CPPU for harvest delay, improved fruit firmness and size and reduction of preharvest drop in Prunus domestica L. (>French= prune)

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Summary:

We applied 10 ppm CPPU at 4 timings during the growth season beginning at small fruit stage (Stage I) when fruit averaged 1 cm in diameter and at monthly intervals thereafter, with the last treatment approximately 1 month prior to an extended harvest. We found that the earliest application of CPPU resulted in improved dry yield per tree that may have been due to slightly lower fruit set after early drop. Although this early number indicates increased early drop, the final number of fruit that dropped cumulatively was lower in this treatment, resulting in lower estimated loss in yield to preharvest drop. Because drying ratio was slightly lower in this treatment than other CPPU treatments (but not the control), the estimated loss was further reduced. Although most results were not significantly different statistically, probably due to small sample size, the numeric differences substantiate results in 2005 that are similar. The percentage of the crop calculated as lost to cumulative drop was 17.7% in the control and 11% in the earliest CPPU timing.

Problem and its significance:

In 1997, farm advisors Bill Krueger and Rick Buchner surveyed several orchards in Tehama, Shasta and Glenn Counties on the incidence of fruit drop in >French= prune and found an average range of 11.5-12.5% drop. In orchards under today=s cultural practices a loss of approximately 10% per acre represents a substantial amount of profit. Preharvest drop in prunes consists of >blue prunes=, which drop erratically throughout fruit development, and normal fruit, which tend to drop during a few weeks as fruit mature. Preharvest drop may be due to several causes, including uneven fruit maturation, heavy set, stress, or endogenous hormonal interactions (Martin, 1981). If fruit were held on the tree longer, permitting larger fruit size and higher yield, a significant benefit for the grower would result, both for fresh and dried fruit markets.

Growth regulators that target fruit retention may also be used to improve firmness, as both abscission and ripening are ethylene-mediated events in fruit development. PGR=s that improve firmness and slow abscission could be tools to extend harvest in >French= prune, lessening the impact on limited dryer facilities. Although selective breeding for differing maturity dates is ongoing at UC Davis, the majority of prune growers farm >Improved French= prune. This single cultivar represents approximately 95% of the prunes grown in California, which equals ~99% of the prunes grown in the U.S. and ~70% of the prunes grown worldwide. The 2004/05 prune crop was estimated at 43,545 tons, only 30% of the previous year=s crop (due to poor fruit set conditions). In 1997 the crop totaled 220,000 tons, however, since that time drying facilities have declined in number, creating an increasingly difficult situation for prune growers whose crop must go to facilities within a very short time frame. The cost of producing an acre of prunes in 1997 ranged from $2300 in the Sacramento Valley to $3817 in the San Joaquin Valley. Growers need an effective, cost-effective strategy for managing production in a climate of decreasing returns. For most, replanting to other new, relatively untested, varieties is not an option.

>Stop drop= trials in >French= prune conducted throughout the 1990's by Southwick, Glozer, Yeager and various cooperators, concentrated on GA (Ralex[7]) and ReTain[7] (Valent BioSciences), an ethylene synthesis inhibitor. Ralex was found to improve firmness and best time of application was at Brix = 12-14%, or slightly higher with a heavy crop load. The best firmness increase was approximately 0.8 lb pressure (Southwick et al., 1999). The best harvest extension was three days however, fruit drop was unaffected, as were fruit size and yield. ReTain[7] did not decrease drop of either normal or blue prunes

during the last 2.5 weeks prior to harvest, did not affect soluble solids, fresh weight, dry weight, count/lb, but did increase fresh yield (and higher dryaway) and increased firmness at two days prior to the conventional harvest. The beneficial effect on firmness was not apparent until two weeks post-application, and potential for delayed harvest can only be estimated as the commercial harvest could not be delayed.

Benefits of CPPU on various fruits include improved fruit set and fruit size. >French= prune fruit set and early size gain might be improved by treatment with CPPU, however, timing of best application is an important parameter to investigate. More than one phase of preharvest drop is found in prune, and CPPU may affect both final fruit set and premature fruit drop at various times of the season. Lilliland (1933) found that >French= prune Stage I growth (end of rapid cell division and expansion in fruit tissue) ceased at ~60 days after full bloom (dafb). The end of Stage I is generally measured by onset of pit hardening or by a slowing of fruit growth in size. Stage II of growth (development of the seed) ended about 95 dafb, at which time Stage III began. Stage III is the final fruit enlargement phase, and often coincides with >June drop=. >June drop=, which is the third wave of abscission in plum, tends to occur slightly before June, or in the early June period (Simons and Chu, 1975). Another kind of early drop in prune is that of >blue prune drop=, which typically occurs in years of cool springs followed by a rapid onset of high temperatures. Symptoms include prune developing color prematurely, usually in June or July and the problem is associated with heat stress and leaf scorch.

In 2005 we evaluated the effects of CPPU (2-chloro-4-pyridyl)-N=-phenylurea) on fruit firmness, fruit drop, fruit size, soluble solids and drying ratio in >French= prune in a commercial orchard in the area of Linda, CA. Applications were of 10 and 15 ppm CPPU on July 14 when fruit was at 6.25 lb pressure, 20.1% soluble solids (%SS, Brix) and at a size of 30 fruit per pound. After approximately 8 weeks, we found that 10 ppm CPPU improved fruit size, dry count per pound, and reduced fruit drop (Table 1). Both 10 and 15 ppm CPPU improved fruit firmness without reducing Brix. This preliminary study suggested that CPPU may be used to delay maturity, improve fruit quality, increase salable fruit yield and reduce drop.

Objectives:

Reduce or prevent preharvest drop, improve firmness and allow delayed harvest in >French= prune with CPPU

a. Apply 10 ppm CPPU at a single commercial orchard site at 4 timings to determine the best timing for reduction of drop, improvement of fruit size and firmness and harvest delay
b. Measure fruit size as a result of treatments to determine timing effect on final fruit size (fresh weight and dryaway)
c. Measure fruit firmness and soluble solids at harvest for indication of maturity and treatment effects
d. Measure cumulative fruit drop
e. Evaluate final crop load as a function of treatment

Plans and Procedures:

Four single tree replicates were used to compare an untreated control to single applications of 10 ppm CPPU, + adjuvant (0.1% Regulaid) at 4 timings: 3 May (2-3 weeks after full bloom and within Stage I to maximize fruit size), 2 June, 30 June and 2 August. Four trees per treatment were chosen at bloom and 2 limbs per tree were used to measure final fruit set after initial fruit drop after bloom. Treatments were applied by mistblower at approximately 100 gallons per acre. Fruit size was measured at treatment on 3 May as a phenological parameter; diameter averaged 1 cm (Fig. 1). Fruit drop was evaluated cumulatively by counting all fruit dropped from June until harvest under each tree. At harvest the total yield per tree was measured by load cell weigh of bins. From each bin a 100-fruit sample was removed randomly and 90 fruit bagged in a net bag for drying. Each bag with fruit was weighed for a 'wet weight' and after drying, for a 'dry weight', from which drying ratio ('dryaway') and number of fruit per pound were calculated. The 10-fruit subsample removed prior to bagging was used for determining individual fruit size, firmness, and soluble solids. Size was determined by weight. Firmness was measured on one cheek per fruit by penetration of flesh after skin removal with a Magness-Taylor penetrometer with an 8mm diameter tip, puncturing 7.5 mm deep. Crop loss was estimated from number of fruit dropped cumulatively, number of fruit per pound and dryaway.

Analyses of variance were performed with Proc GLM in SAS (SAS Institute Inc., Cary, NC) and mean separations tested by Duncan=s Multiple Range Test, $P = 0.05$.

Results and Discussion:

We found that the earliest application of CPPU resulted in improved dry yield per tree that may have been due to slightly lower fruit set after early drop (Table 2). Thus, an early 'thinning' effect may have been produced by CPPU applied shortly after full bloom. The larger Stage I fruit may have experienced increased cell division as a result of CPPU's cytokinin effects; as smaller fruit are weaker 'sinks', they would have preferentially dropped off and the remaining fruit would have been larger. Although fruit size in our samples does not reflect that result with respect to final fruit size (Table 2), the fruit remaining on the tree after the earliest CPPU treatment may have remained 'stronger' fruit throughout the growing season. Thus, these fruit appear to have stayed on the tree better (lower cumulative fruit drop; Table 3), weighed slightly more (fresh weight per 90 fruit; Table 2), and had better firmness at harvest (Table 2). As the final number of fruit that dropped cumulatively was lower in this treatment a lower estimated loss in yield to preharvest drop was found (Table 3). Because drying ratio was slightly lower in this treatment than other CPPU treatments (but not the control; Table 2), the estimated loss was further reduced. Although most results were not significantly different statistically, probably due to small sample size, the numeric differences substantiate results in 2005 that are similar. The percentage of the crop calculated as lost to cumulative drop was 17.7% in the control and 11% in the earliest CPPU timing.

Verification of results from this, and the previous trial, on a larger scale must occur prior to an attempt to register this product for use.

Pertinent literature:

Lilleland, O. 1933. Growth study of the plum fruit - I. The growth and changes in chemical composition of the >Climax= plum. Proc. Amer. Soc. Hort. Sci. 30:203-208.

Simons, R.K. and M.C. Chu. 1975. Spur/pedicel abscission in plum (*Prunus domestical* L. cv. Stanley) morphology and anatomy of persisting and drop fruits. J. Amer. Soc. Hort. Sci. 100:656-666.

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Figure 1. Fruit size at first treatment 3 May.

Table 1. Effects on firmness, size and other quality indices in 'French' prune in 2005 by application of CPPU (2-chloro-4-pyridyl)-N'-phenylurea).

Treatment	Wt /100 fruit (lb fresh)	Drying ratio	Dry count/lb (size count)	Fruit weight (g)	%Soluble solids (Brix)	Firmness (lb)	#Fruit dropped cumulatively[y]	Estimated yield lost to preharvest drop (lb)
Control	2.58 b	2.69 a	107.5 a	18.7 b	29.5 a	1.30 b	1175.2 a	10.9 a
10 ppm CPPU	3.10 a	2.55 a	83.0 b	22.9 a	28.4 a	1.89 a	651.2 b	7.8 b
15 ppm CPPU	2.89 ab	2.66 a	91.8 ab	21.8 ab	28.3 a	1.88 a	756.8 ab	8.2 ab

[X] Mean separation within columns by Duncan's Multiple Range test, P = 0.05.
[y] Actual fruit drop was taken on 1/4 of ground below tree, thus this number represents a whole-tree estimate.

Table 2. Effects on firmness, size and other quality indices in 'French' prune in 2006 by application of 10 ppm CPPU (2-chloro-4-pyridyl)-N'-phenylurea) at 4 timings during growth season.

Timing	Wt /90 fruit (lb fresh)	Drying ratio	Dry count/lb	Fruit weight (g)	%Soluble solids (Brix)	Firmness at harvest (lb)	%Fruit set after early drop (counted 2 June)
Control	3.7	3.00 b	74.7	19.5	25.6	0.91	71.1
3 May	3.8	2.96 b	72.2	19.5	24.6	1.06	64.5
2 June	3.7	3.32 a	81.5	18.8	22.7	0.95	72.1
30 June	3.5	3.21 ab	82.9	19.0	24.3	0.96	70.0
2 August	3.7 ns	3.17 ab	78.9 ns	19.0 ns	22.4 ns	0.92 ns	68.9 ns

[X] Mean separation within columns by Duncan's Multiple Range test, P = 0.05; ns = non significant differences.

Table 3. Effects on cumulative fruit drop, dry yield and estimated crop loss in ‘French’ prune in 2006 by application of 10 ppm CPPU (2-chloro-4-pyridyl)-N’-phenylurea) at 4 timings during growth season.

Timing	Cumulative #fruit dropped from June until harvest	Dry yield per tree (lb)	Estimated yield lost to preharvest drop (lb)		%Crop loss
			Wet	Dry	
Control	733.0	42.2	27.9	9.1	17.7
3 May	486.8	53.5	20.0	6.6	11.0
2 June	851.3	40.2	34.3	10.3	20.4
30 June	841.5	43.3	32.1	9.8	18.5
2 August	723.8 ns	45.4 ns	28.0 ns	8.6 ns	15.9

[X] Mean separation within columns by Duncan’s Multiple Range test, P = 0.05; ns = non significant differences.