IMPACTS
OF THE ELIMINATION OF ORGANOPHOSPHATES AND CARBAMATES FROM RED DELICIOUS APPLE PRODUCTION IN WASHINGTON

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Pesticides and registered trade names included in this report are not intended to be a complete listing. The trade names are included merely as some examples of the pesticides. They are not an endorsement of any particular chemical company's product or an indication that any such product is the exclusive trade name used for any particular purpose.

The following information and estimates are provided as part of a study of the impact of the elimination of carbamate and organophosphate use on major horticultural crops. This section will deal with Red Delicious apples in the state of Washington. In 1996 apples were the number one crop produced in Washington in terms of value with a value of $943,700,000. Washington produced 2,750,000 tons from 155,000 bearing acres.[1] In 1993, Red Delicious accounted for 64 percent of the total acres of apples in Washington State.[2] Although the exact acreage of bearing Red Delicious in the state is not known, it is safe to assume that there are approximately 100,000 acres of bearing Red Delicious.

The scenarios presented include:

- Baseline (current practices).
- Using no carbamates.
- Using no organophosphates.
- Using no carbamates or no organophosphates.
- Use of one carbamate and one organophosphate per year (two scenarios).

General assumptions or comments:

- Due to the extreme destructiveness of insects and fungi, there have not been any long-term or short-term studies as to the effect of operating without carbamates or organophosphates, or both, in commercial orchards in Washington State. There have been limited short-term studies in other states as to operating without carbamates or organophosphates that were reviewed in making yield and damage estimates for this study.[3]
- It must be fully recognized that the yield and damage estimates as a result of reduced use of carbamates and organophosphates in Washington State Red Delicious apples, are estimates based on experience.

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[1] *Washington Agricultural Statistics, 1996 - 1997*, Washington Agricultural Statistics Service, Washington State Department of Agriculture.

[2] *Washington Fruit Survey, 1993*, Washington Agricultural Statistics Service, Washington State Department of Agriculture.

[3] Straub, R.W., E. Stover, P.J. Jentisch, "Carbaryl as a Component in Integrated Crop Management of Apple", *Journal of Economic Entomology* (1997); Swinton, S.M., E.A. Scorsone, *Short-term Costs and Returns to Michigan Apple, Blueberry, and Tart Cherry Enterprises with Reduced Pesticide Availability*, Michigan Agricultural Experiment Station, Michigan State University, Research Report 551 (April 1997).

- The average price per packed 40-pound box of Red Delicious apples in Washington State for all grades and sizes packed over the past five years, was $12.58 per box. Subtracting $7.00 a box for warehouse charges brings the return to the grower of $5.58 per box. This converts to $125.55 per packed 900-pound bin. This was the price used for estimating grower returns.

- Approximately 20 percent of the Washington apple crop is exported. By eliminating the use of carbamates and/or organophosphates, the likelihood of pests occurring in or on fruit escaping detection would increase. Phytosanitary regulations of many countries would then prevent export, reducing the amount of fruit exported. While this could have an impact on fruit prices both in export and domestic sales, this effect is not included in the estimated losses.

- As the quantity of quality apples decreases because of the reduced use of carbamates and organophosphates, a positive impact on fruit prices both in domestic and export markets could result. In this study, this possible effect is not included in estimating potential returns to the grower.

- All scenarios assume continuation of irrigation, fertilization, pruning, and other cultural practices essential to commercial production. It is also assumed, in an effort to reduce warehouse costs, that a rigorous field sorting program is followed.

- In the narrative, all costs are on a per acre basis. Estimates of cost changes are made on all costs including fixed cost. The changes in fixed cost mainly include increased demands on machinery use, especially sprayer use, which in the long run would become variable costs.

Baseline
(current practices)

The last study of the practices and costs involved in maintaining and operating a free-standing Red Delicious apple orchard in Washington was done in 1992.[4] The data used for this study were updated as to machinery costs, input costs, and changes in chemical use that have taken place since 1992. The results of this update, shown in Appendix III, were used as the baseline for this study.

The spray schedule for this baseline situation is shown in Table 1.

[4]Hinman, Herbert R., Paul Tvergyak, Brooke Peterson, Marc Clements, *1992 Estimated Cost of Producing Red Delicious Apples in Central Washington*, EB1720, Washington State University Cooperative Extension (July 1992).

Baseline Insecticide Use

According to a survey of pesticide use in Washington[5], there was an annual average of 5.5 insecticide applications on apples in central Washington. For the purposes of this study, six applications of insecticides, primarily organophosphates and carbamates, for insect pest management were used. Two sprays of Bacillus thuringiensis (Bt) for the control of leafrollers were also added. The sprays are used for controlling the following groups of insect pests:

- A delayed dormant spray for the control of San Jose scale, European red mite eggs, and leafrollers. This spray may also provide early suppression of aphids and lygus bugs.

- Three cover sprays for codling moth control with two applied against first generation and one against second generation. These applications may also contribute to the control or suppression of leafrollers, some aphid species, and San Jose scale.

- Two applications for the control of indirect, sporadic, or localized pests such as lygus bugs, stink bugs, Campylomma, western tentiform leafminer, grape mealy bug, white apple leafhopper, apple aphid, mites, and western flower thrips.

- Two summer applications of Bt for leafroller control.

General Assumptions and Comments Regarding the Baseline Insecticide Program.

- Though the resistance of several species of insect and mite pests to certain pesticides is increasing, particularly codling moth resistance to azinphos methyl (Guthion, Azinphos-M 50WP), it is assumed the level of control currently achieved remains the same.

- Biological control of mites continues to be the principal management tactic for this group of pests.

- Cost of application is often shared with fertilizer applications in that both insecticides and fertilizers are applied together.

- This program is designed to minimize the damage due to direct pests (those that feed on or damage the fruit directly) but also provides a substantial degree of control of indirect pests (pests that feed on foliage or woody portions of the tree influencing the tree's physiology and, therefore, affecting the total yield, fruit size, color, maturity, and tree vigor). There is a considerable tolerance to feeding by indirect pests, but measurement of losses caused by these species is difficult to document except where populations are very high.

[5]Beers, E.H. and J.F. Brunner, *Washington State Apple and Pear Pesticide Use Survey, 1989-90*, Washington State University (1991), 135 pp.

- It is estimated that all insect pests combined cause a reduction in salable crop of about 1.25 percent in this baseline program. There is 0.25 percent loss to codling moth, 0.5 percent loss to leafrollers, and 0.5 percent loss to all other species (Brunner, personal communication).

Baseline Plant Growth Regulators (PGRs)

Plant growth regulators are used to enhance fruit size and shape by thinning at both bloom and postbloom stages and by affecting the rate of fruit growth. Apples tend to bloom excessively; in fact, only 5-10 percent of the total flowers are needed to set a full commercial apple crop. If a high percentage of the flowers set fruit, there will be an excessively heavy crop load that year. The direct effects during that year are too many small fruit and not enough buildup of reserves for fruit buds for the following year. This fluctuation in yield (alternate or biennial bearing) is detrimental to the grower in terms of consistent crop production and, thus, a steady income. This variability in production can ruin established markets for warehouses if fruit volume is not adequate or consistent.

Chemical thinning materials at bloom and after fruit set are necessary to reduce the current season's crop load and to enhance flower bud formation for the subsequent year. One bloom thinning material, monocarbamide dihydrogensulfate (Wilthin), is used at 60-80 percent full bloom. A postbloom thinning treatment, consisting of carbaryl (Sevin, Carbaryl 4L) plus napthalene acetic acid (NAA: NAA-200, NAA-800) applied at petal fall up to approximately 10 mm fruit size, is a standard practice in traditional Red Delicious orchards. Follow-up hand thinning is required to adjust fruit distribution and crop load. Fruit size and shape (typiness) are affected by the use of Promalin (a combination of a synthetic cytokinin and gibberellins). Promalin is used by about 70 percent of Washington apple growers to produce more cosmetically appealing fruit which is demanded by market pressure. Stop-drop treatments are used by all conventional apple growers at least one time and may be used a second time to extend harvest without having excessive fruit drop.

The average PGR program includes five sprays comprised of a bloom thinner, Promalin, one postbloom thinning application, and two stop-drop sprays.

Baseline Fungicide Program

The selection of the Delicious variety for this study greatly simplifies the disease control program. In most years, approximately 85 percent of the Delicious acreage is not treated with fungicides due to the variety's relative resistance to the most common diseases, including powdery mildew. Other varieties, such as Fuji, Gala, and Braeburn, are susceptible to apple scab, fire blight, powdery mildew, and bull's eye rot. Golden Delicious and Granny Smith are considered moderately susceptible to these diseases. Disease control programs on these varieties would likely require four to seven applications of fungicides on almost all bearing acreage.

Red Delicious acreage is sprayed an average of two times per season for the control of primary apple scab infection. Sterol inhibitors such as myelobutanil (Rally) are used most commonly, but with the increased amount of fruit exported, growers have switched to thiram for scab control. Apple scab, if not controlled during the primary infection period, can cause fruit infection due to secondary scab outbreaks. Fruit loss can be about 1 percent on the acreage that is sprayed for scab.

Under the baseline situation, it is assumed that 40 bins per acre will be picked and 39 bins (of all grades and sizes normally packed) will be packed.

In comparing the effects of eliminating or reducing the use of carbamates and organophosphates on yields, chemical use, and orchard costs, Table 13 in Appendix III summarizes it all in a very detailed manner. Referring to Table 13, with 40 bins picked and 39 bins actually packed under the baseline situation:

Total Returns to the Grower	=	$4,896.45
Non-harvest Variable Cost	=	1,931.10
Harvest Variable Cost	=	822.99
Returns Over Variable Cost	=	2,142.36
Fixed Cost	=	1,891.25
Returns Over Fixed Cost	=	251.11

No Carbamates

Elimination of Carbamates from Baseline Insecticide Program

The loss of carbamates from the baseline program would eliminate one insecticide spray. Formetanate hydrochloride (Carzol) is applied for control of western flower thrips, Campylomma, and white apple leafhopper. The loss of carbamates such as formetanate hydrochloride (Carzol) would increase some thrip damage, but organophosphates such as diazinon (Diazinon, Spectracide) or chlorpyrifos (Lorsban) could be substituted for the control of Campylomma and leafhoppers. The use of endosulfan (Thiodan) in place of formetanate hydrochloride (Carzol) would provide some control of true bugs (such as lygus bugs), leafhoppers, and occasional pests such as cutworms but would provide no control of thrips.

It is estimated that there would be an additional loss of 1 percent of the crop due to thrip damage to the fruit. As organophosphates and endosulfan could be used for other insect pests, no additional or significant loss is anticipated from Campylomma, leafrollers, true bugs, and leafhoppers.

Elimination of Carbamates from Baseline Plant Growth Regulator Program

One spray, carbaryl (Sevin, Carbaryl 4L), for postbloom thinning, would be lost if carbamates were eliminated from the baseline spray schedule. Although napthalene acetic acid (NAA: NAA-200, NA-800) is most often used in combination with carbaryl, it is possible to use napthalene acetic acid (NAA: NAA-200, NA-800) up to 20 ppm for fruit thinning. However, napthalene acetic acid (NAA: NAA-200, NA-800) can reduce fruit size slightly, and there is the risk of pygmy fruit formation if it is applied either too early or too late in fruit development.

The loss of carbaryl (Sevin, Carbaryl 4L) would have a serious impact on commercial apple growers as this material is the main workhorse of the postbloom thinning program for Delicious apples. Ironically, carbaryl (Sevin, Carbaryl 4L) is not used by Washington apple growers as a standard insecticide but rather as a thinning material. Although several alternative plant growth regulators have been tested in the northeastern and midwestern apple-producing states, none of these compounds either thins or has any significant fruit size enhancement with Delicious. Alternative programs using ethephon (Ethrel) or NAD (Amid-Thin W) are not possible with Delicious grown under Washington conditions due to severe negative effects on fruit shape (type) and size. It would be safe to estimate a loss of 20 percent packout due to the reduction in fruit size if fruit thinning is inadequate. Another way to express this is by box size; a reduction in one to two box sizes (e.g., size 100 instead of 80) can reduce total fruit volume by 20-30 percent.

Elimination of Carbamates from Baseline Fungicide Program

Two scab sprays would be lost if using thiram for scab control. These two sprays would be replaced by myclobutanil (Rally) (or another sterol inhibitor) or preferably by a lime-sulfur spray followed by a sterol inhibitor. Development of resistance to sterol inhibitors can be slowed somewhat by alternating with lime-sulfur sprays. One concern with using lime-sulfur sprays is that predatory mite populations, which feed on rust mites, may be reduced. Rust mites can be destroyed by lime-sulfur applications. Substitution of thiram sprays should not negatively affect fruit packout rates so no additional loss is anticipated.

Under this situation, it is assumed that 28 bins per acre will be picked, and 27 bins will be packed. The main reason for the large decrease in bins picked from that of the baseline situation is the loss in total fruit volume by the loss of carbaryl (Sevin, Carbaryl 4L) for postbloom thinning. For the purposes of this study, no additional hand-thinning costs have been added to the variable costs. Hand thinning would remain a viable, albeit expensive, method of postbloom thinning.

Table 2 lists the changes in the baseline spray schedule as a result of not being able to use carbamates. Those chemicals listed in bold print are those chemicals being eliminated from and/or added to the baseline spray schedule.

As seen below, in comparing the no carbamate situation with the baseline situation, there is a decrease in the returns to the grower of $1,506.60 due to the number of packed bins decreasing from 39 bins to 27 bins. Non-harvest variable cost increases $20.93 due to an increase of $31.69 in chemical costs and a decrease in overhead and interest on operating capital of $10.77. Harvest

variable cost decreases $237.75 due to a decrease in bins picked from 40 bins to 28 bins. Fixed costs also decrease due to less tractor and machinery use as a result of a decrease in the number of bins harvested. The net results, under the given assumptions, are that by eliminating the use of carbamates, returns over variable cost will decrease by $1,290, and returns over total costs will decrease by $1,273.

		Baseline	No Carbamates	Difference
Total Returns to the Grower	=	$4,896.45	$3,389.85	-$1,506.60
Non-harvest Variable Cost	=	1,931.10	1,952.03	20.93
Harvest Variable Cost	=	822.99	585.24	237.75
Returns Over Variable Cost	=	2,142.36	852.58	-1,289.78
Fixed Cost	=	1,891.25	1,874.92	-16.32
Returns Over Total Cost	=	251.11	-1,022.34	-1,273.46

No Organophosphates

Elimination of Organophosphates from Baseline Insecticide Program

The elimination of organophosphate insecticides from the baseline program would eliminate four insecticide applications: three for codling moth control (azimphos methyl [Guthion]) and one for leafroller, San Jose scale, and aphid management (chlorpyrifos [Lorsban]). The loss of chlorpyrifos (Lorsban) as an early season control of leafrollers, aphids, scale, and other sporadic pests would be significant as there is no substitute for this material. Although there are promising research results for leafroller control using biological agents such as certain parasitic wasps or viruses, these agents are not commercially available for use. Also, there is research underway for the use of pheromones for leafroller control; but at present, none is commercially available or applicable.

Codling moth control would rely on novel technologies; and, as yet, these methods are too new to assign a specific level of control. A combination of pheromones for mating disruption and summer oil sprays to reduce feeding and ovipositing, is the most successful method for codling moth management. Under ideal conditions, the pressure would be nil so that a flare-up of adult moth populations would not occur. However, insect pressure can increase if a neighboring orchard is not achieving adequate control, and moderate to severe fruit damage could occur.

Losses due to fruit damage from leafrollers could be as high as 10 percent if control is not possible. Although losses due to codling moth feeding and egg laying could be similar to the baseline insecticide program, a more realistic estimate is approximately 2 percent fruit loss. Total fruit loss is estimated to be about 15 percent if one accounts for an additional outbreak of insect pests such as Campylomma, true bugs, and fruit-feeding worms.

Elimination of Organophosphates from Baseline Plant Growth Regulator and Fungicide Program

Since organophosphates are not used as plant growth regulators or fungicide control in apples, no impact is noted.

Under this situation, it is assumed that 35 bins per acre will be picked, and 34 bins will be packed. The main reason for the decrease in bins picked from the baseline situation, is loss due to insect damage.

Table 3 lists the changes in the baseline spray schedule as a result of the elimination of organophosphates. Those operations and/or chemicals listed in bold print are those operations being added and those chemicals being eliminated and/or added from the baseline spray schedule.

As seen below, in comparing the no organophosphate situation with the baseline situation, there is a decrease in the returns to the grower of $627.75 due to the number of packed bins decreasing from 39 bins to 34 bins. Non-harvest variable cost increases $249.93 due to an increase of $65.79 in chemical costs, an increase of $95.00 for isomate dispensers, an increase in labor of $53.00, an increase in tractor and machinery variable cost of $23.75, and an increase in overhead and interest on operating capital of $12.39. Harvest variable cost decreases $102.88 due to a decrease in bins picked from 40 bins to 35 bins. Tractor and machinery fixed cost increases $38.40 due to the addition of six summer oil sprays but then decreases $8.18 due to less tractor and machinery use as a result of a decrease in the number of bins harvested. The net results, under the given assumptions, are that by eliminating organophosphates, returns over variable cost will decrease by $775 and returns over total costs will decrease by $805.

		Baseline	No Organo-phosphates	Difference
Total Returns to the Grower	=	$4,896.45	$4,268.70	-$627.75
Non-harvest Variable Cost	=	1,931.10	2,181.03	249.93
Harvest Variable Cost	=	822.99	720.11	-102.88
Returns Over Variable Cost	=	2,142.36	1,367.56	-774.80
Fixed Cost	=	1,891.25	1,921.47	30.22
Returns Over Total Cost	=	251.11	-553.91	-805.02

No Carbamates or Organophosphates

Two endosulfan (Thiodan) sprays would be used for control of true bugs and Campylomma; one spray of imidacloprid (Provado) would be used for controlling leafhoppers, grape mealybug, and other sporadic insect pests. There would be the potential for occasional scale, mite, and aphid outbreaks due to the loss of early season control measures.

The loss of both classes of insecticides would have a serious impact on the control of major indirect and direct pests. In particular, San Jose scale, leafrollers, grape mealybug, leafhoppers, Campylomma, and thrips could cause a loss of up to 25 percent packable fruit. Honeydew producers (such as aphids and grape mealybug) would cause a reduction in packable fruit due to sooty mold forming on the fruit. Codling moth control could be maintained with pheromone

dispensers and summer oil applications if pressure is light. However, it is anticipated that pressure would increase if control is lost due to poor timing of oil applications or dispenser distribution in the orchard, as well as potential buildup of codling moth populations in neighboring orchards. It is feasible that codling moth damage could approach 75 percent fruit loss with infestations. Tree vigor would be reduced due to a buildup in scale, aphid, and mite populations; in turn, flower initiation and fruit development would be reduced due to poor tree vigor. The potential for winter injury and fruit sunscald would increase.

It must be recognized, that under this situation, due to the potential of heavy fruit size loss and insect damage, it is highly likely that in some years no fruit will be picked. However, taking the best case scenario, it is assumed for analytical purposes that 30 bins would be picked, and 24 bins would be packed. The main reason for the six bin difference between bins picked, and bins packed is due to insect damage that cannot be detected when field sorting.

Table 4 lists the changes in the baseline spray schedule as a result of not being able to use carbamates or organophosphates. Those operations and/or chemicals listed in bold print are those operations being added and those chemicals being eliminated from and/or added to the baseline.

As seen below, in comparing the no carbamate or organophosphate situation with the baseline situation, there is a decrease in the returns to the grower of $1,883.25 due to the number of packed bins decreasing from 39 bins to 24 bins. Non-harvest variable cost increases $277.68 due to an increase of $97.48 in chemical costs, an increase of $95.00 for isomate dispensers, an increase in labor of $53.00, an increase in tractor and machinery variable cost of $23.76, and an increase in overhead and interest on operating capital of $9.44. Harvest variable cost decreases $205.75 due to a decrease in bins picked from 40 bins to 30 bins. Tractor and machinery fixed cost increases $38.40 due to the addition of six summer oil sprays but then decreases $16.34 due to less tractor and machinery use as a result of a decrease in the number of bins harvested. The net results, under the given assumptions, are that by eliminating carbamates and organophosphates, returns over variable cost will decrease by $1,956.18, and returns over total costs will decrease by $1,978.24.

		Baseline	No Carbamates or Organo-phosphates	Difference
Total Returns to the Grower	=	$4,896.45	$3,013.20	-$1,883.25
Non-harvest Variable Cost	=	1,931.10	2,209.78	277.68
Harvest Variable Cost	=	822.99	617.24	-205.75
Returns Over Variable Cost	=	2,142.36	186.18	-1,956.18
Fixed Cost	=	1,891.25	1,913.31	22.06
Returns Over Total Cost	=	251.11	-1,727.13	-1,978.24

One Carbamate and One Organophosphate

Situation 1

Growers would need to retain these sprays for specific control of selected pests if serious outbreaks occur. If used as knockdown sprays, pest pressure would be reduced to a level that would not provide total control but perhaps would not severely affect fruit packout. Although there are no data to support these estimates of fruit loss, it is anticipated that early season control of thrips, mites, scales, and leafrollers (with chlorpyrifos [Lorsban]) could keep fruit loss to about 2 percent. Formetanate hydrochloride (Carzol) would be used as the single carbamate spray. The tradeoff is that the grower would be willing to accept the elimination of carbaryl (Sevin, Carbaryl 4L) for postbloom fruit thinning (see Growth Regulator section, page 6) in return for additional insect control. Endosulfan (Thiodan) sprays could be incorporated into the program for control of Campylomma and true bugs.

Under this situation, it is assumed that 30 bins are picked, and 25 bins are packed. The main reason for the decrease in bins picked from the baseline situation is the loss in total fruit volume by the elimination of carbaryl (Sevin, Carbaryl 4L). The main reason for the five bin difference between bins picked and bins packed is due to insect damage that cannot be detected when field sorting.

Table 5 lists the changes in the baseline spray schedule as a result of being able to use only one carbamate and one organophosphate under Situation 1. Those operations and/or chemicals listed in bold print are those operations being added and those chemicals being eliminated from and/or added to the baseline spray schedule.

As seen below, in comparing the one carbamate and one organophosphate Situation 1 with the baseline situation, there is a decrease in the returns to the grower of $1,757.70 due to the number of packed bins decreasing from 39 bins to 25 bins due mainly to loss of fruit size. Non-harvest variable cost increases $320.44 due to an increase of $135.55 in chemical costs, an increase of $95.00 for isomate dispensers, an increase in labor of $53.00, an increase in tractor and machinery variable cost of $23.76, and an increase in overhead and interest on operating capital of $13.13. Harvest variable cost decreases $205.75 due to a decrease in bins picked from 40 bins to 30 bins. Tractor and machinery fixed cost increases $38.40 due to the addition of six

summer oil sprays but then decreases $16.34 due to less tractor and machinery use as a result of a decrease in the number of bins harvested. The net results are that by being able to use only one carbamate and organophosphate, under the above assumptions for Situation 1, returns over variable cost will decrease by $1,872.39, and returns over total costs will decrease by $1,894.45.

		Baseline	One Carbamate and One Organophosphate (Situation 1)	Difference
Total Returns to the Grower	=	$4,896.45	$3,138.75	-$1,757.70
Non-harvest Variable Cost	=	1,931.10	2,251.54	320.44
Harvest Variable Cost	=	822.99	617.24	-205.75
Returns Over Variable Cost	=	2,142.36	269.97	-1,872.39
Fixed Cost	=	1,891.25	1,913.31	22.06
Returns Over Total Cost	=	251.11	-1,643.34	-1,894.45

Situation 2

For the possible outbreak of codling moth due to unusually high pressure (greater than 1 percent fruit damage based on cullage), the grower would then use one azinphos methyl (Guthion) application at the beginning of the first generation. The grower would then eliminate the early season use of chlorpyrifos (Lorsban). It would still be necessary to use pheromone dispensers and summer oil sprays during the entire growing season to control both generations. Carbaryl (Sevin, Carbaryl 4L), would be used as a postbloom chemical thinner, the single carbamate spray. The trade-off is that the grower would be willing to accept the elimination of formetanate hydrochloride (Carzol) as an insecticide in return for better sized apples.

Under this situation it is estimated that the bins picked would be 33, and the bins packed would be 32. The main reason for the decrease in bins picked from the baseline situation is loss due to insect damage.

Table 6 lists the changes in the baseline spray schedule as a result of being able to use only one carbamate and one organophosphate under Situation 2. Those operations and/or chemicals listed in bold print are those operations being added to and those chemicals being eliminated from and/or added to the baseline spray schedule.

As seen below, in comparing the one carbamate and one organophosphate Situation 2 with the baseline situation, there is a decrease in the returns to the grower of $878.85 due to the number of packed bins decreasing from 39 bins to 32 bins. Non-harvest variable cost increases $302.23 due to an increase of $115.94 in chemical costs, an increase of $95.00 for isomate dispensers, an increase in labor of $53.00, an increase in tractor and machinery variable cost of $23.76, and an increase in overhead and interest on operating capital of $14.53. Harvest variable cost decreases $146.31 due to a decrease in bins picked from 40 bins to 33 bins. Tractor and machinery fixed cost increases $38.40 due to the addition of six summer oil sprays but then decreases $12.26 due to less tractor and machinery use as a result of a decrease in the number of

bins harvested. The net results, under the given assumptions, are that by being able to use only one carbamate and one organophosphate, under the above Situation 2, returns over variable cost will decrease by $1,034.77, and returns over total costs will decrease by $1,060.91.

		Baseline	One Carbamate and One Organophosphate (Situation 2)	Difference
Total Returns to the Grower	=	$4,896.45	$4,017.60	$ 878.85
Non-harvest Variable Cost	=	1,931.10	2,233.33	302.23
Harvest Variable Cost	=	822.99	676.68	-146.31
Returns Over Variable Cost	=	2,142.36	1,107.59	-1,034.77
Fixed Cost	=	1,891.25	1,917.39	16.14
Returns Over Total Cost	=	251.11	-809.80	-1,060.91

Without early season control of key pests such as leafrollers, San Jose scale, Campylomma, and occasional aphids and mite populations, fruit loss could approach 10 percent. Honeydew producers could be another problem causing an additional 15 percent fruit loss; tree vigor could also be affected by severe infestations of mealybug and aphids. If codling moth control is achieved with the combination of azinphos methyl (Guthion) and softer management strategies, fruit loss would be 2 percent or less. Total fruit loss due to the pests discussed above as well as other fruit worms and sporadic fruit feeders (about 5%) could amount to 37 percent. Mite flareups could be another problem if early season control is lost and if the oil sprays do not provide adequate control.

Conclusions

Given that the horticultural impacts that the producer will incur by the elimination or reduction of carbamates and/or organophosphates are accurate, it is rather obvious that producers will suffer significant economic losses if the price of quality apples does not rise to counteract their yield and quality losses. By referring to Table 13 in Appendix III, one can see that the major economic loss that producers will incur is due to their yield and quality losses. The increased cost of orchard maintenance under the different situations of reduced carbamate and organophosphate use is minor compared to yield and quality losses.

As mentioned at the beginning of this report, there have been essentially no research studies done in this area or research in Washington and very limited studies done elsewhere in the nation. Thus, further research on the impacts of pesticide use reduction is badly needed before further policy initiatives are taken.

Table 1. Spray schedule for baseline situation.

Operation	Month	Chemicals	Cost	Chemical Type
			($)	
Dormant Spray	March	8 gals. Zinc Sulfate @ $1.59/gal.	12.72	Fertilizer
Delayed Dormant	March	3 pts. Lorsban @ $6.03/pt.	18.09	Insecticide **OP**
		6 gals. Superior oil @ $2.60/gal.	15.60	Insecticide
		4 lbs. Solubor @ $0.80/lb.	3.20	Fertilizer
Primary Scab Spray	April	4 lbs. Thiram @ $4.50/lb.	18.00	Fungicide **C**
Growth Regulator	April	1.5 pts. Promalin @ $54.00/pt.	81.00	Growth Reg.
Bloom Thinning	April/May	6 qts. Wilthin @ $11.61/qt.	69.66	Growth Reg.
		2 qts. Regulaid @ $5.50/qt.	11.00	Surfactant
Leafroller Spray	April/May	2.0 lbs. Bacillus thuringiensis (Dipel) @ $9.08/lb.	18.16	Insecticide
Pink Spray	May	0.5 lbs. Carzol at $39.95/lb.	19.98	Insecticide **C**
		4.0 lbs. Thiram @ $4.50/lb.	18.00	Fungicide **C**
Thinning Spray	May	1.0 oz. NAA-200 @ $0.82/oz.	0.82	Growth Reg. **C**
		1.0 pt. Carbaryl 4L @ $3.24/pt.	3.24	Growth Reg.[1]
		1 qt. Regulaid @ $5.50/qt.	5.50	Surfactant
Cover Spray	May	2 lbs. Guthion @ $8.02/lb.	16.04	Insecticide **OP**
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15	Fertilizer
		1.5 qts. Sorba-Spray Mg. @ $3.00/qt.	4.50	Fertilizer
Cover Spray	June	2 lbs. Guthion @ $8.02/lb.	16.04	Insecticide **OP**
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15	Fertilizer
Leafroller Spray	June/July	2.0 lbs. Bacillus thuringiensis (Dipel) @ $9.08/lb.	18.16	Insecticide
Cover Spray	July	2 lbs. Guthion @ $8.02/lb.	16.04	Insecticide **OP**
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15	Fertilizer
Herbicide Spray	July	0.5 qts. Round-up @ $11.91/qt.	5.96	Herbicide
Minor Insect Spray	August	0.5 pt. Provado @ $59.38/pt.	29.69	Insecticide
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15	Fertilizer
Drop Spray	Aug/Sept	4 oz. NAA-800 @ $3.24/oz.	12.96	Growth Reg.
		1 qt. Regulaid @ $5.50/qt.	5.50	Surfactant
Stop Drop Spray	September	4 oz. NAA-800 @ $3.24/oz.	12.96	Growth Reg.
		1 qt. Regulaid @ $5.50/qt.	5.50	Surfactant
Herbicide Spray	October	2/3 lb. Solicam @ $17.54/lb.	11.69	Herbicide
		2/3 qt. Surflan @ $16.50/qt.	11.00	Herbicide
		2/3 qt. Roundup @ $11.91/qt.	7.94	Herbicide

Note: **OP** = organophosphate; **C** = carbamate

[1] Carbaryl 4L can be used as both an insecticide and a growth regulator. In this situation, Carbaryl 4L is being used as a growth regulator.

Table 2. Chemical sprays in the baseline situation that will be affected by the elimination of carbamates.

Operation	Month	Chemicals	Chemical Cost
			($)
Primary Scab Spray	April	**4 lbs. Thiram @ $4.50/lb. (omit)**	18.00
		10 gals. Lime-Sulfur @ $3.95/gal.	**39.50**
Pink Spray	May	**0.5 lbs. Formetanate hydrochloride (Carzol) at $39.95/lb. (omit)**	19.98
		4 lbs. Thiram @ $4.50/lb. (omit)	18.00
		3 lbs. Endosulfan (Thiodan-WP) @ $7.70/lb.	**23.10**
		5 oz. Myelobutanil (Rally) @ $5.50/qt.	**27.50**
Thinning Spray	May	**2 oz. Napthalene acetic acid (NAA-200) @ $0.82/oz. (an additional ounce)**	**1.64**
		1 pt. Carbaryl (Carbaryl 4L) @ $3.24/pt. (omit)	3.24
		1 qt. Regulaid @ $5.50/qt.	5.50

Note: Chemicals listed in bold print are those chemicals being eliminated from and/or added to the baseline spray schedule.

Table 3. Chemical sprays in the baseline situation that will be affected by the elimination of organophosphates.

Operation	Month	Materials	Chemical Cost
			($)
Delayed Dormant	March	**3 pts. Lorsban @ $6.03/pt. (omit)**	18.09
		(no substitute)	
		6 gals. Superior oil @ $2.60/gal.	15.60
		4 lbs. Solubor @ $0.80/lb.	3.20
Hang Isomate Dispensers	**May**	**400 Isomate C+ Dispensers @ $95/acre**	**95.00**
Cover Spray	May/June	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
		1.5 qts. Sorba-Spray mg. @ $3.00/qt.	4.50
Summer Oil Spray (2X)	**June**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	June	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
Summer Oil Spray (2X)	**July**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	July	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
Summer Oil Spray (2X)	**August**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**

Note: Operations and/or chemicals listed in bold print are those operations being added and those chemicals being eliminated and/or added from the baseline spray schedule.

Table 4. Chemical sprays in the baseline situation that will be affected by the elimination of carbamates and organophosphates.

Operation	Month	Chemicals	Chemical Cost
Delayed Dormant	March	**3 pts. Lorsban @ $6.03/pt. (omit)** **(no substitute)** 6 gals. Superior oil @ $2.60/gal. 4 lbs. Solubor @ $0.80/lb.	($) 18.09 15.60 3.20
Primary Scab Spray	April	**4 lbs. Thiram @ $4.50/lb. (omit)** **10 gals. Lime-Sulfur @ $3.95/gal.**	18.00 **39.50**
Pink Spray	May	**0.5 lbs. Carzol at $39.95/lb. (omit)** **4 lbs. Thiram @ $4.50/lb. (omit)** **3 lbs. Thiodan-WP @ $7.70/lb.** **5 oz. Rally @ $5.50/oz.**	19.98 18.00 **23.10** **27.50**
Thinning Spray	May	**2 oz. NAA-200 @ $0.82/oz.** **(an additional ounce)** **1 pt. Carbaryl 4L @ $3.24/pt. (omit)** 1 qt. Regulaid @ $5.50/qt.	**1.64** 3.34 5.50
Hang Isomate Dispensers	**May**	**400 Isomate C+ Dispensers @ $95/acre**	**95.00**
Cover Spray	May/ June	**2 lbs. Guthion @ $8.02/lb. (omit)** 5 lbs. Calcium Chloride @ $0.43/lb. 1.5 qts. Sorba-Spray Mg. @ $3.00/qt.	16.04 2.15 4.50
Summer Oil Spray (2X)	**June**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	June	**2 lbs. Guthion @ $8.02/lb. (omit)** 5 lbs. Calcium Chloride @ $0.43/lb.	16.04 2.15
Summer Oil Spray (2X)	**July**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	July	**2 lbs. Guthion @ $8.02/lb. (omit)** 5 lbs. Calcium Chloride @ $0.43/lb.	16.04 2.15
Summer Oil Spray (2X)	**August**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**

Note: Operations and/or chemicals listed in bold print are those operations being added and those chemicals being eliminated from and/or added to the baseline.

Table 5. Chemical sprays in the baseline situation that will be affected by the use of only one carbamate and one organophosphate--Situation 1.

Operation	Month	Chemicals	Chemical Cost
			($)
Delayed Dormant	March	3 pts. Lorsban @ $6.03/pt.	18.09
		6 gals. Superior oil @ $2.60/gal.	15.60
		4 lbs. Solubor @ $0.80/lb.	3.20
Primary Scab Spray	April	**4 lbs. Thiram @ $4.50/lb. (omit)**	18.00
		10 gals. Lime-Sulfur @ $3.95/gal.	**39.50**
Pink Spray	May	0.5 lbs. Carzol at $39.95/lb.	19.98
		4 lbs. Thiram @ $4.50/lb. (omit)	18.00
		3 lbs. Thiodan-WP @ $7.70/lb.	**23.10**
		5 oz. Rally @ $5.50/qt.	**23.50**
Thinning Spray	May	**2 oz. NAA-200 @ $0.82/oz.**	**1.64**
		(an additional ounce)	
		1 pt. Carbaryl 4L @ $3.24/pt. (omit)	3.24
		1 qt. Regulaid @ $5.50/qt.	5.50
Hang Isomate Dispensers	**May**	**400 Isomate C+ Dispensers @ $95/acre**	**95.00**
Cover Spray	May/ June	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
		1.5 qts. Sorba-Spray Mg. @ $3.00/qt.	4.50
Summer Oil Spray (2X)	**June**	**4 gal. of Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	June	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
Summer Oil Spray (2X)	**July**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	July	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
Summer Oil Spray (2X)	**August**	**4 gal. Orchex 796 @ $5.50/gal. each time**	**44.00**

Note: Operations and/or chemicals listed in bold print are those operations being added and those chemicals being eliminated from and/or added to the baseline spray schedule.

Table 6. Chemical sprays in the baseline situation that will be affected by the use of only one carbamate and one organophosphate--Situation 2.

Operation	Month	Chemicals	Chemical Cost
			($)
Delayed Dormant	March	**3 pts. Lorsban @ $6.03/pt. (omit)**	18.09
		(no substitute)	
		6 gals. Superior oil @ $2.60/gal.	15.60
		4 lbs. Solubor @ $0.80/lb.	3.20
Primary Scab Spray	April	**4 lbs. Thiram @ $4.50/lb. (omit)**	18.00
		10 gals. Lime-Sulfur @ $3.95/gal.	**39.50**
Pink Spray	May	**0.5 lbs. Carzol at $39.95/lb. (omit)**	19.98
		4 lbs. Thiram @ $4.50/lb. (omit)	18.00
		3 lbs. Thiodan-WP @ $7.70/lb.	**23.10**
		5 oz. Rally @ $5.50/qt.	**23.50**
Thinning Spray	May	1 oz. NAA-200 @ $0.82/oz.	.82
		1 pt. Carbaryl 4L @ $3.24/pt.	3.24
		1 qt. Regulaid @ $5.50/qt.	5.50
Hang Isomate Dispensers	**May**	**400 Isomate C+ Dispensers @ $95/acre**	**95.00**
Cover Spray	May/ June	2 lbs. Guthion @ $8.02/lb.	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
		1.5 qts. Sorba-Spray Mg. @ $3.00/qt.	4.50
Summer Oil Spray (2X)	**June**	**4 gals. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	June	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
Summer Oil Spray (2X)	**July**	**4 gals. Orchex 796 @ $5.50/gal. each time**	**44.00**
Cover Spray	July	**2 lbs. Guthion @ $8.02/lb. (omit)**	16.04
		5 lbs. Calcium Chloride @ $0.43/lb.	2.15
Summer Oil Spray (2X)	**August**	**4 gals. Orchex 796 @ $5.50/gal. each time**	**44.00**

Note: Those operations and/or chemicals listed in bold print are those operations being added to and those chemicals being eliminated from and/or added to the baseline spray schedule.

Scientists Consulted:

Insecticides:	Jay Brunner, Entomologist, Washington State University, John Dunley, Entomologist, Washington State University
Fungicides:	Gary Grove, Plant Pathologist, Washington State University
General Warehouse Information:	Randy Lee, Horticulturist, Beebe Fruit Co.

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Appendix I:
Production Data for Red Delicious Apples

Table 7. Apple production data.

	1993	1994	1995	1996	1997	Average	Percent US Total
bearing acreage (000)							
Washington	147	150	153	155	155	152	33.08%
US Total	460.55	461.87	460.47	461.47	453.22	459.52	
utilized production (000 cwts)							
Washington	50000	56000	47500	55000	50000	51700	48.97%
US Total	105739	111684	103899	103400	103197	105583.8	
utilized cwts / bearing acre							
Washington	340.1361	373.3333	310.4575	354.8387	322.5806	340.2693	
US Total	229.5929	241.8083	225.6368	224.0666	227.6974	229.7604	

Source: Table developed by Edward G. Smith, Agricultural and Food Policy Center, Texas A&M University, College Station, Texas, 1999.

Appendix II:

Budget Data for Red Delicious Apples

Table 8. Budget for producing apples with and without organophosphates and carbamates.

	United States			Washington Fresh & Processed		
	Baseline	No O&C	% Change	Baseline	No O&C	% Change
Yield (cwt/acre)	351.00	216.00	-38.46%	351.00	216.00	-38.46%
Cash expenses ($/acre):						
Fertilizer, and Growth Reg	$285.54	$282.30	-1.13%	$285.54	$282.30	-1.13%
Chemical and Sprays	$253.58	$449.31	77.19%	$253.58	$449.31	77.19%
Fuel and Repair	$128.99	$143.99	11.63%	$128.99	$143.99	11.63%
Labor	$778.98	$831.98	6.80%	$778.98	$831.98	6.80%
Irrigation	$150.00	$150.00	0.00%	$150.00	$150.00	0.00%
Harvest	$822.99	$617.24	-25.00%	$822.99	$617.24	-25.00%
Other variable cash expenses	$212.15	$215.62	1.64%	$212.15	$215.62	1.64%
Total, variable cash expenses	$2,632.23	$2,690.44	2.21%	$2,632.23	$2,690.44	2.21%

Source: Table developed by Edward G. Smith, Agricultural and Food Policy Center, Texas A&M University, College Station, Texas, 1999.

Appendix III:
Baseline for Red Delicious Apples

Baseline Data

Budget Assumptions

The value of orchards in central Washington varies considerably depending on the age of the trees and their current and potential production levels. The better apple orchards in this area are 10-20 years old with an annual production level of 40 bins or more per acre. Such an orchard is currently valued at about $12,000 per acre. The objective is to project what an existing planting would require in the way of equipment, materials, supplies, and labor and what the potential returns would be under a 13 year planning horizon for a person purchasing this orchard. Specific assumptions are:

1. Orchard has 60 acres of apple trees.

2. Apple trees are spur Delicious on Malling 7a rootstock.

3. Tree spacing is 10 x 20 feet yielding 218 trees per acre. About 25 crabapple and Winter Banana apple trees per acre are spread throughout the orchard for pollination purposes.

4. In an effort to reduce packing cost, a rigorous field sorting program is followed. Estimated production is 40 bins picked and 39 bins (of all grades and sizes) packed.

5. Including the irrigation system, but excluding buildings, the orchard is currently valued at $12,000 per acre. In 13 years, the value of the orchard will decrease, due to age of trees and the irrigation system, to about $7,000 per acre.

6. An under-tree permanent sprinkler irrigation system with lateral lines every 40 feet and risers every 30 feet is used in this orchard. Annual repairs, primarily to sprinkler heads, is $25 per acre. The total cost (irrigation charge and electricity) of delivering water under pressure is $125 per acre. The cost of the irrigation system is tied into the investment cost of the orchard.

7. Buildings on the 60 acres include a workshop and machine shed valued at $30,000 and employee housing valued at $75,000.

8. Replacement costs are used for all machinery, equipment, and buildings. The use of replacement prices may overstate costs currently being experienced by fruit growers. However, it provides an indication of the earnings needed to replace depreciable assets. Recent increases in prices paid for machinery and equipment mean that the depreciation claimed on older purchases substantially understates the amount of capital required to replace that asset. When looking at the long-term viability of the enterprise, it is important to consider its ability to replace its depreciable assets on a new cost basis.

9. The property tax on the orchard, irrigation system, machine shop and shed, and housing for labor is $90 per acre.

10. Regular full-time labor costs $12.50 per hour plus housing. This includes wages, industrial insurance, social security, and other fringe benefits. Seasonal labor is paid $7.50 per hour and picking labor is paid $12.00 per bin.

Apple Production Costs

Table 9 outlines the schedule of field operations by calendar month, the type of machinery and labor used, and the hours used per acre for producing apples.

Costs of field operations are divided into two categories. The first is the cost of equipment, building and orchard ownership, or fixed costs. The second category, variable costs, is associated with operating equipment, hiring employees, and purchasing services and materials. Total cost is the sum of fixed costs and variable costs.

Equipment fixed costs include depreciation, interest on the average investment, property taxes, and insurance. These costs are incurred whether or not a crop is grown and do not vary with the enterprise, given ownership of a specific equipment complement. Per-hour fixed costs for equipment are determined by dividing the total annual fixed cost per machine by the annual hours of equipment use over all enterprises for the representative farm. For a specific field operation, equipment fixed costs are determined by multiplying the equipment hours per acre times the equipment per-hour fixed costs. Fixed costs for the machine shed and shop, shop tools, and housing for labor are determined on a per-acre basis by dividing the total annual fixed cost by the number of acres. The per-hour (acre) fixed and variable costs for all equipment and buildings are presented in Table 12.

Interest on investment represents the opportunity cost (returns foregone by investing in the orchard) or interest paid to finance the purchase of the orchard. Total interest cost is calculated on the average value of the orchard ($9,500) over a 13-year planning horizon. A 9 percent interest charge is made against this average value. Orchard depreciation costs represent the loss in orchard value over the 13 year period. These costs need to be recaptured over the life of the investment if the investment is to be profitable.

Variable costs include fuel, oil, repairs, fertilizer, chemicals, custom work, overhead (utilities, legal, accounting, etc.), and interest on operating capital. Labor is also included as a variable cost.

Table 10 lists by operation, as presented in Table 9, the specific services and/or materials used, the quantities used per acre, and the prices paid per unit.

Table 11, presents a summary of costs appearing in Table 9. Most items are self-explanatory; however, fixed costs for tractors, machinery, and buildings warrant additional explanation. These figures represent depreciation, insurance, and taxes on these items as well as interest in the form of returns foregone by investing in the given equipment and building complement rather than in alternative investments (opportunity costs) or interest paid to finance the given equipment and building complement.

Total interest cost on these capital purchases is calculated on the average value of the machinery and buildings over their respective years of use. The 9 percent interest charge made against this average value represents the total interest cost.

Table 12 presents the equipment and buildings used to derive the cost estimates, including current purchase prices, annual hours of use, and per-hour or per-acre fixed and variable costs. Machinery, equipment, and building fixed costs include depreciation and interest on investment, property taxes, and insurance--costs that do not vary with the number of acres produced.

Equipment variable costs include machinery and equipment repair, electricity, fuel, and lubrication costs--costs that vary with the number of acres produced.

Table 9. Schedule of operations and estimated costs per acre for producing apples in the Wenatchee River Valley, Washington.

Operation	Tooling	Month/Year	Mach Hours	Labor Hours	Total Fixed Cost	Variable Cost					Total Variable Cost	Total Cost
						Fuel, Lube, & Repairs	Labor	Service	Mater.	Inter.		
					$	$	$	$	$	$	$	$
Prune & Thin	Hand Labor, Pruning Tools	Nov-Mar 1998	.00	21.00	12.89	.00	183.75	.00	.00	12.40	196.15	209.04
Rake	50hp-wt, Brush Rake	Mar 1998	.50	.55	5.98	2.62	6.88	.00	.00	.50	9.99	15.97
Chop Brush	50hp-wt, Rotary Mower	Mar 1998	.50	.55	4.56	2.90	6.88	.00	.00	.51	10.29	14.86
Fertilize	50hp-wt, Fertilizer Spreader	Mar 1998	.33	.36	3.84	1.70	4.54	.00	.00	2.43	48.66	52.50
Delayed Dormant	50hp-wt, Blast Sprayer	Mar 1998	.50	.55	8.00	4.95	6.88	.00	36.89	2.56	51.27	59.27
Dormant Spray	50hp-wt, Blast Sprayer	Mar 1998	.25	.28	4.00	2.47	3.44	.00	12.72	.98	19.61	23.61
Primary Scab Spray	50hp-wt, Blast Sprayer	Apr 1998	.40	.44	6.40	3.96	5.50	.00	18.00	1.24	28.69	35.09
Pollination	1.5 Bee Hives per Acre	Apr 1998	.00	.00	.00	.00	.00	52.50	.00	2.36	54.86	54.86
Growth Regulator	50hp-wt, Blast Sprayer	Apr 1998	.33	.36	5.28	3.26	4.54	.00	81.00	4.00	92.80	98.08
Bloom Thinning	50hp-wt, Blast Sprayer	Apr-May 1998	.40	.44	6.40	3.96	5.50	.00	80.66	4.06	94.17	100.57
Leafroller Spray	50hp-wt, Blast Sprayer	Apr-May 1998	.40	.44	6.40	3.96	5.50	.00	18.16	1.04	28.65	35.05
Irrigate**	Solid Set 36 Ac. in.	Sea 1998	.00	3.00	.00	25.00	37.50	125.00	.00	8.44	195.94	195.94
Mow Cover (4x)	50hp-wt, Rotary Mower	Sea 1998	2.00	2.20	18.25	11.62	27.50	.00	.00	1.76	40.88	59.13
Pink Spray	50hp-wt, Blast Sprayer	May 1998	.40	.44	6.40	3.96	5.50	.00	37.98	1.78	49.21	55.61
Frost Control	Wind Machine (3 per 60 Acres)	May 1998	1.20*	.50	77.95	23.69	6.25	.00	.00	1.12	31.07	109.01
Thinning Spray	50hp-wt, Blast Sprayer	May 1998	.40	.44	6.40	3.96	5.50	.00	9.56	.72	19.94	26.14
Cover Spray	50hp-wt, Blast Sprayer	May 1998	.40	.44	6.40	3.96	5.50	.00	22.69	1.21	33.35	39.75
Cover Spray	50hp-wt, Blast Sprayer	Jun 1998	.40	.44	6.40	3.96	5.50	.00	18.19	.83	28.48	34.87
Hand Thinning	Labor, Ladders	Jun 1998	.00	.00	8.59	.00	262.50	.00	.00	7.88	270.37	278.96
Leafroller Spray	50hp-wt, Blast Sprayer	Jun-Jul 1998	.40	.44	6.40	3.96	5.50	.00	18.16	.83	28.45	34.84
Cover Spray	50hp-wt, Blast Sprayer	Jul 1998	.40	.44	6.40	3.96	5.50	.00	18.19	.62	28.27	34.67
Herbicide Spray	50hp-wt, Weed Sprayer	Jul 1998	1.00	1.10	7.07	7.64	13.75	.00	5.96	.62	27.96	35.03
Minor Insect Spray	50hp-wt, Blast Sprayer	Aug 1998	.40	.44	6.40	3.96	5.50	.00	31.84	.62	41.92	48.31
Stop Drop Spray	Aerial Application	Aug-Sep 1998	.00	.00	.00	.00	.00	14.25	18.46	.49	33.20	33.20
Stop Drop Spray	Aerial Application	Sep 1998	.00	.00	.00	.00	.00	14.25	18.46	.25	32.96	32.96
Bin Dist & Swamp	50hp-wt, Backfire	Sep 1998	8.00	8.80	46.00	30.21	110.00	.00	.00	1.05	141.26	187.26
Picking	Supervision	Sep 1998	.00	.00	.00	.00	.00	40.00	.00	.30	40.30	40.30
Picking	Labor, Ladders, Picking Bags	Sep 1998	.00	.00	8.64	.00	.00	480.00	.00	3.60	483.60	492.24
Loading	50hp-wt, Highlight Fork	Sep 1998	2.00	2.20	19.33	15.28	27.50	.00	.00	.32	43.11	62.44
Hauling	Custom Hire	Sep 1998	.00	.00	.00	.00	.00	120.00	.00	.90	120.90	120.90
Herbicide Spray	50hp-wt, Weed Sprayer	Oct 1998	1.00	1.10	7.07	7.64	13.75	.00	32.77	.00	54.16	61.23
Fertilize	50hp-wt, Fertilizer Spreader	Oct 1998	.33	.36	3.84	1.70	4.54	.00	9.20	.00	15.43	19.27
Rodent Control	50hp-wt, Fertilizer Spreader	Oct 1998	.25	.28	2.91	1.29	3.44	.00	9.60	.00	14.32	17.23
Rodent Control	Labor, Gopher Probe	Sep 1998	.50	.50	.16	.00	6.25	.00	.62	.31	7.18	7.34

*24 Hours per 60 Acres.
**Irrigation Interest and Depreciation Included in Investment Cost.
***Interest on Average Orchard Value.

Table 9. (Continued) Schedule of operations and estimated costs per acre for producing apples in the Wenatchee River Valley, Washington.

Operation	Tooling	Month/Year	Mach Hours	Labor Hours	Total Fixed Cost	Variable Cost					Total Variable Cost	Total Cost
						Fuel, Lube, & Repairs	Labor	Service	Mater.	Inter.		
Clean-up & Misc	50hp-wt, Trailer	Ann 1998	2.00	2.20	15.56	9.28	27.50	.00	.00	1.66	38.44	54.00
Misc Use	3/4 Ton Pickup 4x4	Ann 1998	8.33	8.33	42.52	32.59	104.12	.00	.00	6.15	142.87	185.39
Misc Use	Four Wheel ATV	Ann 1998	5.00	.00	10.97	5.04	.00	.00	.00	.23	5.26	16.23
Misc Use	Shop Tools	Ann 1998	.00	.00	26.17	.00	.00	.00	.00	.00	.00	26.17
Buildings	Machine Shed and Shop 30 X 70	Ann 1998	.00	.00	45.17	1.67	.00	.00	.00	.08	1.74	46.91
Buildings	Labor Quarters	Ann 1998	.00	.00	112.92	16.67	.00	.00	.00	.75	17.42	130.33
Overhead	Utilities, Legal, Acct., Etc.	Ann 1998	.00	.00	.00	.00	.00	131.15	.00	.00	131.15	131.15
Taxes	Taxes on Orchard	Ann 1998	.00	.00	90.00	.00	.00	.00	.00	.00	.00	90.00
Investment Cost	Orchard Depreciation	Ann 1998	.00	.00	384.62	.00	.00	.00	.00	.00	.00	384.62
Investment Cost***	Interest on Orchard Investment	Ann 1998	.00	.00	855.00	.00	.00	.00	.00	.00	.00	855.00
Total per Acre			38.02	93.62	1891.25	246.79	916.48	977.16	539.11	74.55	2754.09	4645.34

*24 Hours per 60 Acres.
**Irrigation Interest and Depreciation Included in Investment Cost.
***Interest on Average Orchard Value.

Table 10. Materials and services provided by operation.

Operation	Month	Material and/or Service	Chemical Type
Fertilize	March	400 lbs. Calcium Nitrate @ $0.10/lb.	Fertilizer
Dormant Spray	March	8 gals. Zinc Sulfate @ $1.59/gal.	Fertilizer
Delayed Dormant	March	3 pts. Lorsban @ $6.03/pt. 6 gals. Superior oil @ $2.60/gal. 4 lbs. Solubor @ $0.80/lb.	Insecticide **OP** Insecticide Fertilizer
Primary Scab Spray	April	4 lbs. Thiram @ $4.50/lb.	Fungicide **C**
Pollination	April	Rented 1.5 bee hives @ $35.00/hive	NA
Growth Regulator	April	1.5 pts. Promalin @ $54.00/pt.	Growth Reg.
Bloom Thinning	April/May	6 qts. Wilthin @ $11.61/qt. 2 qts. Regulaid @ $5.50/qt.	Growth Reg. Surfactant
Irrigate	Season	Irrigation charge and electricity @ $125.00/acre	NA
Leafroller Spray	April/May	2.0 lbs. Dipel @ $9.08/lb.	Insecticide
Pink Spray	May	0.5 lbs. Carzol at $39.75/lb. 4.0 lbs. Thiram @ $4.50/lb.	Insecticide **C** Fungicide **C**
Thinning Spray	May	1.0 oz. NAA-200 @ $0.82/oz. 1.0 pts. Carbaryl 4L @ $3.24/pt. 1 qt. Regulaid @ $5.50/qt.	Growth Reg. Growth Reg.[1] **C** Surfactant
Cover Spray	May	2 lbs. Guthion @ $8.02/lb. 5 lbs. Calcium Chloride @ $0.43/lb. 1.5 qts. Sorba-Spray Mg. @ $3.00/qt.	Insecticide **OP** Fertilizer Fertilizer
Cover Spray	June	2 lbs. Guthion @ $8.02/lb. 5 lbs. Calcium Chloride @ $0.43/lb.	Insecticide **OP** Fertilizer
Leafroller Spray	June/July	2.0 lbs. Dipel @ $9.08/lb.	Insecticide
Cover Spray	July	2 lbs. Guthion @ $8.02/lb. 5 lbs. Calcium Chloride @ $0.43/lb.	Insecticide **OP** Fertilizer
Herbicide Spray	July	0.5 qts. Round-up @ $11.91/qt.	Herbicide
Minor Insect Spray	August	0.5 pt. Provado @ $59.38/pt. 5 lbs. Calcium Chloride @ $0.43/lb.	Insecticide Fertilizer
Drop Spray	Aug/Sept	Custom aerial application @ $14.25/acre 4 oz. NAA-800 @ $3.24/oz. 1 qt. Regulaid @ $5.50/qt.	NA Growth Reg. Surfactant

Table 10 (continued). Materials and services provided by operation.

Operation	Month	Material and/or Service	Chemical Type
Stop Drop Spray	September	Custom aerial application @ $14.25/acre 4 oz. NAA-800 @ $3.24/oz. 1 qt. Regulaid @ $5.50/qt.	NA Growth Reg. Surfactant
Picking	September	Supervision for 47 bins @ $1.00/bin	NA
Picking	September	Picking labor for 47 bins @ $12.00/bin	NA
Hauling	September	Custom hauling for 47 bins @ $3.00/bin	NA
Herbicide Spray	October	2/3 lb. Solicam @ $17.54/lb. 2/3 qt. Surflan @ $16.50/qt. 2/3 qt. Roundup @ $11.91/qt.	Herbicide Herbicide Herbicide
Fertilize	October	100 lbs. Ammonium Nitrate @ $0.092/lb.	Fertilizer
Rodent Control	October	8 lbs. Rozol @ $1.20/lb.	Poison
Rodent Control	Season	0.5 lb. Strychnine Milo @ 1.24/lb.	Poison
Overhead	Annual	7.5% variable cost	NA

Note: **OP** = organophosphate; **C** = carbamate.

[1] Carbaryl 4L can be used as both an insecticide and a growth regulator. In this situation, Carbaryl 4L is being used as a growth regulator.

Table 11. Itemized cost per acre for producing apples in the Wenatchee River Valley, Washington.

	Unit	Price or Cost/Unit	Quantity	Value or Cost
VARIABLE COSTS: Non-harvest Costs:		$		$
Thiram (carbamate)	lb.	4.50	8.00	36.00
Carzol (carbamate)	lb.	39.9	5.50	19.98
Carbaryl 4L (carbamate)	pt.	3.24	1.00	3.24
Lorsban (organophosphate)	pt.	6.03	3.00	18.09
Guthion (organophosphate)	lb.	8.02	6.00	48.12
Calcium Nitrate	lb.	.10	400.00	40.00
Ammonium Nitrate	lb.	.09	100.00	9.20
Superior Oil	gal.	2.60	6.00	15.60
Solubor	lb.	.80	4.00	3.20
Zinc Sulfate	gal.	1.59	8.00	12.72
Promalin	pt.	54.00	1.50	81.00
Wilthin	qt.	11.61	6.00	69.66
Regulaid	qt.	5.50	5.00	27.50
NAA-200	oz.	.82	1.00	.82
Dipel	lb.	9.08	4.00	36.32
Calcium Chloride	lb.	.43	20.00	8.60
Sorba-spray Mg	qt.	3.00	1.50	4.50
Round-up	qt.	11.91	1.17	13.94
NAA-800	oz.	3.24	8.00	25.92
Provado	pt.	59.38	.50	29.69
Solicam	lb.	20.50	.67	13.74
Surflan	qt.	16.50	.67	11.06
Rozol	lb.	1.20	8.00	9.60
Strychnine Milo	lb.	1.24	.50	.62
Rented Bee Hive	hive	35.00	1.50	52.50
Custom Aerial	acre	14.25	2.00	28.50
Casual Labor	hour	7.50	50.85	380.62
Permanent Labor	hour	12.50	31.87	398.36
Irrigation Charge & Elect.	acre	125.00	1.00	125.00
Irrigation Repair	acre	25.00	1.00	25.00
Tractor Repair, Fuel, & Lube	acre	47.31	1.00	47.31
Machinery Repair, Fuel, & Lube	acre	110.65	1.00	110.65
Building Repairs	acre	18.34	1.00	18.34
Interest on Op. Cap.	acre	74.55	1.00	74.55
Overhead	acre	131.15	1.00	131.15
Subtotal, Non-harvest cost				1931.10
Harvest Costs:		$		$
Hauling	bin	3.00	40.00	120.00
Permanent Labor	hour	12.50	11.00	137.50
Supervision	bin	1.00	40.00	40.00
Picking Labor	bin	12.00	40.00	480.00
Tractor Repair, Fuel, & Lube	acre	36.42	1.00	36.42
Machinery Repair, Fuel, & Lube	acre	9.07	1.00	9.07
Subtotal, Harvest cost				822.99
TOTAL VARIABLE COST				2754.09
FIXED COSTS:		$		$
Tractors	acre	128.91	1.00	128.91
Machinery	acre	274.63	1.00	274.63
Buildings	acre	158.09	1.00	158.09
Orchard Taxes	acre	90.00	1.00	90.00
Interest on Orchard	acre	855.00	1.00	855.00
Depreciation on Orchard	acre	384.62	1.00	384.62
TOTAL FIXED COST				1891.25
TOTAL COST				4645.34

Table 12. Hourly machinery and per acre building costs.

Machine or Building	Purchase Price	Years to Trade	Annual Hours	Deprec-iation	Interest	Insurance	Taxes	Total Fixed Cost	Repair	Fuel and Lube	Total Variable Cost	Total Cost
	$			---------- cost per hour ----------								
3/4T Pickup 4x4	25,000.00	15	600	2.44	2.10	.14	.42	5.10	.75	3.16	3.91	9.02
4-Wheel ATV	6,000.00	10	400	1.13	.84	.06	.17	2.19	.38	.63	1.01	3.20
50hp-wt, 4WD	21,000.00	15	500	2.13	2.34	.16	.47	5.10	1.50	1.81	3.31	8.41
Brush Rake	2,750.00	5	100	4.50	1.46	.10	.29	6.35	1.60	.00	1.60	7.95
Rotary Mower	3,500.00	10	150	2.00	1.20	.08	.24	3.52	2.17	.00	2.17	5.69
Trailer	2,000.00	20	100	.75	1.13	.08	.23	2.18	1.00	.00	1.00	3.18
Fert. Spreader	2,500.00	15	50	2.27	2.97	.20	.59	6.03	1.50	.00	1.50	7.53
Blast Sprayer	14,000.00	10	200	5.60	3.78	.25	.76	10.39	6.25	.00	6.25	16.64
Wind Machine	16,000.00	30	24	15.56	39.00	2.60	7.80	64.96	12.50	7.25	19.75	84.70
Weed Sprayer	2,000.00	10	200	.75	.56	.04	.11	1.46	4.00	.00	4.00	5.46
Backfork	200.00	20	150	.07	.06	.00	.01	.14	.13	.00	.13	.28
High-lift Fork	5,000.00	15	150	1.78	1.80	.12	.36	4.06	4.00	.00	4.00	8.06
Gopher Probe	60.00	10	30	.20	.09	.01	.02	.31	.00	.00	.00	.31
1/2T Pickup 4x4	25,000.00	15	600	2.44	2.10	.14	.42	5.10	.75	2.53	3.28	8.38
Picking Equipment	35.00	3	50	.23	.03	.00	.01	.27	.00	.00	.00	.27
Ladder	125.00	10	80	.16	.07	.00	.01	.25	.00	.00	.00	.25
Pruning Tools	30.00	4	25	.30	.05	.00	.01	.37	.00	.00	.00	.37
				---------- cost per acre ----------								
Mach. Shed & Shop	30,000.00	30	-	16.67	22.50	1.50	4.50	45.17	1.67	.00	1.67	46.83
Shop Tools	10,000.00	10	-	16.67	7.50	.50	1.50	26.17	.00	.00	.00	26.17
Labor Quarters	75,000.00	30	-	41.67	56.25	3.75	11.25	112.92	16.67	.00	16.67	129.58

Table 13. Itemized cost and returns per acre for producing apples in Washington State under different spray

programs.

SPRAY PROGRAM	Normal (Baseline)	No Carbamates	No Organo-phosphates	No OPs or Carbamates	One OP and One Carbamate	One OP and One Carbamate
Bins Picked (Bin = 900 lbs)	40.00	28.00	35.00	30.00	30.00	33.00
Bins Packed (40 lb. boxes)	39.00	27.00	34.00	24.00	25.00	32.00
Returns per Bin to Grower ($/bin)	125.55	125.55	125.55	125.55	125.55	125.55
Total Returns to Grower ($/acre)	4896.45	3389.85	4268.70	3013.20	3138.75	4017.60
VARIABLE COST ($/acre):						
NON-HARVEST COST						
Thiram (carbamate)	36.00	0.00	36.00	0.00	0.00	0.00
Carzol (carbamate)	19.98	0.00	19.98	0.00	19.98	0.00
Carbaryl 4L (carbamate)	3.24	0.00	3.24	0.00	0.00	3.24
Lorsban (organophosphate)	18.09	18.09	0.00	0.00	18.09	0.00
Thiodan-WP	0.00	23.10	0.00	23.10	23.10	23.10
Rally	0.00	27.50	0.00	27.50	27.50	27.50
NAA-200	0.82	1.64	0.82	1.64	1.64	0.82
Isomate C+ Dispensers	0.00	0.00	95.00	95.00	95.00	95.00
Orchex 796	0.00	0.00	132.00	132.00	132.00	132.00
Calcium Nitrate	40.00	40.00	40.00	40.00	40.00	40.00
Ammonium Nitrate	9.20	9.20	9.20	9.20	9.20	9.20
Superior Oil	15.60	15.60	15.60	15.60	15.60	15.60
Solubor	3.20	3.20	3.20	3.20	3.20	3.20
Zinc Sulfate	12.72	12.72	12.72	12.72	12.72	12.72
Promalin	81.00	81.00	81.00	81.00	81.00	81.00
Wilthin	69.66	69.66	69.66	69.66	69.66	69.66
Regulaid	27.50	27.50	27.50	27.50	27.50	27.50
Dipel	36.32	36.32	36.32	36.32	36.32	36.32
Calcium Chloride	8.60	8.60	8.60	8.60	8.60	8.60
Sorba-Spray MG	4.50	4.50	4.50	4.50	4.50	4.50
Round-Up	13.94	13.94	13.94	13.94	13.94	13.94
NAA-800	25.92	25.92	25.92	25.92	25.92	25.92

Table 13 (continued). Itemized cost and returns per acre for producing apples in Washington State under different spray programs.

SPRAY PROGRAM	Normal (Baseline)	No Carbamates	No Organo-phosphates	No OPs or Carbamates	One OP and One Carbamate	One OP and One Carbamate
Provado	29.69	29.69	29.69	29.69	29.69	29.69
Solicam	13.74	13.74	13.74	13.74	13.74	13.74
Surflan	11.06	11.06	11.06	11.06	11.06	11.06
Rozol	9.60	9.60	9.60	9.60	9.60	9.60
Strychnine Milo	0.62	0.62	0.62	0.62	0.62	0.62
Rented Bee Hive	52.50	52.50	52.50	52.50	52.50	52.50
Custom Aerial	28.50	28.50	28.50	28.50	28.50	28.50
Casual Labor	380.62	380.62	388.12	388.12	388.12	388.12
Permanent Labor	398.36	398.36	443.86	443.86	443.86	443.86
Irrig. Chg. & Elect.	125.00	125.00	125.00	125.00	125.00	125.00
Irrig. Repair	25.00	25.00	25.00	25.00	25.00	25.00
Machinery Repair, Fuel, & Lube	110.65	110.65	125.65	125.65	125.65	125.65
Building Repair	18.34	18.34	18.34	18.34	18.34	18.34
Interest on Op. Cap.	74.55	74.11	79.94	80.52	82.22	81.66
Overhead	131.15	120.82	138.15	134.62	136.61	138.57
SUBTOTAL, NON-HARVEST COST	1931.10	1952.03	2181.03	2209.78	2251.54	2233.33
TOTAL VARIABLE COST	2754.09	2537.27	2901.14	2827.02	2868.78	2910.01
FIXED COST:						
Tractors	128.91	114.89	135.35	128.35	128.35	131.85
Machinery	274.63	272.32	298.41	297.25	297.25	297.83
Buildings	158.09	158.09	158.09	158.09	158.09	158.09
Orchard Taxes	90.00	90.00	90.00	90.00	90.00	90.00
Interest on Orchard	855.00	855.00	855.00	855.00	855.00	855.00
Depreciation on Orchard	384.62	384.62	384.62	384.62	384.62	384.62
TOTAL FIXED COST	1891.25	1874.92	1921.47	1913.31	1913.31	1917.39
TOTAL COST	4645.34	4412.19	4822.61	4740.33	4782.09	4827.40
NET RETURN OVER VARIABLE COST	2142.36	852.58	1367.56	186.18	269.97	1107.59
NET RETURN OVER TOTAL COST	251.11	-1022.34	-553.91	-1727.13	-1643.34	-809.80

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