Bud Abscission Dynamics in Pistachios as a Function of Branch Carbohydrate Status and Embryo Growth

Leigh Francis Archer, International Agricultural Development MS Candidate, UC Davis
Narges Mehvelati, Junior Specialist, UC Davis
Lu Zhang, Postdoctoral Scholar, UC Davis
Louise Ferguson, Extension Specialist, UCCE, UC Davis

INTRODUCTION

This trial is an attempt to better understand the physiological mechanism of bud abscission, the visible cause of alternate bearing in pistachios. This investigation was conducted within a complementary study of bud abscission funded in part by Acadian Seaplants Limited. As part of the Acadian trial, 16 individual trees were selected as the 'control' treatment and received control spray applications of water. These trees became the basis for this carbohydrate analysis experiment. Experimental work included bi-weekly calculations of percent bud abscission and individual branch carbohydrate analysis.

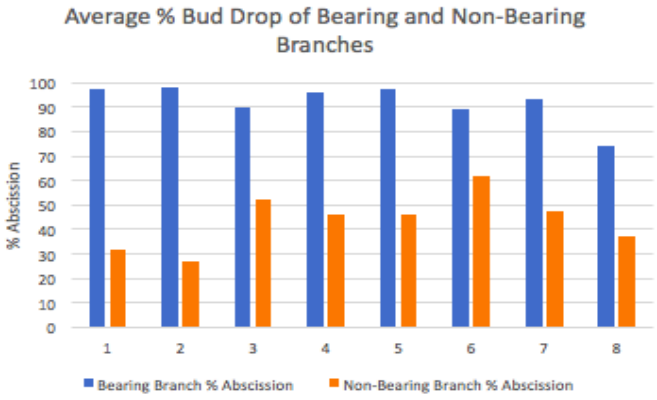

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Figure 1. Average percent bud abscission of 8 untreated trees comparing bearing and non-bearing branches.

Results from the first year of the Acadian trial indicated that there were consistent and significant differences in bud abscission of bearing and nonbearing shoots within trees. This suggests that bud abscission is not directly correlated with total tree cropping status. Rather, abscission is a 'within shoot' phenomenon correlated to the crop load on the one-year-old growth. The working hypothesis is that the developing nut kernels deplete the carbohydrates from the current year's growth where photosynthesis is more active due to the presence of leaves, while the carbohydrate status of last year's wood remains relatively unchanged.

Due to the process by which shoots grow and develop new buds, individual branches within a tree are simultaneously producing the current year's crop and generating buds for the following year. This concurrent growth and development places a high demand on available carbohydrates, and initiates the abscission of the basal inflorescence buds. The buds will generally drop sequentially, from the base of the shoot to the tip, as the kernels begin to develop. Attempts to better understand the mechanism behind the cause of bud abscission have been inconclusive. It is not established whether the competition for carbohydrates between current clusters and developing buds causes a hormonal signal initiating bud abscission, or if other factors are at play. This experiment was implemented to understand

where, within a single branch, nut clusters obtain carbohydrates for growth and development. Much of the research to date has focused on whole tree cropping status and carbohydrate differences between “on” and “off” trees. This trial focused on shoots with and without crop loads to determine the mechanism for abscission at the individual branch level.

RESULTS

Inflorescences on 1-year-old wood develop into nut clusters beginning in mid-April, reaching full size by the end of May. The nut shells of individual pistachios then begin to harden and the inner kernel begins to enlarge. As the kernel begins to grow the basal inflorescence buds on new growth shoots, that have developed beyond the nut clusters, begin to abscise starting from the shoot base and moving sequentially to the tip. Previous studies have shown that greater percent abscission can be seen in shoots with a smaller leaf area to crop load ratio.

This trial affirmed that the second, more severe, phase of bud drop on fruiting branches is significantly related to embryo (seed) development. Previous work has found that the presence of fruit will not impact the uptake of carbohydrates by leaves, but fruit clusters will act on the sink/source relationship of carbohydrate distribution between developing embryos and flower buds.

Bud abscission data was analyzed using a linear regression, R^2, to determine the effect of embryo development on the degree of bud drop. The 2016 preliminary results demonstrated that there was a significant linear regression, R^2=.94, between nut growth and bud drop. Similar results were found during the 2017 growing season. An R^2 value of .97 indicates that bud drop is strongly associated with nut growth and is the result of crop load on the same branch.

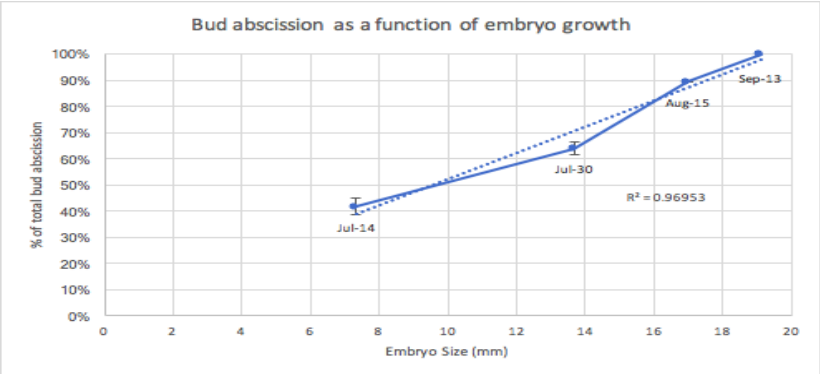

Figure 2: Percent bud drop as a function of embryo length from four sampling dates showing significant correlation between seed growth and bud abscission.

CONCLUSION AND APPLICATIONS

Alternate bearing is not harmful to the tree; however, alternating years of significant yield decreases is disruptive to commercial operations and marketing. Branches, trees, and orchards all tend toward synchrony in alternate bearing, resulting in significant economic losses. Determining the mechanism behind alternate bearing may allow researchers to establish guidelines for appropriately managing bud abscission.

Results from this analysis and previous research suggest that the temporary competition for stored carbohydrates in the new wood of fruit-bearing shoots will initiate a hormonal signal that instigates bud abscission on current year's shoot growth. Removal of carbohydrates from current year's growth in order to meet demand for nutrients, by developing kernels, leaves very little available for inflorescence buds for the following season's crop.

Instead of a continued prominent focus on whole tree fruiting status, results from this study may allow researchers to develop new techniques for mitigating bud abscission based on individual branches within a tree. Characterizing the optimal shoot length, width, and leaf area for regular crop production and determining analytical tools for shoot carbohydrate status may be a useful. This research could benefit growers by providing a better understanding of alternate bearing and potential mitigation techniques.