

# **Multi-level Comparisons of Organic and Integrated Fruit Production (IFP) Systems for ‘Liberty’ Apple in a New York Orchard**

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## **Background**

Increased consumer demand for healthier and more environmentally sustainable fresh fruit has driven international growth in the number of producers and the total land area utilizing organic (OFP) and integrated fruit production (IFP) systems in apple orchards. Organic agriculture is practiced on every continent, with global sales estimated to be greater than US\$23 billion (Willer and Yussefi, 2004). Market demand for organic apples is strongest in the North American and Western Europe (Peck et al., 2005), markets that New York’s conventional apple growers have traditionally accessed. However, greater disease and insect pressures, with limited pest control tools, along with insufficient research in organic tree fruit production has resulted in limited OFP in the Northeast (Table 1).

IFP is widely practiced in much of Western Europe and all of New Zealand as an alternative to conventional systems. IFP has had some market penetration in the Northeastern US with programs such as CORE Values Northeast and an IFP protocol was recently developed for NY State by Cornell University (Robinson et al., 2004), but “integrated” does not invoke the name recognition as “organic” in the marketplace and is not well understood by consumers. Both OFP and IFP apple production systems offer an alternative to the conventional apple production systems that have the potential to adversely affect agroecosystems and the environment at large (Aigner et al., 2003), agricultural workers and their families (Fenske et al., 2000; Curl et al., 2002b), and the health of consumers (Baker et al., 2002; Curl et al., 2002a). There is a great potential for increased adoption of OFP and IFP in NY as the quantity and quality of mechanical and chemical tools for these production systems increases.

Apple orchards managed by OFP follow the United States Department of Agriculture National Organic Program (USDA-NOP) standards, disallowing the use of most synthetically derived materials. The National Organic Standards Board (NOSB) approves a materials list or the guidelines for the particular inputs that are allowed in organic production for the NOP. The NOSB also sets criteria that organic growers must adhere, such as maintaining or improving soil quality. Many other international standards exist for organic certification and these need to be followed if apples are to be exported to international markets (Peck et al., 2005).

Table 1. Estimations of organic and total tree fruit production for New England based on Spring 2005 survey (Source: Merwin et al., 2005).

State	Number of organic orchards	Organic tree fruit acreage	Number of organic farms	Number of tree fruit orchards	Total tree fruit acreage
CT	2	<10	28	100	3,000
ME	10	124	280	138	3,500
MA	3	<10	212	128	4,480
NH	9	<10	86	68	2,100
NJ	2	<10	52	240	2,300
NY	22	125	312	600	50,800
PA	6	12	~ 200	790	29,000
RI	2(?)	11(?)	12 (?)	24	300
VT	13	<25	333	87	2,700

IFP also has multiple international guidelines, but presently no unified national IFP standard exists in the US. Confusion often surrounds IFP because of the similarly named integrated pest management (IPM). IPM is a decision-making tool for growers to effectively manage pests by scouting, utilizing economic thresholds, and selecting “reduced risk” pesticides. In fact both OFP and IFP utilize IPM as a tool for pest control. IFP goes beyond IPM to encompass all aspects of fruit growing in a science-based system that involves biological and chemical pest controls based on monitoring and damage-action thresholds, selection of disease-resistant and locally adapted fruit and rootstock cultivars, strict limits on fertilizer applications determined by crop nutrient status and soil fertility tests, a short-list of permissible and restricted pesticides, and on-farm inspections to certify that growers are following IFP regulations.

While both OFP and IFP systems have been implemented throughout the world there is little understanding of how these systems affect the orchard agroecosystem in the Northeast. Transitional organic and conventional apple orchards have been compared for orchard productivity in California (Caprile et al., 1994; Vossen et al., 1994; Werner, 1997; Swezey et al., 1998), and the harvest or post-harvest fruit quality of organically and conventionally grown apples have been studied in Canada and Switzerland (DeEll and Prange, 1992; DeEll and Prange, 1993; Weibel et al., 2000). In Washington State, organic, integrated, and conventional apple production systems were assessed for horticultural performance, soil quality, environmental impacts, energy efficiency, economic sustainability, and fruit quality (Glover et al., 2000; Reganold et al., 2001; Peck et al., 2006). Weibel et al. (2000) and Peck et al. (2006) found that the nutritional content of fruit are increased when apples are grown under alternative production systems. While individual components of OFP and IFP have been evaluated in Northeastern apple orchards, to date there have been no comprehensive studies to validate the feasibility or profitability of the entire OFP or IFP system, or to compare the quality and nutritional value of apples from these orchards.

A main challenge to growers considering OFP production systems in the Northeast is a formidable pest complex on tree fruits in this region, compared with most other fruit-growing areas in North America (Agnello et al, 2005). In recent years, however, several new pest control products have become available for organic production, such as spinosad formulations, the codling moth granulosis virus, pheromone confusion, and protective kaolin clay films, therefore increasing the feasibility of OFP. Additionally, consumer acceptance of disease resistant

cultivars will allow organic producers to combat fungal diseases, particularly scab and fireblight, through cultivar selection. We are conducting a comprehensive long-term experiment to compare OFP and IFP systems in an established commercial orchard in Ithaca, NY. Our goal is to evaluate the ecological, nutritional, horticultural, and economic aspects of these systems in a representative NY orchard, and to make horticultural recommendations to fruit growers. With two years of support from the Toward Sustainability Foundation (TSF) we are conducting a long-term multi-level comparison of OFP and IFP for ‘Liberty’ apple orchards.

**Objective One:** Evaluate tree physiology and fruit yields, insect and disease pest incidence, soil quality, nutrient uptake by trees, nutraceutical attributes of fruit, consumer perceptions and preferences of OFP and IFP apples, and the variable costs and returns of each system.

**Objective Two:** Create horticultural guidelines that will be transferable to growers producing apples by either OFP or IFP systems.

### **Approach and Methods**

The experiment was established in April 2004, at a 0.9-acre block of ‘Liberty’ apple trees on M.9 rootstocks that were planted in 1994 at Cornell Orchards in Ithaca, NY (see map in Fig. 1). ‘Liberty’ was introduced by Cornell’s fruit breeding program in 1978, and is considered to be one of the most disease resistant apple varieties (Whealy, 2001). The orchard is a high-density planting (622 trees/acre), trained to modified vertical-axe form, with drip irrigation. It has been under typical insect and disease management for the ten years prior to the implementation of this project, with an IPM program similar to most commercial orchards, as recommended in Agnello et al. (2005). The soil is a silty clay loam with about 4.5% organic matter. Our experiment is located at the northern upwind edge of Cornell Orchards, bordered by a highway and the university campus on one side, fallow fields and Cornell maintenance facilities on the east and west sides, and adjacent apple trees to the south. This location effectively prevents pesticide drift into our experiment. Predatory mites are well established at the site, and no residual herbicides had been used in the six years prior to the start of the experiment. The two production systems are randomized in four replicate blocks, each of which contains two plots of four contiguous rows—so that each plot contains at least 64 trees (Fig. 1). Data were taken only from the center two rows in each plot, to minimize edge effects from other treatment units. Crop protectants were applied with a compact Turbo-mist curtain airfoil sprayer (Slimline Manufacturing LTD) that reduces the potential for drift. To further minimize cross-contamination between plots, sprays were applied from one side only toward the center of plots, providing at least three buffer rows around data collection trees. Close inspection of the orchard after applications of highly visible kaolin clay material during the growing season confirmed that cross contamination among the plots of each experimental treatment was negligible. The fruit and foliage of trees in each plot were sampled weekly for insect and disease infestations. Populations of foliar arthropod beneficials, and pests such as mites, aphids, leafhoppers, and leaf-miners were compared in the two treatment systems.

**USDA-NOP certifiable organic treatments:** As mentioned above, the OFP treatment followed all USDA NOP standards and certified materials (Federal Register, 2000). For example, petroleum oils, Dipel (*Bacillus thuringiensis*), and Entrust (spinosad) were used as insecticides. These pesticides were used in conjunction with IPM practices, such as codling moth (*Cydia pomonella*) pheromone trapping, baited apple maggot (*Rhagoletis pomonella*) traps, pest

phenology models, and scouting records. Surround (kaolin clay), lime-sulfur, and Streptomycin was applied when fireblight (*Erwinia amylovora*) infections were likely based upon the CougarBlight model (Smith, 2004). The need for fungicide applications was minimal given the disease-resistance of ‘Liberty,’ but sulfur compounds were applied during mid-summer when weather conditions and scouting records indicated high risk of diseases, such as Botryosphaeria rot (*Botryosphaeria dothidea*), sooty-blotch (*Glosodes pomigena*), and flyspeck (*Schizothyrium pomi*). Organic weed control consisted of mechanical tillage, as needed, with a Rinieri side-sweep subsurface cultivator (Forli, Italy) and a Wonder Weeder (Harris Manufacturing) tractor mounted cultivator. Chemical fruit thinning occurred with applications of lime sulfur and Crocker’s fish oil (Quincy, WA). Organic fertilizers were used when a deficiency was indicated by leaf nutrient concentrations.



*Pictured is a red plastic sphere covered with an application of Tangle Foot. Above and to the right of the sphere is a small vial of butyl hexanoate, a synthesized volatile ester that mimics an aroma naturally produced by apples. The color and shape of the sphere, along with the apple aroma, attracts apple maggots, which perish when they are unable to free themselves from the sphere. These traps are hung every 30 feet in the perimeter of the experimental orchard and are an essential part of the IPM program of both systems.*

**IFP-certifiable system:** IFP followed existing certification schemes developed in Europe and New Zealand, newly developed NY IFP standards, and similar IPM practices listed for the OFP treatment. Additionally, the broad-spectrum insecticides (i.e. organophosphates, carbamates, chlorinated hydrocarbons, synthetic pyrethroids, and residual soil-active herbicides) that are often used in conventional apple orchards were not applied to the IFP treatment. Instead, IFP utilized “reduced risk” pesticides such as those used in OFP, plus dormant oil, Avaunt (indoxacarb), SpinTor (spinosad), Actara (thiamethoxam), and Acramite (bifenazate). Fungicide applications for Botryosphaeria rot, and sooty blotch/flyspeck consisted of Sovran (a strobilurin) as needed. Weeds in the IFP system were controlled by Roundup herbicide (glyphosate) in May and July of each year. Bark mulch was applied to the IFP plots in fall 2005 in an attempt to control weeds with minimal herbicide applications. Fruit thinning employed naphthaleneacetic acid (NAA) or benzyladenine (BA) in conjunction with carbaryl.

Details on the pesticide and scouting programs for OFP and IFP and organic treatments are presented in the Appendices following this proposal. Detailed records of the materials used in each system are available upon request.

**Tree, Fruit, Soil and Economic Evaluations:** Fruit were sampled at intervals from the center two rows of plots, to assess the effects of each production system on harvest maturity. At least three trees in each plot were harvested, counted and weighed on each date. A ten-fruit sub-sample was then graded for size, appearance (insect or disease infestation or damage, color and significant blemishes), soluble solids concentration, titratable acidity and pH, starch hydrolysis,

percent pre-harvest drops and average yield and fruit size per tree, as described in Wargo et al. (2003). Two consumer taste panels (double-blind) were conducted at Cornell's Food Science Department tasting facility each season. The first panel was a Triangle test, where at least 70 tasters were given three slices of apple (two from one treatment and one from the other) and asked to identify which slice is different from the other two. The second panel was a hedonic test, where panelists were asked to rate (from 1 to 9) the sweetness, tartness, overall flavor, firmness, crispness, juiciness, and overall acceptability of apple slices from each treatment. The concentrations of nutraceutical phenolics and the antioxidant activity of fruit from each treatment were assessed in the lab of Dr. Olga Padilla-Zakour at Cornell's Food Science department in Geneva, NY, as described by Eberhardt et al. (2001). Elemental nutrient concentrations in foliage and fruit were determined at the Cornell Soil and Plant Nutrient analytic facilities, by standard methods. Soil nutrient availability, organic matter content, pH, and other quality indices were evaluated in May 2004 to provide base-line reference points. In 2005, soil from each treatment was assessed at two depths (0-6 and 6-12 cm) for aggregate stability, bulk density, soil strength, aggregate stability, soil respiration, potential nitrogen mineralization, soil mineral concentrations, organic matter content, chemical properties, and microbial community fingerprint of bacteria and fungi using terminal-restriction fragment length polymorphism (T-RFLP) DNA separation techniques. Costs of production (labor plus materials) in each system were recorded, and value of harvested fruit was estimated by sales of fruit in the Cornell salesroom, prices obtained from the New York City produce terminal in Hunters Point, and prevailing prices for organic apples in local NY markets. At the end of the three-year transitional phase for organic certification, Dr. Wen-fei Uva, a Cornell Extension economist, will evaluate the relative production costs and profitability of each system for commercial growers.

### **Intended Outcomes and Impacts**

This project is the first comprehensive multi-level comparison of OFP and IFP apple production systems in the northeastern US. Previous comparative studies have not included IFP systems or economic, weed control and soil quality assessments. The few comparable studies involved conventional disease-susceptible varieties assessed by the EIQ model of Kovach, et al (1992), or were situated in arid regions of the Northwest where diseases and arthropod pests of apple are fewer and easier to control. The results from our study will be useful to many tree-fruit growers who are considering the adoption of OFP or IFP systems for their farms (Featherstone, 2000). Access to export markets in Europe may soon depend upon certifiable IFP systems in the US, and several European supermarkets already require a similar certification system—the EUREPGAP protocol. The results of this project could be vital to the future of the NY fruit industry.

*To illustrate how severe insect damage can be on unprotected apples in the Northeast, pictured at right are unsprayed 'Liberty' apples. Plum curculio weevils (*Conotrachelus nenuphar*) are responsible for the damage to these apples. This pest has been especially difficult for organic apple growers to control in the past, but was effectively suppressed in both the OFP and IFP treatments.*



## Results and Discussion

Two years after implementing this experiment, we have collected a dataset that is helping us identify the strengths and weaknesses of these two production systems. We were able to test our systems under a range of climatic conditions, with the summer of 2004 being cool and monthly rainfall well above normal and the summer of 2005 being hot with below average precipitation. In both seasons, we successfully completed all of the proposed observations, and have compiled a dataset that will help discern the long-term changes and ecological processes at work in these production systems. In this report we summarize the main trends observed during the 2004 and 2005 growing seasons.

**Orchard Productivity:** In the first season, there was little difference between the systems in terms of productivity as measured by fruit weight per acre, number of fruit per tree size, or the weight of fruit per tree size (Table 2), meaning both systems were very productive. However, the 2004 variable costs (i.e. spray materials, spray labor, hand thinning labor, weed control labor) for the OFP system were \$1,021/acre, which was twice the cost of the IFP system (Figure 1). The additional costs to the OFP systems were largely due to the eleven kaolin applications needed to maintain sufficient coverage through the rainy summer. Kaolin applications, during 2004, began in early May for plum curculio control and continued till early August for apple maggot control. The kaolin sprays effectively controlled plum curculio, and there was no apple maggot found in the fruit from either system, but there were more fruit damaged by internal Lepidoptera larvae (i.e. codling moth, lesser apple worm, and oriental fruit moth) and slightly more fruit with defects in the OFP system (Table 3). The additional cost of 2004 OFP sprays did not translate into greater returns, with the OFP fruit valued at \$9,839/acre compared to \$10,693/acre for the IFP fruit (Figure 3). Besides greater pest damage, the difference in returns was due to less OFP fruit in the larger box size categories (Table 4), which are more highly valued in the commercial marketplace.

In 2005, OFP yields were 25% greater than IFP yields (Table 2), but nearly 30% of the OFP fruit was unmarketable due to insect and physical damage (Table 3). Greater yields in the OFP system translated into greater crop density and yield efficiency, as tree size was equal between systems (Table 2). The large amount of fruit damage in 2005 was largely a product of ineffective internal Lepidoptera control in the OFP system, but almost all categories of damage were greater in the OFP system (Table 3). High cullage rates along with smaller sized fruit (Table 4) resulted in OFP returns to be \$2198/acre, which was about half as much as the \$4243/acre IFP returns. Additionally, the 2005 OFP costs were \$987, which was marginally greater than the \$843/acre for producing IFP apples. There were only four kaolin application in 2005 due to the drier conditions present and a desire for less residue on the fruit at harvest. For both treatments we were able to significantly lower the cost of production in a year where yields were expected to be below average due to a late spring frost. Costs for both systems were also lower as we learned more about how the orchard agroecosystem responds to the treatments.

The returns discussed here do not include a price premium for organic apples, as the system has only been managed organically for two of the three years needed to transition from conventional to organic management. If a 35-50% price premium, which is not uncommon for some cultivars of apples (Peck et al., 2005), were added to the OFP system the additional costs of production would be more acceptable. Northeastern growers attempting organic production need to be mindful of their pest control costs during the three year transition period or plant trees on virgin ground, thus going directly into organic production without the transition period.

Due to a residue of kaolin remaining on the OFP fruit at harvest, a cost of \$710/acre or \$0.73/bushel was estimated in 2004, but not added to the above variable OFP costs. In conversations with the manufacturer of Surround and several operators of packing houses, the kaolin residue appears to not be a major source of concern if the fruit can be run through a water based sorting line with aggressive brushes rotating in opposite directions. Additionally, if kaolin residue is a concern for the producer, applications should subside at least six weeks prior to harvest. For growers directly marketing fruit or growers who do not have access to water based packing lines this additional cost should be factored into kaolin applications and timing.



*The picture at left shows the type of protective kaolin clay deposit that is necessary to provide complete protection of foliage and fruit in the OFP treatment. In 2004, a wet year, it was difficult to maintain the necessary protective film of kaolin clay on trees in the organic system and eleven applications were needed; however, only four kaolin applications were needed in 2005. One of the weaknesses of the organic system appears to be the cost of the multiple applications needed to maintain the coverage of*

*kaolin and the negative effects of the kaolin on predacious mites. Further experimentation with application rates and timing in 2006 should help to determine the appropriate use of this material.*

OFP fruit thinning, in 2004, consisted of 3% lime sulfur (LS) followed seven days later with a 1.5% LS application, and in 2005 of two applications of 2.5% LS plus 2% Crocker's Fish oil. IFP consisted of two applications of carbaryl plus NAA in 2004 and two applications of carbaryl plus BA in 2005. In both years, both systems received additional hand thinning after these chemical thinning applications. The average OFP fruit size was smaller in both years, significantly so in 2005 (Table 2), and lead to the above-mentioned lower returns in the OFP system. Smaller fruit size is often a reflection of inadequate fruit thinning, as the more fruit per tree causes greater competition for resources. This was more clearly seen in 2005 than 2004 (Table 2).

Leaf nitrogen (N) levels were not significantly different between systems in either year, but in both years both systems were below standard ranges published by Stiles and Reid (Table 4). To remediate this situation, in fall 2005 an application of chicken compost, at a rate of 80 lb/acre, banded in the tree row, was applied to the OFP system. A three to five inch bark mulch was applied to the IFP tree rows, also in fall 2005, which should slowly mineralize N into plant available forms and increase leaf N status, while helping to suppress weeds. Manganese (Mn) levels were below published ranges for both systems in both years (Table 4), perhaps because

'Liberty' can be produced in the absence of fungicides that often contain Mn. An application of manganese sulfate can correct this deficiency. One other striking leaf mineral result was a seven-fold greater concentration of aluminum (Al) in the 2005 OFP leaf samples (Table 4). Despite leaves being triple washed before submission to the nutrient laboratory for mineral analysis, the high Al level in OFP leaves may be a result of the kaolin application as this clay particle film largely consists of aluminum silicate ( $H_4Al_2Si_2O_9$ ). Other leaf tissue mineral concentrations were either not significant between systems or within published ranges for acceptable fruit production.

*Matthew Himmel, a student worker, hand thins apples on 23 June 2005. Hand thinning is a labor intensive and therefore expensive cost for apple production. The use of chemical thinners, such as lime sulfur mixed with oils, has relieved some of the economic burdens of organic production.*



**Fruit Quality:** Harvest maturity indices, as measured by internal ethylene concentration and starch hydrolysis, were similar and peak quality was attained in both systems at the beginning of October for both seasons (Table 6). Fruit firmness, soluble solids concentration (SSC), pH, titratable acidity (TA), the ratio of SSC to TA which gives the perception of sweetness, and the percentage red coloration were statistically equivalent in 2004 (Table 6). In 2005, IFP fruit flesh was a pound firmer, as measured by penetrometer, but there was, on average, a 10% greater red blush on the OFP fruit (Table 6).

For the triangle difference test conducted in 2004, few panelists could detect the difference between OFP and IFP apples (data not shown). Additionally, in the 2004 hedonic and intensity tests, no differences were found for any of the rated attributes (Table 7). However, in 2005 the consumer panelists did detect a difference between the systems in the triangle test and upon subsequent investigation they found OFP apples to be sweeter, marginally tarter, of better overall flavor, and more acceptable overall (Table 7). Interestingly, the consumer panelists found flavor to be different between systems in the 2005 fruit, but not firmness. This is contrary to the analytical measurements mentioned above.

The antioxidant activity of IFP apples was slightly higher in 2004, although fruit from both treatments provided a healthy dose equivalent to at least 550 mg of vitamin C (Table 8). In 2005, the antioxidant activity of both systems was similar between systems, but lower than the 2004 levels (Table 8). Total phenolic content (an important group of nutraceutical compounds) was the same in fruit from both production systems (about 80 mg of gallic acid equivalents per 100 g fruit) in both years (Table 8). Fruit mineral concentrations were relatively similar between systems and years (Table 9).



*Pictured above are the Rinieri side-sweep subsurface cultivator (top left and right), the comparative effects of Roundup versus the Rinieri (bottom left) and the Wonder Weeder (bottom right). During the 2004 and beginning of the 2005 season the Rinieri was used a total of three times, but was inadequate at controlling or suppressing weeds in the OFP plots compared to the IFP plots. Grass, which is the predominant weed in this orchard, was quickly able to re-root after being cut by the Rinieri and was never effectively controlled. The Wonder Weeder features several gangs of lilliston cultivators that should provide more aggressive action against grass and other weeds, with fairly low impact on soil quality.*

**Soil Quality:** Soil fertility and tilth values were comparable between treatments for all essential plant nutrients, organic matter content (OM), pH, and cation-exchange capacity (CEC) in both years (Tables 10 and 11). Soil fertility at the outset of this study was rather good in most respects, and the trees were initially in a well-nourished condition. Soil properties measured in 2005 showed little treatment effect, but often a difference existed between the top and sub-surface soil depths. Cultivation was likely responsible for lowering the bulk density, soil strength, and aggregate stability of the top depth of the OFP soil, but no difference occurred in the lower depth (Table 12). This is a trend that will need to be monitored closely so that soil quality is not excessively compromised in the pursuit of weed free soil. No treatment differences were seen for soil respiration, the total N in the soil solution, or potentially mineralized N (Table 12). Preliminary T-RFLP data analyzed by Additive Main Effects Multiplicative Interaction

(AMMI) modeling showed the treatment difference be secondary to the difference in depth for both bacteria and fungi community structure (data not shown).

## Conclusion

It is important to note at this point that the transitional phase in organic certification lasts for three years, and our experiment is now just two-thirds of the way through that transition process. We expect that differences will continue developing in many of the variables we are measuring during future years as the treatment effects build over time. The past two years provided a good test for the treatments and practices in each system, under variable growing conditions. We were able to establish all of the experimental protocols and collect a comprehensive data set for both systems. After a successful start, we expect this project to provide vital information during the next few years for fruit growers in the Northeast, and elsewhere, who are considering adopting either of these two apple production systems in order to maintain profitability and improve sustainability on their farms. The first two seasons under the different management practices have displayed that the IFP system has the potential to become widely adapted in NY, but the OFP must overcome pest control and small fruit size issues before large-scale conversion to organic can become a sustainable option for apple production in the Northeast.

### ***Budget expenditures for 2005:***

<i>Student wages:</i> 14 weeks at 40 hrs/wk at \$8.50/hr -----	\$ 4,760
<i>Materials and Supplies:</i> Pheromone traps, pesticides, lab reagents, etc-----	850
Soil analyses—8 plots x 2 composite samples/yr at \$26-----	416
Leaf elemental nutrient analyses other than N—16 samples @ 18-----	288
Leaf carbon and nitrogen analyses—8 samples @ \$16-----	128
Fruit elemental nutrient analyses other than N—24 samples @ 16-----	384
Fruit carbon and nitrogen analyses—16 samples @ 16-----	256
Fruit polyphenol and antioxidant analyses—16 samples @ 12-----	192
Pathology and entomology sample pest identification costs—50@ \$10-----	500
Fruit taste panel evaluation fees-----	600
<u><i>Travel:</i> For personnel to &amp; from meetings and labs 800 miles @\$0.42-----</u>	<u>336</u>
 Total direct research costs during 2005 budget year-----	 \$8,710
+10% indirect cost charges to CALS administration-----	<b>871</b>
<b>Total TSF grant funds spent during 2005 budget year-----</b>	<b><u>\$9,581</u></b>

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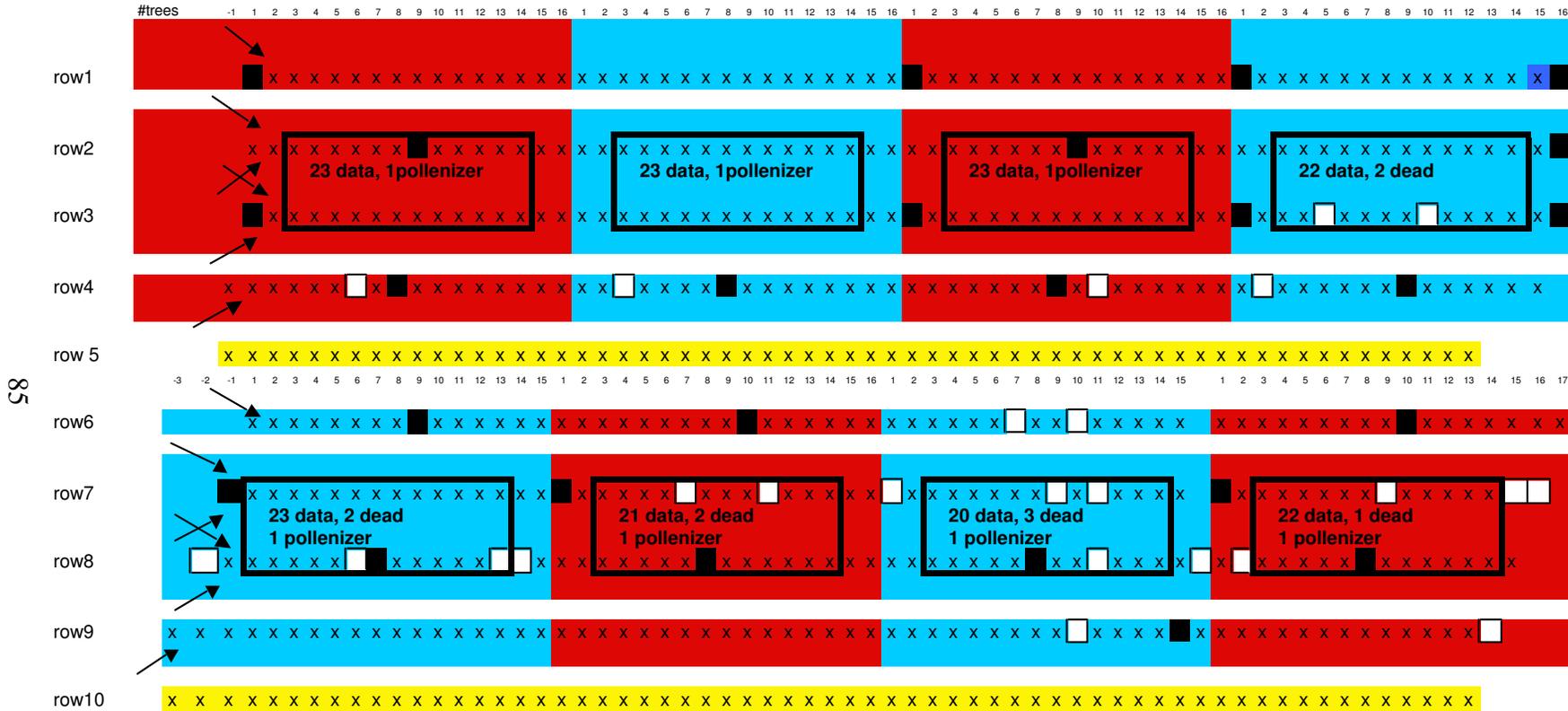
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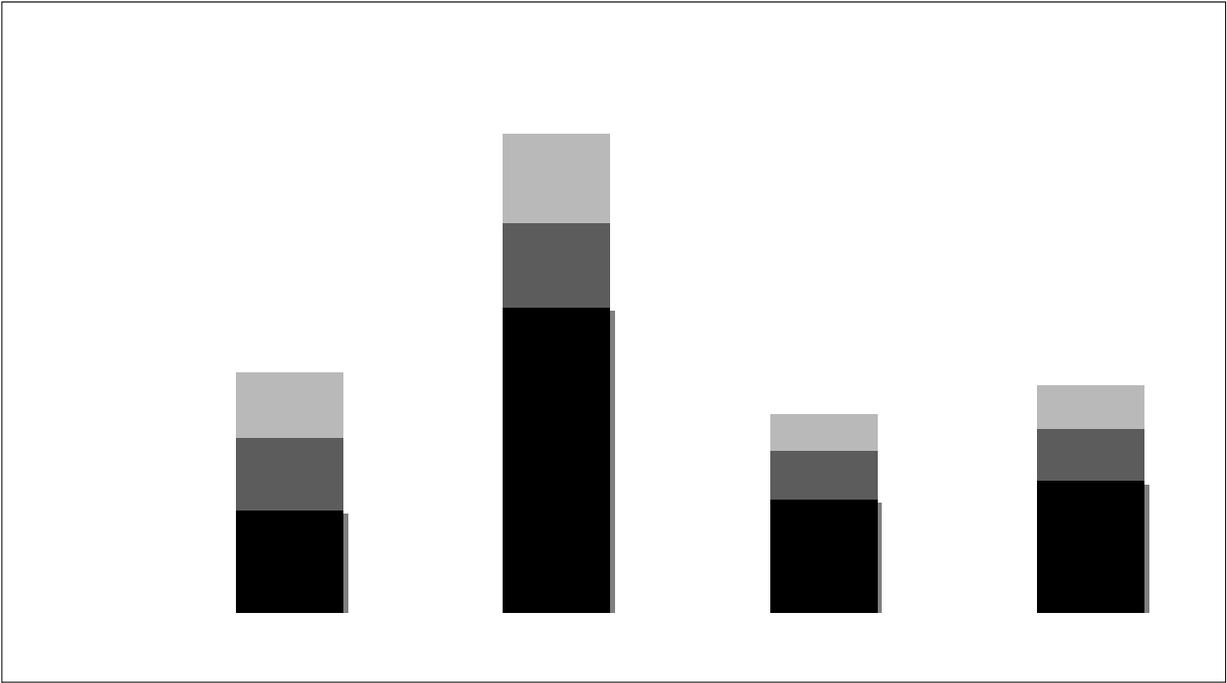
**Figure 1.** Block 94AE (Liberty Apple planting) Treatment randomization and directed spray applications for pesticides.  
 Ithaca, NY Cornell Orchards  
 (1994 planting, plot design spring 2004)

**Multi-level Comparisons of Organic and Integrated Fruit Production (IFP) Systems for ‘Liberty’ Apple Production in a New York Orchard**



**Map Legend:** Blue designates organic plots, and red IFP plots. The “x” signs represent individual trees in the planting. Arrows indicate the direction of spray applications within each treatment unit. Trees used for data collection and observations are surrounded by black rectangular perimeters within each larger treatment unit. White squares represent dead trees. Solid black squares represent pollenizer trees.





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