COMPACT FRUIT TREE

THE INTERNATIONAL DWARF FRUIT TREE ASSOCIATION

VOLUME 33, NUMBER 1 JANUARY 2000

NEW ZEALAND, HERE WE COME

Holding the 2000 IDFTA conference in Napier, New Zealand, the first IDFTA conference held outside North America, poses a few logistics challenges, but these have been overshadowed by the tremendous worldwide interest in the conference. Almost 200 participants will travel over 7,000 miles from North America to attend the conference. Participants will also come from many countries in Europe, from Japan and Australia, and a large contingent is expected from New Zealand.

The conference program, included in this issue, includes over 30 speakers from seven countries. A major focus of the program will be orchard management systems. Speakers will discuss the critical importance of selecting dwarfing apple rootstocks such as M.9 and the long-term influence of tree density. Orchardists from Australia, British Columbia, New York and Washington will discuss the successes and the challenges they have faced with various orchard and tree management systems. Several presentations will discuss the introduction of new varieties from the international perspective.

The success of the conference will be due in part to the enthusiasm of our New Zealand hosts and the generous support for publicity and registration provided by the NZ Fruitgrowers Federation and the "Orchardist."

The IDFTA Tree Fruit Study Tour to New Zealand and Australia, which includes participation and registration for the Napier conference, is fully booked. However, it is still possible to register for the Napier conference and make individual travel arrangements. A registration form for the New Zealand conference, as well as a list of accommodation possibilities (there is not a single conference hotel), is included here.

For information about the Study Tours, please contact Bruce Barritt (phone 509-663-8181, ext. 233; fax 509-662-8714, e-mail etaplz@wsu.edu) or Bob Curtis, Curtis-C Travel (phone 800-562-2580; fax 509-884-4652; e-mail rlcurtis@nwi.net).

IDFTA CALENDAR

February -9, 2000
43rd Annual IDFTA Conference
Napier, Hawke's Bay, New Zealand

June 25, 26, 27, 2000
Summer Tour, New York/Vermont
Lake Champlain area

February 16-21, 2001
44th Annual IDFTA Conference
Grand Rapids, Michigan

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43RD ANNUAL CONFERENCE

INTERNATIONAL DWARF FRUIT TREE ASSOCIATION

FEBRUARY 6 TO 9, 2000

NAPIER MUNICIPAL THEATRE, NAPIER, NEW ZEALAND

The world's premier annual conference, just for tree fruit producers.

CONFERENCE AGENDA & LODGING INFORMATION

Sunday Evening, February 6

Session Chair: Dr. Steve Blizzard, IDFTA President, Valley Sweet, Tulare, California, USA

7:00 Napier—The Art Deco Capitol of New Zealand, John Cocking as 'Bertie', Napier's Art Deco Spokesman

7:20 New Zealand—The Ideal Place for Growing Apples, John Wilton, AgFirst Consultants, New Zealand

7:50 New Zealand Stone Fruit Industry, Rex Graham, Hastings, New Zealand

8:20 The New Zealand Apple and Pear Industry Structures—Political and Marketing, John Paynter, Hastings, New Zealand

Monday Morning, February 7

Session Chair: Jim Hughes, IDFTA Vice President, Hughes Orchards, Picton, Ontario, Canada

8:20 a.m. Welcome to the 43rd Annual IDFTA Conference

Dr. Steve Blizzard, IDFTA President, Tulare, California, USA

8:30 a.m. Program Announcements

Dr. Bruce Barritt, IDFTA Education Director, Wenatchee, Washington, USA

8:35 a.m. ROBERT F. CARLSON DISTINGUISHED LECTURE

New Zealand Horticulture—Success of an Export-led Industry, Dr. Ian Warrington, HortResearch, Palmerston North, New Zealand

9:25 a.m. Orchard Systems—Conditions for Success, Dr. Bob Wertheim, Research Station for Fruit Growing, Wilhelminadorp, The Netherlands

10:05 a.m. Apple Tree Physiology—Implications for Orchard and Tree Management, Dr. Jens Wünsche, HortResearch, Nelson Research Centre, Motueka, New Zealand

10:35 a.m. Developing Intensive Apple Orchards in the Batlow District of Australia (Panel discussion), Ralph Wilson, Greg Mouat and Adrian Vanzella, Orchardists, Batlow, New South Wales, Australia

11:25 a.m. The Evolution of Central Leader Apple Tree Management in New Zealand, Dr. Stuart Tustin, HortResearch, Havelock North, New Zealand

12:00 p.m. Lunch—At the War Memorial Centre, Marine Parade (if prepaid with conference registration) or lunch on your own in nearby Napier restaurants

Monday Afternoon, February 7

Session Chair: Tom Auvil, IDFTA Board Member, Orondo, Washington, USA

1:30 p.m. Breeding Apple Varieties for the World Market, Allan White, HortResearch, Havelock North, New Zealand

2:00 p.m. Progress Toward Better Apples Through Biotechnology, Dr. Herb Aldwinckle, Cornell University, Geneva, New York, USA

2:30 p.m.New Varieties—Managing the Conflicts, Pat Murray, General Manager Strategic Marketing, ENZA, Wellington, New Zealand

3:10 p.m. Evolving Training Systems in My Washington Apple Orchard, Doyle Fleming, Orchardist, Orondo, Washington, USA

3:40 p.m. California Apple Industry—Production Through Marketing, Dr. Steve Blizzard, Valley Sweet, Tulare, California, USA, and Kenton Kidd, California Apple Commission, Fresno, California, USA

4:00 p.m.Methods and Results of Screening for Disease and Insect Resistant Apple Rootstocks, Dr. Bill Johnson, USDA-ARS/Cornell University, Geneva, New York, USA

Monday Evening, February 7

Annual IDFTA Banquet (War Memorial Centre, Marine Parade)

Featuring the presentation of awards for Outstanding Researcher, Grower and Extension/Educator and entertainment

6:00 p.m. Social Hour

7:00 p.m. Dinner

Tuesday, February 8

8:00 a.m. Conference Bus Tour to commercial orchards and research centre in Hawke's Bay District.

Lunch is included.

Wednesday Morning, February 9

Session Chair: Gary Mount, IDFTA Board Member, Princeton, New Jersey, USA

8:30 a.m. Breeding and Evaluation of New Rootstocks for Apple, Pear and Sweet Cherry Rootstocks at Horticultural Research International (HRI)—East Malling, Dr. Tony Webster, HRI, East Malling, United Kingdom

9:20 a.m. Overview of Elite Apple Rootstocks from USDA/Cornell University, Dr. Bill Johnson, USDA-ARS/Cornell University, Geneva, New York, USA

9:50 a.m. New Apple Rootstock Alternatives for the Southern Hemisphere, Michael White and Dr. Stuart Tustin, HortResearch, Havelock North, New Zealand

10:10 a.m. Success Factors for Your High Density Apple Orchard, Dr. Terence Robinson, Cornell University, Geneva, New York, USA

10:35 a.m. A Leap Forward in Orchard Tree Density—Spindle to Super Spindle, The British Columbia Experience (Panel discussion), Jamie Kidston, Orchardist, Vernon, BC; Bruce Currie, Orchardist, Kelowna, BC; and Rob Dawson, Orchardist, Keremeos, BC, Canada

11:05 a.m. Sweet Cherry Orchard Management with Dwarfing Rootstocks in Germany, 25 min Michael Weber, Advisor, Lake Constance Region, Germany

11:30 a.m. Intensive Sweet Cherry Orchard Systems—Rootstock Vigor, Precocity, Productivity and Management, Dr. Greg Lang, Washington State University, Prosser, Washington, USA

12:00 p.m. Lunch—At the War Memorial Centre, Marine Parade (if prepaid with conference registration) or lunch on your own in nearby Napier restaurants

Wednesday Afternoon, February 9

Session Chair: Jamie Kidston, IDFTA Board Member, Vernon, British Columbia, Canada

1:30 p.m. A 10-year Pear Production Summary of 8 Old Home/Farmingdale Clonal Rootstocks, George Ing, Orchardist, Hood River, Oregon, USA

1:50 p.m. Tree Management in My New York Apple Orchard, Darrel Oakes, Orchardist, Lyndonville, New York, USA

2:20 p.m. Managing High Density Apple Orchards in Washington, Tom Auvil, Orchardist, Orondo, Washington, USA

2:40 p.m. Optimizing Tree Density in Apple Orchards, Michael Weber, Advisor, Lake Constance Region, Germany

3:10 p.m. Selecting an Orchard Management System, Dr. Bruce Barritt, Washington State University, Wenatchee, Washington, USA

3:40 p.m. Getting Your Orchard Off to a Good Start, Steve Hoying, Cornell University, Newark, New York, USA

Adjourn

ACCOMMODATION LIST

There is no single conference hotel.

Within walking distance of Napier Municipal Theatre (site of IDFTA Conference):

FULL Edgewater Motor Lodge (359 Marine Parade Beachfront, Napier; phone: 011-64-6-835-1148; fax: 011-64-6-835-6600)

FULL Napier Travel Inn (311 Marine Parade, Napier; phone: 011-64-6-835-3237; fax: 011-64-6-835-6602; e-mail: napiertravelinn@stubbs.co.nz)

FULL Fountain Court (413 Hastings Street, Napier: phone: 011-64-6-835-7387; fax: 011-64-6-835-0323)

FULL Beach Front Motel (373 Marine Parade, Napier; phone: 011-64-6-835-5220; fax: 011-64-6-835-7400)

FULL Shoreline Motel (373 Marine Parade, Napier; phone: 011-64-6-835-5220; fax: 011-64-6-835-7400)

The County Hotel (boutique hotel) (12 Browning Street, Napier; phone: 011-64-6-835-7800; fax: 011-64-6-835-7797)

Palm City Motor Inn (31 Georges Drive, Napier; phone: 011-64-6-835-0005; fax: 011-64-6-835-0006)

Tennyson Motor Inn (P.O. Box 648, Napier; phone: 011-64-6-835-3373; fax: 011-64-6-835-8500)

Other accommodations in Napier:

Blue Waters Hotel (10 West Quay, Ahuriri, Napier; phone 011-64-6- 835-8668; fax 011-64-6-835-0188)

Anchorage Motor Lodge (26 West Quay, Napier; phone: 011-64-6-834-4318; fax: 011-64-6-834-3010)

Harbour View Motor Lodge (806 Hardinge Road, Napier; phone: 011-64-6-835-8077); fax: 011-64-6-834-1017)

The following accommodations are available in Hastings and Havelock North, a 20-minute drive from Napier.

Havelock North:

Te Mata Lodge (21 Porter Drive, Havelock North; phone: 011-64-6- 8774-880; fax: 011-64-6-8774-881)

Havelock North Motor Lodge (7 Havelock Road, Havelock North; phone/fax: 011-64-6-8778-627)

Hastings:

Portmans Motor Lodge (400 Railway Road, Hastings; phone: 011-64-6- 8788-332; fax: 011-64-6-8788-620)

Valdez Motor Lodge (1106 Karamu Road North, Hastings; phone: 011-64-6-8765-453; fax: 011-64-6-8769-497)

Hawthorne Country House (State Highway 2, Hastings; phone/fax: 011-64-6-878-0035)

Fairmount Motor Lodge (1120 Karamu Road, Hastings; phone: 011-64-6-878-3850; fax: 011-64-6- 878-3851)

General information about the Hawke's Bay region (Napier, Hastings and Havelock North) can be obtained from Hawke's Bay Tourism:

P.O. Box 123, Napier, New Zealand
FAX: 011-64-6-834-0299
e-mail: hbt@hawkesbaytourism.co.nz

What Can We Learn from the New Zealand Apple Industry?

Christopher B. Watkins

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Cornell University, Ithaca, NY

Reprinted with permission from 1999 New York Fruit Quarterly 7(3):24-27.

The New Zealand apple industry has chosen to follow the strategy of focusing on the top end of the market by producing premium apple varieties. Continuing to do this requires an integrated approach among growers, researchers, and marketers. In New York, a situation where all fruit could be controlled by a single marketing body may not be a realistic option, but are there lessons the NY apple industry can learn from New Zealand?

Some personal caveats to this paper must be established right up front. Firstly, as a postharvest physiologist, not an agricultural economist or a marketer, the perceptions and opinions expressed here about the New Zealand industry are my own and some bias on my part is inevitable. Secondly, rapid change has become standard in New Zealand society, and right now a furious debate exists throughout the whole industry of the merits of the single desk selling system that will be described shortly. It is possible that some of the features described below that are unique to the New Zealand industry will soon be dismantled under the belief that marketing organizations such as ENZA (New Zealand Apple and Pear Marketing Board) are in conflict with free market dogma.

You may feel that the differences between our industries and those in New Zealand are too large to have relevance to you. However, there are some common critical issues as we confront the challenges of remaining competitive in an increasingly difficult industry. If there is one overwhelming similarity between industries, it is that growers almost everywhere are struggling to stay in business in the face of declining returns for their crop, and are seeking solutions, sometimes with a chainsaw. The New Zealand grower has had an average return across varieties of $11 per carton in recent years, although up to $14.17 in 1997-1998. These returns are a long way from the heady (and probably unrealistic) heights of 1991 when the average was $19.68. For comparison across industries it should be recognized that these values are grower gate return, i.e., exclusive of all cold storage, packaging, freight, sales, promotion and market overheads, research and development, finance charges, and other industry costs. Nevertheless, at current prices, the margin between production costs and returns has continued to decline, now being close to $5.

Also, another similarity is that climatic events beyond our control regularly decimate crops irrespective of growing region. In 1998, for example, the New York industry lost 2.3 million bushels of apples during Labor Day weekend, and in 1996, the New Zealand apple crop dropped from 19 to 16 million bushels overnight, from hail storms. Moreover, fruit are not nuts and bolts—they are living organisms which vary yearly in keeping quality, and poor quality years are not easy for growers, shippers, packers, and marketers to deal with or sometimes, in the case of marketers, even understand.

Emphasis (in research) should be given less to producing more volume and more to developing better and more marketable products.

NEW ZEALAND'S SITUATION

New Zealand is situated in the South Pacific with a small population of 3.5 million people in a country that runs from the equivalent of the Canadian border to South Carolina (about 1,000 miles long, between the 34th and 48th parallels of the Southern Hemisphere). Its climate is subtropical to temperate producing exceptional crop yields, and the export of predominantly agricultural products such as wool, meat, and dairy products has been the country's life blood. From a marketing position, New Zealand is about as far away from large international markets as possible. Despite these distances, New Zealand was a happily complacent country until the 1970s, with one of the highest standards of living in the world, exporting 95 percent of its produce to the United Kingdom. Life changed dramatically when England joined the European Community, and at the same time the oil crisis hit all world economies hard. Distance from the market became a serious issue because of dramatically increasing freight costs. The need to develop new markets and develop new products, especially with added value, became essential.

During the 1970s, a revolution in horticulture started in New Zealand as the success of the kiwifruit demonstrated that fruit exports could contribute increasing returns to the New Zealand economy. Tremendous investment occurred, and the 1980s saw continued growth of horticultural exports to overseas countries. From the mid-70s to 1991, apple exports from New Zealand increased from 7 to 20 million cartons, and from 1995 to 1997, apple exports have earned an average of $570 million/year for the New Zealand economy.

This has occurred largely because of the success of Gala, Braeburn, Granny Smith, and Fuji. In 1985, Granny Smith and Delicious apples were 40 percent and 20 percent of the total crop volume. By 1997, these were minor varieties in comparison with Braeburn and Royal Gala (Table 1), and these proportions continue to change rapidly today. New Zealand produces a relatively small volume of the world's apple crop but has had an impact far beyond its size. The New Zealand industry, like all others around the world, is struggling in the present marketing environment.

TABLE 1

Variety breakdown of export apples from New Zealand in 1997 (Source: Orchardist of New Zealand, Feb. 1998).

Variety	Percentage of export
Braeburn	41
Royal Gala	25
Fuji	10
Cox's Orange Pippin	7
Delicious	6
Granny Smith	5

TABLE 2

Export sales of New Zealand apples in 1997 (Source: Orchardist of New Zealand, Feb. 1998).

	Tray cartons
European Continent	5,724,000
United Kingdom	3,900,000
North America	3,159,000
Asia	2,835,000

THE MARKETING ORGANIZATION AND MARKETING RESTRAINTS

Export apples are sold by a single desk operator, the New Zealand Apple and Pear Marketing Board known as ENZA International. Some parallel exporting from New Zealand takes place when niches not exploited by ENZA are identified by other organizations. At present there is a chance that the apple export business will be deregulated.

ENZA exports apples to 57 countries, with the largest volume going to the European continent, UK, and North America (Table 2). These markets, although most profitable, are also the most protected. ENZA spends considerable resources staying in, and improving access to, existing markets. In addition, oversupply of apples means that more markets are needed to spread volume, but many of these do not pay good prices. Nontariff barriers to export of apples exist, including protocols and phytosanitary barriers. These barriers make access very costly in some cases, e.g., Japan, Switzerland, and Mexico. No duty applies to fruit exported to the United States, but very stringent phytosanitary protocols involve USDA pre-shipment clearance. Subsidies for fruit production in Europe and subsidies for export promotion in the United States for competing markets also exist. Finally, nontariff barriers related to food safety, recyclable/refundable packaging, and integrated fruit production may have huge impacts on exports of fruit, particularly to Europe.

New Zealand is a relatively high cost producer, requiring a premium to cover market access issues and transport costs. Its recent success has been based largely on supply of unique varieties, but this exclusivity is rapidly being eroded by increases in production of Gala, Braeburn, and Fuji in South Africa, Chile, and the United States.

The marketing environment, particularly in Europe and the United States, is changing rapidly. The power of supermarket chains continues to increase, and each of these chains requires fruit to meet its specific standards. Inventory control and the future requirements for "just in time" delivery will impact many current storage and packing operations.

APPROACHES THAT MAINTAIN A VIABLE INDUSTRY

The following list, although not all inclusive, highlights steps that help maintain a viable apple industry in New Zealand.

A Single Marketing Organization or Consolidated Marketing

New Zealand has strength with its single desk marketing structure, which provides a strong coordinating body with the collective resources required to deal with customers and develop effective marketing campaigns. Product differentiation, distribution control, and branding can be maintained more easily.

ENZA sets the quality standards that must be met for export. In the past, when growers' fruit failed to meet these standards overseas, the losses were absorbed in the collective grower pool. Now, growers are directly penalized if quality is poor. ENZA provides market discipline, ensuring that exporters are not undercutting each other, as in the case with other Southern Hemisphere competitors.

ENZA has developed a strategic business framework upon which to maintain and build a sustainable future (New Zealand Apple and Pear Marketing Board Annual Report, 1997). Three phases have been identified. The first involves reducing costs, lifting quality standards and the product mix, developing year-round relationships with customers, investing in research and development, and ensuring assets are used and managed efficiently. Closer relationships with ZESPRI, the kiwifruit equivalent of ENZA, will be developed to obtain benefits from joint inventory control, shipping, technology, and overseas support offices. The second phase is focused on finding ways to use ENZA's skill base and intellectual property, such as plant materials owned by the Horticulture and Food Research Institute (HortResearch), to generate increased revenue. This has involved the formation of a joint venture company, Chiquita-ENZA Chile Limitada, (formerly ENZA's Chilean subsidiary, known as ZEUS, and the Chilean subsidiary of Chiquita Brand International), developing alliances and networks with Northern Hemisphere producers. A commercial and marketing presence in the Northern Hemisphere will be established as well to build 12-month marketing capabilities. Phase 3 will establish ENZA as a global horticultural business.

Product Differentiation

The New Zealand industry believes that its future lies in maintaining product differentiation, both for existing and new varieties. This view is impacting heavily on growers. It can be argued that the immediate priority should be in maintaining value of existing varieties, because it is lower risk and does not require heavy capital expenditure at a time that the industry is strapped for cash (Wilton, 1997). However, it is clear from the planting in the last five years that growers are both improving existing varieties and planting new ones.

Existing Varieties

While existing varieties are losing their exclusivity, New Zealand fruit is still being sold at a premium. To maintain this premium, fruit quality requirements are increasing and product specifications are being matched with market demand. Color standards are increasing, e.g., Braeburn from 40 to 50 percent. Size range also provides opportunities for product differentiation, especially for varieties such as Gala for which competitors have difficulty growing large fruit. ENZA would like to have less dependence on Gala and Braeburn. However, these varieties are relatively easy to grow and manage, and improvement of production efficiencies is ongoing. Tighter quality standards are forcing growers to increase marketable yields by optimizing uniform tree size, full canopy, correct vigor, and cropping balance. The bottom line is that investment in orchard redevelopment must be a continuous process.

New Varieties

It is in this area that I believe New Zealand is leading the way internationally with new approaches, some of which are controversial. Introducing new varieties has traditionally been a long process. It took Braeburn 30 years to gain acceptance, and this timeframe is no longer seen as acceptable. The aim of the industry is to have several new varieties at various stages of testing at any one time, and the industry accepts that all will not be "winners." The varieties of most interest now are HortResearch-developed Pacific Rose and Southern Snap. These are from a series of selections (GS series) from a cross between Gala and Splendour. These varieties have gone from trial selection stage to export in 10 years. The first apples were exported in 1991, and about 100,000 tray-cartons were sold in 1996. Over a million trees of Pacific Rose currently are planted in New Zealand. This type of production, together with appropriate marketing, will maximize the chance of acceptance and associated international impact. Moreover, these trees are protected by plant variety rights and are not available to competitors. This new approach to product development is also illustrated by the fact that Pacific Rose and Southern Snap have been planted in Washington State and in France under license. The aim of planting in the Northern Hemisphere is to provide a 12-month supply of the varieties and increase revenue streams from 6 to 12 months. Most importantly, by controlling the variety, the volume, and the markets, ENZA will be able to control availability of the varieties.

Market Research

Closely linked, and indeed implicit, in the success or failure of product differentiation is market research to identify strengths and weaknesses of a product, market requirements and trends. Growing horticultural products is no different from any other business and should be market driven, not production driven. Two United States examples are salient here: Braeburn and new variety evaluations (Tippler, 1996).

The Braeburn Story

The Braeburn story shows, for example, that introduction of a new apple variety takes hard work and that the rapid penetration of this variety in 1995 was not accidental. First, despite the general belief that stone fruit and other summer fruit are the only fruit that sell well during the time that New Zealand enters the United States market, research indicated that apples are still a popular eating choice then. Extensive radio campaigns in key markets highlighted the fresh new season of apple availability. Marketing research indicated that the bi-coloration of Braeburn was seen as a negative by consumers because of perceptions of unripeness and that, in summer, apples are perceived as mealy, dry, and tasteless. ENZA made a conscious decision to demo the variety as much as possible to dispel the notion that a shiny red apple is not always a good eating apple. Considerable success was realized for this crisp, juicy apple with sweet-tart flavor. Repeat purchases were in excess of 75 percent, and in 1995 the variety was sold out 4 to 6 weeks earlier than planned.

New Varieties

ENZA has a new variety evaluation program in place in its major markets, including the United States. The aim is to learn about the strengths and weaknesses of a variety in the marketplace by conducting consumer evaluations, sensory evaluation under controlled environments, obtaining technical evaluations, and sales and customer observations. For consumer evaluations, selected apple varieties are sent to regions for consumer testing of their attributes. Answers are collated for each geographical region and entered in the "New Variety Database" as part of the decision making for growers in deciding what varieties to plant. Sensory evaluation is more clinical and involves matching people types (ethnic, demographic features) with apple characteristics. This information pinpoints potential target markets or niches. Technical evaluations are incorporated to determine quality characteristics such as storage life and any observations relating to disorder incidence. Though not specific to the US, the apple variety Splendour used as a parent in the GS series described above had wonderful flavor and texture but too thin a skin for successful export marketing. Identification of this type of problem as early as possible saves further wasted investment. Finally, sales and customer observations, especially by supermarket buyers, are added to the information base used for decision making by ENZA and growers in New Zealand.

Research and Development (R&D)

New Zealand has always had a research community that is committed to the apple industry with pioneering work on many facets of horticulture, including the development of the center leader pruning system and control of calcium-related diseases. Until the 1990s, two government organizations were responsible for R&D. Commodity groups were involved in identifying research needs, but no financial inputs were required. Initial changes involved cutting government contributions to R&D by 30 percent over a 3-year period, and horticultural industries like all others were expected to pay for industry-directed research. The concept was that government, i.e., taxpayer, funding should be directed toward long-term goals. If the industry had a problem, then paying for research is no different than hiring an accountant or a lawyer. Both the kiwifruit and apple industries developed mechanisms for allocating R&D funds. By early this decade, it amounted to about two to three million dollars each. This change had many benefits, including real interest by the industry in research results and readiness to apply these as appropriate. Also, funding was appropriate to the problem at hand; limitations to quick resolution of a serious commercial problem could be overcome by application of sufficient resources. The downside for the scientist was that business procedures, specifically "give me enough information to solve my problem," often conflicted with the time honored practice of "needing one more season's worth of results."

The second and most major change came in 1992, however, when all scientific research in New Zealand was reorganized into stand-alone companies, in the case of horticulture, The Horticulture and Food Research Institute of New Zealand Ltd. (HortResearch). Briefly, each company is expected to cover its costs by meeting research objectives in research programs submitted to an independent research foundation and by commercial contracts. The former funding known as Public Good Research is focused on longer term problems and initially was quite separate from associated industry. However, financial support, i.e., commitment, from industry has been important in decision making about the extent of resources and, increasingly, industry is having an influence on allocation of research priorities. At present, the Public Good Science Fund for horticulture (which includes vegetable research based in another Institute) is $21 million a year, and the ENZA funding alone is about $3 million. The bottom line is that research structures have been put into place to ensure that both short- and long-term research needs are met and to provide the industry with excellent leverage to ensure work that is of priority to its success is carried out. Because ENZA and, less directly, growers are involved in these decisions, priority can be placed on research related to product development, market needs, (e.g., phytosanitary), and quality problems rather than emphasizing production issues. Also, ENZA can control the information that has been obtained, e.g., that pertaining to many production and quality aspects of new varieties, only available to growers in the New Variety database.

CONCLUSIONS

New Zealand has no alternative other than to follow the strategy of focusing on the top end of the market by producing premium apple varieties. Continuing to do this requires an integrated approach among growers, researchers, and marketers. The strategies outlined above to maintain international competitiveness are ambitious, but no other choice seems obvious. In New York, a situation where all fruit would, could, or should be controlled by a single marketing body is not a realistic option. However, unless you are a grower who is supplying niche markets such as pick your own, roadside retail, or specialty items such as organic produce, changes in the local and world marketing structures will continue to drive down prices.

I consider the take-home messages to be learned from the New Zealand apple industry to be:

1. Marketing is the critical factor in meeting the challenges impacting our industries by increasing competition, both internationally and nationally, as well as changes occurring at the supermarket level. This marketing has to be coordinated and is expensive. Therefore, collective approaches by growers are required—it is they whose livelihoods are on the line. One New Zealand lesson may be that it is important to seem big, even when you are small.
2. Existing varieties have to be differentiated in the marketplace and, where possible, new varieties introduced. These products need to have characteristics that are desired by the consumer such as good texture and shelf life, as well as being grower friendly in terms of production and management. There are two possible scenarios—either the rate of new variety introduction will be limited and the changes of the last decade are an aberration, or that the rate of change will continue. If the former is correct, we can relax as we slide down the slippery slope of reducing grower returns as apple consumption continues to stagnate or decline. If the latter is correct, we are in a new age of ever-changing premium varieties, and it is this one that the New Zealand industry is betting on. Moreover, it is the only view that provides a fighting chance of successfully competing against other fruit products. Survival of our industry lies in better marketing of new and existing varieties to create excitement and thus interest in our products. We cannot compete on commodity apples alone.
3. Research expenditure by industry is an absolute requirement, not a luxury. Funding by industry ensures that research is directed to address its needs, both short and long term. Emphasis (in research) should be given less to producing more volume and more to developing better and more marketable products. In this view, the research programs should be consumer-led rather than production-pushed.
4. Growers have to be prepared to take big risks. The approach of testing limited number of trees may be okay if you are satisfied with the status quo. For example, growers of Washington State Delicious have a variety with excellent production characteristics that they have defined in the consumers' minds. New Zealand growers do not have that option and have abandoned the conservative approach. That is why there are a million trees of a single variety in the ground that I am betting most of you have not heard of. They may not have a choice. You may or may not!

REFERENCES

Tippler, K. 1996. Developing markets for new apple varieties. New York Fruit Quarterly 4(1):3-6.

Wilton, J. 1997. Orchardist of New Zealand 70(11):15-17.

AUSTRALIAN PERSPECTIVE:

Evaluation—The Key to Success of New Varieties

Garry Langford

National Coordinator Australian Pome Fruit Improvement Program Ltd., Tasmania, Australia

Presented at the 42nd Annual IDFTA Conference, February 20-24, 1999, Hamilton, Ontario, Canada.

The Australian Pome Fruit Improvement Program Ltd. (APFIP) was formed in February of 1997 after several years of lobbying by Australian growers. The company is wholly owned by the Australian Apple and Pear Growers Association and has been initially funded by a compulsory levy of 1.5 cents (Aust.) per carton of fresh pome fruit. The levy is collected along with other industry levies for research and development, marketing/promotion and industry administration.

The Horticultural Research and Development Corporation, a federal government agency, matches the levy dollar for dollar. The company is managed by a board of 5 directors and activities are administered by a national coordinator. The aim of the company is to become largely self-funded in supplying its services, therefore reducing its reliance on the industry levy by performing commercial operations such as rootstock production. The company has a 2 hectare rootstock production block at Monash in the Riverland of South Australia which is in commercial production of M.26, MM.106 and Ottawa 3 rootstocks.

The company has the following objectives:

- to facilitate equitable and prompt access to high quality pome fruit propagation material and information for the pome fruit industry in Australia.
- to develop pome fruit propagation material with characteristics that will maximize the commercial potential for pome fruit production in Australia.
- to develop and promote standards for pome fruit material that will assist the international competitiveness of the Australian pome fruit industry.

The company has the following six main functions:

- develop and promote standards for pome fruit material.
- evaluate varieties and rootstocks throughout different growing regions.
- facilitate and promote efficient quarantine standards.
- multiply and provide selected budwood and rootstocks.
- safeguard rootstock and budwood material in repositories.
- seek and acquire rootstocks and varieties.

CULTIVAR EVALUATION

Background

The pome fruit industry in Australia represents 0.8% of world production, and our growing areas are spread over a continent, ranging from the subtropics in Queensland to latitude 43˚S in Tasmania with all the associated climatic differences. Cultivar evaluation is one of the most important of our functions, supplying an information service to the industry.

As recently as the last 10 years, varieties from breeding programs around the world were available for widespread distribution and evaluation, mostly by government departments of agriculture. Rationalization of government agencies in Australia has led to major downsizing, and these agencies no longer have the staff or resources to conduct trials. Elements of our industry are comfortable with this as some evaluation carried out by government agencies was perceived as being too scientific and too slow at producing results. The rationalizing effect on government-funded breeding programs around the world has required them to be more income focused. The nursery industry has picked up the baton to a large extent on cultivar evaluation, but their evaluation usually involves only varieties to which they have the rights. No varieties are bred and released to the world just for the satisfaction and the warm inner glow it gives the breeder, it is done for financial return.

Cultivar evaluation one of the most important of our functions.

Future

With the focus on income from new varieties, more ways of controlling varieties to maximize returns will come to the fore. Already production royalties are a reality, and with this come specifications for products to meet trademark requirements. How many times have we heard in our industry: “We grow that variety well here but those guys in . . . do a poor job and spoil the market for us.” With a diverse range of growing conditions in Australia, some regions will be excluded from growing a particular variety as it cannot produce to the specification. Growers need to be aware of this information early so they can make business decisions based on sound advice, not just a hunch or anecdotal evidence. New varieties will fail to gain a foothold in the marketplace if they are not grown in the areas best suited to them. The growers will lose money, the variety owner/agent will also lose money and have a variety that is known as a dud in a particular area. That kind of information is the fastest travelling of any news. We are becoming global farmers and, if we are not prepared to move into other growing areas to grow a “winner,” we should not do it poorly in our own area. Pink Lady is a good example of this with cooler areas such as the Huon Valley in Tasmania not being able to consistently grow the variety to the specification required for export to the United Kingdom.

Evaluation Site Setup

APFIP Ltd. has established a network of evaluation sites across Australia for varieties and rootstocks. The focus of information collection is balanced between objective and subjective methods. It is important we gather information that growers and variety owners require in a timely manner. Evaluation sites have been established at Stanthorpe in Queensland, Orange in New South Wales, Shepparton in Victoria and Lenswood in South Australia, and sites will be planted in Tasmania and Western Australia this winter.

All these sites have been established using procedures developed in consultation with growers, nurseries and government agencies. The procedures are based on the ISO 9002 standard. There is a general direction for all involved in food production to have effective record keeping procedures in place and the ISO standard offers an effective template for this. The evaluation manual developed so far is stored on our home page at <www.apfip.com.au> under a secure password. Procedures developed are listed in Table 1.

Evaluation Groups

The evaluation groups in each region have a maximum of 9 members. There is provision for department of agriculture representation in each group, and the majority of group members are growers. The groups operate under the direct control of APFIP Ltd. Members of the groups who have sites on their properties are regional custodians. All group members sign agreements with APFIP Ltd. to carry out tasks associated with the site in accordance with the procedures. The agreements include clauses for nonpropagation and confidentiality of information collected. Varieties that enter the sites are known only as a code number which is allocated by APFIP Ltd., therefore the growers involved do not know the variety name or its source. This allows us to collect independent and unbiased information.

Evaluation sites are selected by members of the group. This decision is made with regard to knowledge about local growing conditions. Its important not to have sites in areas where the local growers anecdotally think apples and pears grow poorly. The combination of the grower representation in the group and site selection gives credibility to the information that is collected.

Variety owners or agents are required to prove their right to the variety they are proposing to enter for evaluation and also the virus status of the material. The national coordinator supplies basic information about the variety, such as color and season, to the groups.

Although no evaluations have been completed to date, information regarding aspects of tree growth, pest and disease susceptibility/resistance, fruit size, shape, color, and season along with other characteristics will be collected.

Cultural Practices

Cultural practices for the sites mirror normal orcharding operations, with trees hand thinned because of the diverse and sometimes unknown flowering times. This practice allows us to gather information about variety pest and disease resistance in a functioning orchard. The basics of the evaluation sites design are set out in Table 2.

Information Release

All information gathered is to be disseminated by APFIP Ltd. in consultation with variety owners. Evaluations will be published in the Australian industry magazine “Pome Fruit Australia,” regional pome fruit newsletters and on our home page. We will also conduct displays of fruit in local areas away from the evaluation site, which will not have public access. Obviously where a variety has received a good report of its characteristics

TABLE 1

Evaluation procedures.

- Receiving evaluation material
- Trial design
- Site selection
- Chemical use
- Site preparation
- Handling trees before planting
- Establishing trees
- Labeling and identification
- Hygiene
- Post-planting care
- Training and pruning
- Removal of trees
- Records
- Evaluation
- Use of information collected
- Regional evaluation groups

TABLE 1

Trial design for variety and rootstock evaluations.

Replication	Rootstocks	Planting distances/ orientation	Maximum time in the site
Varieties: 6 trees/rootstock with 3 rootstocks/ variety. (Maximum of 18 trees/variety.)	MM.106 is standard to all sites as a control/reference. The other 2 stocks are selected by the groups.	2 meters in rows with no requirement for row widths. Orientation is to be north-south where possible.	7 years, if a variety shows poor characteristics it can be removed earlier.
Rootstocks: 10 trees/stock, with Gala, Fuji and Pink Lady as the scion variety. (Maximum	Comparative stocks are selected by the rootstock owner/ agent, a maximum of 2.	Same as for varieties.	Same as for varieties.

in a particular region, the owner or agent will use this to promote the variety/rootstock.

Evaluation Costs

The evaluation groups currently receive a maximum of $2,000 (Aust.) per year to maintain the sites, plus $5 (Aust.) per tree for all new trees planted in the site. This may or not be enough; early estimates show that it will cost approximately $35,000 (Aust.) per annum to maintain 10 sites. We will continue to monitor this as the sites grow and adjust the financial commitment as required. Because the benefits of effective evaluation impact both the variety owner/agent and growers, both should contribute to the cost. A schedule of fees has been developed for owners/agents based on the number of trees in evaluation. The fees are set at relatively low levels to encourage as many owners/agents to use our network as possible.

CONVERSION FACTORS ENGLISH VS. METRIC

To convert Column 1 into Column 2, multiply by:	Column 1	Column 2	To convert Column 2 into Column 1 multiply by:
	Length		
.621	kilometer, km	mile	1.609
1.094	meter, m	yard	.914
3.281	meter, m	foot, ft	.3048
39.4	meter, m	inch	.0254
.03281	centimeter, cm	foot, ft	30.47
.394	centimeter, cm	inch	2.54
.0394	millimeters, mm	inches	25.40

metric: 1 km = 1000 m; 1 meter = 100 cm; 1 meter = 1000 mm
English: 1 mile = 5280 ft; 1 mile = 1760 yards; 1 yard = 3 ft; 1 ft = 12 inches

	Area		
247.1	kilometers^2, km^2	acre	.004047
2.471	hectare, ha	acre	.4047
.4047	trees/hectare	trees/acre	2.471

metric: 1 ha = 10,000 m^2 = .01 km^2
English: 1 acre = 43,560 ft^2

	Volume		
1.057	liter	quart (US)	.946

English: 1 US gallon = 4 quarts

	Mass—Weight		
1.102	ton (metric), t	ton (English)	.9072
2.205	kilogram (kg)	pound, lb	.454
52.5	ton (metric) of apples	apple packed box, *carton	.01905

metric: 1 metric ton = 1000 kg
English: 1 ton = 2000 lb; 1 packed box or carton* of apples = 42 lb

	Yield or Rate		
0.446	ton (metric)/hectare, t/ha	ton (English)/acre	2.242
.892	kilogram/hectare, kg/ha	pound/acre	1.121
.991	ton (metric) of apples/hectare, t/ha	bins* of apples/acre	1.009
.4047	trees/hectare	trees/acre	2.471
0.107	liter/hectare	gallon (US)/acre	9.354

metric: 1 metric ton = 1000 kg; 1 hectare = 10,000 m^2
English: 1 ton = 2000 lb; apple bin* = 900 lb; 1 acre = 43,560 ft^2

	Temperature		
1.8 C + 32	Celsius, C	Fahrenheit, F	.555 (F-32)

**Commercial cartons (packed boxes) of fruit and field/storage bins of fruit do not have universal weights. The weight of fruit in a packed box or carton varies around the world and with the type of fruit, but is here taken for apples as 42 lbs (19.05 kg); the weight of fruit in a bin also varies but is here taken for apples as 900 lbs (408.2 kg).*

Lessons Learned about Tree Support from the 1998 Labor Day Storm

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The most durable support system was the "single high wire and conduit stake" trellis system.

On the morning of September 7, 1998 (Labor Day), a massive storm roared through the western New York apple industry with winds in excess of 80 miles per hour and hail. It ruined an estimated four million boxes of apples and uprooted or broke off many acres of trees. A similar storm with winds in excess of 100 mph hit the Grand Rapids, Michigan, area on May 31, 1998, also destroying many fruit trees. Extension agents from Michigan report that a severe fire blight epidemic resulted from the damage caused by the storm, resulting in additional loss of hundreds of acres of dwarf apple trees.

Following the 1998 storms in western New York and following earlier storms from remnants of hurricanes in eastern New York and Connecticut, we have reevaluated our recommendations for tree support systems used in dwarf orchards to determine if improvements can be made. Our observations are:

1. All tree support systems will fail if the winds are strong enough, but some systems performed much better than others when winds were in excess of 80 mph.
2. Trees supported by a single 1/2"or 3/4" (1.25 or 1.9 cm) steel tube (conduit) fared the worst. Although the "conduit stake" will generally support the tree when it is young and will give some support to the cropping leader of young trees, the steel tube cannot support the tree during high winds especially when carrying a crop. We learned this 15 years ago after hurricane winds came up the East Coast and broke many trees that were supported by a conduit pole. The storm of 1998 gave the same result. This support system is most commonly used on central leader trees with interstems and M.26, which are semi-free-standing. When carrying a heavy crop even these trees need better support than a single conduit pole when winds exceed 40 mph.
3. Trees that are supported by a small diameter wood pole (2" [5 cm] diameter) also fared poorly. Square 2" x 2" wood poles are the worst. They often snap off at a knot in the wood. Round 2" diameter wood poles are slightly better with clear differences in performance depending on the quality of the pole. "Peeler cores," which are the remnant of trees that are peeled for plywood, are no better than the 2" x 2" square poles. This is because they are made from the softer wood at the center of a log. Other whole tree 2" diameter wood poles did slightly better but still broke in large numbers since the forces of the wind exceeded the breaking strength of the poles of that diameter. This support system is commonly used with trees with M.9 trained as slender spindles and is the most common support system in Holland. Although these small diameter wooden poles can normally support both the tree and heavy crops, they are inadequate for the kinds of winds experienced in New York and Michigan in 1998.
4. Trees supported by 3" diameter or larger wood poles fared well. This support system has been used for slender spindle trees in the past, but the cost of the poles and installation has reduced its popularity.
5. Trees supported by a 1/2" or 3/4" conduit steel stake tied to a single-wire trellis generally survived better than other systems. Support systems using a two-wire trellis and a conduit stake (one wire at the height of the lower scaffold branches and the other at the top of the poles) were even better, especially with brittle varieties like Gala which can snap off at the graft union on M.9 or M.26. Systems using bamboo instead of conduit also survived well but not as well as steel conduit. Nevertheless there are cases in western New York where even this sys-

FIGURE 1

Tree support system for Vertical Axis and Slender Spindle using the single high wire and 1/2” steel stakes with a driven post as the anchor.

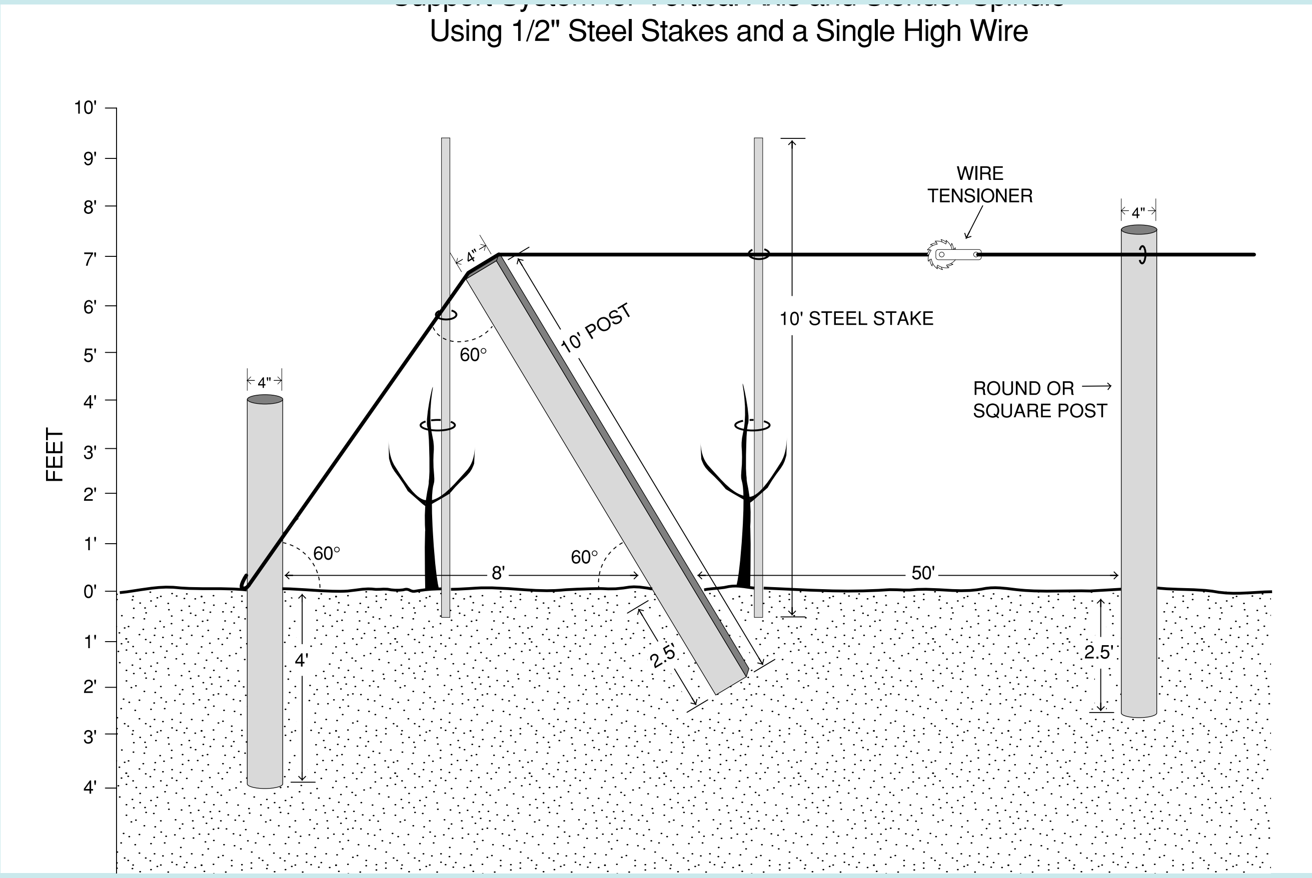
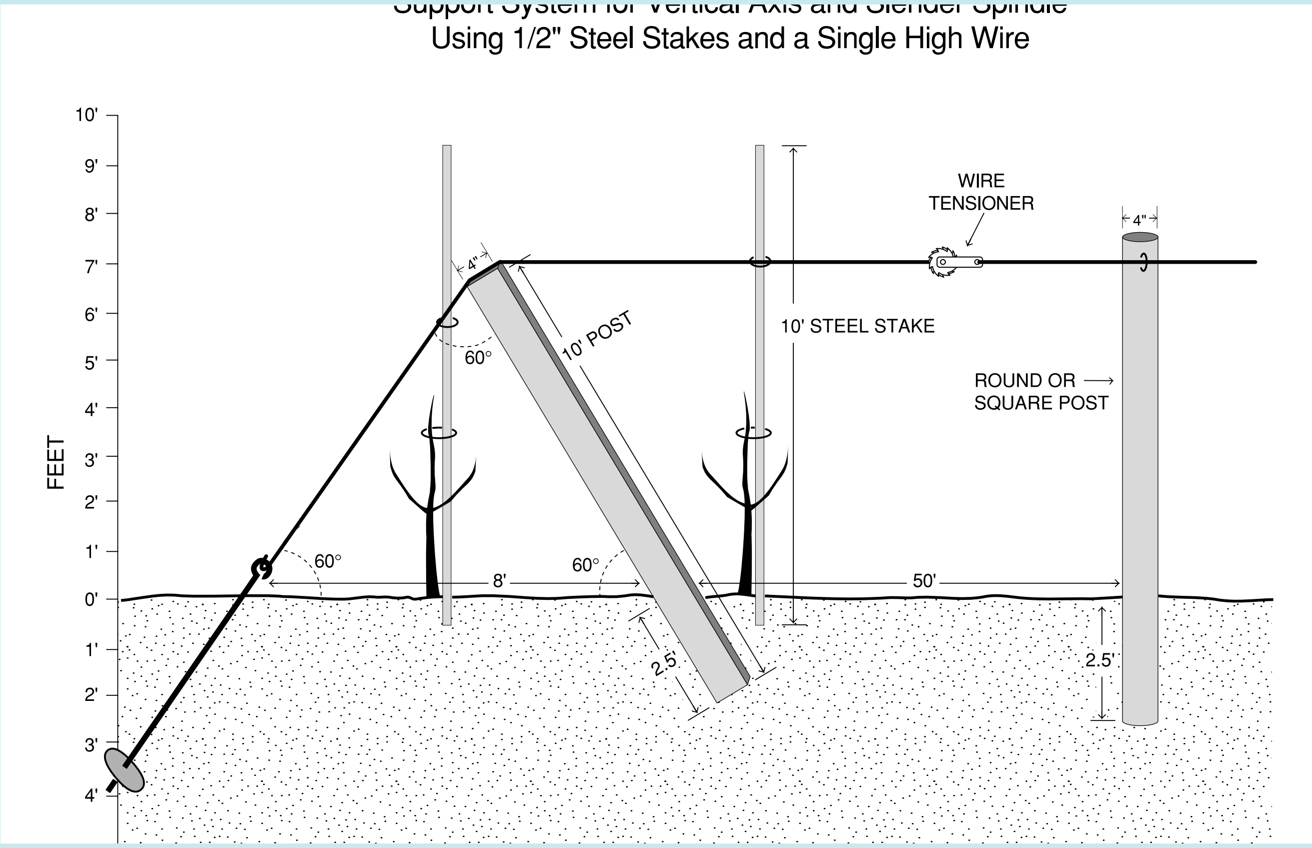


FIGURE 2

Tree support system for Vertical Axis and Slender Spindle using the single high wire and 1/2” steel stakes with a screw type anchor.



tem failed. One notable example occurred when a trellis was supported by cement poles and the hurricane force winds broke off the cement poles, bent the conduit, broke off the trees, and then piled them all up together in the hedgerow. The success of the "single high wire and conduit stake" system depends on how well the steel stakes are attached to the wire, the distance between in-line poles, the strength of the anchoring system, and the tension of the wire.

Over the last 15 years we have studied tree support systems and have benefited from the knowledge of John Wall of Kiwi Fence Company and of Fred Smith of Innovative Fence Company. We have learned from trial and error many of the important points of good tree support systems. Based on our experience and our assessment of the successes and failures following the 1998 storms we suggest fruit growers consider the following points when designing support systems for new dwarf apple orchards.

1. A tree support system must be designed for the worst case scenario growers are likely to encounter during the lifetime of the orchard. The infrequency of storms like the one we had in 1998 has led many to gamble and install minimal support systems. These storms proved that "conduit" pipe, bamboo, or 2" diameter wood stakes alone are not adequate for tree support and we no longer recommend them except for training purposes. The need for stronger support systems than these was very evident in 1998, but growers rightfully must still consider the cost of stronger systems and should not invest unnecessarily in support systems.
2. The "single high wire and conduit stake" system is a good compromise between cost and excellent tree support. This support system survived the storms of 1998 better than other systems and is what we recommend for dwarf orchards. Figures 1 and 2 show the basics of the system. For brittle varieties like Gala, a two-wire and conduit trellis system should be used (Fig. 3). The lower wire is placed at the height of the lowest tier of scaffold branches. These lower scaffolds are then attached to the wire to prevent a twisting motion of the tree in high winds that can break brittle graft unions with M.9 or M.26 rootstocks. The strength of this system lies in 1) the anchoring system at the end of each row, 2) the use of high tensile wire, 3) the use of 4" (10 cm) diameter in-line wood poles spaced no further than 50 ft (15 m) apart and 4) in the attachment of the steel poles to the wire. These four key factors that resulted in this system surviving better than other systems the 1998 storms are discussed below.

THE ANCHORING SYSTEM

We prefer a system based on an equilateral triangle formed by angling the first in-line pole back toward the anchor to a 60˚ angle with the ground. The pole forms one side of the triangle. The other two sides are the wire, which comes down over the top of the pole and is attached to the anchor near the ground and the ground from the base of the anchor pole to the base of the first in-line pole. By having the first in-line pole angled back toward the anchor, the pull of the wire on the anchor is more evenly transferred to the anchor. If the first in-line pole is vertical, it acts as a lever and the force on the anchor from the wire tension is increased. The anchor itself can be any immovable object. Growers have successfully used buried objects

FIGURE 3

Tree support system for Vertical Axis and Slender Spindle using the two wires and 1/2" steel stakes . This system is recommended for Gala and other brittle varieties.

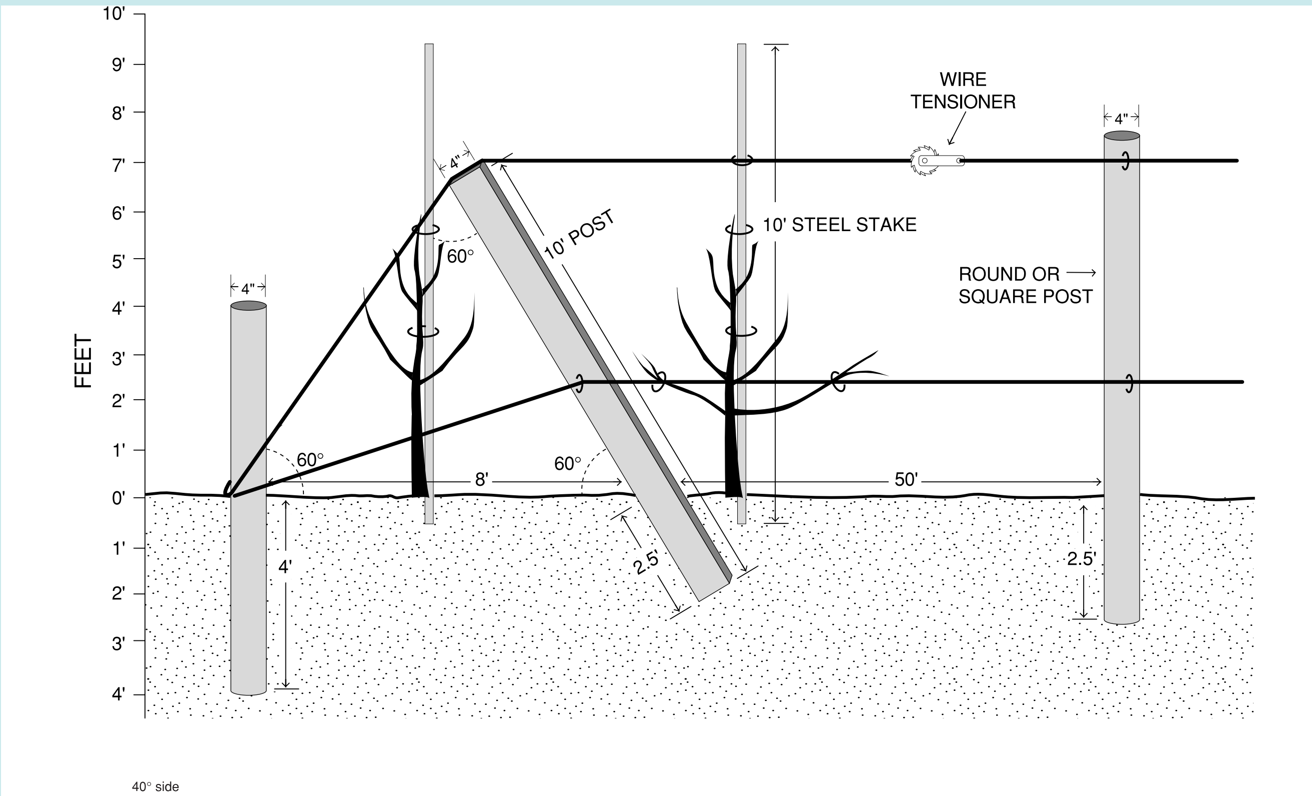


FIGURE 4

Tree support system for V-Slender Spindle using a variation of the single high wire and conduit tree support system.

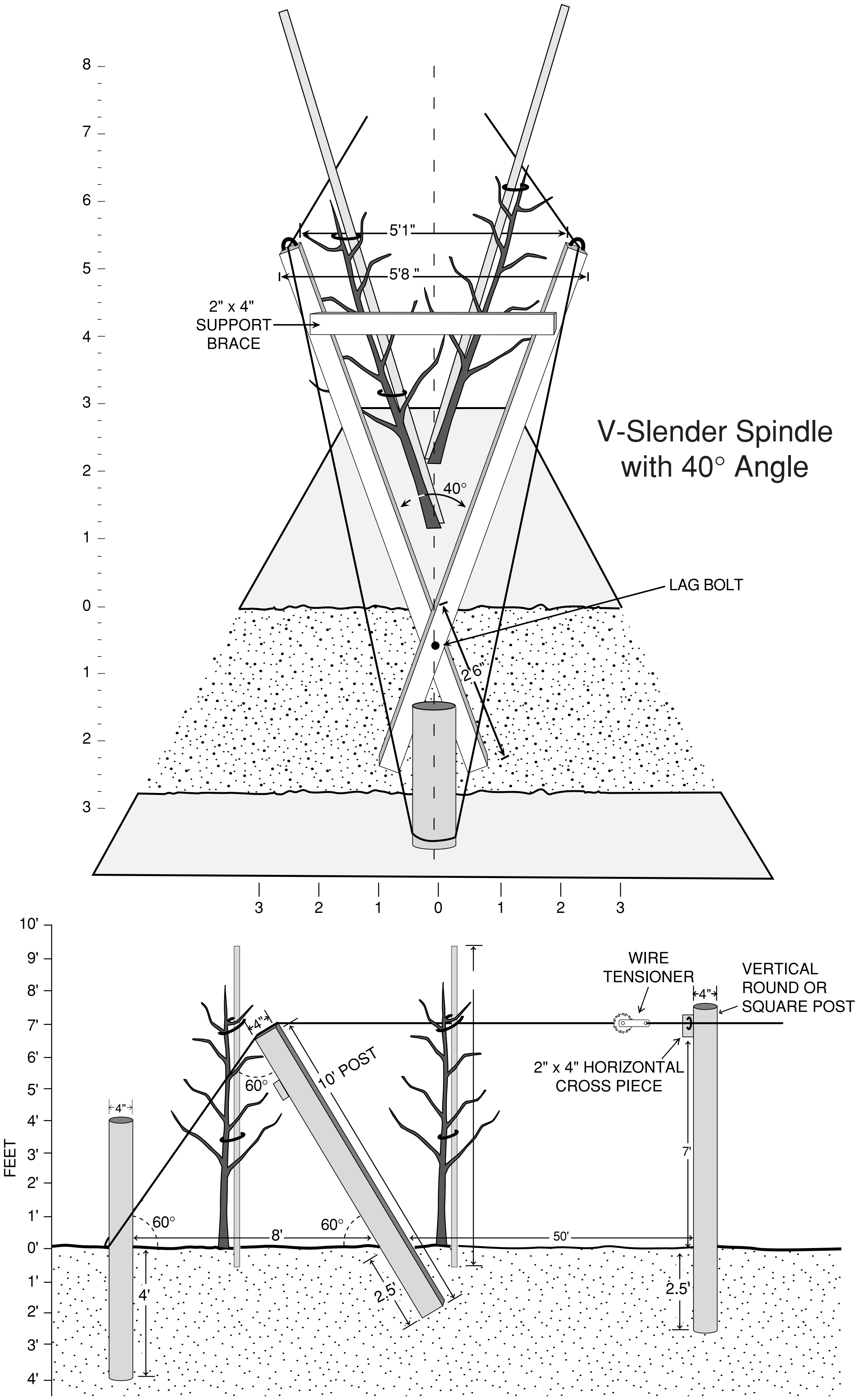
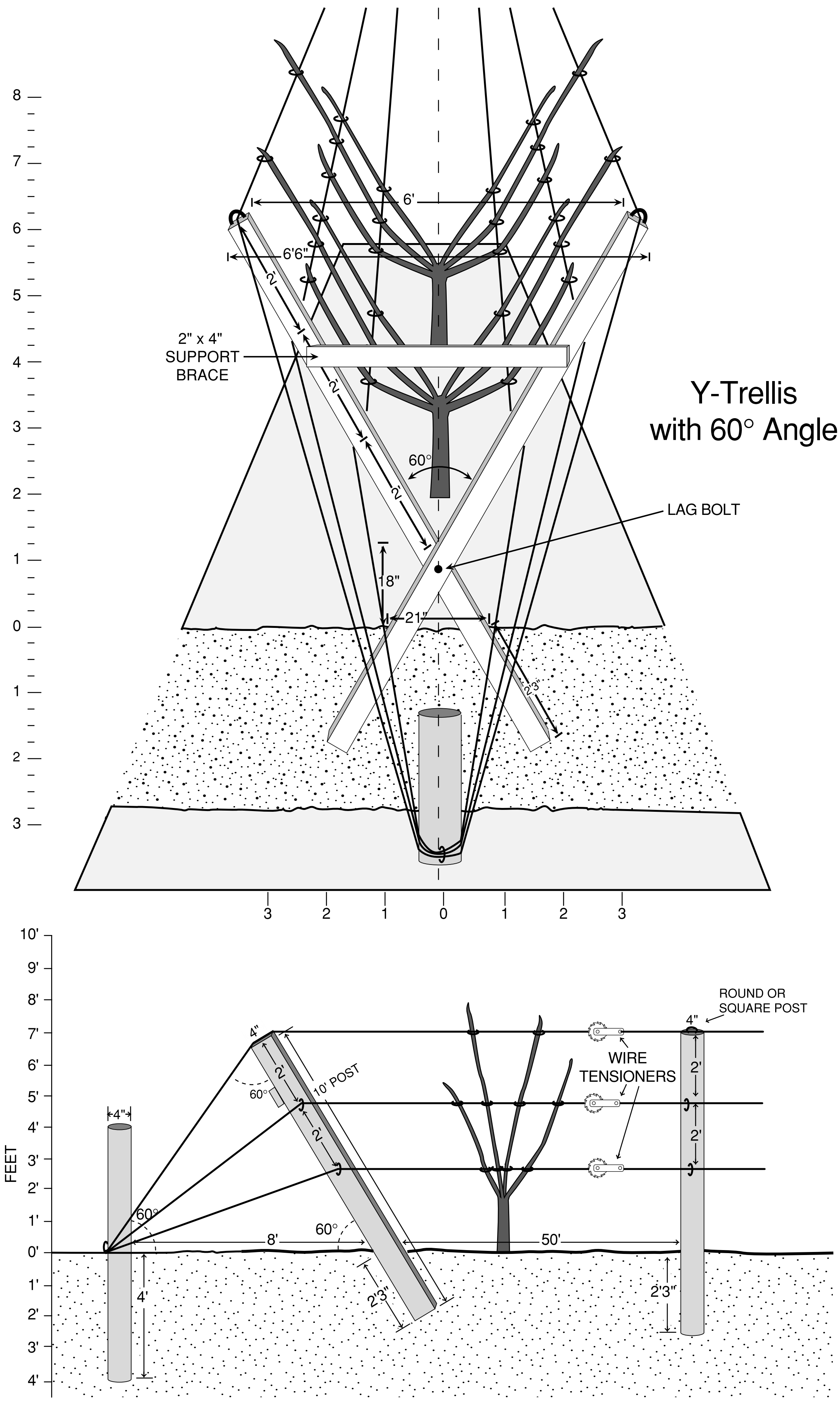


FIGURE 5

Tree support system for V-Slender Spindle using six wires and the equilateral triangle anchor system.



(deadmen), screw type anchors (Fig. 2) or driven posts (Fig. 1). We like driven posts, since in many soils the screw anchors do not hold. The driven anchor post should be vertical and should be 4 ft (1.2 m) in the ground. If this post is angled back, the wire tension will cause it to knife through the soil, resulting in a loss of wire tension and the failure of the system. The strongest position relative to the angle of pull by the wire coming down to the ground at 60˚ is for the post to be vertical. If anchor posts are installed by auguring a hole and then tamping in the post, their failure rate is very high. Anchor posts must be driven.

Variations of the single high wire system using the same equilateral triangle anchoring system have been successfully used with other trellis systems including V-systems. For V- or Y-systems, the first in-line pair of V-posts is also angled back toward the anchor post forming the equilateral triangle (Figs. 4 and 5).

HIGH TENSILE STRENGTH WIRE

Our preferred wire is a galvanized high tensile 12.5 gauge wire. The type of galvanizing, or the weight of zinc coating deposited on the wire, can greatly affect its useful life. If the coating is too thin, corrosion will shorten the life for the wire. We recommend type III galvanizing, which has a life expectancy of up to 50 years. The wire must have enough tensile strength to withstand the initial tension of 150 ft lb and also the increased tension resulting from low-temperature contraction of the wire or from the fruit weight near harvest.

The wire should be attached to the posts with 1.75" (4.4 cm) long galvanized fence staples. Staples should not be driven all the way home into the wood to allow uniform tension when the wire is tightened (Fig. 3). To prevent staple pull-out, several stapling techniques have been developed for dips and rises in the land over which the trellis passes (Figs. 6-8). The wire should be stapled to the top of the last in-line pole (angled pole) using the method detailed in Fig. 6. With the wire on top of the pole, the wire tension will help hold the pole in the ground.

WOOD POSTS

Our preferred size of post is a 4" (10 cm) diameter, 10 ft (3 m) long pole. It should have a blunt end and should be driven into the ground 2.5 ft (.75 m), thus leaving 7.5 ft (2.25 m) out of the ground. Over the years we have tried smaller wood posts but after the results of the 1998 storms we recommend the 4" poles. The strongest poles are round and made from lodgepole and southern yellow pine. We have also used dimensional 4" x 4" wood poles, but these are not as strong as round poles. Red pine poles are also common but are less desirable since that species has tiers of branches that originate at one point on the tree, giving a series of knots at that level which is a weak point in the pole. The distance between in-line posts is an important factor in the structural strength of the system. Over the years we have used distances from 48 ft (15 m) up to 80 ft (24 m) between poles. The storms of 1998 made it clear that to withstand 100 mph winds the distance between poles should not exceed 50 ft (15.2 m) (Fig. 1).

ATTACHMENT OF THE STEEL POLE TO THE WIRE

We learned from the East Coast hurricane of 15 years ago that if the conduit steel tubes were attached loosely to the wire then the poles would slide down the wire during high winds. This resulted in the tree breaking off and then the entire pole and tree being stacked down the row at the next wood support post. The pole must be attached rigidly to the wire so it cannot slide up or down the row. Our preferred method for attaching the poles to the wire is to use a 16 gauge galvanized "potato bag wire tie." The tie is looped around the pole, then around the wire and back around the pole and then tightened down with a twist of the wire ends (Fig. 9).

FIGURE 6

How to staple wires.

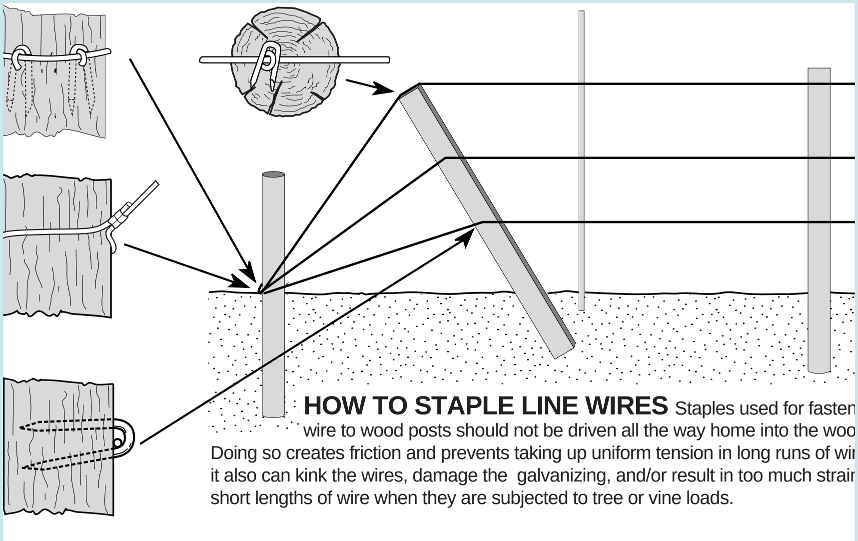
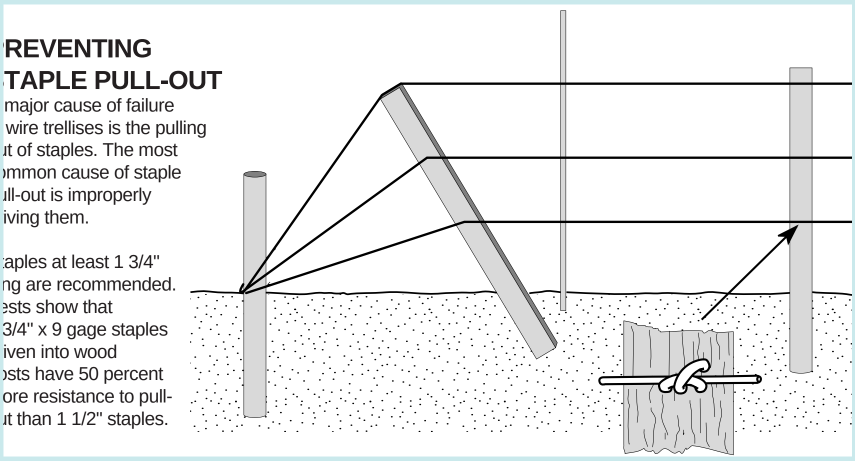


FIGURE7

Preventing staple pull out.



SUMMARY

The investment in a good support system is essential for dwarf apple orchards. The support system will not only protect the tree during infrequent wind storms such as experienced in 1998 in New York and Michigan but will also allow the young tree to carry heavy crops. The value of dwarf, high density apple trees is directly related to their increased production during the early years and the ease of management and fruit quality as the trees age. The economic success of the dwarf orchard depends on the trees surviving for 15 to 20 years. A good support system that will last for 20 years and require little maintenance will help ensure fruit growers' success. The single wire and conduit stake tree support system, if installed properly, is a very strong but economical support system. It survived the Labor Day storm of 1998 better than other economical systems.

ACKNOWLEDGEMENT

We gratefully acknowledge the ideas and experience in trellis construction of Mr. Fred Smith of Innovative Fence Company, Marion, NY. He provided Figures 6-9. This work was funded in part by the New York Apple Research and Development Program.

FIGURE9

Method of attaching steel stakes to wire using wire ties.

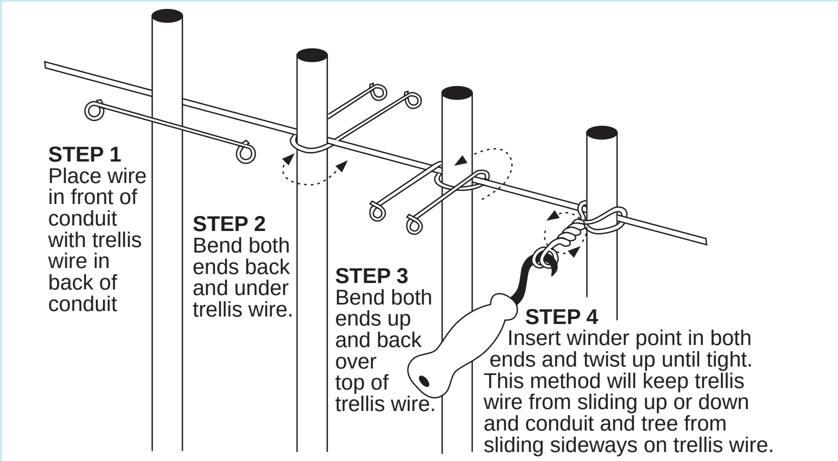
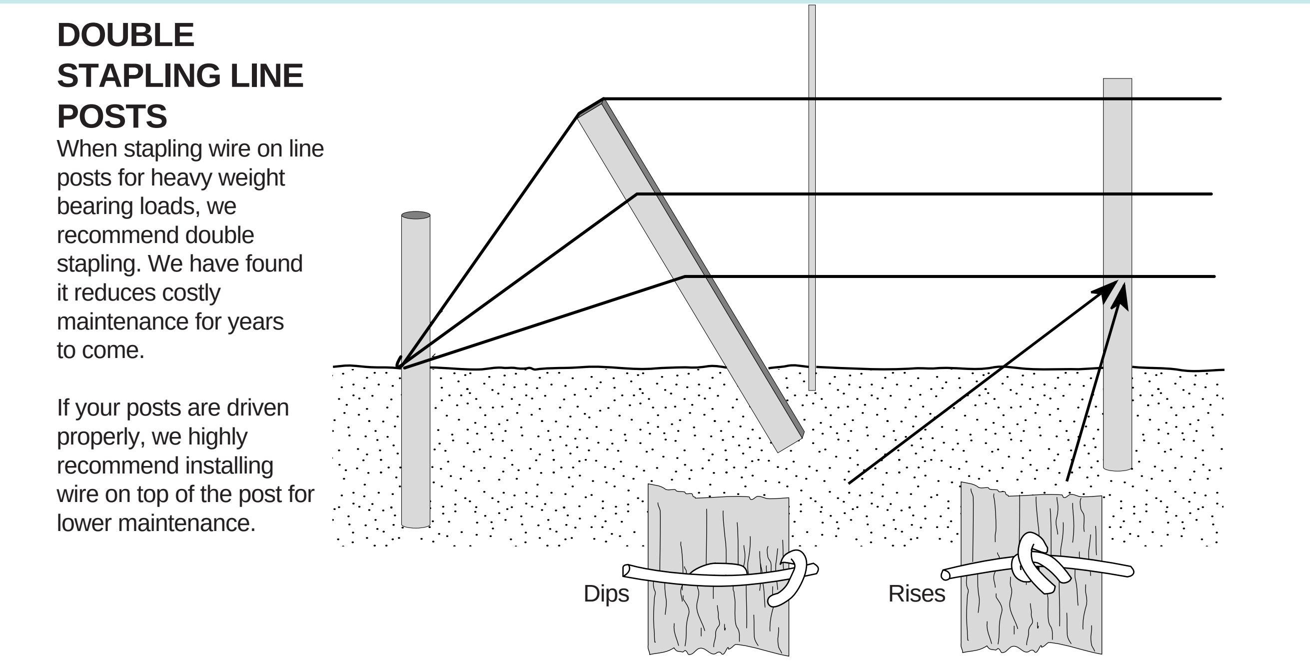


FIGURE 8

Double stapling line posts.



Developing New Peach Tree Growth Habits for Higher Density Plantings

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Peach production worldwide relies on the use of vigorous, spreading scion cultivars grafted onto rootstocks of similar vigor. Regardless of the desired growing system, from low density to high density, from large open-center to closely spaced tree walls to "Y" trellis systems, the standard, vigorous tree type must be made to fit the system. For the development of high density peach production systems severe pruning is necessary. Pruning invigorates trees and leads to excessive vegetative growth which may adversely affect fruit quality and subsequent flower bud formation due to shading. Summer pruning of excess regrowth can help to alleviate the problem, but the economic benefits of this practice are still in question.

As currently grown, peaches produce rather poorly when compared with other tree fruits. The average production of peaches in the U.S. is only 9 to 10 MT/ha (4 to 4.5 tons/acre). Apples produce 18 to 22 MT/ha (8 to 10 tons/acre), and pears, 13 to 27 MT/ha (6 to 12 tons/acre). The advantages of high-density fruit production have been clearly demonstrated in improving apple yields. Apple systems rely on the use of dwarfing rootstocks. Spur-type scions are important for some cultivars. Commercially acceptable dwarfing rootstocks are not available for peach (Marangoni et al., 1984). While there are possibilities for the development of dwarfing rootstocks for peach, there clearly are opportunities for other approaches to growth habit manipulation in peach. These opportunities are based upon 1) the existence of a great variety of different growth habits, some of which will be discussed below, and 2) unlike apple, most commercial peach varieties have been developed by breeding programs. Therefore the development of new varieties with different growth habits is feasible within our current peach breeding structure.

PEACH GROWTH HABITS

Dwarf

Dwarf trees vary in size but rarely reach over 2.4 m (8 ft) in height. There are at least two types of dwarf trees. The "brachytic" dwarf is characterized by very short internodes, long leaves, and a dense canopy. The brachytic dwarf has received some attention in breeding programs and high fruit quality brachytic dwarf varieties have been released (Hansche, 1989). However, the dense canopy is a problem for this growth habit and its future is uncertain. Another dwarf type tree (A72) was reported by Monet and Salesses (1975) in France, but it has received little attention. Seedlings from open pollinations of these dwarf trees exhibit a wide range of sizes. Leaves are not "oversized" and overall the canopies are much more open than those of the brachytic dwarfs. At the USDA-ARS Appalachian Fruit Research Station in Kearneysville we are just beginning to analyze the potential for this dwarf type. Fruit quality at this time is poor and at least several generations of crossing to high fruit quality types will be necessary for variety development.

... the development of new varieties with different growth habits is feasible ...

Compact

The "classic" example of the compact growth habit is the variety Com-Pact Redhaven. Compact trees have shorter internodes than standard trees, wider branch angles, and a greater number of and longer laterals than produced on standard trees (Scorza, 1984). These characteristics make for a dense canopy and reduced light penetration (Scorza et al., 1984). Com-Pact Redhaven can be found in home garden nursery catalogs but is not, to our knowledge, grown for commercial fruit production. The attraction for home growers may be the reduced tree size but the dense canopy and excessive pruning necessary for adequate light penetration would be a disadvantage to commercial growers.

Spur-type

Many stone fruit species including plum, apricot, and cherry produce fruiting spurs. The first report of spur-type growth in peach was published by Scorza (1987). Spur growth type peaches were found in some exotic peach germplasm that had been imported into the U.S. Some were apparently peach-almond hybrids and their spurriness was most likely inherited from the almond parent. Yet, the trees that produced the greatest densities of spurs were peach x peach hybrids with dwarf and compact in their backgrounds. The spur-type trees were not dwarf or compact. So it appears that the spur character may be inherited from tree types such as dwarf and compact without inheriting other growth traits such as dwarfism. At the USDA Station in Kearneysville, we are continuing to develop and evaluate spur-type peach trees.

Weeping

Weeping peaches have been released as ornamentals. There are at least two programs in Europe, including one in Bologna, Italy, and one in Bordeaux, France, that are developing commercial fruit quality weeping peach varieties. Bassi et al. (1994) suggested that the weeping peach may be of interest for new training systems, similar to the Lepage system in pear with a zigzag stem made from the scaffold branches alternately radiating from the trunk one above the other.

Columnar

Columnar trees were first reported from Japan where they have been developed as ornamentals (Yamazaki et al., 1987). Left to grow naturally, they will attain a height of 4.9 m (14 ft) and a crown diameter of about 1.5 m (5 ft). The most striking feature of the columnar tree is its narrow branch angles (Scorza et al., 1989) (Figure 1). Fruit quality of the original columnar (also known as "pillar") tree is very poor and yields are low. The breeding program at USDA-Kearneysville and at several locations in Italy (Bologna and Forlì) has significantly improved the fruit quality and productivity of columnar trees. The fact that columnar trees have a naturally narrow canopy appears to make them ideally suited to high-density spindle tree or "wall" systems.

"Mixed" Growth Types

Beyond the naturally occurring peach growth habits, we have found that through intercrossing of the different growth habits we can produce new tree types, including columnar dwarfs, columnar compacts, trees with ball-shaped canopies, and others. One of the potentially more useful of these mixed types is the upright tree (Bassi et al., 1994) which is a combination of the columnar and standard tree types. Upright trees are more spreading than columnar trees but retain the upright growth habit suitable for high-density production systems. Upright trees with high fruit quality are being developed both at USDA-Kearneysville and in Italy (Bologna and Forlì).

EVALUATION OF COLUMNAR TREES

Tree performance of dwarf, compact and other peach tree growth habits has been published previously (Hansche and Beres, 1980; Scorza et al., 1984, 1986; Bassi et al., 1994). Here we present an initial evaluation of the original, unimproved columnar tree in terms of pruning and fruit production at several planting densities.

Tree Density Trial

A columnar genotype from the University of Florence peach collection named Pillar was budded in September 1987 to peach seedling PS A5, a rootstock selected by the University of Pisa that induces a slight reduction of vigor, high yields and ripening uniformity. The 1-year-old trees were planted in November 1988 at the University of Bologna's Cadriano Experimental Station. At budbreak in the following spring, their leaders were headed back to about 20 cm (8 inches) from the graft union to promote uniform canopy growth.

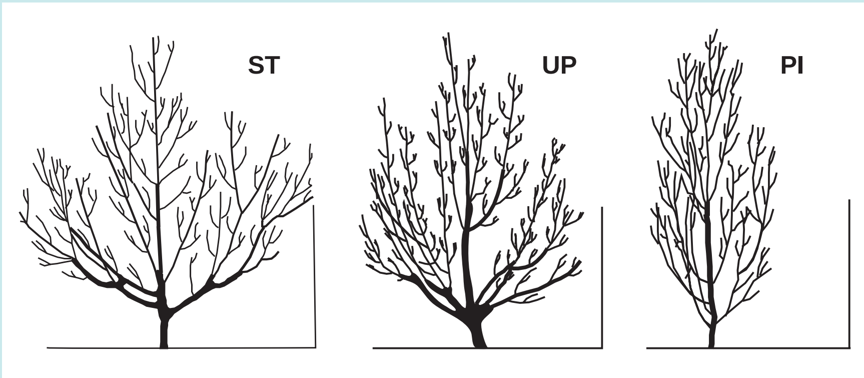
Three planting densities with three replications of five trees each were tested: 1) medium density (MD), 3 x 4.3 m (9 x 13 ft), 775 trees/ha (314 trees/acre); 2) high density (HD), 1.5 x 4.30 m (4.7 x 13 ft), 1550 trees/ha (627 trees/acre) and 3) ultra high density (UHD), .75 x 4.30 m (2.3 x 13 ft), 3100 trees/ha (1255 trees/acre). Pruning consisted of thinning cuts to remove branches that were intercrossed or otherwise obviously competing for light. Some thinning and heading cuts were made on 2- to 3-year-old wood to reduce branch density. Trunk diameter 20 cm (8 inches) from the ground (always above the graft union) and canopy height and diameter were recorded at the end of each season on the three central trees in each replication. The weight of dormant season prunings per tree was recorded from 1989 to 1993, total yield per tree and average fruit weight were recorded from 1990 to 1993 and in 1993, 5 years after planting, the fruits were graded by size. The data were statistically analyzed by analysis of variance, LSD and chi-square tests to verify differences.

RESULTS

The MD trees had grown the most and the UHD the least 5 years after the orchard was planted, an effect of tree-to-tree competition (Table 1). Trees at the highest density required less pruning (40%) in terms of weight of wood removed than the trees at the lowest density, but the yield/tree at the lowest density was almost twice that of the highest density. While yields were low in this trial due to the shy bearing nature of the unimproved pillar trees that were used, the relative yields under the different tree densities offer some insights as to the spacing and training that will be useful for the columnar tree type. On a per-acre basis, the UHD trees produced 40% more fruit than HD trees and at least twice as much as MD trees. These values can be attributed to the fact that, by the second year after planting, the UHD trees had already occupied all

FIGURE 1

Schematic representation of standard (ß†), upright (UP), whichis a ST x PI hybrid, and pillar (PI), or columnar, peach trees.



of the allotted in-row space. In the fifth year the yield/acre was similar for the two higher densities, confirming that the yield efficiency of columnar trees did not decline at HD. Fruit size was adversely affected in the higher densities, especially at the UHD.

These findings indicate that columnar trees are promising for high-density peach production systems. They also suggest that, at increasing density, tree management practices such as nutrient and water inputs must be carefully calibrated to maintain fruit size.

CONCLUSIONS

The peach is a species rich in diversity for plant growth habit. Most of the growth habits are the result of single gene changes and are readily manipulated by breeders. In spite of this fact, there has been relatively little effort to genetically alter peach tree growth habit. The peach industry suffers from low productivity and lacks efficient high-density production systems similar to apple. Over the years we have demonstrated the performance of various novel peach tree growth habits. The columnar tree is a particularly promising growth type for high-density production systems. This is the first report that demonstrates the performance of the columnar peach. We have developed high fruit quality and higher yielding columnar and upright selections. They will be tested at several locations in the U.S., including the USDA Kearneysville Station, and at several locations in Italy, including Bologna. These trials will provide critical information on the practical utility of the columnar and upright trees for growing peaches at high densities.

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TABLE 1

Growth and yield of columnar peach trees 5 years after planting.

Trees/haz	Tree spacing (m)	Tree height (m)	Canopy diameter (m)	Cumulative pruning weight (kg/tree)	Cumulative yield (kg/tree)	Cumulative yield (MT/ha)	Fruit with diameter >2.5 inches (%)
Ultra high density							
3100	.75 x 4.3	2.47by	.67c	1.8c	9.9b	28.2	
(1255)	(2.3 x 13 ft)	(8.1 ft)	(2.2 ft)	(4.0 lb)	(21.8 lb)	(12.6 tons/acre)	47.4
High density							
1550	1.5 x 4.3	2.65ab	.88b	3.4b	13.7b	19.5	
(627)	(4.7 x 13 ft)	(8.7 ft)	(2.9 ft)	(7.5 lb)	(30.2 lb)	(8.7 tons/acre)	77.3
Medium density							
775	3 x 4.3	2.83a	1.0a	4.8a	19.2a	13.7	
(314)	(9 x 13 ft)	(9.3 ft)	(3.4 ft)	(10.6 lb)	(42.2 lb)	(6.1 tons/acre)	70.6

ZEnglish units (acre, ft, lbs, tons, inches) in brackets.
yValues within columns followed by the same letter are not statistically different.

1998 NC-140 Cherry Rootstock Trial Update

F. Kappel, G. Lang, R. Perry, R. Andersen, L. Anderson, A. Azarenko, R. Crassweller, F. Eady, T. Facteau, A. Gaus, G. Greene, B. Lay, S. Southwick and T. Roper

Presented at the 42nd Annual IDFTA Conference, February 20-24, 1999, Hamilton, Ontario, Canada.

New rootstocks are needed to keep the cherry industries in North America competitive. For sweet cherry, we still need dwarfing rootstocks that can reduce the size of sweet cherry trees by 20-70% and produce large, high quality fruit. A smaller canopied tree can reduce expensive harvest labor costs. A smaller tree can improve pest management practice efficiencies and facilitate new strategies in avoiding fruit cracking. The standard rootstock for sour cherry is mahaleb. This rootstock is productive, as demonstrated in the 1987 NC-140 cherry rootstock trial. However, we still need a stock that can be longer-lived where soil maladies such as Armillaria and Phytophthora root rot exist and where soils are heavy or shallow. The NC-140 Regional Rootstock Committee has served well in developing uniform trials to evaluate new elite rootstocks for stone and pome fruit. The 1987 NC-140 rootstock trial located in 16 sites indicated there are several promising rootstocks that could improve cherry production (Perry et al., 1996). The members of the NC-140 cherry rootstock subcommittee organized a follow-up trial and established it among cooperator sites in 1998. Individual cooperators obtained financial support from local sources, the International Dwarf Fruit Tree Association (IDFTA) and Gisela Inc.

MATERIALS AND METHODS

Plots were established at 11 states and provinces in the spring of 1998 (Table 1). Most sites were assigned enough trees for a full complement of rootstock treatments. Some sites received only a partial planting and are so designated. F. Kappel, BC, and G. Lang, WA, facilitated the procurement of propagules and monitored the propagation which was done by Meadow Lake Nursery, McMinnville, OR (all treatments except P.50), and ProTree Nursery, Brentwood, CA (P.50). Sites are testing from 8 to 19 rootstocks each (Table 2). The trees were arranged in randomized complete block designs with single tree plots and generally 8 replications per rootstock. There are 3 separate trials,

Plots were established at 11 states and provinces in the spring of 1998.

TABLE 1

Cooperators and rootstock research sites for the 1998 NC-140 Cherry rootstock trials.

State/Province	Cooperator/Institution	Site
Sweet Cherry – Bing		
British Columbia	F. Kappel; Ag. Canada	Summerland
California	S. Southwick; UC-Davis	Winters
Colorado	A. Gaus; Colorado State University	Grand Junction
Oregon	T. Facteau; OSU, Hood River, &	The Dalles and
Corvallis		
	A. Azarenko; OSU, Corvallis	
Utah	L. Anderson; Utah State University	Farmington
Washington	G. Lang; Washington State University	Prosser
Hedelfingen		
Michigan	R. Perry; Michigan State University	Traverse City
New York	R. Anderson; NY Ag. Exp. Station	Geneva
Ontario	B. Lay & F. Eady; Hort. Res. Inst.	Vineland
Pennsylvania	R. Crassweller; Penn State University	Erie County
Montmorency Sour Cherry		
Michigan	R. Perry; Michigan State University	Traverse City
New York	R. Anderson; NY Ag. Exp. Station	Geneva
Ontario	B. Lay & F. Eady; Hort. Res. Inst.	Vineland
Pennsylvania	G. Greene; Penn State University	Biglerville
Utah	L. Anderson; Utah State University	Farmington
Wisconsin	T. Roper; University of Wisconsin	Sturgeon Bay

according to scion cultivars: 1) Bing in the west, 2) Hedelfingen in the east and 3) Montmorency sour cherry. Pollenizers (Van and Lapins in Bing trials and Blackgold, Vandalay and Kristin for Hedelfingen) were randomly established in the trials. All trees were of relatively small caliper, which required them all to be pruned to a whip and headed at 80 cm (32 inches). Cooperators are following a standard central leader protocol as devised by the NC-140 cherry subcommittee. All other management practices are being followed according to local recommendations. Data for the trials will be submitted by cooperators to be processed and summarized by Kappel, BC, for the Bing trial and by Perry, MI, for the Hedelfingen and Montmorency trials. Standard data submitted will include the following annual measurements: survival, trunk caliper, yield per tree, average fruit size, fruit to tree size ratio (yield efficiency), bloom density (years 2 and 3) and canopy volume (years 5 and 10).

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TABLE 2

Rootstock treatments established in the 1998 NC-140 cherry trial.

	Scion		
Rootstocks	**Bing**	**Hedelfingen**	**Montmorency**
CT.2753		y	
CT.500		y	
Edabriz	x	x	x
Erdi V		y	
Gi.195/20	x	x	x
Gi.209/1	x	x	x
Gi.318/17	x		
Gi.473/10	x		
Gi.5	x	x	x
Gi.6	x	x	x
Gi.7	x	x	x
Mah	x	x	x
Mazz	x	x	
MXM 2		x	
MXM 60		x	
P.50	y	y	
W.10	x	x	x
W.13	x	x	x
W.53	x	x	x
W.72	x	x	x
W.154	x		
W.158	x	x	x

y = established in some locations.

Acceptance and Adoption of IPM in Ontario Apple Orchards— A Success Story

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Presented at the 42nd Annual IDFTA Conference, February 20-24, 1999, Hamilton, Ontario, Canada.

Practicing IPM allows growers to realize that their goal need not be to eradicate pests but simply to maintain pest populations below economically damaging levels.

Integrated pest management (IPM) is a multidisciplinary approach to managing agricultural pests in a manner which is environmentally sustainable and economically viable. IPM integrates cultural, biological and chemical controls with a thorough knowledge, understanding and use of:

- pest biology and behavior
- monitoring techniques
- economic (action, spray) thresholds
- use and timing of appropriate management tools
- record keeping
- resistance management strategies

For Ontario apple growers IPM has become an important tool to assist them in their day-to-day operations as well as long-term orchard management and planning. Practicing IPM allows growers to realize that their goal need not be to eradicate pests (the old belief of “the only good pest is a dead pest”) but simply to maintain pest populations below economically damaging levels.

Another important concept in the adoption and use of IPM is that many of the benefits derived are long term and are often difficult to quantify. For example, delaying resistance of a pest by following sound resistance management strategies can save the grower thousands of dollars over many years. Similarly the judicious use of well-timed controls can result in the gradual build-up of natural enemies over several seasons, further reducing the need for chemical control.

Finally, and perhaps most significantly, IPM is a philosophy. It is a way of thinking that allows growers, consultants, extensionists and others to view orchard production as both agriculturally sustainable and environmentally responsible while remaining economically viable. It represents to the individual practicing it an appreciation and deep respect for the lifestyle of farming, other living organisms, the environment and the consumer who buys the fruits of the growers’ labor.

DEVELOPMENT OF IPM IN ONTARIO’S APPLE ORCHARDS

In 1969 a pilot project for monitoring apple pests was initiated in the Georgian Bay area by Agriculture Canada. The program was commercially implemented by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and by the early 1980s most apple growing regions had access to pest monitoring information. Benefits were obtained by growers primarily by reducing the number of pesticide applications and timing sprays for more effective pest control.

Today, OMAFRA continues to use representative “regional” orchard sites to obtain information for updating regular agriphone messages. The agriphone, accessible to apple growers during the growing season, is a voice message with a 2- to 3-minute update outlining current pest activity and IPM compatible control strategies.

In 1999 apple growers in this province have available to them a new publication entitled Integrated Pest Management for Ontario Apple Orchards (Solymar et al., 1999). This comprehensive manual describes biology, monitoring, economic thresholds and management options for all apple pests including insects, mites, plant diseases, weeds, nematodes and vertebrates. Through a provincial grant every apple grower in Ontario will receive a free copy of this manual. Additional information is supplied by OMAFRA via newsletters, information meetings, pest management workshops and local apple study groups.

Apple growers in Ontario have largely embraced the basic principles of IPM. Some have taken a further step in forming grower-funded IPM groups in which participating growers hire their own pest management scout(s) or consultants. These trained individuals monitor each orchard for a number of pests and report directly back to individual growers. Growers then use this information along with their knowledge of IPM (i.e., pest biology and behavior, thresholds) to make management decisions on whether to respond and treat the problem.

A recent study conducted by the Ministry of Agriculture, Food and Rural Affairs compared different pest management programs used by Ontario apple growers (Solymar, unpubl.). The following measures of IPM adoption were compared: the number of and actual costs of sprays applied and the environmental impact of these programs using Environmental Impact Quotients (EIQ), a pesticides impact model introduced by Cornell University researchers (Kovach et al., 1992). The EIQ and EIQ Field Use Ratings were developed based on extensive data bases including EXTONET, PESTICIDE MANAGEMENT and EDUCATION, CHEM-NEWS, SELCTV, the National Pesticide/Soils Database (developed by the USDA Agricultural Research Service and Soil Conservation Service) and numerous Material Safety Data Sheets (MSDS). Using this system, each pesticide is rated according to its impact on potential farm worker and consumer health and on negative environmental impacts. Summing the EIQ Field Use Ratings allows for the use of individual pesticides in the comparison of different orchard spray programs.

In the Ontario study the following programs were compared:

Calendar Spray Program

This scenario involves a program in which a grower applies a fungicide and insecticide every 10-14 days regardless of whether they are needed or not. This was the norm prior to the implementation of the Ontario apple IPM program in the early 1980s.

Regional Pest Management Program

In this program a number of representative orchards in each apple growing area are monitored by scouts hired by the Ministry of Agriculture, Food and Rural Affairs. Pheromone traps, visual lures and leaf counts are used, along with computerized day degree models and disease forecasting models to recommend timing of sprays. Updates on pest activity and spray timings are available to growers via an "agriphone" answering machine updated 3 times per week. Some selective insecticides are favored. Currently, an estimated 99% of Ontario apple growers have access to regional agriphones.

Grower-Funded IPM Program

In this system a group of growers hires its own IPM scout or consultant. The scout or consultant monitors and reports back to individual growers in the program on a weekly basis. Site-specific pests such as tentiform leafminer, mullein bug and mites are closely monitored. Participating growers are generally familiar with IPM practices through courses, workshops or study groups. Selective pesticides are favored over disruptive, excessively toxic, or broad-spectrum pesticides. (Approximately 35% of Ontario's apple acreage is now on such a program.)

Advanced IPM Program

This is a program based on a probable orchardist's IPM program in years to come. In this scenario, all orchards are grown at a density of 1480 trees/ha or more (600 or more trees/acre) on dwarfing rootstocks, tree row volume spraying is individually calculated for each orchard block and "biorational" products such as insect growth regulators (IGRs) are registered to replace most broad spectrum pesticides currently in use. Intensive whole orchard monitoring and widespread use of biological control agents are standard.

The average number of sprays used per season varies with the program (Figure 1). The calendar spray program had the highest number of sprays and the advanced program had the least.

The spray cost analysis (Figure 2) followed the same basic pattern with calendar sprays being the most expensive and IPM

FIGURE 1

Average number of sprays per season for four different spray programs for apple orchards in Ontario.

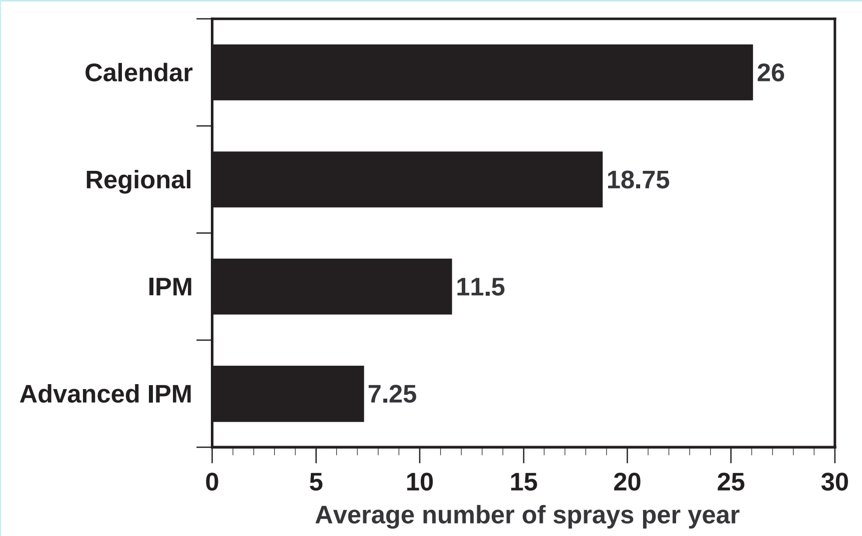
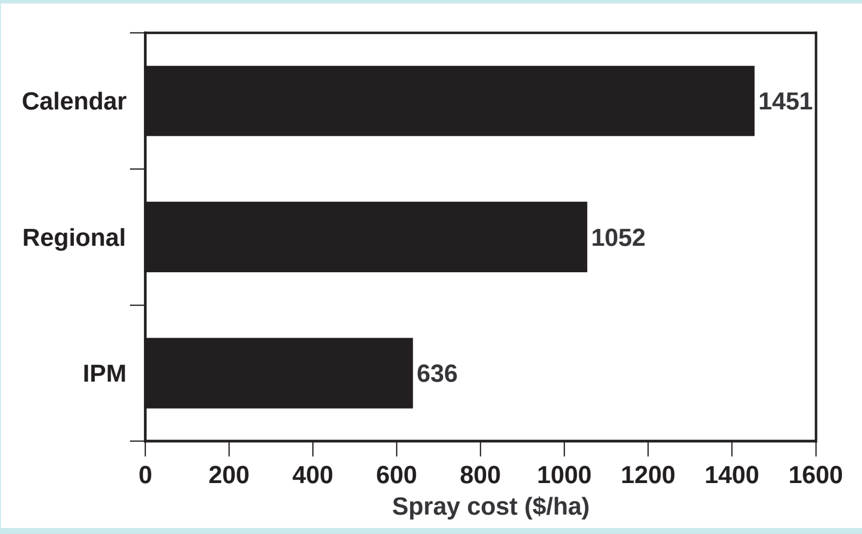


FIGURE 2

Spray cost analysis for ha per season (CAN$) for three different spray programs for apple orchards in Ontario.



programs being the least expensive. Note that no dollar calculations were made for the advanced IPM since the cost of materials was not available.

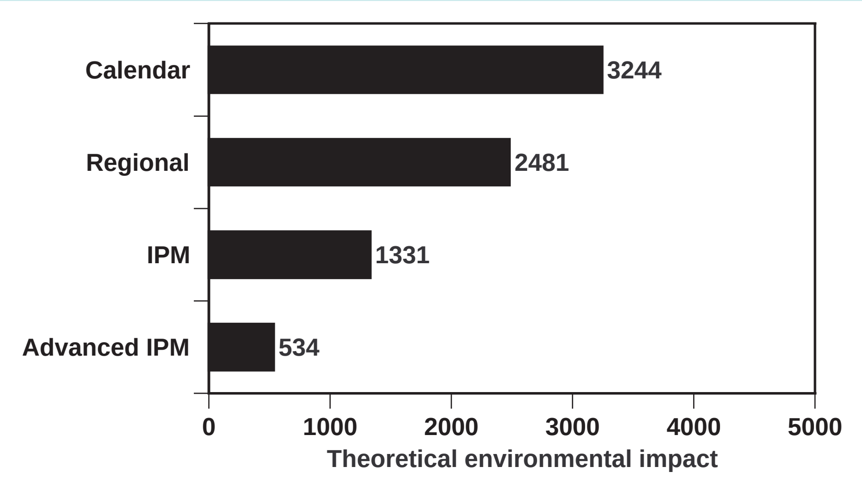
Finally, Figure 3 illustrates the "theoretical" environmental impacts of the four different programs. The actual values calculated for each program are not important, it is the comparison of values between programs that is important. The relationship between the first three programs illustrates that Ontario orchardists using IPM have significantly lowered the environmental impact of agricultural chemicals applied to their apple orchards.

Based on the above model, in the future the environmental impacts of apple orcharding could be reduced to roughly one quarter of current IPM programs as indicated by the advanced IPM scenario. This also clearly indicates that the trend toward increasing tree densities and dwarfing rootstocks not only makes good economic sense but is a more environmentally sustainable way of orcharding as well.

Unfortunately, in spite of the success of IPM as an ongoing process in Canadian apple production, there are still some major roadblocks to the further development and adoption of more sustainable technologies. As the industry moves away from the more broad spectrum pesticides there is greater interest in newer chemistries which are often less toxic, more IPM compatible and friendlier to the environment. However, because of the registration process in Canada, the industry often does not get access to new chemistries as soon as other countries and therefore remains at a competitive disadvantage, particularly to our major competitors to the south. This became very evident to the first author when attending an international IPM workshop in Switzerland in July 1998.

FIGURE 3

Spray cost analysis for ha per season (CAN$) for three different spray programs for apple orchards in Ontario.



THE IPM CONTINUUM

The development and level of adoption of Integrated Pest Management on farms are ongoing processes. Apple growers in Ontario continuously seek to improve their IPM program in an attempt to make it more environmentally sustainable. As well, many orchardists are finding that IPM can benefit them in other ways, such as improving the public's perception of farming and the use of IPM as a marketing tool.

The following outlines stages through which an apple grower can progress as he/she follows the IPM continuum, Table 1.

TABLE 1

Stage	Program	Decision Making Resources
1	Calendar Spraying	● Publication 360 (Anon., 1968)
2	Regional Pest Management	● Publication 360, ● IPM manual, ● regional agriphones, ● some selective pesticides used
3	Integrated Pest Management	● weekly "Representative Block" scouting ● IPM manual ● economic thresholds ● regional agriphones ● emphasis on selective pesticides and some pesticide alternatives to reduce impacts on beneficials use of resistance management strategies
4	Advanced Integrated Pest Management	● regular and frequent "Whole Farm" scouting ● IPM manual ● economic thresholds ● emphasis on pesticide alternatives and "preventive" management; use of selective pesticide as a last resort ● extensive use of resistance management strategies

FORMING A GROWER-FUNDED IPM GROUP

In Ontario, growers in some apple growing regions have formed intensive or grower-funded IPM groups. These grower groups hire pest management scouts (or consultants) to monitor their orchards on a weekly basis in order to stay current and to respond in a timely manner to potential pest problems. Growers on such a program also benefit by being able to fine-tune their IPM programs beyond just local agriphone recommendations. Since some pests can be a problem in some orchard blocks and not others, growers can focus their efforts on managing these "hot spots" in their orchards. Knowing what the pest situation is at all times also allows "preventive" management rather than "reactive" management. In summary, a grower-funded program allows a more environmentally sustainable approach to managing pests, can potentially save the grower hundreds of dollars in pesticide application costs and gives peace of mind knowing the pest situation in one's orchard at all times. In 1999, over 50% of the apple acreage in Ontario will be on such a program.

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Bolstering the Soil Environment— Site Preparation

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Like most investments, establishing an orchard is a financial risk, with growers having little control over the adverse effects of climate and fluctuating market conditions over long periods of time. Coupled to this, there are orchards in all tree fruit industries that are under-performing in terms of tonnage potential and fruit quality. Very often this poor performance is related to soil factors. Bolstering the soil environment by correcting adverse soil properties prior to establishment will enable growers to jump-start their new orchard and develop the canopy required for early and sustained high production of quality fruit. The approach discussed below is one which has been developed in South Africa and is now accepted commercial practice in the SA tree fruit industry.

INVESTIGATING THE SOIL

The best way to start is to conduct a proper investigation of the soil and site at least two full years before planting. This will require someone who has experience in soil-related aspects of orchard establishment. A soil investigation normally requires 4 test holes per hectare at the site, dug on a 50 x 50 m (164 x 164 ft) grid. If the soils are highly variable, the grid can be tightened. The nature of the terrain and the limitations within each soil profile are recorded and the individual soil units are classified and representatively sampled on a layer basis for fertility analysis. A separate set of samples can be drawn for testing for replant disease and nematodes, if required. One or more of the following limitations are most often present: 1) insufficient topsoil depth, 2) impenetrable subsoils (fragipans, compacted clays, weathering bedrock, etc.), 3) rising water tables on low lying soils, 4) perched water moving down slope above a restricting subsoil layer, 5) pronounced stratification in alluvial soils, 6) limited water holding capacity, 7) low cation exchange capacity, 8) soil acidity (especially acid subsoils), 9) salinity, 10) macro- and micro-nutrient imbalances, 11) replant disease, nematodes and 12) toxic elements such as arsenic.

The required soil preparation is determined by the occurrence and severity of these limiting soil factors as well as the depth requirement for the root system of the orchard. One or more of the soil physical problems listed above and replant disease are often the most serious limiting factors. The important thing to remember is that these limitations can be effectively corrected only prior to establishment.

ROOTING DEPTH REQUIREMENTS

Tree fruit root systems have a basic gravitropic growth habit, i.e., they exhibit a strong tendency to grow downward. The soil depth to which tree roots can penetrate is primarily a function of subsoil properties and their effect on root activity. Secondary influences are the vigor of the rootstock/scion combination and orchard management practices such as the presence of cover crops and mulch, herbicide use, irrigation frequency and volume, etc. Dwarfing rootstocks can have deep, healthy root systems if subsoil conditions are conducive to high root activity. From an orchard management point of view, keep the following in mind when establishing an orchard:

1. the effective rooting depth of the soil in its present condition in relation to the desired depth of rooting,
2. the requirement for anchorage in relation to the presence or absence of permanent tree support,
3. soil moisture availability in relation to climate and water (rainfall and irrigation) requirements of the tree,
4. protection against adverse fluctuations in soil temperature and moisture,
5. protection against mechanical or herbicide damage to shallow roots.

It is obvious that a deeper root system is a safer investment. As a general rule of thumb, a minimum rooting depth of 60 cm (24 inches) should be considered a basic essential soil requirement. This

... conduct a proper investigation of the soil and site at least 2 full years before planting.

means that the tree root system must be able to penetrate to this depth with ease.

GETTING RID OF EXCESS WATER

The degree of waterlogging in a wet year and the approach to soil drainage should be considered before any manipulation of the soil is undertaken. Excess moisture in the root zone impacts negatively on root activity by restricting gas exchange in and out of the soil, keeping spring soil temperatures low, contributing to frost heaving, forcing new roots to grow just below or even on the soil surface, making the root system more susceptible to attack by soil pathogens and contributing to the old problem of tree leaning. The choice and design of a drainage system are functions of the soil type, slope and, most importantly, the degree of waterlogging in a wet year. How many sub-surface drainage systems are there in orchards in your area that do not remove excess water in the root zone rapidly and effectively enough? A very effective way of estimating the depth and duration of waterlogging is to install a number of simple well points on the land. Rigid, perforated drainage pipe works well. Subsurface drainage systems are often deployed ineffectively on sloping and undulating land when the design incorporates a fixed-interval drain spacing, ignoring the fact that some areas are wetter than others. Consider the following options carefully:

1. Cut-off (stone) drains for preventing surface water, or water perched on an impermeable subsoil layer, from moving laterally down-slope into a lower lying orchard. A critical aspect of installation of these drains is that the trench be dug and the drainage pipe laid at least 20 cm (8 inches) into the impermeable subsoil material so as to prevent slippage under the drain. Always cover the drainage pipe with fine stone and then back-fill with larger ones.
2. Deep (1 to 3 m; 3 to 6 ft) subsurface systems for deep, porous soil materials with a rising water table. These systems should be properly designed and can be installed one or more years in advance as long as the depth of installation is below the planned depth of sub-soiling or deep ploughing.
3. Shallower subsurface systems for the removal of perched water tables between depths of 30 and 90 cm (1 and 3 ft). These drains are normally spaced closer together and can be installed after subsoiling, taking care not to re-compact the freshly loosened soil along the tree row. For effective removal of excess water, these drains have to be installed at closer spacings than the deeper systems mentioned above. A point is reached where these drains are too shallow and closely spaced to be economical and some form of surface modification should be considered.
4. Surface modification (ridging, berming or landscaping) in very shallow, fine textured and/or slow draining soils. In cases where the topsoil depth is limiting and the subsoil cannot be utilized (i.e., heavy, clay horizons with no structure and permeability, bedrock, other hardpans, etc.), soil depth and drainage can be improved with a form of surface modification. Excess surface water is re-directed away from the base of the tree line, into the driveway and out of the orchard, which should always be planted with a row direction conducive to surface drainage. Surface modification can make orchard management slightly more difficult, but the investment in additional topsoil depth and drainage on these shallow soils ultimately gives a better orchard, both in terms of productivity as well as tree uniformity.

In soils which are prone to periodic waterlogging, it is critical that the required drainage be correctly installed prior to establishment. This will ensure that the additional root zone depth created by deep soil manipulation remains free of excess water.

SOIL FERTILITY

The lime and nutrient element requirement of the soil is determined by the soil analysis. Recommendations based on the soil fertility norms for tree fruit in your area should always be fully incorporated into the soil before planting. This will ensure the right soil chemical environment in which newly formed tree roots can function and explore the full depth of the root zone. The most effective way to accomplish this is to first remove all surface vegetation and make sure the topsoil is in a friable condition. The required lime and fertilizer are then broadcast as uniformly as possible on the soil surface before any physical manipulation of the soil is undertaken. Lime, if not incorporated, reacts with the soil at the surface only, raising the pH in the immediate vicinity of the lime particles. Because the solubility of lime decreases roughly 100 fold with each unit increase in pH, the dissolving process is considerably retarded. The result is a sharp and undesirable pH gradient with depth. To counter this effect, make sure that the lime is free of lumps, finely divided and uniformly broadcast before mixing it with the soil. Apart from the neutralizing effect on soil acidity, lime is also a source of calcium and magnesium. Make sure that the right form of lime is applied to ensure the correct balance between these two nutrients.

Phosphorus (P) is not very mobile in soil and also needs to be uniformly spread and mixed into the soil to the desired depth. If left on the soil surface, P can also react with lime, further reducing the solubility and mobility of these ameliorants. Potassium (K) is more mobile but can take time to leach into heavy soils. Potassium can be applied together with phosphorus if this is the case. On coarse textured soils with low cation exchange capacities, K can be applied post-plant, together with nitrogen.

DEEP PHYSICAL MANIPULATION OF SOIL

Some form of deep soil manipulation is often required and is used to 1) break up restricting subsoil layers, 2) loosen and mix top- and subsoils and 3) mix in any required lime and fertilizers to the desired depth. To ensure effectiveness and permanence of the action, it is important that this be done at optimum soil moisture content. A soil moisture content just below field water capacity, when the soil is most friable, is often required. However, structured clay subsoils and hardpans often need to be slightly drier to ensure the maximum amount of fragmentation and loosening. Only a visual, physical inspection of the soil profile will reveal this. Sub-soiling a wet soil is a waste of time and money and can negatively affect the potential of the soil as a growing medium.

The choice of the implement used should always match the desired effect on the soil. The implement must also be capable of reaching the required depth, normally between 60 and 100 cm (24 to 40 inches). Three basic actions or a combination thereof are normally considered:

1. Subsoiling or ripping: A ripper

shank, normally mounted behind a Caterpillar tractor with sufficient horsepower, is used for breaking hardpans and fracturing weathered bedrock materials.

2. Deep shift ploughing: For loosening and breaking unstable, structured clay subsoils, without bringing these materials to the surface, use deep shift ploughing. Otherwise structured subsoils will slake, crust and form barriers against infiltration and aeration. The shifting-plough moldboard is usually attached to the lower portion of a large ripper shank and operates at depths between 45 and 90 cm (18 to 36 inches).
3. Deep delve ploughing: For deep mixing of applied fertilizers with both the topsoil as well as the subsoil, a larger, higher moldboard is required. These implements often require at least a D7 Caterpillar tractor to provide sufficient horsepower. Two passes are often required to obtain an adequate soil mix, especially if the lime requirement of the soil is high.

Best results are obtained when this soil manipulation is done on a full surface basis. Ripping along the planting line is, at best, second best.

SURFACE MODIFICATION

If soil investigation has revealed that the soil is too shallow and cannot be deepened by sub-soiling, the only alternative is to ridge. Topsoils are always chemically ameliorated, mixed and physically loosened to a friable condition before ridging. The correct way to ridge soil is to mark out the tree rows with stakes at 20 m (65 ft) intervals after this has been done. Work from the future driveway, using a single or double set of offset discs to throw the soil out to either side onto the tree line. This can be done with a tractor of 80 to 100 HP. With the correct action, very little touching up is required. Make sure the final product has no localized dips and depressions which will interfere with the removal of surface water. A gradual taper to the midpoint of the driveway is most often required but, if problems with infiltration are anticipated, the top can be flattened slightly.

The height difference between the midpoint of the driveway and tree row is dependent on the chosen row width, depth of topsoil, degree of waterlogging and amount of slope, but is rarely more than 25 to 30 cm (10 to 12 inches). Row direction must be chosen to facilitate the movement of surface water out of the orchard. It is important in situations where surface modification is undertaken to make sure that the work is completed in time to establish an effective ground cover in the driveway in the fall to prevent soil erosion. Ground covers take time to establish. Use your knowledge of the growing conditions in your area to make the right choices. A most noteworthy benefit of surface modification is the remarkable improvement in orchard uniformity that is obtained on non-uniform soils. Surface modification should never be so drastic as to significantly increase the surface area for evaporation as well as fluctuations in soil temperature.

OLD ORCHARD SITES

Most old orchard soils require fumigation. Correction of soil biological properties, in this case replant disease, is always undertaken after the chemical and physical amelioration of the soil (including ridging, if it is required) has been completed. Make sure that soil temperature and moisture conditions are optimal (±15-18oC; 60-65˚F) and just below field water capacity and that the soil is loose and well aerated. This will give an optimum balance between diffusion of the fumigant through the soil and contact time with the soil matrix, the two important requirements for effective soil fumigation.

Depth of placement of the fumigant is important. In cases were a single probe is used to inject the fumigant, a good rule of thumb is to fumigate at half the depth to which the soil has been loosened. This would normally mean a depth between 30 and 45 cm (12 and 18 inches). Fumigants are expensive and can be justified only when used under ideal conditions.

SPRING PLANTING—GETTING IT ALL TOGETHER

The window of opportunity during which the soil is at the right temperature and moisture content for optimal physical, chemical and biological manipulation can be open for only a relatively short period, especially if the growing season is short. Success can be achieved only with a well thought out plan. Use the checklist in Table 1 as a guide to successful establishment two years in the future. It always pays to invest at the front end and lay a solid foundation for a successful orchard.

TABLE 1

1.	Soil investigation; plan for soil prep and orchard layout	summer of 2000
2.	Order rootstocks/variety	summer 2000
3.	Install deep subsurface drainage, if required	summer/fall 2000
4.	Clear land of any trees; erosion control	fall of 2000
5.	Soil samples	spring 2001
6.	Remove sod, soil surface in friable condition	early summer 2001
7.	Broadcast lime and fertilizers	early summer 2001
8.	Soil manipulation	summer 2001
9.	Cut-off drainage above orchard, if required	summer 2001
10.	No traffic after soil prep; mark out rows	summer 2001
11.	Ridging, berming, if required	summer 2001
12.	Fumigation (if required)	summer/fall 2001
13.	Establish cover crop in drive alley	summer/fall 2001
14.	Planting	spring 2002

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Bolstering the Soil Environment—Nematodes

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To promote tree growth in a new orchard, a holistic approach to the health of the soil environment should be adopted. As a nematologist, my interest might tend to focus on the plant-parasitic nematode worms that may suppress early root growth. It would be a mistake, however, to become too narrowly focused on just the pathogens in the soil. As a scientist, my concern probably should be to determine which elements of the soil environment could prevent successful establishment and which can promote soil health, i.e., a balanced sustainable ecology.

In thinking about the soil environment, we can regard soil-inhabiting organisms conceptually as a multi-branched and interwoven food-web rather than the older ecological notion of a food-chain. Within such a food-web in a healthy soil, we can expect to find the total biomass made up of bacterial biomass (75-94%), earthworms (0-18%), protozoans (5-6%), fungal biomass (<1%) and nematodes (0.25%). Plant-parasitic nematodes are normally only about 10% of the total nematode biomass, with the rest being saprophytes, bacterivores, fungivores, and predators which attack soil fauna including the plant parasites. Plant-parasitic nematodes can be indicators of poor soil health. If the plant-parasitic nematodes become much more numerous than the average 10%, this expansion indicates an ecological situation which is no longer sustainable and which will progress toward plant disease.

The non-parasitic nematodes (saprophytes, bacterivores, fungivores, predators) and particularly the bacterivores aid in the mineralization process of soil carbon (C) and nitrogen (N). Organic soil amendments, such as poultry manure and straw or papermill waste, can be used to balance the soil C:N ratio to a range of 12:1 to 20:1. When the C:N ratio is within that range, the organic amendments function as a control to plant-parasitic nematodes. The reason is thought to be partly the release of ammonia, but other mechanisms may also be active. In the nitrification process from manure through ammonia to nitrate nitrogen, a series of flushes of growth of differing bacterial species takes place. Besides the possible release of antibiotics which might affect plant-parasites, each flush provides food for bacterivorous nematodes, which in turn are spatial competitors of the plant-parasites. The non-parasitic nematode groups are apparently less sensitive to the nematicidal activity of the C:N balance.

Chemical fumigation with commercial products can damage this food-web, causing long-term harm by killing off much of the soil biomass, which in turn reduces the metabolism of amended organic matter. Consequently, if chemical fumigation must be used to reverse an imbalance of plant-parasites, growers should use as benign a product as possible and ensure that the fumigant is placed where needed by using an applicator that treats only the tree row. Treatment to the depth of root establishment is also important. When establishing a new orchard, the use of nematode-suppressive plants such as Tagetes marigolds or Rudbeckia sp. (black-eyed susan) in the row and suppressive grasses seeded between rows prior to tree-planting may be sufficient to avoid the need for chemical fumigation.

Plant-parasitic nematodes can be indicators of poor soil health.

Bolstering the Soil Environment—Earthworms and the Soil Ecosystem

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Earthworms have generally been underestimated and overlooked as major contributors to physical, chemical and biological processes occurring in soils. They are often viewed as good for fish bait and less so as an important component of the soil ecosystem. This article will summarize the present state of knowledge of the influence of earthworms on the soil ecosystem with specific reference to orchard soils.

SOILS WITHIN LANDSCAPES

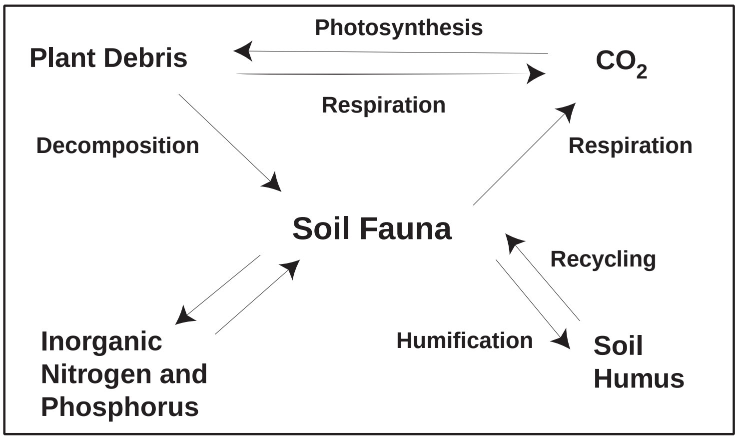
Soils are natural bodies that occur as unique entities within the landscape. Understanding the processes that occur to develop and "build" soil is of utmost importance for the maintenance of an optimum soil quality. Optimizing the soil quality in agroecosystems involves balancing inputs (fertilizer, pesticides, herbicides, energy from machinery, etc.) with economic outputs (i.e., yield of crop) such that the inputs are minimized and the outputs maximized. Soil management for optimization of soil quality aims to ensure a sustainable soil resource base for years to come.

Soils develop over time as a function of climate, their position within the landscape, the make-up of the original geologic parent material and biological components. The true importance of organisms as major factors in soil function has been realized only in the last few decades. Understanding the roles of various soil organisms in this ecosystem may work to minimize inputs through the mindful management of the soil resource.

Management of orchard soils should move toward maintaining an environment for sustaining a healthy population of earthworms.

FIGURE 2

Fauna are central to soils as a source of life (from Juma, N.G. 1999. The Pedosphere and its Dynamics: Soil Ecology. [www.soils.rr.ualberta.ca/Pedosphere/content/section10/page03.cfm]).



THE SOIL ENVIRONMENT AND ORGANISMS

A healthy soil is a porous medium composed of solids, liquids and gases and is biologically active. Minerals and organic materials combine to create aggregates. The arrangement of aggregates and airspace within the soil constitutes the physical structure. The physical structure of the soil is analogous to a steel framework of a building. It holds the soil world together; the collapse of this physical structure results in an unproductive, unhealthy soil. If this structure is maintained, it provides a healthy habitat for soil flora and fauna.

Soil fauna are responsible for major processes occurring within soil (Figure 1). If there were no soil fauna for important roles such as decomposition and humification of organic matter, leaves and twigs dropped from plants would simply accumulate at the soil surface and would not become incorporated. Instead soil fauna make vital components such as nitrogen and carbon available for use by growing plants and other organisms. In other words, fauna are essential members of the dynamic cycle of life in soils.

Earthworms are a major group of large fauna that play a significant role in the dynamics of a healthy soil. Earthworms are pegged as ecosystem engineers, the organisms that affect the availability of resources through modifications of the physical environment.

FIGURE 2

Earthworm burrows created by the anecic species L. terrestris (nightcrawler).

EARTHWORMS AS ECOSYSTEM ENGINEERS

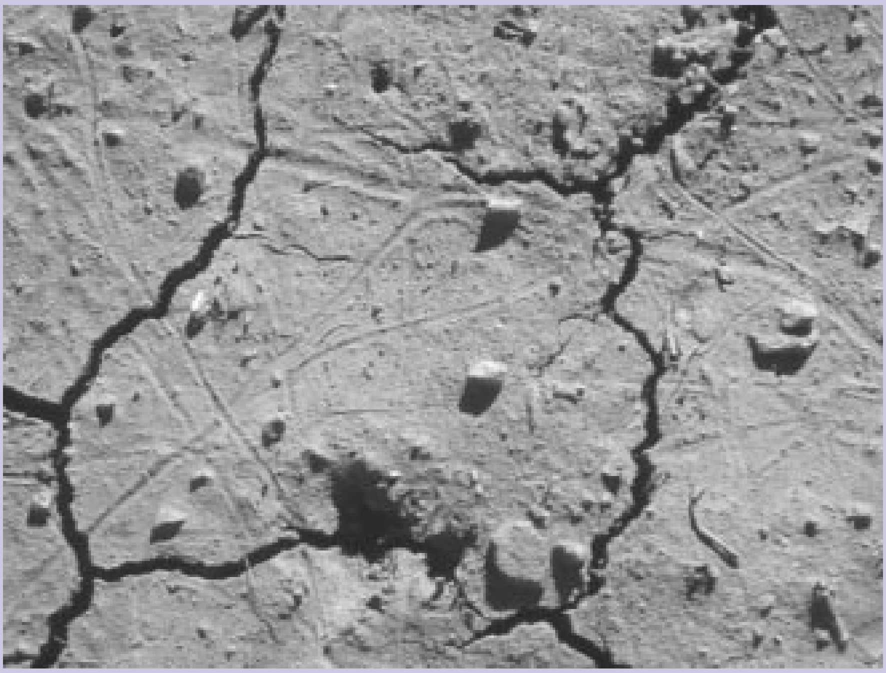
Earthworms move through soil by creating channels and burrows (Figure 2). They ingest and excrete both organic and mineral components as they travel through the soil in search for food. They feed on dead plant tissue and the fungi, bacteria and other microorganisms associated with it. Therefore they are important soil ecosystem engineers because as they burrow through the soil they are modifying the physical soil environment. They create the environments for other living organisms in the soil and thus affect the availability of various resources. Therefore earthworm activity has profound implications for physical, chemical and biological processes occurring in soil.

EARTHWORMS AND SOIL PHYSICAL AND CHEMICAL PROPERTIES

Most research on earthworms in soils has focused on their influence on the physical properties. Extensive review papers on this topic have recently been published (see Additional Reading below). Macroporosity is the most significant physical property influenced by earthworms. Generally earthworm activity increases overall porosity in soils. This is attained through the creation of burrows and channels. However, variations in earthworm ecological groups influence porosity and the functional behavior of burrow systems in soils.

FIGURE 3

Earthworm tracks created by nightcrawlers during their search for food.



There are three main ecological groups of earthworms, 1) anecics, 2) endogeics and 3) epigeics.

1. Anecic species tend to create long vertical burrows often extending to beyond 2 m (6.5 ft) depth. The worm will pull plant material into its burrow, ingesting it as it moves through the channel. The earthworm will continue to maintain the same channel until other circumstances such as stress and availability of food force it to evacuate and create a new one. Lumbricus terrestris (or the "nightcrawler" or "dew worm") is the most common member of this group.
2. Endogeic species feed on organic-rich mineral soils, usually within the top 10 cm (4 inches) of the soil profile. They likely do not maintain the same burrow since they randomly scavenge through the mineral layers, feeding as the soil passes through their bodies.
3. Epigeic species live in organic soil layers and therefore are generally found only above the soil mineral surface.

The work of the anecic and endogeic species in soils alters the water status, gas diffusion and the stability of soil aggregates in different ways. More specifically, vertical channels created by anecic "nightcrawlers" have been shown to significantly affect water seepage through the soil profile (Figure 3). Endogeic species play an important role in the ability of the soil to store and transfer water and air by creating channels within the near surface of the soil profile. This has major implications for adequate root development and growth both through creating voids which roots may follow and providing a conduit for water and air to be made available to the rooting system. The burrows of earthworms increase the surface area available for absorbing water, and their channels increase conductivity, aiding in adequate drainage during intense rainfall events. The increase in porosity by earthworm channeling also allows for the soil to transmit nitrogen and oxygen to living organisms throughout the soil.

Earthworms create casts which are the soil materials formed by their excretion. Through casting within and on top of the soil, they create new structural units that have been shown to be more stable than surrounding aggregates. Also by channeling and casting they translocate soil materials, resulting in "bioturbated" or thoroughly mixed surface layers. In fact, in some soils the entire top 10 cm (4 inches) of the profile has been identified as being formed entirely of earthworm casts.

EARTHWORMS AND ORCHARD SOILS

Soil Compaction

Soil compaction can be a serious problem in orchard soils, particularly in the rows between trees where machinery passes. Earthworm numbers and diversity have been shown to be detrimentally influenced by soil compaction in agricultural soils. In an apple orchard soil a researcher found that younger worms were the most influenced by compaction because they usually occupy the upper few centimeters of the soil profile where machinery compaction is most influential. The adult earthworms usually live lower in the soil profile where the soil is less affected by machinery compaction. Another factor may be that cocoons are often deposited on or near the soil surface and could be destroyed by the machinery. Similar results were also found for a study in conventional agricultural fields with varying amounts of machinery compaction. The loss of younger earthworms would likely reduce the ability of the species to properly reproduce itself in the compacted soil.

Alternatively, earthworms have been shown to ameliorate compacted soil through their burrowing and creation of macropores. However, some soils can be so compact that even earthworms cannot penetrate them. Also, a compacted soil is usually relatively infertile, and healthy earthworms may avoid these areas and migrate to more suitable soils. This can leave the compacted soils lacking in earthworms, and therefore the soil may remain in a deteriorated state until temporarily ameliorated, possibly by a tillage event.

Influence on Pathogen Distribution

Research being conducted in pathology of orchard trees has noted earthworms as major influences on spatial distribution of pathogens. More specifically, pathogens such as Pseudomonas syringae and Venturia inaequalis that have been linked to fruit rot and apple scab are often found in large amounts in the leaf litter beneath trees. Earthworms play a major role in the incorporation of leaf litter into the soil which may isolate pathogen-bearing organic materials. Anecic earthworm species such as "nightcrawlers" are likely the most important in isolating the litter since they pull organic debris deeper in the soil profile within their permanent burrows. If there are sufficient earthworms present, the litter can be completely incorporated into the soil before budbreak in the spring, effectively reducing the potential for disease outbreak.

However, another study has shown that surface earthworm casts in apple orchards can contain high populations of Phytophthora cactorum, pathogens linked to crown or collar rot in apple trees. Further studies are warranted on the influence of different earthworm species and ecological groups on the spatial distribution of disease pathogens.

Pesticides and Herbicides

The control of various pests using pesticides and herbicides in orchard soils can influence earthworm populations. Copper used in some fungicides and pesticides has been shown to reduce earthworm numbers. In one study the reduction of earthworms due to copper in a pesticide resulted in the build-up of tree litter on the soil surface, indicating the importance of earthworms as decomposers of the raw organic materials in orchards. It has also been shown that cadmium, lead and zinc have accumulated in the tissues of earthworms, however the degree of toxicity varies between earthworm species and heavy metals.

CONCLUSIONS

A healthy soil often contains significant populations of earthworms. This is due to the manipulations and creation of structures supporting many healthy processes that occur in soils for supporting life and biodiversity. Management of orchard soils should move toward maintaining an environment for sustaining a healthy population of earthworms.

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