NEW YORK FRUIT QUARTERLY

Editorial

Agricultural Labor 2006

As we enter the month of July it would be prudent for us all to assess our position concerning our labor resources. What can we expect in the next six months? What will be the cost associated with harvest this upcoming season? Will I have an adequate pool of employees to meet my farm's needs? If any or all of these are your concerns, then you are not alone!

The unemployment rates in this country so far in 2006 have hovered at or about 5 percent. This is a rate that suggests that all those who need or desire to work, have currently found employment. There may be some shifting from job to job, but there is little need for anyone in this labor pool to seek positions in the agricultural, seasonal category. This leaves US agriculture with little recourse other than to seek those traditionally associated with the migrant stream.

The fact that there is already an enhanced border security in place has made an impact on those in this pool of potential employees. Worker shortages are already an everyday occurrence in 2006. At this point in time in 2005, there was certainly not such intense pressure to retain workers. This new awareness of the realities associated with not having workers in sufficient numbers has affected the hours and wages offered to these workers. It will be interesting to observe if Washington State, for example, releases as it has in the past, its harvest workers once the sweet cherry harvest is completed. Reports are suggesting that there will be efforts to find work to keep these workers around for the apple harvest. They learned a costly lesson in 2005 when workers that year did not need to travel as far north as Washington to find good paying jobs later in the year.

Here in New York each grower needs to stop and review all of the strategies at their disposal to insure an adequate supply of harvest workers. Each grower should realize by now that his or her potential workforce may have many more options to select from. This being the case, it becomes very important to put together the most attractive package to retain this necessary human resource. Housing, transportation and health care are factors that will be important to retaining an adequate number of workers.

The H2A program may offer some interesting options in 2006. I feel that it will provide some insurance as to the number of employees and the means to retain them. This second factor may be very important as the harvest in the state grinds on. We are already seeing offers to currently employed farm workers to move for as much as $2 more per hour.

The work in Washington, DC will continue during the summer and fall and will attempt to define how America will handle this immigration issue. Here in New York it is time to assess each farm's human resource program in order to protect your investment. This is not the time to be too conservative in your planning for harvest. If you fail to plan, you plan to fail!

Paul Baker
Executive Director
NY State Horticultural Society

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FRONT COVER: Sweet Cherry Trees covered with plastic nettings to prevent bird feeding. (Photo courtesy of NYSAES Field Research Unit.)

BACK COVER: Clean bins are essential to control postharvest rot of apples.

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Controlling Birds with Netting: Blueberries, Cherries and Grapes

Fran Dellamano
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The cost of fruit crop damage by birds is probably under-estimated by most growers, and many only realize how serious the damage is when they exclude birds with a netting system. This article explains how overhead netting can be a practical solution to bird problems in blueberries, cherries and grapes. Bird netting is also a practical economic remedy.

Bird damage varies from farm to farm and from one area to another. Birds damage fruit in three ways:

1. By eating fruit
2. Damaging fruit and
3. Causing fruit to be harvested early before full size, sugar and maturity are reached resulting in an inferior product to be marketed.

The cost of crop damage by birds is probably underestimated by most growers, and many only realize how serious the damage is when they introduce a bird netting system.

Growers have experimented with all types of easy fixes: guns, noisemakers, visual objects, etc. These, unfortunately, only work for a short time. Netting is the only control measure that will give close to 100% bird control. In the 1960's I experimented with netting, but the chemical Measurol was cheaper and easier to use. In 1989 the food label for Measurol expired and is it no longer available. When ingested, Measurol is highly toxic to birds and humans.

Figure 1. Derrick Farm homemade netting rewind machine with final roll (14'x300') beside it.

Since that time, growers have been relying on scare devices or just hoping for the best. But in many areas birds have been taking and damaging more than their share. A few small growers and home gardeners have been installing netting over individual rows. On Long Island, many premium grape growers use over-the-row netting. The NYS Agricultural Experiment Station in Geneva and a grower in New England are the only two cases I am aware of that use netting to protect sweet cherries. One blueberry grower in NY State uses overhead netting as do 10 or so in New England.

Netting

The netting for commercial growers discussed in this article is a netting cover, 6 ft to 10 ft above the ground and supported by wire. This allows routine agricultural activities under the netting such as spraying, cutting grass, and harvesting. This past year, I visited four growers that have used overhead netting for years. Their systems and procedures are discussed below.

Derrick Farm, Okham, MA Walter Derrick has six acres under netting. They use 10 ft 4" x 4" poles with about 7 ft out of the ground. The poles are installed around the perimeter of the block. At the head and foot of each row the poles are spaced 14 ft apart with wider spacing on the sides, and the perimeter poles are anchored. Plastic wire is strung along the tops of the poles with cross wires 28 ft apart. Netting with 3/4" holes that is 14 ft wide is used. It takes three people 4.5 hours/acre to put up the netting and 3 people 1 hour/acre to take it down. The netting is stored in a barn in the winter. He uses 14 gauge coated single strand electric wire cut in 4"-6" lengths instead of cable ties to attach netting to the support wires. He sells his crop U-pick.

Al Wereszezak, Herkimer, NY Al Wereszezak has been netting five acres of blueberries for 15 years. Al puts up and takes down the systems each year and stores the netting in a barn on rolls for the

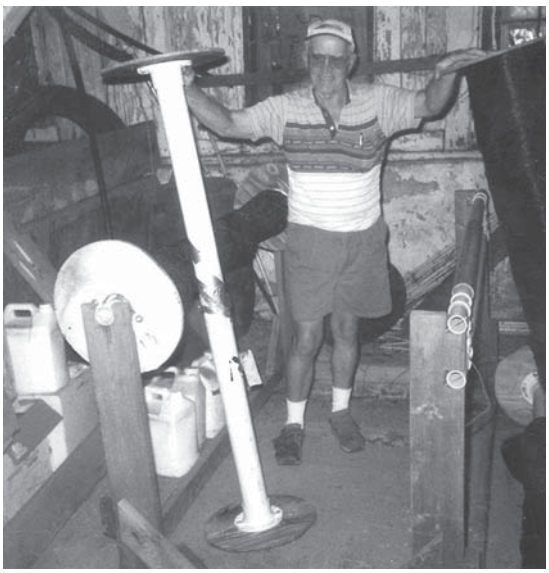


Figure 2. Al Wereszezak homemade gadget to wind up and rewind netting. He uses 45' wide netting. His right hand shows the reel core made of PVC pipe. In his left hand is a final roll of netting.

Figure 3. Al Wereszezak showing his 5 acres of netted blueberries. Note height of netting.On the ground is a homemade core for re-rolling the netting. Note the bottom wire and netting cable tied to the bottom wire.

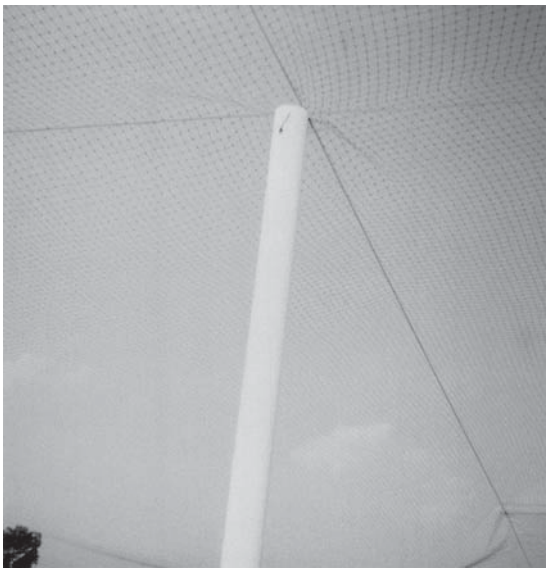


Figure 4. PVC (2") wire support used at Parlee Farm. Note wire on the top that attaches to the support wires.

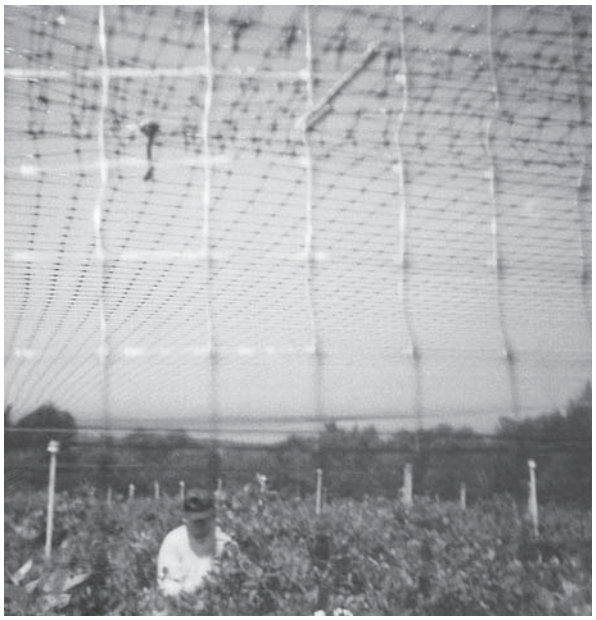


Figure 5. Netting used at Derrick Farm. Note 12 gauge copper electric wire bent on ends which is used to mend 2 rolls of netting together and to secure to support wire.

Figure 6. U-pickers at Derrick Farm. Note that excess netting lays on ground and is not attached. U-pickers lift netting to get in.

winter. It takes 19 man hours/acre to put up the system and less than 1 man hour/acre to take it down. Al does not use cable ties, but instead cuts 12" lengths of 12.5 gauge wire. The wire pieces are not straightened but still have some of the curve from the wire roll. This needle of wire is used to hold the netting together and also to hold the netting on the wire by alternating the looping down the support wire. Al buys one acre of netting each year. The cost is $700-$800/acre and the netting lasts about five years. Because Al uses 1.5 inch netting some small birds do get in. Al says netting allows him to keep berries on the bush until they are ripe and sweet. He sells his crop U-pick.

Mark Parlee Farm, Tynsboro, MA Mark Parlee has five to six acres of blueberries which he has netted for eight years. He is also putting in a new sweet cherry block on Gisela rootstock under netting. Mark sprays with a large John Deere tractor with a cab and a Jacto sprayer, both of which are high. His netting is 9'-10' tall to allow for spraying operations. The 3/4" netting comes in 14' width and is sewn together in the parking lot before installing overhead. The netting is pulled back into a sausage-type roll and tied to poles and wire for the winter. Large 6" diameter poles are used around the outside and inside where the netting is tied. Wire is strung on top of the poles. Within the netted area where two wire supports cross, a 2" PVC water pipe is used as a support. Six men can put up the netting on two acres in a day. About the same amount of time is needed to take the netting down. The annual cost of labor is about $350-$500 per acre. The cost to put up and take down the netting is high because workers must use ladders since the netting is over 8' high.

Nourse Farm Whatley, MA Tim Nourse has two acres under netting. Since he is in tobacco country, his netting support system is the same as the tobacco shade cloth system. The poles

are 30" x 30". The outside poles are anchored, and the netting is over 8' high to facilitate spraying operations with big equipment. Wood Hyacinthia stakes are used to hold the netting together and to the wire. Nourse Farm uses plastic wire, and they remove the nets for the winter. They cover the tops of the poles with some type of smooth protection (rubber inner tubes, plastic bottles, etc.) to prevent the net from catching on the pole as it moves in the wind.

TABLE 1

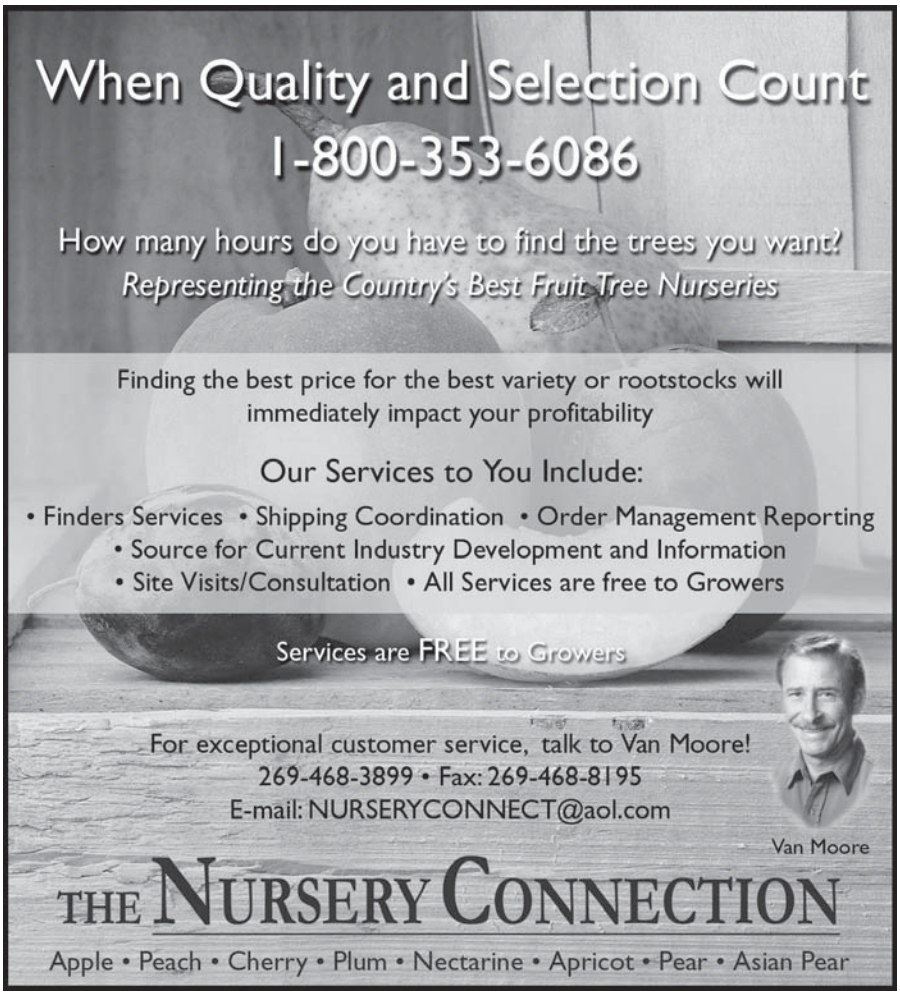
Material cost and labor to erect a 1 acre bird netting system (7-8 feet above ground).

Items	Cost/acre
25-10' poles (5-6"diam)	$ 600
20-6' poles for anchors (5-6"diam)	$ 200
1 roll of 12.5 gauge high tensile wire	$ 80
Labor to pound poles	$ 500
Misc. items	$ 250
Netting	$ 650
Total	**$2,280**

TABLE 2

Annual labor and materials cost and labor to erect and takedown a 1 acre bird netting system (7-8 feet above ground).

Items	Cost/acre/year
Netting ($700/acre for 5 years)	$ 140
Interest on cost of system (5% on $2,288)	$ 114
Wire and pole	$ 64
Labor to put up and takedown nets (30 hours @ $10/hour	$ 300
Total	**$ 619**



Conclusions

1. Growers who are using overhead netting consider it a profit generator rather than a financial liability by increasing yield and allowing proper fruit maturity before harvest.
2. If netting is installed higher than 7' the installation and removal costs increase dramatically. It may be less expensive to purchase low-profile tractors and sprayers.
3. For sweet cherries, where netting needs to be 12' to 14' high, growers have devised catwalks over a tractor or wagon to save time in installation and take down.
4. I believe that using cable ties may be too time consuming, especially during removal when they must be cut. The short lengths of wire that Al Weresyezak uses appear to be very efficient. Also, Walt Derrick's use of electric copper wire seems better than cable ties.
5. Netting that has 3/4" mesh is needed to keep small birds out. A 1.5" mesh may be satisfactory as used by Al Weeresyezak. In a sweet cherry trial at the Geneva Experiment Station, rain nets above the trees with 6" gaps between the nets and bird netting only on the sides has provided excellent bird control. Typically birds do not dive down through holes in the top, thus netting with 1.5" holes may be used on the top and netting with 3/4" holes on the sides. Dr. Paul Curtis of Cornell University points out that this strategy may not work if small birds learn to perch on support wires or poles and then go through the netting from the top.
6. Pounding support poles gives a stronger support system than augering in the poles. The only way to set a pole with a dug hole is to add cement. The outside poles still need bracing with a shorter smaller pole pounded outside the netted area serving as an anchor.

Fran Dellamano is a retired Cornell fruit extension educator. He currently is a fruit farmer and provides farm supplies and consulting to the fruit industry.

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Keeping Apples Disease-Free During Storage and Shipping

David Rosenberger, Anne Rugh, and Frederick Meyer

Cornell University's Hudson Valley Laboratory, Highland, NY

This work supported by the New York Apple Research and Development Program and the New York Apple Research Association.

Most inoculum of blue mold decay recycles from year to year on field bins. Good bin sanitation can keep inoculum levels low. If fruit must be treated with diphenylamine after harvest to control physiological storage disorders, then adding either Scholar or Penbotec to the drench solution will protect fruit from decay inoculum that collects in the drench solutions.

Blue mold and gray mold are the most common postharvest diseases of apples. Blue mold decays are soft, watery, and have a musty or earthy odor. The blue mold pathogen, *Penicillium expansum*, invades fruit wounds or fruit stems during long-term controlled atmosphere storage.

Fruit with gray mold often look like baked apples because they have a uniformly light tan skin, fairly firm flesh, and a cider-like odor. The gray mold pathogen, *Botrytis cinerea*, can invade fruit at wounds, but it also infects fruit in the field. In other crops, such as strawberries and kiwi, *B. cinerea* infects fruit during or shortly after bloom, then remains quiescent until fruit begin to ripen. Gray mold in stored apples often originates at the calyx end of fruit, a location that would be consistent with field infections of the calyx shortly after bloom.

When first introduced, the benzimidazole fungicides thiabendazole (Mertect 340F), benomyl (Benlate), and thiophanate-methyl (Topsin M) provided excellent control of both *P. expansum* and *B. cinerea* when applied in postharvest drenches. Even though benzimidazole-resistant strains of both pathogens emerged soon after these products were introduced in the 1970's, the benzimidazole fungicides continued to provide good control of blue mold decay until the early 1990's because the fungicides were almost always applied with diphenylamine (DPA). DPA suppressed benzimidazole-resistant strains of both pathogens. Gray mold can still be controlled using postharvest drenches that contain DPA plus thiabendazole (Mertect 340F). By the mid-1990's, however, blue mold had become a serious problem in some storages in New York State because *P. expansum* had developed resistance to the benzimidazole-DPA combination.

Epidemiological Studies

Studies were initiated in the mid-1990's to identify inoculum sources for *P. expansum* and sanitation methods that could be employed to reduce inoculum levels. Contaminated field bins were shown to carry huge quantities of inoculum from one season to the next, with some bins carrying more than 10^9 spores per bin (Table 1). Spores on contaminated bins are washed off the bins in autumn when the apples in the filled bins are given postharvest treatments using recycled drench solutions. Inoculum that accumulates in the drench solution causes decays, which can result in even dirtier bins being returned to the field the next season. Sanitizing bins has been shown to remove 99% of viable conidia, but few packinghouses routinely sanitize bins because of the cost involved and questions about the economic benefits of bin sanitation.

Although field bins were identified as a major inoculum source for *P. expansum*, the relative importance of recycled inoculum from field bins, as compared to "new" inoculum originating from the field each year, raised questions about the value of

TABLE 1

Numbers of viable *Penicillium* spores per bin that were released into wash water as determined by washing bins with a portable drencher and dilution-plating sub-samples from the wash water.

	Number of spores per bin recovered in wash water*
Summer 1999	
Group I non-sanitized oak bins	8.35×10^8
Group I following fresh sanitizer wash	1.54×10^6
Group I washed at the end of sanitizer usefulness	7.44×10^6
Group II non-sanitized oak bins from another CA room	4.25×10^8
Summer 2000	
Wooden bins (mixed oak and other wood)	2.23×10^9
Plastic bins from the same storage room	4.82×10^8

*Means were derived from washing five replicates of 5 bins each in 1999 and four replicates of five bins each in 2000. All of the non-sanitized bins contained dried-up decayed fruit that had been left in the bins as they were bundled at the end of the packing lines, and the decayed fruit present in the bins may have accounted for much of the inoculum.

bin sanitation. The effort to sanitize field bins might be wasted if large quantities of inoculum could be brought into the storage each year on apple surfaces or via soil stuck on the runners of field bins. Therefore, we initiated work to quantify populations of *P. expansum* that could be found in orchard soil and on apples at harvest time.

Quantifying *P. expansum* in orchard soils: Quantifying *P. expansum* populations in soil is difficult because of the diversity of organisms present in soils. To deal with this problem, we modified a selective medium described by Hocking and Pitt (1980) so that it could be used to isolate *P. expansum* from soil and from other environments that harbor a diverse microflora. The selective medium we used, DG18-P, does not prevent growth of other species of soil-inhabiting *Penicillium*, so quantifying *P. expansum* density in soils still required that colonies appearing on soil dilution plates be sub-sampled onto Czapek yeast-extract agar (CYA) where *P. expansum* could be readily identified due to its distinctive colony morphology and growth rate. Nevertheless, this selective medium provided a useful tool for quantifying inoculum from different sources.

Soils from five different apple orchards near Highland, NY, were sampled at various times during 2004 and 2005. In the four orchards that were being actively managed, soil was collected from the herbicided area beneath the tree canopy. The fifth orchard had been abandoned about 20 years ago and was largely overgrown with weeds, brambles and other shrubs. In each orchard, samples were collected from within the drip-line of five different trees that were separated by at least 10 meters. Soil was sampled by removing surface debris and/or cover plants with a shovel and then collecting approximately 50 cc of soil from the upper 8 cm of the soil profile at five different locations beneath each of the five sample trees. The five sub-samples from each tree were mixed together, but the bulked subsamples from each tree were evaluated separately to provide five replicate evaluations from each orchard.

Population densities of *Penicillium* species in the soils were determined by dilution plating on DG18-P agar. Three arbitrarily selected *Penicillium* colonies from each of ten soil-dilution plates were sub-cultured onto CYA plates for species identification. In a few cases where soil dilution plates had low numbers of colonies, more than three subcultures were taken from other plates in the same replicate to bring the total number of subcultures to 30 per replicate, or 150 per orchard. Benzimidazole resistance of all 150 subcultures per orchard was determined by stab-inoculating PDA amended with 5 ppm MBC (the fungicidal metabolite in benomyl and thiophanate-methyl). The relationship between the weight of the soil sampled and soil dry weight was determined by drying 4 grams of soil for 24 hours in a drying oven set at 100 °C. The ratio between original sample weight and dry weight was used to adjust counts so that the final concentration of *Penicillium* species in soil could be expressed as the number of colony-forming units (cfu) per gram of dry soil.

Densities of *P. expansum* in orchard soils ranged from 14 to 218 cfu/g of dry soil in the managed orchards but were roughly 10 times higher in the abandoned orchard (Orchard E, Table 2). Spore densities in orchard soils were surprisingly consistent from year to year in the four orchards soils that were evaluated in both 2004 and 2005.

We assumed that even in a worst-case scenario involving wet harvest weather with soil occasionally balled into the bin runners, bins would be unlikely to carry more than an average of 1 kg soil into drench solutions. Given that assumption, the contribution of orchard soils to build-up of *P. expansum* inoculum in postharvest treatment solutions is dwarfed by the inoculum that can originate with badly contaminated bins (Table 1). Contaminated bins can carry 10,000 times more inoculum than a kilogram of soil from the managed orchards that we tested and more than 1,000 times more inoculum than would be contained in a kilogram of soil from the abandoned orchard we tested.

Quantifying *P. expansum* on apple fruit at harvest: To determine how much inoculum may come into storages on the surface of harvested fruit, 10 arbitrarily selected apple fruits were harvested from each of three trees in four different orchards during the fall of 2005. One of the orchards was sampled on two different

TABLE 2

Results from sampling orchard soils in the Hudson Valley to determine populations of *P. expansum* and proportions of the populations that were benzimidazole-resistant.

Orchard	sampling date	cfu *Penicillium* species per g soil[z]		*P. expansum* as a percent of total *Penicillium* population	% *P. expansum* with benzimidazole resistance[x]	Estimated *P. expansum* spores per bin assuming 1 kg soil/bin
		all species	*P. expansum*[y]			
A	23-Jul-04	262	33	12.6	27	33,000
A	17-Jun-05	1008	218	21.6	24	218,000
B	3-Sep-04	3,440	182	5.3	0	182,000
B	17-Jun-05	1626	186	11.4	1	186,000
C	30-Jun-04	298	14	4.7	8	14,000
C	9-Jun-05	698	46	6.5	10	46,000
D	19-Jul-05	310	40	12.9	13	40,000
E	8-Sep-04	15,268	2,137	20.6	0	2,137,000
E	16-May-05	5,447	1,610	29.6	0	1,610,000

[z] The number of colony-forming units (cfu) was determined by dilution plating and is roughly equivalent to the number of spores present in the soil.

[y] The proportion of *P. expansum* present in the total population of *Penicillium* species was determined via sub-sampling onto Czapek yeast-extract agar.

[x] Incidence of benzimidazole resistance was determined by stab-inoculating agar plates amended with 5 ppm MBC.

TABLE 3

Results from washing apple fruit collected in Hudson Valley orchards to determine populations of *P. expansum* present on fruit surfaces at harvest.

Orchard	Variety/treatment	Sample date	Mean cfu/apple	No. of sub-cultures evaluated	% of total cfu that were *P. expansum*	Estimated *P. expansum* spores/bin of 2000 apples
A	Empire	21-Sep-05	52.0	540	28.3	29,467
A	Empire	**17-Oct-05	3.0	90	10.0	600
B	Rome Beauty	21-Oct-05	15.3	315	14.6	4,478
C	Golden Delicious	21-Sep-05	5.3	180	8.9	948
D	Delicious	21-Oct-05	20.7	315	19.7	8,135
HVL-1*	Honeycrisp	8-Sep-05	50.0	84	59.5	59,524
HVL-2	Honeycrisp	8-Sep-05	22.5	84	21.4	9,643
HVL-3	Honeycrisp	8-Sep-05	36.3	84	34.5	25,030

*Samples from Hudson Valley Lab research plots left unsprayed during summer (HVL-1) or sprayed with Topsin M + Captan (HVL-2) or Pristine (HVL-3) one day prior to sampling.

** Spore numbers were presumably reduced compared to earlier sampling in the same orchard due to 13.5 inches of rainfall that occurred 7-15 October.

dates. In addition, 10 apples were collected from each of four different Honeycrisp trees in replicated experimental plots that had received different summer fungicide regimes as part of a separate experiment at the Hudson Valley Lab. In all cases, fruit were brought to the lab where they were washed for 30 seconds in 500 ml of sterile distilled water containing 0.01% Tween 20. The wash water was then filtered to trap the *Penicillium* spores. The filter was subsequently washed in 5 ml of sterile distilled water and a sub-sample of that wash water was spread onto each of 5 plates of DG18-P agar. Plates were incubated at 25 °C for seven days, after which all visible colonies on the plates were counted. Varying numbers of arbitrarily selected colonies from each plate were sub-cultured onto CYA plates to determine what proportion of the *Penicillium* population on apple fruit consisted of *P. expansum*. Results were expressed as numbers of all *Penicillium* species per fruit and numbers of *P. expansum* per fruit (Table 3). The potential spore load for a full field bin was calculated by assuming that a field bin would hold approximately 2000 fruit.

The *P. expansum* populations on fruit surfaces ranged from a low of about 9 to a high of 28 cfu/fruit in the five samples taken from sprayed orchards (Orchards A-D, Table 1). In Orchard A, where fruit were collected from the same block of trees on both 21 September and again on 17 October, the significantly reduced population detected in the second sampling was probably attributable to the week of heavy rain that immediately preceded the second sample date. Empire apples were still available in this orchard on 17 October because some fruit damaged by hail during early summer were not harvested.

The number of *P. expansum* spores detected on Honeycrisp fruit in our fungicide trial was greatly affected by the fungicide treatments (Table 3). Fruit from control trees that received their last fungicide spray (Topsin M 11 oz/A+ Ziram Granuflo 4 lb/A) on 19 July had more than twice as many *P. expansum* spores as fruit that were sprayed with Pristine (4.8 oz/100 gal) the day prior to harvest. Trees treated with Topsin M 4 oz/100 gal plus Captan 80WDG 10 oz/100 gal on the day prior to harvest had only one-sixth as many *P. expansum* spores as control trees (Table 3). Nearly 60% of all *Penicillium* spores on apples from control trees turned out to be *P. expansum*, whereas only 21% and 35% of the *Penicillium* spores on fruit from the Topsin M/Captan and Pristine treatments, respectively, were *P. expansum*. Those results suggest that the fungicides may be more effective against *P. expansum* than against some of the other *Penicillium* species that are present in orchards. Based on our limited sampling in 2005, the numbers of spores that might be brought into storage on fruit surfaces is dwarfed by the inoculum previously measured on contaminated field bins (Table 3).

The accumulated evidence from measuring *P. expansum* populations on field bins, in orchard soils, and on apple fruit at harvest suggests that badly contaminated field bins are by far the most important potential source of inoculum for *P. expansum* under conditions prevalent in New York State. In the absence of effective fungicides, sanitizing contaminated field bins should reduce losses to blue mold decay in storages where decay has gradually increased from year to year. Where storage operators choose to use one of the new fungicides (pyrimethanil or fludioxonil) to control *P. expansum*, bin sanitation should still be used to reduce selection pressure for resistance to these new fungicides. It may not be cost effective to sanitize all bins every year, but badly contaminated bins (i.e., those showing visible blue stains from fruit that had blue mold decay) should always be sanitized before they are returned to the orchard for refilling.

Postharvest Fungicide Options

The best option for minimizing blue mold decay in stored fruit involves using clean bins, avoiding drenches after harvest, and storing apples in sanitized storage rooms. Sanitation alone can significantly reduce the incidence of decay as illustrated by the experimental results from inoculations with varying inoculum densities (Table 4). However, postharvest treatment with diphenylamine (DPA) may be needed to control storage scald and/or carbon dioxide injury with some cultivars. Postharvest fungicide treatment may also be desired to control gray mold decay caused by *Botrytis cinerea*. When fruit are moved into storage without a postharvest treatment, the incidence of blue mold is usually low, but gray mold sometimes emerges as a problem.

Thiabendazole (trade name: Mertect 340F) and captan are still registered for postharvest treatment of apples. Captan is usually used in combination with Mertect 340F. Many storage operators report that the combination of Mertect 340F and captan is more effective than Mertect 340F used alone. However, in repeated

TABLE 4

Effects of inoculum density and 1-MCP treatment on incidence of decays caused by *P. expansum* following wound inoculations at harvest in 2004 and 2005.

Inoculum density: Number of spores/wound:	% fruit with decay				Grand means for effects of inoculum density
	No 1-MCP applied		With 1-MCP applied		
	2004 63 days	2005 60 days	2004 63 days	2005 60 days	
5	9 a[z]	48 a	13 a	72 a	40 a
25	23 b	64 b	27 b	89 b	56 b
100	36 c	80 c	43 c	94 c	67 c
Grand means: 1-MCP effects[x]	**44 A**		**56 B**		

[z] Means within columns followed by the same small letter are not significantly different ($P \leq 0.05$) as determined using Fisher's Protected LSD to separate means from the two-way analyses.

[x] The grand means for effect of 1-MCP treatment represent the means of all three inoculum concentrations for both years of the experiment and were significantly different ($P \leq 0.05$).

testing where wounded fruit were inoculated just prior to application of fungicides, captan has always been less effective for protecting fruit than are Penbotec, Scholar, and (in the absence of resistance) Mertect 340F. The difference between perceived effectiveness of captan in commercial operations as compared to controlled trials may be related to the way captan works. Captan may kill spores that accumulate in drench solutions, thereby decreasing inoculum availability and reducing fruit infection, even though it performs poorly in controlled tests where inoculum is applied to fruit just before or after captan treatment. That hypothesis is currently being tested.

Two new fungicides were recently registered for postharvest treatment of apples in the U.S. Pyrimethanil (trade name: Penbotec) and fludioxonil (trade name: Scholar) are extremely effective for controlling blue mold and gray mold on apples. Both Penbotec and Scholar are fully compatible with DPA and calcium chloride. Both products are very stable and hold up well in postharvest drench solutions. Both products are registered for use in drenches as well as for application in packinghouse line sprays. The line spray application should reduce chances that decays will develop in packed fruit after it enters distribution channels.

Packinghouse operators choosing to use these new fungicides should use Penbotec in one year and Scholar the next year so that *Penicillium* spores that recycle on bins will not be repeatedly exposed to the same fungicide year after year. Penbotec and Scholar have different modes of action, and both of them are distinctly different from Mertect 340F. Alternating annually between Penbotec and Scholar should reduce selection pressure for resistance to both of these new fungicide chemistries. Adding captan to the Penbotec or Scholar in drench solutions might further reduce selection pressure for resistant isolates, but that strategy needs further testing before it can be recommended. Alternation of chemistries for fungicides applied in packinghouse line sprays is of less concern because the treated fruit are moved into the retail supply chain before any surviving infections can sporulate, thereby reducing or eliminating selection for fungicide resistance.

Although Scholar and Penbotec are approved for use in the United States, residue tolerances for these fungicides have not yet been established in some apple-importing countries. Before applying these fungicides to apples destined for export, packinghouse operators should verify that the importing country will accept product treated with the fungicide in question. A database of approved MRLs (maximum residue levels) for various commodities and countries can be found at the following website: http://mrldatabase.com.

Effect of 1-MCP on Postharvest Decays

Studies were conducted in NY to determine if 1-MCP makes apples more susceptible to postharvest decays, but our results were not always consistent with results from researchers in other areas. In experiments we conducted during the 2003-

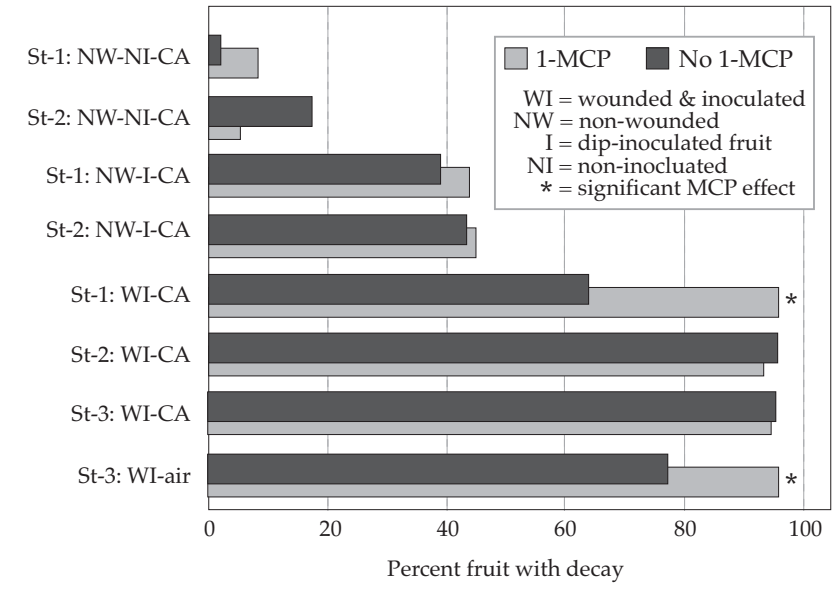


Figure 1. Effects of 1-MCP treatment on incidence of decay in experiments initiated in fall of 2003. Treated and non-treated fruit were held in three different CA storages, and a comparable sample was held in air storage at St-3. None of the fruit in these experiments received any postharvest fungicide treatment.

TABLE 5

Effects of fungicide and 1-MCP treatments on fruit firmness and on development of blue mold decay in wound-inoculated Empire apples that were stored in cold air for 90 days at 36°F.

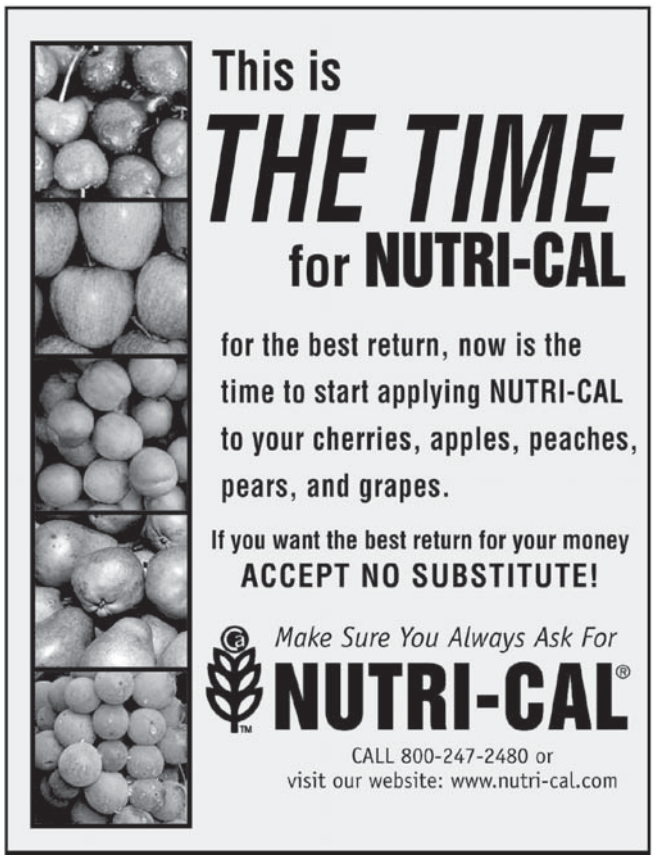
Material and rate of formulated product per 100 gal drench solution	% fruit with blue mold		Mean fruit firmness (lb)	
	With 1-MCP	No 1-MCP	With 1-MCP	No 1-MCP
Control	100*b*	94 b	11.1 a	9.1 a
Mertect 340F 16 fl oz	100*b	86 b	11.3 a	9 a
Scholar 50W 8 oz	0 a	1 a	11.3 a	9.3 a
Penbotec 40% 16 fl oz	0 a	0 a	11.3 a	9.5 a
Grand means: effects of 1-MCP			**11.2 B**	**9.3 A**

*Means within columns followed by the same small letter are not significantly different ($P \leq 0.05$) as determined using Fisher's Protected LSD to separate means from the two-way analyses. Means followed by asterisks indicate significant differences between simple means for fruit with/without 1-MCP treatment.

2004 storage season, fruit treated with 1-MCP developed more decay than non-treated fruit in one of seven observations involving fruit held in three different CA storages, but treatment with 1-MCP had no statistically significant effect on decay development in the other six CA trials (Figure 1). However, in one trial in 2003 and in a number of subsequent experiments, inoculated fruit held in cold-air storage developed more decay when treated with 1-MCP than did non-treated fruit.

In an experiment conducted at the Hudson Valley Lab in 2004 and repeated in 2005, wounded Empire apples were inoculated with *P. expansum* using three different inoculum densities. Some fruit were treated with 1-MCP and other fruit were stored without treatment. All of the fruit were held in cold-air storage at 36° F for approximately nine weeks. Incidence of decay was consistently higher in fruit treated with 1-MCP than in non-treated fruit (Table 4).

Why have our trials and those of other researchers provided inconsistent results concerning effects of 1-MCP on decay incidence? We suspect that results vary depending on storage conditions (CA or cold-air) and varying delays between the application of 1-MCP and the establishment of the CA atmospheres. Both 1-MCP treatment and low-oxygen storage conditions may disable the natural defense mechanisms that allow stored apples to defend themselves against infections by



P. expansum. When apples are held in cold-air storage, 1-MCP treatment may slow or arrest the normal wound-healing response in the fruit, but low-oxygen conditions in CA storage probably have the same effect. As a result, comparisons of decay development in inoculated fruit would show an effect of 1-MCP treatment in cold-air storage, whereas that effect might be masked in CA storages.

Even if treatment with 1-MCP slightly alters the susceptibility of apples to postharvest infections, another experiment showed that such differences are not detectable if fruit are treated with effective postharvest fungicides. For that experiment, uniformly wounded Empire apples were immersed for 30 seconds in a suspension containing 10,000 spores/ml of *P. expansum*, with half of the spores from a benzimidazole-sensitive isolate and the other half from a benzimidazole-resistant isolate. Fruit were then immersed for 30 seconds in either water or fungicide suspensions. Fungicide treatments were similarly applied to equal numbers of non-wounded, non-inoculated fruit that were used for firmness evaluations at the end of the experiment. The day after fruit were inoculated and fungicide treatments were applied, half of the wounded and inoculated apples and half of the non-wounded, non-inoculated apples from each treatment (i.e., 20 fruit per replicate) were exposed to 1 ppm 1-MCP. All fruit were then moved to a 36°F cold room where they were held until 3 January. Inoculated fruit were observed for decay development after 90 days of cold storage. Firmness of the non-wounded, non-inoculated apples was determined at the same time using 20 fruit from each of four replicates and testing opposite sides of each fruit.

Mertect failed to control decay because the inoculum included resistant isolates, but the other fungicides provided excellent decay control through 90 days of cold storage (Table 5). Fruit treated with 1-MCP were significantly firmer than those not receiving 1-MCP treatment, but none of the fungicide treatments had any effect on fruit firmness. This experiment clearly showed that even under high-inoculum conditions, 1-MCP treatment will not adversely affect fungicide performance, nor will fungicides interfere with the effectiveness of 1-MCP treatments.

The introduction of 1-MCP may have helped to reduce losses to decay during long-term storage by delaying fruit senescence and allowing fruit to arrive in stores in better condition. Grocery store surveys have shown that the incidence of decays in fruit in poly bags has declined since 1-MCP was introduced. It is impossible to determine if the reduction of decay in bagged fruit in grocery stores is attributable to effects of 1-MCP, or to other factors such as improved packinghouse sanitation. It is most likely that a combination of factors is involved for the improved quality noted in grocery stores over the past several years.

Summary

Studies on inoculum cycling of *Penicillium expansum*, the cause of blue mold decay in stored apples, has shown that most inoculum recycles from year to year on field bins. Proper bin sanitation can keep inoculum levels low, and the incidence of decays in wounded fruit declines as inoculum levels are reduced. If fruit must be treated with diphenylamine after harvest to control physiological storage disorders, then adding either Scholar or Penbotec to the drench solution will protect fruit from decay inoculum that collects in the drench solutions. Although treatment with 1-MCP can make fruit more susceptible to decay when fruit are held in air storage, 1-MCP treatment does not appear to affect decay incidence in CA storages.

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David Rosenberger is a research and extension professor of Plant Pathology and superintendent of the New York State Agricultural Experiment Station's Hudson Valley Lab. He leads Cornell's research and extension program in postharvest diseases. Anne Rugh and Frederick Meyer are research technicians who work with Dave.

Will I Be Able to Plant the Next Great Apple? The New Paradigm in Apple Varieties

Peter Ten Eyck
Indian Ladder Farms
Altamont, NY

Most new apple varieties worldwide are being introduced to growers and the wholesale fruit marketplace as managed clubs. This limits who can grow and sell the variety but may also avoid overproduction and may improve grower returns. The NY fruit industry needs to work with Cornell University to ensure a mutual understanding of how new varieties from Cornell will be introduced.

In the 40 plus years since I got my degree in pomology at Cornell I have struggled to maintain the tradition of growing apples in Albany County. In 1935 a survey in the county was conducted and reported that there were 52 farms whose principle source of income was from apples. Barrels of 'Helderberg' apples were still bringing premium prices on the wharves of New York City.

Indian Ladder Farms is now in its 90th year of business and my daughter Laura and I are trying to figure out what to do. We can't find any comfort in the fact that we are one of the two remaining fruit farms left in the county and since we choose to retire the development rights on our farmland instead of installing an 18 hole golf course, our only course of action is to stay in farming. I find that I am not able to sell apples to Wal-Mart or the other big chains. Even with high quality fruit there is no way that I can be the lowest cost producer and make a profit on the traditional apple varieties in the ground. Most of my orchard is planted to yesterday's 'McIntosh' and 'Empire' at wide row spacing, and I can no longer be satisfied with a 500 bu. per acre yield. Thus, we are planning on growing fruit for our friends and neighbors in a sustainable manner. And the most important aspect of being sustainable is to be able to make a living doing it!

The first step is to replant about 5% of the orchard every year. This means no tree is over 20 years in age and there are multiple opportunities to change the "stocks in your portfolio" This way you can stay light on your feet to new technology and market changes.

The second step is to decide what is the apple the consumer will want to buy during the 20 year lifespan of a tree. What characteristics do I need to look for in a new variety?

It needs to be flavorful, crisp and juicy and have an excellent storage and shelf life.

Most of all it must have some aspect that clearly defines it from the rest of the pack.

Apples average 12 to 13 Brix in sweetness. It takes at least a 1% increase to be able to detect a change in sweetness, so to be distinctly different a minimum of 12% to 14% would be required. I understand that new selections can have soluble sugars as high as 19 or 20%.

Hardness and crispness are extremely important components in today's marketplace. Apples coming out of storage need to have a minimum firmness of 13 pounds and several pounds firmer for the future. A new variety must not only have this attribute but also the ability to hold its firmness under a variety of environmental effects such as growing and storage conditions

Acidity is also necessary to provide balance in the taste of apples. 'Honeycrisp' has surprisingly high acidity, which complements its sugar. The trouble is that everyone's perception of acid is different.

Finally there are the issues of aromatics and flavor which will help me make my choice of a new variety to plant.

I am not even going to go into the issues of the tree and whether it will be an early and annual bearer and well adapted to my soil and climate.

'Pinova' was a variety that I was watching that had a lot of the characteristics I have mentioned and when they changed the name to 'Corail' I ordered some trees. But the next spring, about the time I was expecting delivery, I was told the variety had been "taken private" by the Stemilt Co. in Washington and trademarked with the name 'Pinata' a my order was cancelled.

Who owns these apple varieties anyway? If they came out of some land grant University don't they belong to the apple growers of that state?

It turns out to be more complicated than that. The plant patent act of 1970 gives plant breeder's intellectual property rights to new plant varieties and in 1980 a Supreme Court decision decided that living things could be patented. Research Universities received and have invested huge amounts of taxpayer dollars in buildings, orchards and people to develop new apple varieties for the public good. Traditionally what was good for the growers was considered the same as the public good. Times have changed and tensions have developed in the system. There has been polarization between the large and small grow-

ers. The top 20% of the growers are large and grow 80% of the apples (although these farms are still family farms). They most likely will be the survivors because they are lowest cost producers. The majority of the growers in the state are smaller and mostly trying to market directly to the consumer with a wide variety of crops and dealing with a public that no longer eats to sustain themselves but eats as a recreational experience. We have become a nation of food grazers! A few large and well capitalized farms have become international and vertically integrated. Can universities justify applied research to these companies? Can they justify receiving research dollars from these companies in the name of the public good? Universities have also broadened and deepened their research agendas, shifting to more basic research, crowding out applied research.

The world has become small with local products on the shelf next to products from any country you can name. The cost of developing a new variety is very high and even with a few thousand dollars invested by the growers themselves, universities find it difficult to compete. New Zealand has the largest and best known breeding program called HortResearch. A new company was formed in 1994 with HortResearch supplying the varieties and "Pipfruit New Zealand", "Apple and Pear Australia", and "Associated International Group of Nurseries", supplying the money. It is called PREVAR and is a multimillion dollar venture covering all facets: breeding, testing of selections, management of intellectual property, marketing and licensing of apple varieties. This is the competition we are up against. What can we expect from our traditional programs?

The University of Minnesota has an outstanding fruit breeding program that developed the 'Honeycrisp' apple and released it to the public domain in the traditional way, and over the last few years they have received royalty payment on a per tree basis. As I understand it, this revenue is about to run out and it appears that taxpayer dollars are going to be decreasing due to budget constraints and other priorities. The plant breeders need money to deliver the next 'Honeycrisp' and it no longer can be done by $1.00 per tree royalties. As a result, the rights to a potentially important variety, currently called Minnesota "1914", have been sold to a private developer for up front dollars that will allow this fine program to continue. In the agreement each Minnesota apple grower will be able to plant a few trees without having to pay for the rights from the private developer.

Most new apple varieties worldwide are being introduced to growers and the wholesale fruit marketplace as managed clubs. This limits who can grow and sell the variety but may also avoid overproduction and may improve grower returns. Many NY growers will not be able to grow some varieties from other areas of the world. However, we have our own apple breeding program at Cornell University led by Dr. Susan Brown.

Let's take a look at our own program at Geneva. In the last 5 years Dr. Susan Brown has planted over 25,000 new seedlings and is collecting data on over 50 acres of orchard. Approximately 326 new selections have been propagated from 66 different crosses. These selections involved over 60 different parents to diversify selections and to develop unique and distinctive apples. In the last three years a

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total of 1,150 breeding selection "second test" trees have been planted, with 547 trees planted at 8 grower sites in 2005, another 500+ for this year and 1,500+ available for 2007. Dr. Brown is planning a showcase tasting for this November. This is truly a world class program and I am looking forward to some solutions to my "what to plant" problem.

In April, Cornell and Motts/ Cadbury Schweppes announced an agreement in which Motts will provide the fruit breeding program with some money in each of the next 9 years for the exclusive rights to "processing varieties", in order to ensure access to new varieties and to diversify their mix. The impact of this money should not be detrimental to the fresh fruit program as existing selections that do not make the grade due to appearance or high acidity, etc, will be available and additional crosses probably won't be needed. The money will be used to select existing selections for processing attributes (such as high anti oxidants) and to pay some of the overhead of common data collecting and record keeping as well as some of the common maintenance and spraying. NY 674 is one of the varieties involved and there are issues with some growers who have had the variety on their farm for some years and developed some non processing fresh fruit markets for the apple. What happens to them? The NY fruit industry needs to work with Cornell University to ensure a mutual understanding of how new varieties from Cornell will be introduced.

A few issues that I am thinking about that will require some collective thought by all the growers in the state are as follows:

- We need to identify our elite selections using professional marketers and consumers not just growers.
- We should propagate trees for grower testing. Decide who gets to test, how many trees and how many locations are needed. Also realize we must maintain non-distribution forms and patent status. Codes must be used in testing because disclosure of a breeding number in grower meetings or web sites could start the clock running on the length of patent protection.
- We should realize it is in our best interest in have plant material released to other stations in Europe and South America so if a variety catches on there will be a royalty stream back to our breeding program.
- We should consider an Intellectual Properties agreement between Cornell and the various commodities groups who have made contributions to breeding programs. So that if a major income stream develops everyone knows what is going to happen to the money. Michigan State has worked out such an agreement with their growers. It creates a Commercialization Advisory Group that sets strategies for inventions arising out of mutually funded projects. It recognizes the University owns the patents and gives growers the right of first refusal. This arose when Michigan State sold the rights to some blueberry varieties that they had been working on with growers to a competitor on the west coast.
- Lets keep an eye out for a "world class apple" and have ready a mechanism to have a managed supply where we grow one apple less than the market demands in any given year. Club varieties like 'Pacific Rose', 'Jazz', 'Cameo', 'Pink Lady', and 'Ambrosia', all have different schemes but also have the common themes of managed supply and total control of product quality. A key issue here is to get the variety trademarked. Patents run out, but trademarks last forever if they are properly maintained.
- We need to understand in a managed supply situation, not everyone gets to play and not everyone will get to pack or market. This is fair when you consider that any group that is willing to invest the huge marketing and promotion costs without a guarantee of success and doesn't know when the next great apple comes on the scene, should be the ones who reap the rewards.
- We should bring more money to the table to support our industry. Federal and State funds will be shrinking and we will have to carry more of the burden to get what we want. We have opportunities to get matching money from state programs and the Farm Viability Institute. We are looking at rich and diverse choices of new apple selections but we must invest to maximize the potential reward.
- Finally let's find a way to see to it that every New York grower gets a chance to plant at least some of all New York bred apples. Even if it is restricted to on-farm sales.
- If you have any thoughts or ideas please feel free to contact me via E-Mail at peter@indianladderfarms.com and we can share them.

Peter Ten Eyck is a fruit grower in Albany County NY and is a member of the NY Apple Research and Development Board.

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The 9th International *Rubus* and *Ribes* Symposium

Sponsored by the International Society for Horticultural Science

Courtney Weber

Department of Horticultural Sciences, NYSAES, Cornell University
Geneva, NY

Every four years the international group of researchers on berry crops gathers to share research findings. This past December the symposium was held in Chile, which is fourth in world production of raspberries. The Chilean fruit industry has always focused on the export market and they have made great strides in certification for organic production and other certifications such as EurepGap to meet the demands of their customers. Their production methods and fruit handling procedures rival those in the U.S. and Western Europe.

The 9th International *Rubus* and *Ribes* Symposium and pre-conference tour was hosted by Dr. M. Pilar Banados and the Universidad Católica de Chile (Catholic University of Chile) November 30 - December 7, 2005. The tour took place throughout the central growing region, ending with the symposium in the southern resort town of Pucón. Approximately 183 delegates from 39 countries gathered to tour the vibrant berry growing area and exchange the latest breeding, pest control and production research findings. *Rubus* is the scientific genus name for the group of fruits including raspberries and blackberries, which are sometimes called caneberries or brambles. *Ribes* is the name for the genus that includes red and black currants and gooseberries. The symposium is held approximately every four years with the next meeting scheduled for Serbia in 2010. It is a part of the International Society for Horticultural Science series of symposiums with the proceedings written up as an *Acta Horticulturae* issue.

Chile is a long, narrow country hugging the west coast of Southern South America and has many diverse climates, ranging from desert in the north to a central Mediterranean climate to southern tundra. The central valley between the Andes and the low coastal ranges is ideal for fruit production. The country is divided into 13 regions that are numerically labeled, with Region I being the northernmost region in the country. There are two to seven provinces in each region. Most berry production is concentrated in the center of the country, stretching from just north of Santiago to about 250 miles south of the city. On the world market, Russia, Serbia, the U.S., Poland, Chile, and the Ukraine are the largest producers (Table 1). Other significant production is located in Germany, Canada and the U.K. Chile produces large quantities of raspberries and blackberries both for the fresh market (30%) during winter months in the northern hemisphere, and for processing (70%) with production often on small farms averaging less than two acres in size. A total of about 25,000 acres are grown, of which 82% is planted to 'Heritage' red raspberry, a Cornell variety. In addition to caneberries, significant acreages of strawberries, grapes and tree fruits are grown. Currants are a relatively minor crop, but have increasing interest. Mainly red currants are produced for the European fresh market.

With a national population of only 15 million, the Chilean fruit industry has always focused on the export market. Chilean growers are adaptable and have an ample supply of labor to compliment their excellent climate for fruit production. They are making great strides in certification for organic production and other

TABLE 1

Total world raspberry production by weight including fresh and processed berries.

Country	Production [a] (mT)	% of World Production
Russian Federation	175,000	33.7
The Union of Serbia and Montenegro	90,000	17.3
United States	62,000	11.9
Poland	38,000	7.3
Chile [b]	37,000	7.1
Ukraine	25,000	4.8
Germany	20,000	3.8
Canada	13,000	2.5
United Kingdom	12,000	2.3
Other	48,000	9.2
World Total [c]	**520,000**	**100**

[a] Statistics for world production except Chile from FAO (Food and Agriculture Organization of the United Nations) for 2005.
[b] Statistics for Chile from the USDA Foreign Agricultural Service (FAS) for 2003.
[c] FAO and FAS statistics combined.

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Figure 1. Shade cloth for sunscald protection of 'Heritage' raspberry. Note the gaps in the shade cloth to reduce wind damage. Also note the floral mesh used to support the primocanes.

certifications such as EurepGap to meet the demands of their customers. Their production methods and fruit handling procedures rival those in the U.S. and Western Europe.

The pre-conference tour of the caneberry production area began in Region V with Hortifrut production fields in Nogales, just north of Santiago. This region is similar in climate to central California. Varieties included 'Navajo' and 'Tupy' blackberry and 'Heritage' raspberry as well as proprietary raspberry varieties. Shade cloth was used extensively to protect the berries from sunscald and floral mesh was used to trellis the primocane varieties (Figure 1). Pinching of primocanes to delay production was also used extensively on 'Heritage' to prolong the season.

Figure 2. Cardboard sleeve holding two raspberry and one blueberry half pint clam shell containers being marketed by Hortifrut.

Next on the agenda was the oldest 'Marion' blackberry field in Chile in Pirque, where berries are 100% handpicked for processing. The next day brought us to Region VII to small caneberry growers and a very large strawberry grower hand picking 'Camarosa' for IQF berries. The modern plant and efficient field capping moved a steady supply of strawberries through the plant. The final day of the tour showcased organic production of 'Amity', 'Heritage' and 'Meeker' raspberry and 'Boysenberry' in Region VII, all for processing. Drip irrigation was evident in most fields but surface irrigation was used on about 20% of the fields.

Traveling south to Region VIII brought us to cooler season production more similar to the Pacific Northwest. Hortifrut production of fresh market 'Chilliwack', 'Tulameen', 'Heritage', 'Autumn Bliss' and 'Golden' raspberries rivaled the best fields I have seen anywhere. Hortifrut is using innovative packaging to market raspberries and blueberries together (Figure 2). The final stop of the tour was Sunberry in Angol to see red currant production ('Junifer') as well as raspberry and blackberry ('Lochness'). Sunberry ships fresh worldwide following the Prosafe GAP, EurepGap and Tesco Nature's Choice programs.

The symposium featured speakers from all over the world, including experts in breeding and genetics, production, nutritional aspects and pest control. Overall there were 46 oral presentations and 65 posters on all aspects of *Rubus* and *Ribes* research. Wayne Wilcox (Cornell University) was a featured invited speaker on *Phytophthora* root rot, current control practices and advances in biocontrol agents. The *Trichoderma* strain GV41 shows promise, especially in combination with raised beds and possibly gypsum amendments. Courtney Weber also presented data on a program to develop resistant cultivars by utilizing molecular markers and marker assisted selection.

Chad Finn (USDA-ARS, Corvallis) presented data on new raspberry varieties including root-rot-resistant 'Cascade Delight' from Pat Moore's program (Washington State University), 'Alice' and 'Jaclyn' from Harry Swartz (University of Maryland) and 'Octavia' from Vicki Knight (East Malling, UK). John Clark reported on the exciting new developments in primocane blackberry varieties in his program at the University of Arkansas. Bernadine Strik (Oregon State University) reported on the increasing blackberry industry in the world with a 70% increase in China and rapid expansion in the Michoacan region of Mexico where systems have been developed for year-round production.

The nutritional value of brambles was the topic of multiple speakers including collaborative papers from Pat Moore, Penelope Perkins-Veazie (USDA-ARS, Lane, OK), and Courtney Weber on the environmental effect on antioxidant and phenolic content of raspberries between the east and west coast production areas. Dr. H. Speisky of Chile also reported on antioxidant content of Chilean berries.

The 9th International Rubus and Ribes Symposium was an unqualified success. The relationships forged and renewed in this short period will serve the industry worldwide for decades to come. The Chilean hosts are to be commended for an excellent tour and symposium and for their exemplary hospitality. Chile is truly a beautiful and wonderful country with tremendous capacity and potential for the future.

Courtney Weber is a research and extension professor of fruit breeding at the New York State Agricultural Experiment Station. He leads Cornell's breeding program in berry crops, plums and apricots.

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The Tall Spindle Apple Production System

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This work supported by the New York Apple Research and Development Program and the New York Apple Research Association.

In the late 1990's a new planting system called the Tall Spindle system was developed from a combination of the Slender Spindle, the Vertical Axis and the Super Spindle systems. It uses high tree densities, highly feathered trees, bending of the feathers below horizontal at planting, and no permanent scaffold branches. It may be the most profitable system for NY growers.

There has been a steady increase in tree planting density over the last 50 years from 35 trees/acre to, in some cases, more than 2,500 trees/acre. Some experimental orchards have used densities up to 4,000 trees/acre. During the 1980's and 1990's the Slender Spindle training system (Wertheim, 1968) was the most common system in Northern Europe, while the Vertical Axis (Lespinasse, 1980) was more common in Southern Europe, North America, and New Zealand. In the 1990's a few growers planted the very high density Super Spindle system (Nuberlin, 1993) with greater than 2,000 trees/acre. By the late 1990's an amalgamation of these three systems gave rise to a new system we began calling the Tall Spindle system.

Development of the Tall Spindle System

This new planting system achieves the goals of very high early yields, high sustained yields and excellent fruit quality, while moderating the initial investment as compared to the Super Spindle system (Table 1). The important components of this system are:

1. High planting densities (~1,000-1,500 trees/acre).
2. The use of a fully dwarfing rootstock.
3. Highly feathered nursery trees (10-15 feathers).
4. Minimal pruning at planting.
5. Bending feathers and below horizontal at planting.
6. No permanent scaffold branches.
7. Limb renewal pruning to remove and renew branches as they get too large.

Each of the puzzle pieces is important and fruit growers must successfully integrate these puzzle pieces to be profitable. Ignoring one or more of the puzzle pieces has resulted in difficulty managing vigor with this planting system (Hoying and Robinson, 2000).

The Tall Spindle is based on the Slender Spindle tree developed by Bob Wertheim (1968), which was designed to improve early yields and management efficiency by planting higher tree densities and reducing tree height to allow all management to be done from the ground. However, the short stature of the Slender Spindle tree and moderate density often resulted in moderate yield and dense canopies. In the 1970's and 1980's, most Slender Spindle orchards had densities from 600-1000 trees/acre and had a tree height and diameter of about 6 ft.(1.8m). A significant trend in the late 1980's and 1990's was to increase tree planting density in Slender Spindle orchards to improve yields (Oberhofer, 1987). Some growers attempted to increase planting density by planting double and triple rows. However, the dense canopies were difficult to manage and vigor usually became a problem as the orchard matured. During the early 1990's, much higher tree densities, between 2,000 and 5,500 trees/acre, were tested in single rows and a more narrow and taller tree form was developed: the Super Spindle system. These trees had a tree diameter of 1.5-2 ft (45-60cm) and a tree height of 8 ft (2.5m). Through managing this system, growers and researchers learned that by never allowing permanent scaffold branches to develop the tree could be kept very compact for many years. However, the cost of the Super Spindle system was prohibitive for all except those who grew their own trees.

A second trend over the last 20 years has been greater emphasis on obtaining a significant yield in the second year after planting through the use of highly feathered trees. However, many of the

TABLE 1

Establishment Costs for 3' X 11' Tall Spindle Orchard System (10 rows X 400' long)

Item	Number/acre	Material Costs ($/acre)	Labor Costs ($/acre)	Total Cost ($/acre)
Trees	1320	$8,580	$100	$8,680
Anchor poles (6 ft)	20	$120	$100	$220
Inline poles (12 ft)	110	$1,100	$550	$1650
Wire	12,000 ft	$280	$100	$380
Staples, tightners and crimps		$50	$100	$150
Total		**$10,130**	**$950**	**$11,080**

trees used in the 1980's and 1990's had feathers that started at 20 inches (50cm) above the soil. The low height of the feathers required significant labor to tie the branches up when they began to fruit in order to prevent fruit from touching the ground. In the late 1990's, the minimum height of feathers was raised to 30-35 inches (Balkhoven-Baart et al., 2000). This allowed branches to hang in a pendant position when cropping and still not touch the ground, thus eliminating the need to tie up branches.

A third trend was an increase in tree height from 6-8 ft.(11.8-2.4 m) to 9-10 ft. (2.7-3.0 m) to obtain higher mature tree yield (Robinson and Lakso, 1991). This resulted in greater light interception, which is directly related to yield, and a greater distance between fruiting branches spread along the trunk. In the 1990's, many growers began to avoid pruning Slender Spindle trees after planting or during the first few years. If the central leader was cut, as was typical with slender spindle trees, a vigorous frame developed, which needed a lot of summer pruning labor to maintain light distribution in the tree for good fruit quality. Without pruning of the leader and with feathers starting at 30 inches above the soil, the tree can be allowed to crop in the second year, which results in the natural bending of lateral branches to keep the canopy narrow. In the 1990's, as growers allowed Slender Spindle trees to grow taller, yields increased, and fruit quality often increased as well since there was more space between the branches along the axis. These trends led to the development of the Tall Spindle Tree with a tree diameter of 3-4 ft (90cm-1.2m), a tree height of 10 ft (3m) and a density between 1,000 and 1,500 trees/acre.

Figure 1. Tall Spindle orchards utilize highly-feathered trees planted at 3 ft. spacing.

Characteristics of the Tall Spindle System

Tree Density Tree density with Tall Spindle orchards can vary from a high of 1452 trees/acre (3' x 10') to a low of 838 trees/acre (4' x 13'). The proper density is decided by considering the vigor of the variety, vigor of the rootstock, and soil strength. With vigorous scion cultivars, growers should use a more dwarfing stock and greater planting distances. With weak scion cultivars, a more vigorous rootstock and/or closer planting distances should be used. Despite some latitude in planting distances, growers should remember that to obtain high early yields high tree densities are essential. For weak and moderate growing cultivars such as Honeycrisp, Delicious, Braeburn, Empire, Jonamac, Macoun, Idared, Gala, NY674, Golden Delicious, etc., we suggest an in-row spacing of 3ft (90cm) (Figure 1). For vigorous varieties such as McIntosh, Spartan, Fuji, Jonagold, Mutsu, etc., and tip bearing varieties such as Cortland, Rome, Granny Smith and Gingergold we suggest an in-row spacing of 4ft (1.2m) Between-row spacing should be 12-13 ft (3.6-3.9m) on slopes and 10-11ft (3.0-3.3 m) on level ground.

Rootstock Although high tree density is the single most important factor affecting yield in the early years of an orchard's life, dwarfing rootstocks are the foundation for any successful Tall Spindle planting system. Most successful Tall Spindle plantings are planted with dwarfing rootstocks such as M.9 or B.9. In recent years in the U.S., the fire blight-resistant dwarf rootstocks from Geneva®¨ (G.16, G.11 and G.41) have been used successfully in Tall Spindle plantings. Within the M.9 class of dwarfing rootstocks, there are significant differences in vigor between clones. The weaker clones (M.9NAKBT337, M.9Flueren56, B.9 and G.41) are especially useful with vigorous scion varieties on virgin soil. The more vigorous clones (M.9Pajam 2, M.9Nic29, M.9EMLA, G.16 and G.11) are much better when orchards are planted on replanted soil or when weak scion cultivars are used. Although M.9 is used around the world with great success in high density plantings, it is highly susceptible to fire blight and Woolly apple aphids. The new dwarfing rootstocks that are resistant to these problems, such as the Cornell Geneva series, should improve the worldwide performance of high-density orchards.

Tree Quality An essential component of the Tall Spindle system is a high branched (feathered) nursery trees. Several studies have shown that the greater the number of lateral branches or feathers, the greater the yield in the second and third year. The Tall Spindle system depends on significant second and third year yield for the economic success of the system. If growers use whips or small caliper trees which do not produce significant quantities of fruit until year four or five, often the carrying costs from the extremely high investment of the Tall Spindle orchard overwhelms the potential returns and negates the benefit of the high tree density on profitability. We recommend that the caliper of trees used in tall spindle plantings be a minimum of 5/8 in (16mm) and that they have 10-15 well positioned feathers with a maximum length of 1 ft (30cm) and starting at a minimum height to 30 in (80cm) on the tree (Figure 2). Generally, nursery trees in North America do not have this number of feathers. However, in the last two years a few nurseries have produced highly feathered trees. Many nursery trees have 3-5 long feathers instead of 10 short feathers. The tree with few long feathers requires more branch management than the tree with more short feathers.

Figure 2. A young Tall Spindle orchard with highly feathered trees (15+ feathers) planted in NY State at 3' x 12". Note tree height is 6' at planting.

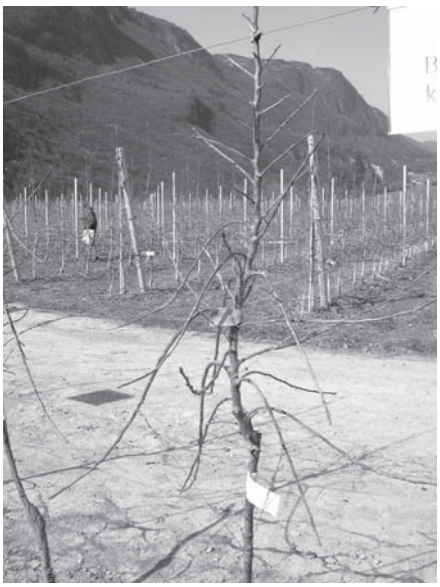

Figure 3. Highly feathered tree with all large feathers tied down below horizontal

Pruning at Planting Minimal pruning is practiced at planting. Highly feathered nursery trees having 10 to 15 small branches along the trunk require almost no pruning except to remove these large feathers having a branch diameter larger than one-half that of the main trunk immediately above where the feather originates. When nursery trees have fewer but bigger feathers, only those that are thicker than two-thirds of the trunk diameter are taken out. No heading is done except when the tips have been damaged or dehydrated during the packaging or manipulating prior to, or during planting. Although not recommended for Tall Spindle orchards, if whips or non-branched trees are used, they should be headed at 5ft (1.5m) at planting.

Branch Angle Manipulation The most important method of inducing early cropping is tying down of the larger feathers below horizontal right after planting (Figure 3). One of the most significant differences between the Tall Spindle and the more traditional Vertical Axis and Slender Spindle is that the Tall Spindle tree typically has no permanent lower tier of branches. With the Tall Spindle all of the larger feathers (more than 10" or 25cm long) are tied or weighted below the horizontal at planting to induce cropping and to prevent them from developing into substantial lower scaffolds. The pendant position results in a weak fruiting branch instead of a scaffold branch. Smaller, less vigorous feathers usually bend with cropload without any tying. With the Vertical Axis and Slender Spindle systems the feathers are allowed to be brought down to horizontal with fruit load in the third year or are tied down a little above horizontal, which allows them to grow into scaffolds over the first four years. Growers who attempt to plant feathered trees at the Tall Spindle spacing but do not tie the feathers down often end up with limbs in the lower part of the tree that are too strong. This situation requires severe limb removal pruning at an early age, which invigorates the tree and makes long term canopy containment problematic. This simple change in tree management allows long-term cropping of many feathers and little invasive pruning for the first 5-8 years at the very close spacing of the Tall Spindle system.

After the initial tying or weighing down of feathers at planting, new lateral branches that arise along the leader do not need to be tied down. In most climates, if moderate vigor lateral shoots arising along the leader are not pruned, often cropload in the second or third year will bend branches down below horizontal and a natural balance between vigor and cropping will be established without additional limb positioning. Thus with the Tall Spindle, no additional limb tying is needed after the initial tying or weighing down of the feathers at planting. On the other hand, in vigorous conditions and/or warmer climates where winter chilling is insufficient, often limbs become too large before they set sufficient croploads to bend the branches down. In these situations, tying down of all vigorous limbs must be done annually for the first 3-5 years until the tree settles down and begins to crop heavily. However, in most traditional apple growing areas, growers often invest too much money in limb tying, which should be limited to only the feathers at planting. Thereafter, the precocity of the rootstock induces heavy cropping and a natural balance is established.

Cropload Management As the tree begins to bear, management of cropping with the Tall Spindle during the first four years to avoid biennial bearing is critical to maintaining a proper balance between vegetative growth and cropping. With

Figure 4. A young Tall Spindle orchard has a supported trunk, a narrow cylindrical shape and no permanent branches. Vigorous branches are removed leaving only small diameter fruiting branches on the trunk.

precocious dwarfing rootstocks, young apple trees can often overset in the second or third year, resulting in biennial bearing as early as the fourth year. This then results in increased vigor in the fourth year, just as the trees have filled their allotted space and reduced vigor is needed. Varieties differ in their biennial bearing tendency, and this must be incorporated into the croploads allowed on young trees. For annual cropping varieties like Gala, we recommend croploads of 15-20 apples/tree in the second year, 50-60 apples/tree in the third year, and 100 apples/tree in the fourth year. For slow growing and biennial bearing varieties like Honeycrisp, croploads should be half that used with Gala.

Mature Canopy Shape The Tall Spindle tree is essentially a 10 ft (3m) trunk with small fruiting branches inserted all along its length (Figure 4 and Figure 5). A simplified training recipe is given in Table 2. To achieve this tree in only three years, the central leader is not cut (headed) at planting. This results in a 5-6 ft tall tree at planting, which is already 50% of its final height (Figure 1). This relatively tall, thin tree needs support before the fully leafed-out canopy acts as a sail resulting in tree breakage during strong windstorms. Thus a 3-4 wire trellis must be installed by the time the tree leafs out. A 3-4 wire trellis is preferred to a individual tree stake and a single wire trellis since the tree density makes cost of an individual tree stake (conduit pipe) prohibitive. Some growers of the Tall Spindle system use an inexpensive bamboo tree

Figure 5. A mature Tall Spindle tree has a dominant trunk, but no permanent branches. Vigorous branches are removed leaving only small diameter fruiting branches on the trunk.

TABLE 2

Simplified pruning and training plan for the Tall Spindle system.

FIRST LEAF	
At Planting	Plant highly feathered trees (10-15 feathers) at a spacing of 3-4' x 11-12' (90cm-1.2m x 3.3m-3.6m). Adjust graft union to 6" (15 cm) above soil level. Remove all feathers below 24" (60 cm) using a flush cut. Do not head leader or feathers. Remove any feathers that are larger than 2/3 the diameter of the leader
3-4" Growth	Rub off 2nd and 3rd shoots below the new leader shoot to eliminate competitors to the leader shoot.
May	Install a 3-4 wire tree support system that will allow tree to be supported to 3m. Attach trees to support system with a permanent tree tie above 1st tier of feathers leaving a 2 inch diameter loop to allow for trunk grow.
Early June	Tie down each feather that is longer than 10" (25 cm) to a pendant position below horizontal.
SECOND LEAF	
Dormant	Do not head leader or prune trees.
10-15 cm growth	Pinch lateral shoots in top 1/4 of last years leader growth removing about 5 cm of growth (the terminal bud and 4-5 young leaves).
Early June	Hand thin crop to single fruit four inches apart. (Target 15-20 fruits/tree)
Mid June	Re-pinch all lateral shoots in top 1/4 of last years growth. Tie developing leader to support system with permanent tie.
THIRD LEAF	
Dormant	Do not head leader. Remove overly vigorous limbs that are more than 2/3 the diameter of the leader using a bevel cut.
Late May	Chemically thin according to cropload, tree strength, and weather conditions, then follow up with hand thinning to appropriate levels to ensure regular annual cropping and adequate fruit size. (Target 50-60 fruits/tree).
June	Tie developing leader to support system with a permanent tie.
August	Lightly summer prune to encourage good light penetration and fruit color.
FOURTH LEAF	
Dormant	Do not head leader. Remove overly vigorous limbs that are more than 2/3 the diameter of the leader using a bevel cut.
Late May	Chemically thin and follow up with hand thinning to appropriate levels to ensure regular annual cropping and adequate fruit size.(Target 100 fruits/tree).
June	Tie developing leader to support system with a permanent tie at the top of the pole.
August	Lightly summer prune to encourage light penetration and fruit color.
MATURE TREE PRUNING (Fifth-Twentieth Leaf)	
Dormant	Limit tree height to 10' (3m) by cutting leader back to a fruitful side branch. Annually, remove al least 2 limbs including lower tier scaffolds that are more than 2/3 the diameter of the leader using a bevel cut. Shorten bottom tier scaffolds where needed back to side branch to facilitate movement of equipment and preserve fruit quality on lower limbs. Remove any limbs larger than 1" diameter in the upper 2ft (60cm) of the tree
Late May	Chemically thin and follow up with hand thinning to appropriate levels to ensure regular annual cropping and adequate fruit size. (Target 100-120 fruits/tree).
August	Lightly summer prune to encourage light penetration and maintain pyramidal tree shape.

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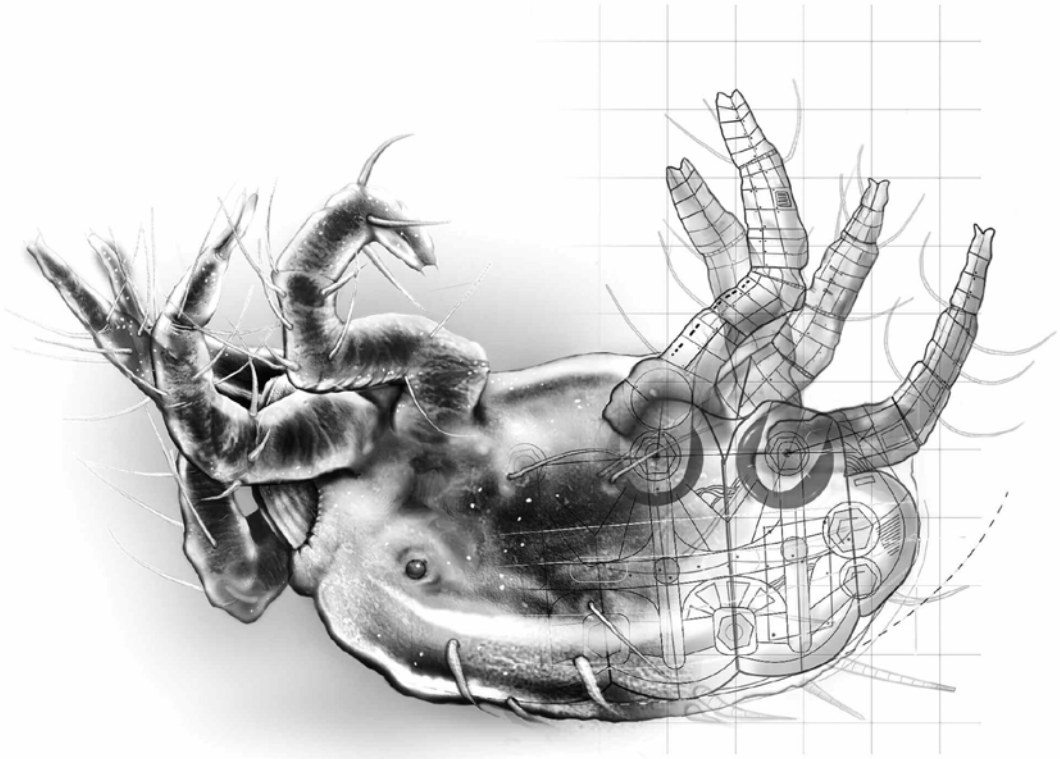

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stake at each tree tied between a lower and higher wire.

The feathers or lateral branches are tied below horizontal either at planting or early during the first summer to induce cropping and to limit the width of the canopy (Figure 3). The leader's shoot is supported with the trellis and is not headed in succeeding years until year four or five, when mature tree height has been achieved and heavy cropping has begun. The upper part of the tree is composed of small fruitful branches that bend with crop below horizontal. The narrow, slender shape of the Tall Spindle canopy helps ensure that most of the canopy is well exposed to light resulting in excellent fruit quality.

Renewal Pruning Good light distribution and good fruit quality can be maintained as trees age if the top of the tree is kept more narrow than the bottom and there is a good balance between vegetative growth and cropping. For the Tall Spindle system, maintaining a conic shape as the trees age is critical to maintaining good light exposure, fruiting and fruit quality in the bottom of the tree. (Figure 6) In our experience, the best way to maintain good light distribution within the canopy as the tree ages is to remove whole limbs in the top of the tree once they grow too long, rather than shortening them back. A successful approach to managing the tops of trees has been to annually remove one to two upper branches completely. To assure the development of a replacement branch, the large branch should be removed with an angled or beveled cut so that a small stub of the lower portion of the branch remains. From this stub, a flat weak replacement branch often grows. If these are left unheaded, they will naturally bend down with crop. When this style of pruning is repeated annually, the top of the tree can be composed completely of young fruitful branches. The younger branches do not result in as much shade as larger older branches and are naturally shorter than the bottom branches thus maintaining the conic shape of the tree. When this strategy, termed limb renewal pruning, is employed with the Tall Spindle system, good light distribution can be maintained over the life of the tree.

Performance of the Tall Spindle in NY State

We began testing the Tall Spindle system (3' x 11') in 1997 at Geneva in a planting of both higher and lower densities (Robinson, 2005). In our report published last year in *the New York Fruit Quarterly*, the Tall Spindle system was the second highest yielding system, exceeded only by the much higher density Super Spindle system. Unfortunately, when the trial was planted we could not obtain the highly feathered trees here in the U.S., which are essential to the optimum performance of the Tall Spindle. Our trees had 3-5 feathers instead of 10-

Figure 6. A mature Tall Spindle Gala orchard in NY State

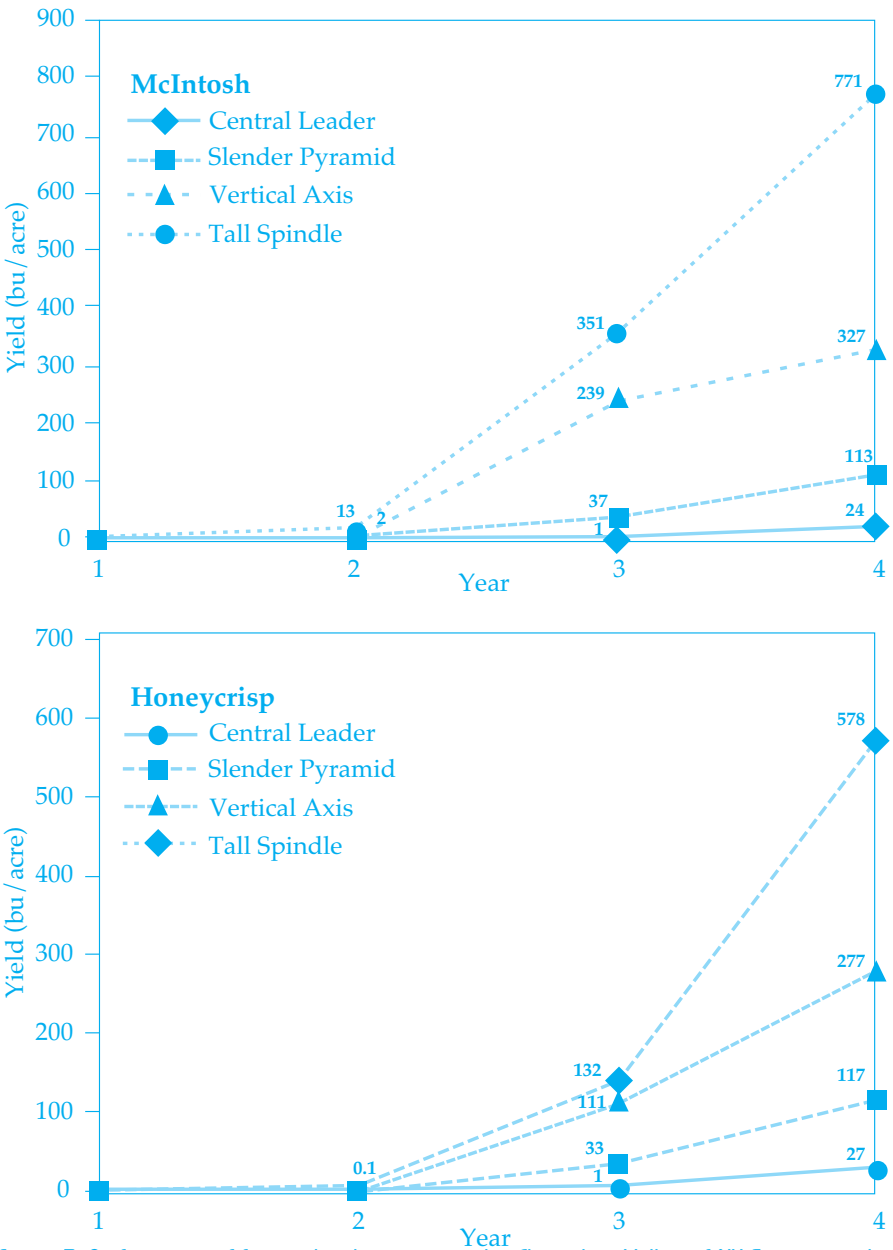

Figure 7. Performance of four orchard systems in the Champlain Valley of NY State over the first four years with McIntosh and Honeycrisp.

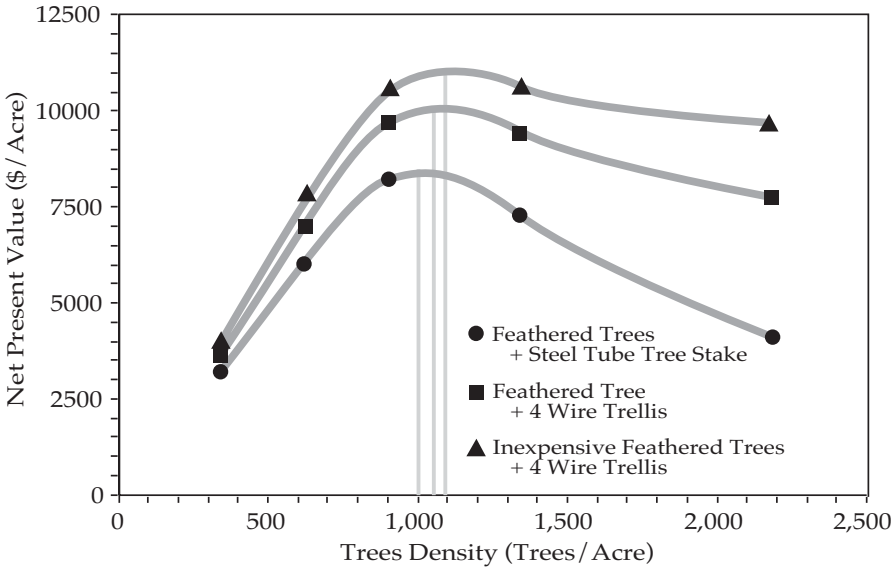

Figure 8. Effect of tree density on orchard profitability after 20 years (Net Present Value/acre).

15 feathers. Thus its performance was not up to the potential of more highly feathered trees.

In 2002 we planted a new trial in the Champlain Valley to test the Tall Spindle. In this case we obtained trees with 6-8 feathers. The results after four years have been quite impressive (Figure 7). With McIntosh and Honeycrisp the Tall Spindle system has had twice the yield of the more traditional Vertical Axis. With McIntosh the yields reached 771 bushels/acre in the fourth year while with Honeycrisp the fourth-year yield was 578 bushels/acre. It appears that the Tall Spindle will be quite manageable and very productive.

This year (2006), we recently planted two new trials of the Tall Spindle system in the Hudson Valley and Wayne County. In this case with Gala, Honeycrisp, and Fuji, we obtained trees with 8-10 feathers. We expect even greater yields from the new trials since we have better quality trees.

Conclusions

The key objectives for a new orchard are to maximize yield in the early years and still effectively produce large yields of high quality fruit after the trees are mature. The Tall Spindle system accomplishes these objectives by combining high tree planting densities, highly feathered trees that have many small branches instead of a few large branches, minimal pruning at planting or during the first three years, branch angle management by tying down all of the larger feathers at planting to induce cropping and prevent the development of strong scaffold branches that cause difficulty in tree management in later years, and branch caliper management by the systematic removal of large branches to keep the tree manageable. Since large branches contribute to the development of large trees, the Tall Spindle trees that have no large scaffold branches

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remain small. Our most recent economic analysis shows the optimum economic density for NY is the 1,000-1,100 trees / acre of the Tall Spindle system (Figure 8). It appears to be an excellent system for NY apple growers.

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