

EFFECT OF RETAIN[®] ON REDUCING PISTILLATE FLOWER ABORTION IN SERR WALNUT USING SPEED SPRAYER APPLICATION

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ABSTRACT

Pistillate flower abortion (PFA) in walnut is the loss of female flowers early in the season, typically 2 to 3 weeks after bloom. It was first noted in the Serr cultivar soon after the earliest plantings came into production in the early 1970s. Serr is an important early maturing, high edible yield variety, which extends the harvest period and initiates marketing conditions. PFA can reduce dry, in-shell walnut yield 75%. In the 1980s, field-based research by Catlin et al., confirmed from detailed tagging of flowers that PFA is always associated with high numbers of pollen grains present on the receptors (stigmas) of female flowers. Research by Polito showed that the large number of resulting pollen tubes growing down the style of the female flower produced excessive ethylene and that this is most likely the cause of flower abortion. Polito also tested two non-commercial compounds which either promoted or inhibited ethylene production and observed corresponding increases and reductions in PFA. Preliminary tests by the author in 2003 with Retain[®], a commercially available ethylene biosynthesis inhibitor, resulted in a four-fold increase in fruit set when individual fruiting shoots were treated. In 2004, commercial speed sprayer applications of Retain[®] at 62.5 and 125 ppm were performed in two locations using a Latin square experimental design and four, six-tree replications. A 23% to 60% increase in fruit set was recorded, depending upon the amount of PFA in the control. Differences in percent set between pre-receptive and receptive flowers were less with the higher Retain[®] rate. Application at 40% bloom also appeared more effective than at 70%. This conclusion was supported by a separate test involving application of Retain[®] at 125 ppm to walnut flowers ranging from pre-receptive to fully receptive. Improvement in percent set was greatest on flowers treated in the pre-receptive stage. Further testing is planned with the goal of obtaining Retain[®] registration.

INTRODUCTION

For over thirty years, scientists with the University of California Pomology Department at Davis, in cooperation with their colleagues in Cooperative Extension, have researched the cause and solution for pistillate flower abortion (PFA) in walnut (Polito et al.). PFA is the loss of nut-producing pistillate flowers early in the season, typically 2 to 3 weeks after bloom. This was first noted in the Serr cultivar soon after the earliest plantings came into production in the early 1970s. Originally referred to as the Serr drop problem, flower loss due to this phenomenon sometimes exceeded 90 percent in certain orchards and years. Determining the cause of the disorder proved extremely difficult. By the late 1980s the above researchers had eliminated mites, walnut blight, numerous nutritional deficiencies including nitrogen, calcium, and boron, tree age, shading, pruning practices, water stress, intra-tree competition for nutrients, incompatible pollen and lack of pollination. Cherry Leafroll virus, the cause of Blackline, was also studied as a possible cause and eliminated (Polito et al.). In the 1990s, field-based research led by UC Davis Pomology faculty confirmed from detailed tagging of flowers and yields from individual trees varying in distance from a pollen source that PFA is always associated with high numbers of pollen grains present on the receptors (stigmas) of female flowers. Reduction of the

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pollen load in test orchards by catkin removal decreased PFA and increased yield. Tests on cultivars other than Serr (Chandler, Vina and Chico) showed the presence of PFA but not at levels which typically resulted in economic loss. The discovery of excessive pollen affecting walnut flower abortion also led to the UC recommendation that Serr growers remove the pollenizer trees from their orchards and shake the catkins from the remaining Serr trees during the early bloom period. Growers accomplish this with the mechanical shaker normally used for harvest.

Serr growers in northern California became so frustrated with the poor yields received from this potentially high-producing variety that most orchards were removed. This left the majority of the state Serr acreage in southern California where it enjoyed popularity as an early maturing, high edible yield variety which helped extend the harvest period and set marketing conditions. However, from 1998-2003, Serr has yielded very poorly in orchards which typically produced about two ton of in-shell walnuts per acre. Use of the catkin shaking recommendation has also been met with frustration because a single shake has been insufficient to adequately reduce the pollen load. Many Serr growers also do not own shakers and therefore find timely coordination of this practice difficult. Growers who have shaken also report mixed results depending upon their proximity to surrounding orchards with varieties adding to their pollen load.

Research by Dr. Polito (unpublished) showed that the excessive pollen tubes growing down the style of the female walnut flower produce excessive amounts of ethylene, a natural plant hormone associated with organ senescence. Elevated ethylene levels are likely the cause of flower abortion. Polito also field tested non-commercial compounds which either promoted or inhibited ethylene production and observed corresponding increases and reductions in PFA.

Recently, Retain®, a commercially available ethylene inhibitor developed by Valent BioSciences, has been tested and registered on stone fruit for improving post harvest shelf life. In 2003, the author tested Retain® on individual walnut fruiting shoots and recorded a four-fold increase in set compared to untreated flowers. These positive results led to the commercial sprayer application tests reported in this paper.

MATERIALS AND METHODS

Two Serr walnut orchards were selected in the southern San Joaquin Valley for the study. One orchard was in Kings County and the other was in Tulare County. These sites are both approximately 35 miles south of Fresno, California. The Kings County site was an 11 year-old, mature canopied orchard 55 feet in height. Directly north of the Serrs was a Chandler walnut orchard. The pollen from Chandler catkins overlaps about 80 percent of the Serr pistillate bloom and is implicated in exacerbating Serr PFA. This hypothesis is supported by the grower who reported that the annual per acre production of the first 15 Serr rows used for this study averaged only 1000 pounds dry in-shell walnuts over the past four years.

The Tulare County site was similar in age but half the height and wider spaced. Hartley, a walnut cultivar whose male catkins overlap the latter half of Serr pistillate bloom, was northwest of the test site about 100 yards. Open ground was directly north of the test rows and Payne walnut, whose catkins dehisce during the first half of Serr pistillate bloom, was northeast of the test about 200 yards.

Four treatments were applied to four, six-tree plots using a Latin Square experimental design to measure the variability between replications and the effect of distance from the Chandlers. Retain was tested at 62.5 and 125 ppm in 200 gal/ac. and compared to a water and

untreated control. Application was made at 70 percent bloom (3/24/04) to the Tulare site and at 40 percent bloom (3/25/04) to the Kings site. Both applications were performed between 7:30 am and 9:00 am when ambient temperatures ranged from 57° F. to 59° F.

Immediately following application, 15 shoots possessing two pistillate flowers in a pre-receptive stage were tagged for future set evaluation on each of the two middle trees in each plot. This was repeated for 15 shoots in the stage of peak receptivity. Set counts were then performed three and nine weeks post-treatment.

Harvest was also performed at each site on individual plots. During harvest, a 40 pound random sample was collected from the elevator belt and used to calculate a dry, in-shell conversion factor following commercial hulling and drying. A five- pound subsample was then submitted to Diamond Walnut Cooperative of California for third party quality evaluation.

In addition to the speed sprayer trials, an experiment was conducted in the Kings County orchard to test the effect of pistillate flower bloom stage on Retain[®] efficacy. Retain[®] was applied to flowers in the non-refracted, partially refracted and fully refracted stages of stigma development and compared to untreated flowers in various stages of pollen receptivity. Each of the four treatments were applied to five shoots bearing two flowers and replicated on 15 individual trees randomly selected but adjacent to the Chandler orchard. Percent set was then recorded three and nine weeks after treatment.

Treatment separation for all the tests was determined using Duncan's multiple range test at $p=0.05$.

RESULTS AND DISCUSSION

Table 1 shows the effect of Retain[®] on percent fruit set at the Kings County site when treatment was performed at 40% pistillate bloom. After nine weeks, there was a significant increase in fruit set with both concentrations of Retain[®] compared to the untreated and water controls. The high rate of Retain[®] increased fruit set by 60%. The application of water at 200 gpa had no effect on fruit set. Table 2 shows the resulting effect of improved fruit set on dry inshell walnut yield per acre. Both rates of Retain[®] significantly increased yield by about 1000 pounds per acre over the untreated trees. Trees treated with water were not significantly different from untreated trees. Although there was no differences in plot yields averaged down the field (row), plot yields increased significantly with greater distance from the Chandler orchard on the northern edge of the trial. This suggests that pollen density still affected yield even with the application of Retain[®].

Table 3 shows the effect of pistillate flower bloom stage on Retain[®] efficacy. Flowers in the pre-receptive and early stages of stigma reflection had significantly higher percent set than flowers at peak receptivity. In contrast to flowers treated at full bloom, which were eight percent higher than those untreated, flowers treated at the pre-receptive stage set almost 24% more flowers than the untreated. This data suggests Retain[®] has greater efficacy when applied early in the bloom period. Its residual must also be sufficient to inhibit ethylene production from excessive pollination during the 5-7 day receptivity period.

Table 4 shows the effect of Retain[®] on percent fruit set at the Tulare County site when application was made at 70% bloom. Initially thought to be optimal timing, the lack of significant improvement after nine weeks supports the findings obtained in the bloom stage timing trial. In addition to the late application, pistillate flower abortion was not as great in this orchard as the Kings County site. The Tulare site also was not adjacent to a walnut cultivar whose pollen release period overlapped with Serr pistillate bloom.

The yields recorded from the Tulare site correlate with the fruit set data by showing no statistical differences (Table 5). The low rate of Retain[®] was very similar in yield to the water and untreated trees. The high rate of Retain[®] produced 433 dry inshell pounds more than the untreated and suggests a concentration effect may exist between the two rates tested.

Table 1. Effect of speed sprayer application of Retain[®] on percent fruit set of Serr walnut, Kings County. Applied to four, six-tree replications at 40% bloom. Evaluated at three and nine weeks post application. P=0.05

Treatment	Percent Set	
	3 Weeks	9 Weeks
Untreated	52.4 b	52.9 b
Water	50.8 b	48.9 b
Retain @ 62.5 ppm	81.7a	78.9 a
Retain @ 125 ppm	89.7 a	84.7 a
Lsd	17.8	17.9
Treat X Bloom	NS	NS

Table 2. Effect of speed sprayer application of Retain[®] on the yield of Serr walnut, Kings County. Applied to four, six-tree replications at 40% bloom. Fifty-four trees/ac. Row data represents yields equidistant from the adjacent Chandler orchard. Column data represents yields P=0.05

Treatment	Yield per acre (lbs)	Row Yield	Column Yield
Untreated	5063 b	1. 5593	1. 4771 d
Water	4726 c	2. 5116	2. 5288 c
Retain [®] @ 62.5 ppm	6056 a	3. 5675	3. 5630 b
Retain [®] @ 125 ppm	6094 a	4. 5555	4. 6249 a
Lsd	159.8	NS	159.8

Table 3. Effect of Retain[®] applied by handgun at 125 ppm on percent set of Serr pistillate walnut flowers at different receptivity stages. Applied to five, two-flower shoots per tree and 15 trees. Kings County. P=0.05

Treatment	Percent Set	
	3 Weeks	9 Weeks
Pre-Bloom	96.7 b	96.0 a
Early Bloom	95.3 b	91.8 ab
Full Bloom	83.3 a	80.7 bc
Untreated-various bloom stages	75.2 a	72.5 c
Lsd	11.1	12.3
Treat X Bloom	NS	NS

Table 4. Effect of speed sprayer application of Retain[®] on percent fruit set of Serr walnut, Tulare County. Applied to four, six-tree replications at 70% bloom. Evaluated at three and nine weeks post application. P=0.05

Treatment	Percent Set	
	3 Weeks	9 Weeks
Untreated	76.2 b	71.7 a
Water	78.9 ab	72.4 a
Retain @ 62.5 ppm	83.3 ab	78.3 a
Retain @ 125 ppm	86.6 a	76.9 a
Lsd	8.7	
Treat X Bloom	**	NS

Table 5. Effect of speed sprayer application of Retain[®] on the yield of Serr walnut, Tulare County. Applied to four, six-tree replications at 70% bloom. Fifty trees/ac. P=0.05

Treatment	Yield per acre (lbs)
Untreated	3298
Water	3293
Retain [®] @ 62.5 ppm	3278
Retain [®] @ 125 ppm	3731
	NS
Lsd	514.5

CONCLUSIONS

Retain[®] appears to show promise in significantly reducing PFA in Serr walnut, resulting in corresponding increases in dry inshell yield. Commercial speed sprayer applications increased fruit set by as much as 60% in this single season test conducted in two locations. Tested at 62.5 and 125 ppm in 200 gpa, Retain[®] increased yield by about 1000 pounds compared to untreated controls. This represented a 20% increase. Results from the individual shoot application timing trial strongly suggest that Retain[®] performs best when applied early in the bloom period rather than near its peak. Flowers treated when their stigmas were not yet receptive to pollen showed a 24% increase in fruit set compared to untreated flowers. Fruit set in this pre-bloom stage was 16% better than flowers treated during full bloom. This data supports the lack of significant improvement in fruit set and yield recorded in the second speed sprayer trial treated at 70% bloom. Although not significant, there appears to be a slight concentration effect between the two Retain[®] rates tested. The application of water at 200 gpa had no effect on reducing PFA.

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