Effects of Kaolin Particle Film and Rootstock on Tree Performance and Fruit Quality in ‘Doyenne du Comice’ Pear

David Sugar, Richard J. Hilton, and Philip D. VanBuskirk

Oregon State University, Southern Oregon Research and Extension Center,
569 Hanley Road, Medford, OR 97502

Additional index words. *Pyrus communis*, *Pyrus calleryana*, *Cydonia oblonga*, Quince rootstock, high density plantings, fruit finish

Abstract. Tree growth and productivity in ‘Doyenne du Comice’ (‘Comice’) pear were not affected by kaolin (Surround WP) treatment programs consisting of applications at 30 or 60 g·L⁻¹ of water applied either three or six times per growing season and repeated for 3 years. In 2 of 3 years, kaolin treatment programs reduced the extent of russet on the fruit surface, although the comparative effectiveness of different concentrations or numbers of applications was not consistent. It appears that kaolin treatment programs can be used in ‘Comice’ pear production without adverse effects on tree growth and performance. In a relatively high density planting (1098 trees/ha), ‘Comice’ pear trees growing on *Pyrus calleryana* rootstock were less yield-efficient and had lower bloom and crop density and fruit set than trees growing on Quince A (*Cydonia oblonga*) rootstock. Fruit from trees growing on *P. calleryana* were generally smaller and had less surface russet than did fruit from trees growing on Quince A.

Kaolin particle films have been used widely in recent years in apple production in the Pacific Northwest to reflect solar radiation and thus lower fruit surface temperatures and reduce incidence of sunburn (Glenn et al., 2002). In pear production, kaolin particle films can also reduce fruit temperatures and reduce sunburn, but have primarily been deployed for suppression of the pear psylla (*Cacopsylla pyricola*) and for reduction of surface russet on green-skinned cultivars (Glenn et al., 1999; Hilton, 1999; Puterka et al., 2000; Sugar et al., 2005). Because kaolin particle films cover the above-ground portions of the tree with a visible white coating, some growers of ‘Doyenne du Comice’ pear (‘Comice’) raised concerns regarding the potential for negative effects of applications of kaolin particle films repeated through all or part of the foliar period and continued for a number of years. In apple, kaolin particle films have been found to increase leaf photosynthetic efficiency, due to decreased leaf temperature of sun-exposed leaves during conditions of high ambient temperature (Glenn et al., 2002). The effects of kaolin particle film applications on tree growth and fruit quality in pear have not been previously reported. Measurement of the impacts of kaolin particle films is necessary to assess the net effect on pear tree production and fruit quality.

The objective of this study was to measure the effects of early season (April–May) and full season (April–July) kaolin particle film treatment programs on vegetative growth and key fruit production and fruit quality characteristics in ‘Comice’ pear during three consecutive growing seasons. Since the experimental plots included ‘Comice’ pear trees on two different rootstocks, the effects of rootstock on the above parameters were also assessed.

Materials and Methods

The trial was conducted in a 0.9 ha commercial ‘Comice’ pear block planted at 2.1 × 4.3 m (1098 trees/ha) in 1995, within a larger pear orchard. The area was divided into eight blocks with five treatments of eight replications each, arranged in a randomized block design. All applications were made by air-carrier sprayer set to deliver 954 L·ha⁻¹. Each replication consisted of three adjacent trees with all samples taken from the center tree of the replication. The treatments consisted of kaolin (Surround WP, Engelhard Corp., Iselin, N.J.) applied at the rate of 30 g·L⁻¹ of water, kaolin at 60 g·L⁻¹ of water, and an untreated check. For each rate of kaolin, two application schedules were compared: 1) three early-season applications beginning at petal fall and then at 2-week intervals, and 2) six applications consisting of the three early-season applications followed by three later applications at 2- to 3-week intervals. The treatment regimes were repeated over 3 years, 2001–03. In 2002, the grower treated the entire block with kaolin (28.0 kg·ha⁻¹) by mistake 5 d before the first experimental application. Other standard sprays for arthropod pests and diseases were applied as needed by the orchard management. The kaolin application dates were 25 April, 9 May, 23 May, 13 June, 27 June, and 18 July in 2001; 23 April, 7 May, 22 May, 12 June, 7 July, and 23 July in 2002; and 22 April, 6 May, 21 May, 10 June, 1 July, and 22 July in 2003.

Sampling for tree performance and fruit quality consisted of determining the cross sectional area of the sample tree by measuring the diameter of the trunk one foot above ground level and then evaluating the trees for yield efficiency, bloom density, fruit set, crop density, fruit finish, and fruit soluble solids. Bloom was measured by counting the total

number of clusters per replication, and fruit set and yield parameters were determined by counting and weighing all the fruit at harvest for each replication.

Shoot growth was quantified by randomly selecting and tagging ten shoots per replication in the spring and measuring those shoots following applications of kaolin and after leaf fall. In 2001, shoot growth was measured after three early-season sprays had been applied but before initiating the late season spray sequence, and after leaf fall. In 2003, shoot growth was measured after leaf fall only. Shoot growth was not measured in 2002.

Fruit finish was evaluated on 25 fruit per replication of each treatment, collected at maturity. Each fruit was rated for extent of fruit russet using the Horsfall-Barrat scale (Horsfall and Barrat, 1945) and for incidence of sun rash, a physiological disorder of ‘Comice’ pear, which results in the formation of dark blemishes on the fruit surface, the cause of which is unknown (VanBuskirk and Sugar, 1986). For clarity in expressing the results and uniformity among years, the percentage of the total number of fruit that individually had 6% or more of the fruit surface covered in russet was used in comparing treatments. This corresponds approximately to the level at which fruit may be downgraded commercially. In addition, the average russet index value (Horsfall-Barrat category) was calculated.

To determine fruit soluble solids, slices from five randomly selected fruit per replication were pooled and juice was expressed through a garlic press. Soluble solids values were determined using a hand-held refractometer (Atago U.S.A., Inc., Bellevue, Wash.).

After the experiment was initiated in 2001, it was found that three of the eight blocks were planted on *Pyrus calleryana* seedling rootstock while five were on Quince A (*Cydonia oblonga*) rootstock. Accordingly, kaolin effects were analyzed across rootstocks, and rootstock effects were analyzed across kaolin treatments. Repeated measures analysis of variance was conducted on both treatment and rootstock as experimental factors. Analysis of fruit weight was conducted using the number of fruit per tree as a covariant. Data were transformed to log(x+1) or arcsine (for percent data) before analysis.

Results and Discussion

Bloom and yield evaluations. Kaolin treatments did not affect bloom density, fruit set, fruit weight, yield efficiency, or crop density (Table 1). Bloom density was highest in 2001 and 2003 and lowest in 2002. This reflects a common tendency in ‘Comice’ pear, which leads to alternate bearing. Fruit set was highest in 2002 when buds were few and lowest in 2003 when a high number of buds was coupled with poor pollination conditions. As a result of the poor fruit set in 2003, the crop density was reduced and average fruit weight increased.

Trunk and shoot growth. Overall, trunk cross-sectional area increased approximately 35% from 2001–02 and nearly 50% from 2002–03 (Table 1). No significant differences

in trunk area were observed among kaolin treatments. No significant differences in shoot growth were observed among treatments in either 2001 or 2003 (Table 2).

Fruit finish and soluble solids. No differences in extent of russet among kaolin treatments were observed in 2001, but differences were apparent in 2002 and 2003 (Table 3). In 2002, the full-season kaolin program (six applications) reduced russet to a greater extent than the early-season program (three applications), regardless of kaolin concentration. In contrast, in 2003 the higher kaolin concentration in both the early-season and full-season programs reduced russet to a greater extent than did the lower concentration (Table 3). Differences among treatments may have been more pronounced in 2002 and 2003 as the general level of fruit russet was higher in those years than in 2001. In 2001 and 2003, no differences in sun rash incidence were attributable to kaolin treatment (Table 3). However, in 2002 sun rash was reduced by kaolin applied six times at 30 g·L⁻¹ or applied either three or six times at 60 g·L⁻¹. There were no significant differences in fruit soluble solids in any year.

No adverse effects were apparent after 3 years of continuous use of kaolin at relatively high rates and multiple applications. The above results suggest that kaolin applications may be used in 'Comice' pear production without impacting tree growth and productivity. Furthermore, the results support the previous finding that kaolin treatments may reduce the extent of russet development on 'Comice' pears (Sugar et al., 2005). While the previous study tested only early-season applications, the results from 2002 in the present study suggest the potential for greater russet suppression from a full-season program.

Rootstock effects. Differences in production characteristics between the two rootstocks were apparent in all 3 years of the study (Table 4). 'Comice' pears on *P. calleryana* rootstock had substantially larger trunk cross-sectional area and lower bloom density, crop density, and yield efficiency than those on Quince A. In 2002 and 2003, the fruit set in *P. calleryana*-rooted trees was also significantly lower than in quince-rooted trees. Shoot growth was higher on *P. calleryana*-rooted trees in 2001, but this was not apparent in 2003. Even though trees on *P. calleryana* had cross-sectional areas that were, on average, about two-thirds larger than trees on quince, there was no significant difference in the percent increase of the trunk cross-sectional area over the course of the study. In 2 of 3 years, fruit from *P. calleryana*-rooted trees were smaller than fruit from quince-rooted trees (Table 5). In all 3 years, fruit from *P. calleryana*-rooted trees had less russet than fruit from quince-rooted trees. Rootstock did not affect incidence of sun rash or fruit soluble solids.

In the United States, use of quince as a rootstock for pear is largely limited to the 'Comice' cultivar, due to poor compatibility with other commercially important cultivars. Use of both quince and *P. calleryana* rootstocks is further limited geographically by their sensitivity to low-temperature injury (Lombard

and Westwood, 1987). Few published reports compare 'Comice' performance on quince with that on *P. calleryana*. Westwood and Lombard

(1982) reported that 'Comice' pear trees on *P. calleryana* were larger and had higher yield than 'Comice' on Quince C for the first 5 years

Table 1. Effect of kaolin treatment programs on production factors in 'Comice' pear.

Treatment ^z	Fruit set (%)	Trunk cross-sectional area (cm ²)	Yield efficiency (kg·cm ⁻²)	Bloom density (buds/cm ²)	Mean fruit wt (g)	Crop density (fruit/cm ²)
2001						
Untreated check	19.5 a ^y	67.9 a	0.24 a	5.2 a	246 a	0.9 a
Kaolin, 30 g·L ⁻¹ × 3	15.6 a	71.0 a	0.24 a	6.4 a	252 a	1.0 a
Kaolin 30 g·L ⁻¹ × 6	16.9 a	76.9 a	0.18 a	5.0 a	246 a	0.8 a
Kaolin 60 g·L ⁻¹ × 3	16.8 a	72.2 a	0.20 a	4.9 a	254 a	0.8 a
Kaolin 60 g·L ⁻¹ × 6	17.6 a	73.8 a	0.23 a	5.4 a	248 a	0.9 a
2002						
Untreated check	40.2 a	93.5 a	0.16 a	2.1 a	212 a	0.8 a
Kaolin 30 g·L ⁻¹ × 3	35.7 a	95.2 a	0.18 a	2.5 a	205 a	0.9 a
Kaolin 30 g·L ⁻¹ × 6	36.7 a	103.0 a	0.16 a	2.1 a	212 a	0.8 a
Kaolin 60 g·L ⁻¹ × 3	51.7 a	99.2 a	0.17 a	1.6 a	211 a	0.9 a
Kaolin 60 g·L ⁻¹ × 6	37.3 a	102.4 a	0.15 a	2.2 a	215 a	0.7 a
2003						
Untreated check	5.9 a	140.7 a	0.12 a	5.7 a	349 a	0.3 a
Kaolin, 30 g·L ⁻¹ × 3	7.3 a	136.1 a	0.15 a	5.6 a	330 a	0.5 a
Kaolin 30 g·L ⁻¹ × 6	7.3 a	158.2 a	0.11 a	4.6 a	346 a	0.3 a
Kaolin 60 g·L ⁻¹ × 3	7.2 a	149.3 a	0.14 a	5.2 a	345 a	0.4 a
Kaolin 60 g·L ⁻¹ × 6	6.9 a	150.6 a	0.14 a	5.4 a	360 a	0.4 a

^zTreatments were either applied as three early-season applications beginning at petal fall and then at 2-week intervals (×3) or as six applications consisting of the three early-season applications followed by three subsequent applications at 2- to 3-week intervals (×6).

^yWithin columns for each year, means followed by the same letter are not significantly different ($p > 0.05$) according to Fisher's protected LSD test.

Table 2. Effect of kaolin treatment programs on shoot growth in 'Comice' pear.

Treatment ^z	Shoot growth (cm)			
	Before 8 June	After 8 June	Seasonal total	Seasonal total
2001				
Untreated check	49.6 a ^y	14.1 a	63.6 a	67.2 a
Kaolin 30 g·L ⁻¹ × 3	48.6 a	10.5 a	59.2 a	74.4 a
Kaolin 30 g·L ⁻¹ × 6	48.2 a	17.4 a	67.2 a	69.8 a
Kaolin 60 g·L ⁻¹ × 3	52.5 a	12.9 a	66.3 a	68.5 a
Kaolin 60 g·L ⁻¹ × 6	47.8 a	10.6 a	58.4 a	69.2 a

^zTreatments were either applied as three early-season applications beginning at petal fall and then at 2-week intervals (×3) or as six applications consisting of the three early season applications followed by three subsequent applications at 2- to 3-week intervals (×6).

^yWithin columns for each year, means followed by the same letter are not significantly different ($p > 0.05$) according to Fisher's protected LSD test.

Table 3. Effect of kaolin treatment programs on fruit finish and soluble solids in 'Comice' pear.

Treatment ^z	Russet index	Fruit with >6% russet (%)	Fruit with sun rash (%)	Soluble solids (°Brix)
2001				
Untreated check	3.2 a ^y	31.0 a	7.0 a	13.0 a
Kaolin 30 g·L ⁻¹ × 3	3.1 a	26.8 a	6.8 a	13.1 a
Kaolin 30 g·L ⁻¹ × 6	3.0 a	14.7 a	6.3 a	12.5 a
Kaolin 60 g·L ⁻¹ × 3	2.9 a	22.0 a	3.6 a	12.4 a
Kaolin 60 g·L ⁻¹ × 6	3.0 a	21.0 a	3.1 a	11.9 a
2002				
Untreated check	3.9 a	62.0 a	18.0 a	15.5 a
Kaolin 30 g·L ⁻¹ × 3	3.4 a	40.0 ab	15.0 a	14.8 a
Kaolin 30 g·L ⁻¹ × 6	2.9 b	17.0 b	9.0 b	14.9 a
Kaolin 60 g·L ⁻¹ × 3	3.3 ab	36.0 ab	8.0 b	14.6 a
Kaolin 60 g·L ⁻¹ × 6	2.9 b	21.0 b	6.0 b	14.5 a
2003				
Untreated check	5.3 a	92.0 a	4.0 a	13.4 a
Kaolin 30 g·L ⁻¹ × 3	5.0 ab	87.0 a	9.0 a	13.7 a
Kaolin 30 g·L ⁻¹ × 6	5.0 ab	84.0 a	4.0 a	13.9 a
Kaolin 60 g·L ⁻¹ × 3	4.8 b	85.0 a	5.0 a	13.4 a
Kaolin 60 g·L ⁻¹ × 6	4.7 b	83.0 a	2.0 a	13.9 a

^zTreatments were either applied as three early-season applications beginning at petal fall and then at 2-week intervals (×3) or as six applications consisting of the three early-season applications followed by three subsequent applications at 2- to 3-week intervals (×6).

^yWithin columns for each year, means followed by the same letter are not significantly different ($p > 0.05$) according to Fisher's protected LSD test.

Table 4. Rootstock effects on yield and growth parameters in 'Comice' pear.

Treatment	Fruit set (%)	Trunk cross-sectional area (cm ²)	Yield efficiency (kg·cm ⁻²)	Bloom density (buds/cm ²)	Crop density (fruit/cm ²)	Seasonal shoot growth (cm)
2001						
<i>Pyrus calleryana</i>	18.9 a ^z	92.4 a	0.11 a	2.5 a	0.5 a	69.0 a
Quince A	16.2 a	59.2 b	0.29 b	7.3 b	1.2 b	58.7 b
2002						
<i>Pyrus calleryana</i>	29.0 a	126.2 a	0.08 a	1.4 a	0.4 a	---
Quince A	47.0 b	80.6 b	0.22 b	2.6 b	1.0 b	---
2003						
<i>Pyrus calleryana</i>	5.0 a	192.1 a	0.06 a	3.7 a	0.2 a	66.0 a
Quince A	9.0 b	115.3 b	0.20 b	6.4 b	0.5 b	69.9 a

^zWithin columns for each year, means followed by the same letter are not significantly different ($p > 0.05$) according to Fisher's protected LSD test.

Table 5. Rootstock effects on fruit quality parameters in 'Comice' pear.

Treatment ^z	Mean fruit wt (g)	Russet index	Fruit with >6% russet (%)	Fruit with sun rash (%)	Soluble solids (°Brix)
2001					
<i>Pyrus calleryana</i>	236 a ^z	2.9 a	15.0 a	6.7 a	12.3 a
Quince A	258 b	3.2 b	28.8 b	4.5 a	12.7 a
2002					
<i>Pyrus calleryana</i>	211 a	3.1 a	27.5 a	8.4 a	14.6 a
Quince A	211 a	3.5 b	43.5 b	14.1 a	15.1 a
2003					
<i>Pyrus calleryana</i>	328 a	4.3 a	73.0 a	5.3 a	13.5 a
Quince A	358 b	5.4 b	96.0 b	4.6 a	13.8 a

^zWithin columns for each year, means followed by the same letter are not significantly different ($p > 0.05$) according to Fisher's protected LSD test.

of bearing, but had similar yield efficiencies. Westwood et al. (1963) reported relatively high yield efficiency in 'Comice' trees on *P. calleryana* rootstock planted at 6.9 × 6.9 m. While pears on *P. calleryana* are generally precocious and of high yield efficiency, they are also relatively vigorous, and thus inap-

propriate for high-density plantings. It is likely that the low yield efficiency observed in *P. calleryana*-rooted trees in this study reflects the consequence of confining vigorous trees in relatively small spaces. In contrast, the vigor of the quince-rooted 'Comice' trees was more compatible with the allotted space.

Literature Cited

- Glenn, D.M., G.J. Puterka, T. van der Zwet, R.E. Byers, and C. Feldhake. 1999. Hydrophobic particle films: A new paradigm for suppression of arthropod pests and plant diseases. *J. Econ. Entomol.* 92:759–771.
- Glenn, D.M., E. Prado, A. Erez, J. McFerson, and G.J. Puterka. 2002. A reflective, processed-kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. *J. Amer. Soc. Hort. Sci.* 127:188–193.
- Hilton, R. 1999. Pear pest management using a particle film. *Proc. Oreg. Hort. Soc.* 90:49–50.
- Horsfall, J.G. and R.W. Barrat. 1945. An improved grading system for measuring plant diseases. *Phytopathology* 35:655.
- Lombard, P.B., and M.N. Westwood. 1987. Pear rootstocks. In: R.C. Rom and R.F. Carlson (eds.). *Rootstocks for fruit crops*. John Wiley and Sons, New York.
- Puterka, G.J., D.M. Glenn, D.G. Sekutowski, T.R. Unruh, and S.K. Jones. 2000. Progress toward a liquid formulation of particle films for insect and disease control in pear. *Environ. Entomol.* 29:329–339.
- Sugar, D., K.A. Powers, and S.R. Basile. 2005. Mancozeb and kaolin applications can reduce russet of 'Comice' pear. *HortTechnology* 15:272–275.
- VanBuskirk, P., and D. Sugar. 1986. Sun rash of pear in southern Oregon. *Proc. Oreg. Hort. Soc.* 77:118–121.
- Westwood, M.N., F.C. Reimer, and V.L. Quackenbush. 1963. Long term yield as related to ultimate tree size of three pear varieties grown on rootstocks of five *Pyrus* species. *Proc. Amer. Soc. Hort. Sci.* 82:103–108.
- Westwood, M.N., and P.B. Lombard. 1982. Rootstocks for pear. *Proc. Oreg. Hort. Soc.* 73:64–67.