Economics of Using Soybean Oil to Reduce Peach Freeze Damage and Thin Fruit

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SUMMARY. Using soybean oil to control insect pests, delay bloom, and thin fruit in peach [*Prunus persica* (L.) Batsch] production could reduce yield losses and fruit thinning costs compared to the current practice of using petroleum oil spray to control insect pests alone. The higher annual cost of soybean oil spray compared to petroleum oil spray was more than offset by higher average annual revenue from increased peach yields and lower thinning costs. At one location, soybean oil to delay bloom and thin fruit unambiguously reduced production risk. At another location, both mean and variance of returns were higher, but a lower coefficient of variation suggested lower relative risk for the soybean oil spray alternative. Risk resulting from the unanticipated influence of weather and mismanagement on the effectiveness of soybean oil spray were not considered in this analysis. More research is needed to hone in on the optimum soybean oil spray rates under alternative environmental and management conditions.

Dormant sprays of petroleum oil are currently used on peach trees to kill overwintering insect pests. Research at the University of Tennessee has shown that dormant sprays of soybean oil kill overwintering insects and, when applied in water at rates of 8% to 10% oil solution, have the added benefits of thinning flower buds and delaying flower bud development by as much as 6 d (Deyton and Sams, 1996). The bud-thinning and bloom-delay effects could reduce peach crop loss resulting from late spring freezes and reduce the cost of thinning flower buds. Furthermore, gaining Environmental Protection Agency (EPA) approval for these uses may be relatively quick and inexpensive because soybean oil is a food product and because of an EPA ruling, which exempts it from normal Federal Insecticide, Fungicide, and Rodenticide Act requirements (U.S. Congress, 1996). The objective of this study was to estimate the potential impacts of the bloom-delay and bud-thinning effects of soybean oil spray on the income and risk of peach production.

Materials and methods

To enable comparison of soybean oil spray with current production technologies, three sets of peach enterprise budgets were developed for the 1980–96 period. The first set of enterprise budgets (current-practice budgets) reflected the cost and return of producing peaches in Tennessee using dormant applications of petroleum oil to control scale insects such as San Jose scale (*Quadraspidiotus perniciosus* Comstock) and terrapin scale (*Mesolecanium nigrofasciatum* Pergandei), and mites such as European red mite (*Panonychus ulmi* Koch). The second set of budgets (bloom-delay budgets) included the bloom-delay effect and was constructed by substituting soybean oil spray for the dormant application of petroleum oil. Based on previous research by Deyton and Sams (unpublished data), soybean oil was emulsified with 10% lecithin. The soybean oil spray emulsion was applied at an 8% concentration with water at a rate of 200 gal / acre (1,871

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$L \cdot ha^{-1}$). At this concentration, 16 gal / acre (150 $L \cdot ha^{-1}$) of soybean oil spray would be applied. In addition to the bloom-delay effect, the third set of budgets (thinning budgets) included the bud-thinning effect of soybean oil spray by reducing the cost of labor for hand thinning by 100%, 85%, and 30%.

These percentages were chosen because the reduction in hand thinning resulting from soybean oil spray was not know with certainty. Chemical and mechanical thinning have not always been effective in eliminating 100% of hand-thinning labor. Baugher et al. (1988) found that removal of 45% to 59% of blossoms with a mechanical bloom-thinning method reduced hand-thinning labor by 30%; hence, the 30% thinning budgets were developed as a conservative lower range of reduced hand-thinning labor. The 100% thinning budgets were developed as an optimistic upper range of reduced labor. These budgets reflect the results of research that found no hand-thinning requirements after using soybean oil spray (Deyton and Sams, 1996), and research that found a commercially acceptable level of chemical thinning, defined as needing no hand thinning (Byers, 1998). The 85% thinning budgets were developed to account for the possibility that bud thinning may be required in some years to remove double fruits and thin pockets of blossoms that may be unevenly affected by soybean oil spray.

Implicitly assumed in the aforementioned budgets was that peach producers manage the application of soybean oil spray to achieve the desired bloom-delay and thinning effects. In reality, deviations in environmental and management factors can greatly influence the effectiveness of soybean oil spray in delaying bloom and thinning flower buds. For example, the timing of soybean oil application is important. In fact, applying soybean oil spray before the completion of endodormancy can advance bloom (Erez, 1987; Erez et al., 1971). Nevertheless, this research provides insight into the potential benefits of soybean oil spray in a historical setting under ideal environmental and management conditions.

The budgets were based on a mature-orchard peach budget developed by the University of Tennessee Agricultural Extension Service in 1992 (Johnson and Jenkins, 1992). Some of the chemical inputs used in the 1992 peach budget were not in use in the early years of the analysis period. Budgets for all years were based on the 1992 chemical use strategy and peach yield was held constant at the level reported in the 1992 budget except when freeze damage or other known events reduced yields. Consequently, these budgets isolated the economic impacts of soybean oil spray use by eliminating the effects of technological innovation and other factors that would affect production cost and return.

Retail prices of soybean oil spray were not available because no market existed for its use. Consequently, the retail price of dormant soybean oil spray was estimated for Sept. 1998 based on information obtained from Archer Daniels Midland (personal communication). The prices for degummed soybean oil and refined lecithin were \$0.29 and \$0.52 / lb (\$0.64 and \$1.15 / kg), respectively. At 7.67 lb / gal (0.92 $kg \cdot L^{-1}$) of soybean oil and 8.4 lb / gal (1.01 $kg \cdot L^{-1}$) of lecithin, a dormant soybean oil spray emulsion containing 10% lecithin was estimated to cost \$2.44 / gal (\$0.64 / L). The cost of putting the emulsion in 55-gal (208 L) drums for shipment to retailers was estimated to be \$0.46 / gal (\$0.12 / L), giving a total material cost of \$2.90 / gal (\$0.77 / L). Applying a 20% markup for additional manufacturing costs and profit gave an estimated wholesale price of \$3.48 / gal (\$0.92 / L). Finally, a shipping cost of \$0.25 / gal (\$0.07 / L) (Tennessee Farmers' Cooperative, personal communication) and a 20% markup to cover other costs and profit gave an estimated retail price of \$4.48 / gal (\$1.18 / L) of dormant soybean oil spray.

Peach prices used for each year of the analysis were state-average nominal prices received by growers as reported annually by the Tennessee Agricultural Statistics Service (Tennessee Department of Agriculture, Nashville, Tenn.) deflated by the gross domestic product chain price index, 1992 = 100 (GDP index) (Council of Economic Advisors, 1998; U.S. Department of Commerce, 1998). Deflated state-average prices were used to capture the year-to-year interaction of supply and demand on price in Tennessee while eliminating changes in price caused by inflationary pressures. The dormant soybean oil spray price was adjusted to 1992 dollars using the GDP index. Other input prices from the 1992 budget were used directly in each annual budget (Johnson and Jenkins, 1992). Total variable costs in 1992 dollars were then subtracted from total revenues in 1992 dollars to get returns to land, trees, and ownership (management and risk) for each year. To correspond with the last year of the analysis period, returns were adjusted to constant 1996 dollars using the 1996 value of the GDP index.

Historical data for the period 1980–96 from the University of Tennessee's Knoxville Experiment Station (KES) and for 1987–96 from the Middle Tennessee Experiment Station (MTES) in Spring Hill, were examined to identify years in which the peach crop was lost or reduced because of late spring freezes. In the identified years, peach yields were reduced in the current-practice budgets below the levels expected from a full crop to reflect diminished yields resulting from lost production. Production costs also were adjusted to reflect reduced costs resulting from lost or reduced yields.

To estimate the effectiveness of soybean-oil-induced bloom delay in preventing crop loss, the historical data were examined to determine the full bloom dates and the spring freeze dates for each year in which there was a crop loss. For some years, there was no full bloom date because the buds were killed by severe winter freezes. For other years in which there was crop loss from late spring freezes, the bloom-delay effect from using soybean oil spray was estimated by delaying the historical full bloom dates by 6 calendar days (Deyton and Sams, 1996). The delayed dates for each stage of bloom, which included all bloom stages from first swelling to post bloom, then were estimated based on growing degree hour requirements as described by Logan et al. (1990).

The delayed bloom periods for the years in which the experiment station data indicated a crop loss were compared to daily minimum temperature data from each experiment station to determine if a damaging freeze occurred during the delayed bloom period. If a daily minimum temperature fell below the critical temperature for 90% bud mortality during a particular bloom stage, budgeted peach yield was reduced to zero. The critical tem-

Table 1. Tennessee peach enterprise budget for 1980 with current production practices, mature orchard, 110 trees/acre, 1992 dollars.

Item	Description	Unit	Quantity	Price ($)	Amount ($)
Revenue					
Peaches	2 Bushel / tree	bushel[z]	220	14.75	3,244.95
Variable expenses					
Fertilizer	10N–4.3P–8.3K	lb (0.454 kg)	330	0.06	19.80
Lime		ton (0.907 t)	0.4	14.00	5.60
Dormant oil-petroleum		gal (3.785 L)	4.5	2.59	11.66
Herbicide	Paraquat	qt (0.947 L)	1.25	8.40	10.50
Herbicide	Norflurazon	lb	4.5	10.54	47.43
Fungicide	Captan	lb	2	2.63	5.26
Fungicide	Benomyl	lb	0.5	15.25	7.63
Insecticide	Azinphosmethyl	lb	9	5.11	45.99
Insecticide	Formetenate	oz (0.03 L)	10	0.90	9.00
Hand thinning		h	30	5.25	157.50
Trunk spray	Chlorpyrifos	qt	1.5	11.15	16.73
Baskets	1/2 bushel	each	440	1.00	440.00
Harvest	Hand picked	bushel (22.6 kg)	220	0.60	132.00
Tractor	40 hp	h	18.11	2.44	44.18
Other machinery		acre (0.405 ha)			35.81
Total variable expenses		acre			989.07
Return to land, trees, and ownership					
1992 dollars		acre			2,255.88
1996 dollars		acre			2,471.09

[z]1 bushel = 50 lb (22.6 kg).

peratures used in the model were 1.0, 5.0, 9.0, 15.0, 21.0, 24.0, and 25.0 °F (–17.2, –15.0, –13.8, –9.4, –6.1, –4.4, and –3.9 °C) for first swelling, green calyx, red calyx, first pink, first bloom, full bloom, and post bloom, respectively (Griffin, 1984). For cases in which the minimum temperature was equal to the critical temperature, budgeted peach yields were reduced by 50% to reflect 10% bud survival. If the minimum temperatures did not reach the critical temperatures during the delayed bloom period, yields for a full peach crop were budgeted indicating 100% bud survival.

Peach yields in the bloom-delay budgets were revised to represent increased production in years in which bloom delay was estimated to be effective in reducing losses from late spring freezes. For this portion of the analysis, the cost of hand thinning was retained in the budgets to isolate the income effects of bloom delay.

Peach yields in the thinning budgets used the same yield each year as estimated for the bloom-delay budgets. The income effects of 100%, 85%, and 30% reductions in the cost of hand thinning were incorporated into these budgets for each year in which hand thinning would otherwise have been required. For some years of the analysis, hand thinning would not have been required because of bud mortality from freeze damage.

One reason peach producers might want to use soybean oil spray is if it reduces risk. Risk is defined by economists as variation in income caused by factors outside the farmer's control (Boehlje and Eidman, 1984). In this research, risk is represented by the variance in income caused by changes in peach yield per acre and changes in cost resulting from using either petroleum or soybean oil spray, with peach prices and other input prices held constant among alternatives. If a particular production alternative has an average annual income (expected income) greater than or equal to another alternative and a lower variance in income, it is unambiguously less risky than the other alternative. If the mean and variance of income are both higher or both lower for one alternative than another, an unambiguous statement about the risk of one alternative versus the other cannot be made. However, the relative risk of the two

Table 2. Peach full bloom dates, freeze kill dates, and budgeted peach yields for the current-practice budgets, Knoxville Experiment Station, 1980–96.

Year	Full bloom date	Freeze date	Budgeted yield (bushels/acre)[z]
1980	3 April	No freeze damage	220
1981	1 April	No freeze damage	220
1982	22 March	7 April	0
1983	25 March	19 April	0
1984	1 April	No freeze damage	220
1985	No full bloom	21 January	0
1986	26 March	No freeze damage	220
1987	30 March	1 April	110
1988	28 March	No freeze damage	220
1989	17 March	No freeze damage	110
1990	15 March	21 March	0
1991	23 March	No freeze damage	220
1992	22 March	3 April	0
1993	5 April	No freeze damage	220
1994	25 March	No freeze damage	220
1995	28 March	No freeze damage	220
1996	No full bloom	5 February	0

[z]1 bushel / acre = 50 lb / acre (56 kg·ha^{-1}).

Table 3. Estimated delayed bloom dates, damaging freeze dates, and budgeted peach yields for years when bloom delay could have been effective in reducing crop losses, Knoxville Experiment Station, Knoxville, Tenn.

Year	Delayed full bloom date	Damaging freeze date	Budgeted yield (bushels/acre)[z]
1982	28 March	7 April	0
1983	31 March	19 April	0
1987	5 April	No freeze damage	220[y]
1990	21 March	21 March	110[y]
1992	28 March	3 April	0

[z]1 bushel / acre = 50 lb / acre (56 kg·ha^{-1}).
[y]Yields were budgeted to increase by 110 bushels / acre from the yields in Table 2 as a result of using soybean oil spray. This 110-bushel increase represents half of a full crop.

alternatives can be inferred. Relative risk can be measured by comparing the coefficients of variation of the two alternatives. If a particular alternative has a lower variance (or standard deviation) in income, compared to its average annual income, than another alternative, it is relatively less risky. Thus, one alternative is relatively less risky than another alternative if its coefficient of variation is smaller. With regard to this study, the hypothesis is that using soybean oil for bloom delay and fruit thinning is less risky than not using it. The means, standard deviations, and coefficients of variation of returns to land, trees, and ownership are calculated for the current-practice and thinning budgets to test this hypothesis.

Results and discussion

Table 1 shows an example of a current-practice budget for a year without freeze damage (1980) expressed in 1992 dollars. The budgeted peach yield of 220 bushels / acre (12,320 kg·ha^{-1}) and the 1980 peach price of $14.75 / bushel ($0.64 / kg) (in 1992 dollars) resulted in gross revenue of $3,245 / acre ($8,019 / ha) [1 bushel = 50 lb (22.6 kg)]. Total variable production expenses were $989 / acre ($2,444 / ha) which resulted in a return to land, trees, and ownership of $2,256 / acre ($5,575 / ha) in 1992 dollars and $2,471 / acre ($6,106 / ha) in 1996 dollars.

For the 1980 bloom-delay budget (not shown), variable production expenses were $1,041 / acre ($2,572 / ha). These expenses were $52 / acre ($128 / ha) higher than the variable expenses for the current-practice budget because of the higher cost of soybean oil spray compared to petroleum oil spray. When reduced labor requirements were included in the 1980 thinning budget for hand-thinning labor savings of 100% (not shown), total variable expenses were $884 / acre ($2,184 / ha), which was $105 / acre ($259 / ha) less than the current-practice budget. As a result, returns to land, trees, and ownership were $2,204 and $2,361 / acre ($5,446 and $5,834 / ha) in 1992 dollars and $2,415 and $2,587 / acre ($5,968 and $6,393 / ha) in 1996 dollars for the bloom-delay and 100% thinning budgets, respectively.

The last column of Table 2 shows the peach yields used in the current-practice budgets for KES during the 1980–96 period. During that period, the peach crop was destroyed by late spring freezes in 1982, 1983, 1990, and 1992, and by severe winter freezes in 1985 and 1996. A spring freeze in 1987 resulted in yield being reduced to half of the full budgeted yield. In 1989, yield was reduced by factors other than freeze damage.

The last column of Table 3 presents the yields budgeted for the bloom-delay and thinning budgets for years when boom delay could have been effective. Yields in these budgets for other years were the same as those reported in Table 2 for the current-practice budgets. For 1982, 1983, and 1992, estimates for KES indicated that delayed bloom would not have saved the crop. Estimates indicated that delayed bloom would have saved the entire crop in 1987, increasing budgeted yield from 110 to 220 bushels / acre (6,225 and 12,449 kg·ha^{-1}). In 1990, a minimum temperature equal to the critical temperature for 90% bud kill occurred on the same day as the estimated delayed full bloom date; therefore, 10% bud survival increased budgeted yield from 0 to 110 bushels / acre (0 to 6,225 kg·ha^{-1}).

Table 4. Redhaven peach full bloom dates, freeze kill dates, and budgeted peach yields, Middle Tennessee Experiment Station, Spring Hill, Tenn., 1987–97.

Year	Full bloom date	Freeze date	Budgeted yield (bushels/acre)[z]
1987	1 April	1 April	0
1988	28 March	No freeze damage	220
1989	22 March	11 April	0
1990	16 March	8 April	0
1991	25 March	No freeze damage	220
1992	26 March	3 April	0
1993	12 April	No freeze damage	220
1994	1 April	No freeze damage	110
1995	31 March	No freeze damage	220
1996	No full bloom	4 February	0

[z]1 bushel / acre = 50 lb / acre (56 kg·ha^{-1}).

Table 5. Estimated delayed bloom dates, damaging freeze dates, and budgeted peach yields for years when bloom delay could have been effective in reducing crop losses, Middle Tennessee Experiment Station, Spring Hill, Tenn.

Year	Delayed full bloom date	Damaging freeze date	Budgeted yield (bushels/acre)[z]
1987	7 April	1 April	110[y]
1989	28 March	11 April	0
1990	22 March	8 April	0
1992	1 April	3 April	0

[z]1 bushel / acre = 50 lb / acre (56 kg·ha^{-1}).
[y]Yield was budgeted to increase by 110 bushels / acre from the yield in Table 4 as a result of using soybean oil spray. This 110-bushel increase represents half of a full crop.

Table 6. Per acre returns with and without bloom delay, Knoxville Experiment Station (KES) and Middle Tennessee Experiment Station (MTES), 1996 constant dollars.

Year	Returns without bloom delay and bud thinning, KES (current practice)	Returns with bloom delay, KES (bloom delay)	Returns without bloom delay and bud thinning, MTES (current practice)	Returns with bloom delay, MTES (bloom delay)
		$ / acre[z]		
1980	2,471	2,415	---	---
1981	2,294	2,237	---	---
1982	–272	–329	---	---
1983	–272	–329	---	---
1984	2,250	2,193	---	---
1985	–272	–329	---	---
1986	2,505	2,449	---	---
1987	1,912	3,880	–272	1,855
1988	3,073	3,017	3,073	3,017
1989	1,880	1,824	–272	–329
1990	–272	1,726	–272	–329
1991	2,631	2,575	2,631	2,575
1992	–272	–329	–272	–329
1993	3,378	3,322	3,378	3,322
1994	3,549	3,493	1,718	1,661
1995	2,884	2,828	2,884	2,828
1996	–272	–329	–272	–329
Mean return	1,600	1,783	1,233	1,394
Additional mean return	---	183	---	161

[z]$1 / acre = $2.47 / ha.

Yields used in the current-practice budgets for MTES during the 1987–96 period are shown in the last column of Table 4. Peach crops were destroyed by late spring freezes in 1987, 1989, 1990, and 1992. In 1994, the crop was reduced by factors other than freeze damage. In 1996, the crop was destroyed by a severe winter freeze.

The last column of Table 5 presents the yields used in the bloom-delay and thinning budgets for MTES

Table 7. Per acre returns with and without bloom delay and 100%, 85%, and 30% savings of bud-thinning labor, Knoxville Experiment Station, Knoxville, Tenn., 1996 constant dollars.

Year	Returns without bloom delay and bud thinning (current practice)	Returns with bloom delay and bud thinning (100% thinning)	Returns with bloom delay and bud thinning (85% thinning)	Returns without bloom delay and bud thinning (30% thinning)
		$ / acre[z]		
1980	2,471	2,587	2,562	2,467
1981	2,294	2,410	2,384	2,289
1982	–272	–329	–329	–329
1983	–272	–329	–329	–329
1984	2,250	2,366	2,340	2,245
1985	–272	–329	–329	–329
1986	2,505	2,622	2,596	2,501
1987	1,912	4,053	4,027	3,932
1988	3,073	3,189	3,164	3,069
1989	1,880	1,824	1,824	1,824
1990	–272	1,726	1,726	1,726
1991	2,631	2,747	2,722	2,627
1992	–272	–329	–329	–329
1993	3,378	3,494	3,469	3,374
1994	3,549	3,665	3,640	3,545
1995	2,884	3,000	2,975	2,880
1996	–272	–329	–329	–329
Mean return	1,600	1,885	1,870	1,814
SD	1,445	1,538	1,527	1,487
CV	90	82	82	82
Additional mean return	---	285	271	217

[z]$1 / acre = $2.47 / ha.

Table 8. Per acre returns with and without bloom delay and 100%, 85%, and 30% savings of bud-thinning labor, Middle Tennessee Experiment Stations, Spring Hill, Tenn., 1996 constant dollars.

Year	Returns without bloom delay and bud thinning (current practice)	Returns with bloom delay and bud thinning (100% thinning)	Returns with bloom delay and bud thinning (85% thinning)	Returns without bloom delay and bud thinning (30% thinning)
		$ / acre[z]		
1987	–272	1,855	1,855	1,855
1988	3,073	3,189	3,164	3,069
1989	–272	–329	–329	–329
1990	–272	–329	–329	–329
1991	2,631	2,747	2,722	2,627
1992	–272	–329	–329	–329
1993	3,378	3,494	3,469	3,374
1994	1,718	1,661	1,661	1,661
1995	2,884	3,000	2,975	2,880
1996	–272	–329	–329	–329
Mean return	1,233	1,463	1,453	1,415
SD	1,556	1,554	1,544	1,504
CV	126	106	106	106
Additional mean return	---	230	220	183

[z]$1 / acre = $2.47 / ha.

for years when bloom delay could have been effective. Yields in these budgets for other years were the same as those reported in Table 4 for the current-practice budgets. In 1987, the temperature dropped to the critical temperature for 90% bud kill when the buds were estimated to be in the first-bloom stage on 1 April. For that year, 10% bud survival increased budgeted yield from 0 to 110 bushels / acre (0 to 6,225 kg·ha^{-1}). For the remaining years, temperatures below the 90% bud kill temperature occurred after the delayed full bloom dates and bloom delay was insufficient to save the crops.

Because soybean oil spray was more costly than petroleum oil spray, returns in 1996 dollars were lower for the bloom-delay budgets than for the current-practice budgets in years when soybean oil spray was not effective in influencing yields (Table 6). In fact, at KES, returns were lower with bloom delay than without it in 15 of 17 years. In only 2 of 17 years (1987 and 1990) were returns higher with bloom delay than without it. Nevertheless, returns were sufficiently higher in those two years to increase average annual returns enough to make the use of soybean oil spray for bloom delay $183 / acre ($452 / ha) more profitable than without bloom delay. Similarly, at MTES, bloom delay was effective in only one of 10 years, but the higher return in that year offset the lower returns in the other 9 years enough to make the annual use of soybean oil spray for bloom delay $161 / acre ($398 / ha) more profitable than without it.

When the additional production cost savings resulting from the bud-thinning effect of soybean oil spray were included at 100% and 85%, returns were higher with soybean oil spray than without it in 11 of 17 years at the KES (Table 7). In the other six years when returns were lower with soybean oil spray (1882, 1983, 1985, 1989,1992, and 1996), soybean oil spray was not effective in saving the entire peach crop so there was no cost savings from reduced hand thinning labor. The 30% thinning budgets had lower returns in all years except 1987 and 1990 when partial peach crops were saved by bloom delay. When bud-thinning effects were included along with the bloom delay effects, the increases in average annual returns compared to current production practices were estimated to be $285 / acre ($704 / ha), $271 / acre ($669 / ha), and $217 / acre ($536 / ha) for the 100%, 85%, and 30% thinning budgets, respectively. Also, compared to bloom-delay budgets, the 100%, 85%, and 30% thinning budgets respectively provided $102 / acre ($252 / ha), $88 / acre ($217 / ha), and $34 / acre ($84 / ha) higher average annual returns at KES.

At MTES (Table 8), average annual returns were higher compared to the current-practices budgets in 5 of 10 years when the benefits of bud thinning were included in the 100% and 85% thinning budgets. As with the 30% thinning budgets for KES, the return was higher only in 1987 when a partial crop was saved by bloom delay. The increases in average annual net returns compared to the current-practice budget were $230 / acre ($568 / ha), $220 / acre ($543 / ha), and $183 / acre ($452 / ha) for the 100%, 85%, and 30% thinning budgets, respectively. Furthermore, compared to bloom-delay budgets, the 100%, 85%, and 30% thinning budgets respectively provided higher average annual returns of $69 / acre ($170 / ha), $59 / acre ($146 / ha), and $22 / acre ($54 / ha) at MTES.

Tables 7 and 8 present the standard deviations and coefficients of variation of returns for the current-practice and thinning budgets. For KES (Table 7), mean returns were higher with soybean oil spray, but standard deviations were also higher leaving no clearly superior alternative in terms of the tradeoff between expected return and variance of returns. Nevertheless, the lower coefficients of variation suggest that using soybean oil spray to delay bloom and thin fruit was less risky relative to mean returns than current production practices regardless of whether labor savings were 100%, 85%, or 30%. For MTES (Table 8), the soybean oil spray alternatives also had lower coefficients of variation than using current practices. In addition, the standards deviations of returns decreased slightly, suggesting that soybean oil spray unambiguously reduced economic risk at that location.

Conclusions

The estimated annual cost of dormant soybean oil spray applications to delay bloom, thin fruit, and control mites and scale insects was higher than the cost of using petroleum oil spray applications to control mites and scale insects alone. This higher annual cost, however, was more than offset by higher average annual revenues resulting from the reduction in crop losses caused by the bloom-delaying effect of soybean oil spray. Substantial economic benefits were estimated from using soybean oil spray to delay bloom and thin fruit even when only half a peach crop was saved twice in 17 years (1980–96) at KES and once in 10 years (1987–96) at the MTES.

Results also suggest that relative risk could be reduced at both location by using soybean oil spray to delay bloom and thin fruit rather than current practices. In addition, at MTES, soybean oil spray would unambiguously reduce risk.

If all peach producers used soybean oil spray to delay bloom and the crop were saved in a given year, peach supply would have been higher than its historical level and the peach price in that year likely would have been lower than the historical price used in this study. Thus, return to land, trees, and ownership would have been lower than estimated in the bloom-delay and thinning budgets. Nevertheless, the results of this study would hold for early adopters of soybean oil spray until sufficiently large numbers of adopters began to have an appreciable effect on supply.

A simplifying assumption was made that peach producers efficiently manage the use of soybean oil spray to achieve the optimum bloom-delay and fruit-thinning results. Although the soybean oil spray rates in this study were shown to be effective in Tennessee experiments, their effectiveness is sensitive to differences from year to year in environmental conditions. Furthermore, mismanagement of soybean oil spray could add to cost without delaying bloom or thinning fruit or, at the other extreme, over-thin the fruit or advance bloom causing economic loss from underproduction and increased possibility of freeze damage. Risk resulting from unanticipated environmental conditions and mismanagement were not considered in this analysis. Knowing how unanticipated environmental conditions and mismanagement influence the effectiveness of soybean oil spray in optimally delaying bloom and thinning fruit is important before strongly recommending soybean oil spray for these uses. More research is needed to hone in on the optimum soybean oil spray rates under alternative environmental and management conditions.

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