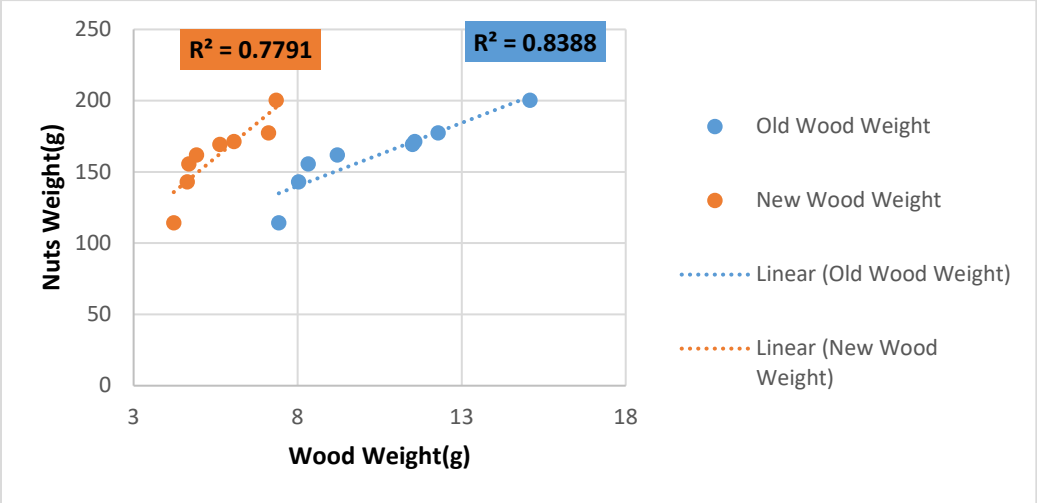

Figure 9. Regression between wood weight and nut weight. There is statically significant linear regression between wood weight and nut weight.

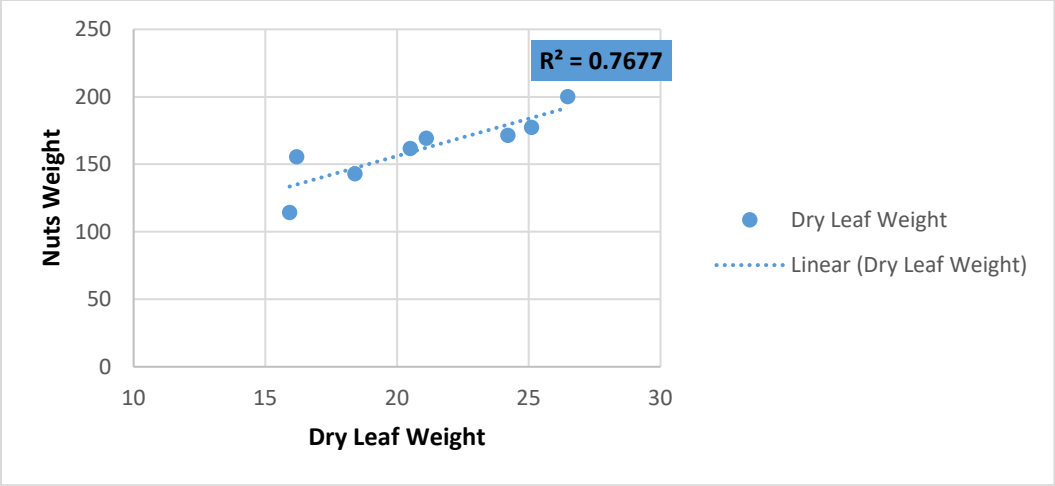

Figure 10. Regression between dry leaf weight and nut weight. There is statically significant linear regression between dry leaf weight and nut weight

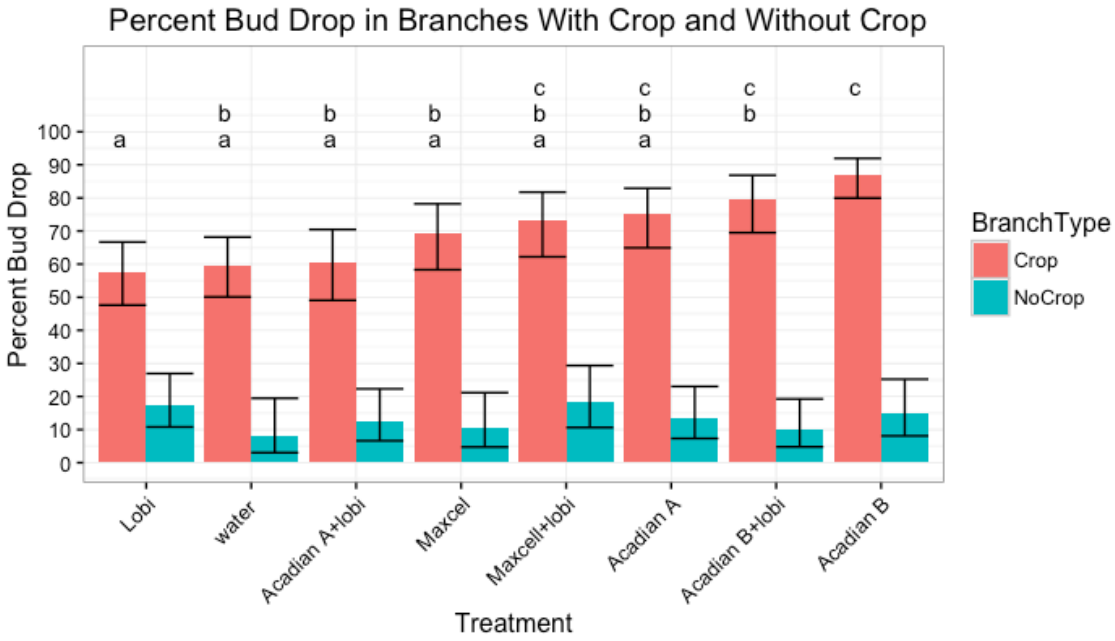

Figure 11. The results of means comparison at $p<0.05$. Treatments with different letters are significantly different. Generally, considering that all the treatments had bud abscission percentages equal to or higher than the control demonstrates that all the treatments were ineffective or exacerbated bud abscission