NEW YORK FRUIT QUARTERLY

CONTENTS

FRONT COVER: BOB ANDERSEN, who will retire in July 2004 after 15 years of leading Cornell's Stone Fruit Program, is featured with his new white-fleshed sweet cherry "White Gold®."

BACK COVER: Apple Integrated Fruit Production (IFP) is an extension of IPM that also considers crop management strategies that protect the environment and food safety.

Editorial

WhiteGold®: A New White Fleshed Sweet Cherry From Geneva

Featured on the cover of this issue of the the NY Fruit Quarterly is the new white-fleshed sweet cherry named White Gold®. It was released in 2001 by Cornell University fruit breeders, after being tested as NY 13688. This cherry, which ripens in early-mid-season and is self-fertile, is now catching the attention of growers and nurseries. Commercialization of this cultivar is managed for Cornell Research Foundation by International Plant Management, Inc., a Lawrence, Michigan-based business that specializes in testing and marketing of fruit plants. WhiteGold® is the first self-fertile, light-fleshed cherry distributed for commercial release in the USA. It has considerable potential for three different markets: brining and processing markets that currently use 'Royal Ann' ('Napoleon') and 'Emperor Francis' (both of which need a good pollenizer like WhiteGold®), fresh market use in climates where 'Rainier' is not hardy, and for homeowners who want a self-fertile, light-colored cherry but have limited space.

WhiteGold® has established a fine record for consistent cropping at Geneva and in other Eastern USA grower trials in Maryland and Michigan. With moderately heavy cropping levels it has good sized, medium-large cherries that are slightly larger than 'Emperor Francis', but not as large as 'Rainier'. Stems are medium long. Pull force of fruits at maturity is similar to 'Emperor Francis'. Bloom time is early-mid-season, right around the time of 'Emperor Francis'. Tolerance of rain induced fruit cracking is rated as similar to 'Emperor Francis', which is intermediate, meaning less tolerant than 'Sam' but better than 'Rainier' and 'Gold'. Tolerance to cherry leaf spot and bacterial canker are exceptionally good.

The sweet cherry breeding program at Cornell University has also recently released Black Gold™ a dark, self-fertile variety that was also released in 2001. In 2004 this program also released two more hardy sweet cherries: BlackYork™ (NY 1725), a dark fleshed, processing cherry for use in yogurt and BlushingGold™ (NY 8182), another brining-type cherry that ripens between Emperor Francis and Gold. Ironically, just as Cornell's sweet cherry breeding program is gaining momentum, further sweet cherry breeding by Cornell University faculty may be discontinued. With my retirement in July of 2004 new breeding efforts will cease due to lack of funding for applied research for sweet cherry breeding. The situation is still evolving but if any future sweet cherry work is to be initiated at the University there will need to be grant funds available from NY growers to support the work. New York fruit growers may soon have the opportunity to vote on a research market order which could create an applied funding source for continuation of Cornell's cherry breeding and other work on stone fruits.

Robert L. Andersen
Professor and Sweet Cherry Breeder (Retired)

NEW YORK FRUIT QUARTERLY
VOLUME 12 • NUMBER 2 • SUMMER 2004

This publication is a joint effort of the New York State Horticultural Society, Cornell University's New York State Agricultural Experiment Station at Geneva, and the New York State Apple Research and Development Program.

Editors:
Terence Robinson and Steve Hoying
Dept. of Horticultural Sciences
New York State Agricultural Experiment Station
Geneva, New York 14456-0462
Telephone: 315-787-2227
Fax: 315-787-2216
Subscriptions: $20/year. Contact Karen Wilson, NYSHS, PO Box 462, Geneva, NY 14456
or call: 315-787-2404
Advertising: Warren Smith: 845-255-1442
Production: Communications Services, NYSAES, Geneva

The New York State Apple IFP, Our "Most Friendly Practices"

Juliet Carroll[1] and Terence Robinson[2]

[1]New York State Integrated Pest Management Program
[2]Department of Horticultural Science
New York Agricultural Experiment Station, Cornell University
Geneva, NY

This work was funded in part by the New York Apple Research and Development Program.

The New York apple industry developed a comprehensive strategic plan in 2001 calling for NY state apple growers to become the premier suppliers of high quality apples to domestic and foreign customers and to do it in a manner that is in harmony with the environment. The plan calls for Cornell to develop a market oriented integrated fruit production (IFP) program for apples in NY. Cornell University faculty and Cooperative Extension personnel, in collaboration with the NY Apple Research and Development Program Board of Directors, recently completed a draft of an IFP protocol for apples. Integrated Fruit Production is defined as the economically successful production of high quality fruit with the best possible protection of the agro-ecosystem, human and domestic animal health, wildlife and the environment.

Fruit consumers and buyers are aware of, and are looking for environmental and food safety characteristics in the food they purchase (Hartman, 1996). They want to be assured that the fruit and fruit products they consume are produced in an environmentally friendly manner, using a minimum of plant production chemicals and leaving a minimum of residue on the fruit. They also want to be assured that the fruit is free from microbial contamination and safe for human consumption. These things can be achieved by adherence to Good Agricultural Practices (GAP) all along the food production chain: from the orchard, to the storage and packing plant, to the grocery store (Rangarajan et al. 2000).

The NY apple IFP protocol details eco-friendly insect, mite, disease, vertebrate and weed pest management, orchard establishment, tree training and pruning, fertilization, fruit thinning, harvest and post harvest practices. These provide a set of guiding principles for apple producers, buyers and consumers seeking NY apples that are grown in the safest and most environmentally sound manner possible using current technology. The availability of GAP guidelines, IPM guidelines (Agnello et al. 2004), (Agnello et al. 1999), and now an IFP protocol for apple, provides NY apple growers a wealth of informational resources that will allow them to produce apples in both an environmentally friendly and safe manner, and capture markets that seek "most friendly practices."

What is the Scope of the NY IFP Protocol?

IFP combines orchard horticultural practices with integrated pest management to arrive at a holistic approach to growing apples from orchard establishment through post harvest. With IFP, some orchard management practices that are legal are not allowed due to the negative effects on the environment or food safety. For example, some crop protection chemicals, cannot be used because of their persistence in the environment. And another example, bins must be thoroughly cleaned after being emptied of fruit to reduce microbial contamination and pest inoculum. An overview of the main areas of the IFP is presented below.

Integrated Fruit Production (IFP) is a comprehensive production strategy that attempts to produce fruit with the best possible protection of the agro-ecosystem, human and domestic animal health, wildlife and the environment while still being profitable. A draft of a NY protocol for IFP has been produced by Cornell faculty and extension staff. We now seek the input of all the segments of the fruit industry on the draft protocol.

Horticultural Practices. IFP guidelines in this category are concerned with protecting the soil tilth, limiting erosion, preventing nutrient contamination of either groundwater or surface water resources and using varieties and rootstocks that resist pests. When new orchards are planted, site characteristics, variety/rootstock combinations, and planting systems are combined in a harmonious fashion that is both economically and environmentally sound. It is especially important that the planting system produce sufficient quantities of high quality fruit to be profitable. Properly maintaining the soil structure, organic matter levels, fertility, soil fauna and micro-flora will help maintain healthy, productive trees that more effectively resist pest problems. The use of resistant rootstocks and/or varieties will reduce the need for pest control measures over the life of the orchard. The goal of fertilization and irrigation programs in integrated production is to minimize offsite nutrient losses, maintain soil nutrients within the optimal range, and to do this as much as possible through natural cycles while promoting yields of high quality fruit. Trees should be trained and pruned to achieve a balance between vegetative growth and cropping. This should result in compact yet open canopies that provide light and air penetration to the entire canopy for optimum fruit quality and reduced disease.

Integrated Pest Management (IPM). The aim of IPM is to protect the tree and its fruit from weeds, insects & mites, diseases and animals using ecologically and economically sound management practices. This means that practices are chosen that will enhance safeguards to the environment and human health while minimizing the use of agrochemicals. Priority is given to cultural, biological, and genetic management practices. Under the IFP protocol, pests (weeds, insects, mites, diseases and vertebrates) and their negative effects must be monitored regularly and recorded. Scouting methods must be based on scientifically sound principles appropriate to the region or locality, and the decision to treat must be based on established thresholds or through the use of forecasting. IPM insect and mite monitoring activities along with thresholds and disease forecasting methods are used in the IFP protocol as described in the Cornell Pest Management Guidelines for Commercial Tree-Fruit Production and the Cornell Apple IPM manual (Agnello et al. 2004), (Agnello et al. 1999).

Weed management. Under the IFP protocol the goal of ground cover management is to limit weed competition to trees in a manner that maximizes production but minimizes soil erosion, nutrient runoff and the use of herbicides (avoiding residual herbicides completely). Secondarily, the aim of groundcover management is to maintain ecological stability and species diversity. A weed suppression strip (less than, or equal to 1/3 the distance between row spacing) can be maintained along the tree row. Close mowing of the orchard drive lanes during summer and fall will help to limit reproduction of weeds.

Arthropod management. Populations of key natural enemies (e.g., phytoseiid mites) must be preserved. This should be done by using management practices that encourage their natural build-up or, when practical through artificial introductions, as in the case of predatory mites. Decisions to treat must be based on economic action thresholds and must use methods that have low environmental impact. Many action thresholds are based on degree days (DD) calculated from daily maximum and minimum temperatures. Insect and mite monitoring, sampling and action thresholds are crucial aspects of arthropod management in apples.

Use of the Good Agricultural Practices contained in the IFP protocol protects the farmer, his customers and the environment.

Disease Management. Cultural practices for disease management should be used where practical, and should include orchard sanitation to remove overwintering sources of inoculum, pruning and removal of cankered limbs to reduce inoculum pressure, and weed and canopy management to facilitate air circulation and promote rapid drying of plant tissues. Varieties and rootstocks that have some level of tolerance or resistance to diseases are preferred. Disease forecasting, spray timing and scouting are crucial aspects of disease management in apples.

Vertebrate Management. Close and regular mowing of orchard drive lanes and surrounding headlands to minimize available protective habitat and food sources during the growing season is essential to reduction of vole and rabbit populations. "Most friendly" IFP practices for vertebrate control include exclusion fencing, netting, wire trunk guards, visual scare devices, and habitat manipulation. Habitat manipulation and preservation can also be used to promote the presence of helpful predators such as fox and birds of prey.

Spray Technology. When pest or tree management requires the use of chemical sprays, environmentally safe spraying methods that improve deposition and reduce drift should be used. New sprayer designs greatly enhance application, are safer to use and easier to maintain. Wherever possible tractors should be fitted with cabs and adequate filtration to protect the operator. The sprayer should also be regularly serviced to ensure correct application, including calibration, maintenance and mechanical adjustment. Care must be taken while filling sprayers to avoid operator contamination and environmental pollution, and the spraying operation should be done in a way that ensures good deposition, minimizes drift, and protects the operator while keeping in mind the safety of others. Spraying operations should be timed and materials should be chosen to minimize harm to honey bees and other pollinators, and application records should be kept for all types of pesticide applications. After use, the sprayer should be thoroughly cleaned and stored in a safe, secure building to ensure that it is in good working condition the following season. Pesticides should be stored in a secure, frost-free, ventilated storage building.

Harvest and Post Harvest. Post harvest management must be done in a manner that maintains high fruit quality and ensures food safety. Bins of harvested fruit should never left in the orchard overnight; this reduces the possibility that rodents will find their way into bins before they are moved to storage. Should soil become wedged into bin runners, the soil must be thoroughly removed before the bin is stacked on top of another. A sanitation system should be used in the packing plant to kill bacteria, yeasts, and fungal spores in water flumes. Empty bins should be removed from the packing area, as soon as possible to be cleaned and to prevent contamination with airborne spores. Decayed and culled fruit should be removed from the packing area at the end of each day, and the floors of the packing area cleaned. Calcium treatments should be applied as field sprays rather than as post-harvest treatments. Post-harvest drench treatments should be used only when such treatments are essential for controlling superficial scald or carbon dioxide injury. Drencher reservoir tanks should be fitted with appropriate agitation systems to keep post-harvest treatment chemicals in suspension. Solutions should be changed regularly and reservoir tanks cleaned before refilling.

Professionally Trained Growers. An essential key to the successful use of the NY-IFP protocol is to train and educate growers. Growers must continue educational efforts in order to be aware of the current best management practices in nutrition, tree training, pruning, crop load management, farm employee health and welfare regulations, food safety practices, and integrated pest management. Growers are required by the New York State Department of Environmental Conservation (DEC) to be Certified Pesticide Applicators and to attend DEC-approved training programs offering re-certification credits. Cornell Cooperative Extension offers yearly meetings in the three major apple-growing regions of NY state. In addition, there are meetings and programs offered by the New York Apple Association, the agrochemical industry, private consultants, crop advisors, and The New York Fruit and Vegetable Expo.

Crop Production Chemicals: Red, Yellow, or Green?

Under the NY- IFP protocol, agrochemicals are classified into green, yellow and red lists based on the optimal combination of the following characteristics: least toxicity to humans, least toxicity to natural enemies, least toxicity to other non-target organisms, potential for pollution of ground and surface water, tendency to stimulate pest increases, target pest selectivity, environmental persistence, environmental fate, necessity of use and excellent to good control of the target pest. Pesticides identified as having all or most of these characteristics are considered "green." Pesticides identified as having areas of concern or restrictions are considered "yellow." All other products are not permitted and considered "red" because they have few, if any, of the above characteristics. The NY-IFP protocol includes only the green and yellow lists. When the use of an agrochemical is justified, products from the green list are preferred; however, when a suitable "green" product is not available, then products from the yellow list can be used with the restrictions noted in the IFP protocol. No products from the red list may be used with IFP.

Agrochemicals must be used in a manner that does not promote the development of resistance in the target organism. Some general anti-resistance strategies include: 1) using pesticides only when necessary to avoid economic loss or crop injury, 2) using fungicides in a protective rather than an after-infection mode, 3) using the highest labeled rate of a chemical when resistance is not prevalent; however, for arthropods, rates should not be inflated beyond those necessary for acceptable control, 4) using spray schedules that incorporate pesticides with different modes of action, 5) regularly calibrating the sprayer, 6) applying pesticides with enough water to ensure adequate coverage, and 7) adjusting sprayers to direct spray on to the target to minimize drift.

The use of reduced-risk or "green" pesticides is central to IFP, however, unless such materials are inexpensive enough to allow the farmer to sustain the practice of using them, their economic risk will outweigh the environmental risk. As growers and marketers sell fruit that is produced using "most friendly practices," they will need to ensure that the price on such fruit gives the farmers sufficient economic profitability to allow the continued use of IFP methods. This brings to the forefront one of the important underlying principals of IFP, and that is that it requires the interdisciplinary involvement of researchers, extension personnel, private consultants, growers, packers, shippers, buyers, retailers, policy makers, and consumers in order to be successful.

Implementing the NY Apple IFP Protocol

The development and implementation of apple IFP programs around the world have generally been market driven as growers or marketers have attempted to respond to market pressures to protect the environment, minimize the use of pesticides and ensure food safety. In some cases the effort to develop IFP programs has been made to maintain market access as buyers have demanded IFP production methods. In other cases, IFP programs have been developed to build new markets or increase market share. In the case of the NY apple industry, leading growers and marketers have encouraged this effort to both maintain market access and to assure new buyers that NY apples are produced using sound IFP methods. The implementation of the protocol could provide a market advantage for growers, packers, shippers, and marketers.

The implementation of the NY IFP protocol could be done either informally by growers using the protocol as a guide or formally with a certification program administered by a compliance group. Since the IFP effort in NY was begun, the apple industry has begun implementing a market assurance program of Best Management Practices from Europe named EUREPGAP. This program requires certification by an independent third-party auditor, that the crop was produced using the BMP's that are proscribed by the EUREPGAP protocol. EUREPGAP requires growers to use the best pest and crop management practices but does not specify what they are. The NY apple IFP protocol differs from EUREPGAP in that it deals with specific apple IPM and horticultural BMPs, while the EUREPGAP scheme is written from a global, all-fruits-and-vegetables perspective. Does the NY apple industry want a certification program for IFP to differentiate IFP-fruit in the marketplace, or would it prefer to implement the protocol informally? The implementation of the NY IFP protocol is not an area in which Cornell University faculty and extension personnel typically become involved, except for those who assist with business plan development. It will be up to growers, growers' groups or industry groups to develop IFP certification and auditing programs to certify their fruit as IFP-grown. Canada has developed a national IFP for apples, with each Province developing their own set of detailed guidelines. The NY IFP was developed to ensure compatibility with both Ontario's and Quebec's IFP programs to preserve important export outlets for NY apples.

Beyond certification, what are the benefits of having an IFP protocol for NY apples? The principles underlying IFP can be implemented as educational tools and for grower self-assessments. The NY-IFP protocol can provide the NY apple industry with rallying points to promote awareness and discussion of environmental and food safety impacts of production practices. The NY-IFP protocol can provide farmers and agencies with sources of information to uphold the need for cost share dollars and grant funds for transitioning to and adopting IFP practices (ex. NRCS and EQIP). Certainly, there is benefit in connecting environmental conservation, BMPs, IPM, and GAPs into whole farm production management that benefits environmental conservation and food safety.

The main principles of IFP are: to promote the production of safe foods, with minimal environmental impact and when needed the minimal use of reduced-risk pesticides through adoption of IPM. It is important to recognize that transitioning to IFP is a process influenced by economics, information, know-how and technology. It is also important to develop cross-disciplinary efforts to provide a foundation of knowledge and support and to provide for the industry's ability to conduct self-assessments and measure progress. To be successful, IFP must not only promote social and environmental goals, but economic sustainability at all levels of apple production and marketing as well.

An IFP protocol must be a dynamic and flexible set of guiding principles (Anonymous 2003). Pest outbreaks and challenging production years will occur, bringing about the need to re-evaluate the IFP protocol and make needed adjustments to safeguard the apple crop and promote apples as a healthy and wholesome food. The NY apple IFP protocol is a dynamic and flexible document. The IFP protocol will be capable of integrating new strategies that are justifiable and reconcilable with the principles of integrated fruit production as it addresses pest management, crop production, food safety, environmental conservation, and market preservation.

Much work went into developing the NY apple IFP protocol which has resulted in a sound and solid set of environmentally friendly production practices. The NY ARDP Board of Directors has discussed the most recent draft with us and has given us their suggestions. We are now seeking broader input from the NY apple industry. If you work with the NY apple industry and would like to review the New York Integrated Fruit Production (IFP) Protocol for Apples we would appreciate your comments and suggestions. For a copy of the NY IFP protocol contact either Juliet Carroll or Terence Robinson.

Acknowledgements

The authors and contributors to the NY Apple IFP protocol are gratefully acknowledged and listed below:

Cornell University and Cornell Cooperative Extension

Terence L. Robinson, James R. Schupp and Alan N. Lakso, Horticultural Sciences, Geneva

Lailiang Cheng, Ian A. Merwin and Christopher B. Watkins, Horticulture, Ithaca

Arthur M. Agnello, Andrew J. Landers, Jan P. Nyrop, W. Harvey Reissig and Richard W. Straub, Entomology, Geneva

William W. Turechek and David A. Rosenberger, Plant Pathology, Geneva

Paul Curtis, Natural Resources, Ithaca

Deborah I. Breth, Steve Hoying Lake Ontario Fruit Team, Albion, Newark

Michael J. Fargione, Hudson Valley Commercial Fruit Program, Highland

Kevin A. Iungerman, Northeast New York Commercial Fruit Program, Ballston Spa

Juliet E. Carroll, NYS IPM Program, Geneva

References

Agnello, A.M.; Landers, A.J.; Turechek, W.W.; Rosenberger, D.A.; Robinson, T.L.; Schupp, J.R.; Carroll, J.E.; Cheng, L.; Curtis, P.; Breth, D.I.; and Hoying, S.A. 2004. Cornell Pest Management Guidelines for Commercial Tree-Fruit Production. Cornell University, Ithaca. 232 pp.

Agnello, A.; Kovach, J.; Nyrop, J.; Reissig, H.; Rosenberger, D.; and Wilcox, W. 1999. Apple IPM, A Guide for Sampling and Managing Major Apple Pests in New York State. NYS IPM Program, Number 207, Cornell University, Ithaca

Anonymous. 2003. Integrated Fruit Production Guidelines for Apple Orchards in Canada. Canadian Horticultural Council, Ontario. 51 pp.

Hartman, H. 1996. The Hartman Report Phase I. Food and the Environment: A Consumer's Perspective. The Hartman Group, 10422 SE 14th St, Bellevue, WA 98004.

Merwin, I. 2004. Groundcover Management Effects on Orchard Production, Nutrition, Soil and Water Quality. New York Fruit Quarterly. 12 (2): 20-24.

Rangarajan, A.; Bihn, E.A.; Gravani, R.B.; Scott, D.L.; and Pritts; M.P. 2000. Food Safety Begins on the Farm: A Grower's Guide - Good Agricultural Practices for Fresh Fruits and Vegetables, Cornell University, Ithaca. 28 pp.

Juliet Carroll is the fruit IPM specialist at Cornell University in the IPM program. Terence Robinson is an associate research and extension professor in the Department of Horticultural Science who specializes in orchard management.

Postharvest Fruit Quality and Storage Life in Relation to Mineral Nutrients

William J. Bramlage and Sarah A. Weis

Department of Plant and Soil Science
University of Massachusetts, Amherst, MA 01003

Today's market demands high quality fruit. Mineral levels in the fruit as it grows and after it is harvested are highly significant factors in producing and maintaining fruit quality. Clearly N, Ca, B, Mg and K have the most impact on fruit quality.

"Quality of fruit" means different things to different people. In this article, we view it as the fruit grower does: possessing the properties that yield a profitable price. These include size, color, firmness, and freedom from defects. Of these, size and color will be determined before harvest, and so we are focused primarily on maintaining firmness and freedom from defects after harvest, if we include loss of a "fresh appearance" as a developed defect. It shall be argued that taste should be included, and we will comment on taste where there is relevant information available.

A long list of mineral nutrients are essential for plant growth, but not all of them have been related to postharvest fruit quality. Therefore, we will discuss the effects of only nitrogen, calcium, phosphorus, boron, potassium, and magnesium. Let's look at how these elements are related to the growers' task of delivering quality of apples to the consumer.

Nitrogen (N)

To stimulate growth of young trees, N is commonly applied at high rates. These rates might continue as cropping begins since they can increase yield. But even if they are reduced when trees begin to bear (as they should be), the response to lower rates will probably be slow because reserves of N can accumulate in the tree and the soil during the time of high N fertilization. It is not unusual for harvested fruit, especially from younger trees, to be high in N.

The consequences can be very serious. At harvest high N fruit tend to be larger, greener, softer, more subject to preharvest drop and more likely to be affected with corkspot and/or bitter pit. Following storage, they are more likely to develop scald, bitter pit, brown core, internal browning, and internal breakdown. They are also more likely to develop rots. Furthermore, research has shown that in Red Delicious apples, high N can reduce the development of fruit flavor as they ripen.

Much attention has been given to the form of N being applied. Are some forms less damaging to quality than others? We have conducted many experiments including different N forms, and rarely have we found N form to be a significant factor. We believe that it is the total amount of N being applied during the growing season, not the form or the timing, that influences postharvest quality.

Calcium (Ca)

In 1936 bitter pit in apples was first related to fruit Ca content. Since then, awareness that Ca plays a central role in postharvest fruit performance has become universal. In warmer growing regions bitter pit is generally a big concern, but in cooler regions such as the Northeast we are usually more concerned with more subtle effects of Ca. Ca is one of the cellular regulators of fruit ripening and deterioration: when Ca is low, these processes proceed more rapidly. We see this in the susceptibility of the fruit to many problems. When Ca is low, fruit are likely to ripen earlier and have greater pre-harvest drop, to have more watercore at harvest and to develop more scald, browncore, internal breakdown, internal browning, bitter pit, and rots during and after storage. Of these, only internal breakdown and bitter pit may be direct symptoms of low Ca. The others simply result from the fruit being "older" and less resistant to whatever stresses are producing the symptoms.

Ca is often said to be related to fruit softening, with low Ca levels producing softer fruit. Large increases in fruit Ca definitely increase firmness. However, none of the practical Ca treatments are likely to increase Ca sufficiently to result in firmer fruit. We have nearly 30 years of data on effects of Ca treatments, and significant differences in firmness have been rare. Our opinion is that a Ca treatment might increase firmness slightly, but if so, you've received a bonus benefit. Ca treatments should be applied to reduce the occurrence of storage disorders, not to obtain firmer fruit.

Phosphorus (P)

The significance of P in maintaining fruit quality is hard to assess. In Europe, increased fruit P has often led to longer postharvest life, and periodically there are reports in North America, especially from Canada of benefits from P treatments. However, we have conducted numerous trials with P-containing materials that have raised fruit P, and seldom have they produced any benefit. Others, especially in the Northeast, have had similar results. Thus we believe that, under our conditions, P treatments of established trees are quite unlikely to improve fruit quality.

Boron (B)

B deficiency in apples is a constant threat on most Northeastern soils. Growers should apply B annually unless they have clear evidence that B level is sufficient in their orchard. B deficiency causes corking inside fruit that can lead to misshapen and cracked fruit. Its effect destroys visual quality of fruit. Growers should be aware however, that excess B treatment can cause earlier ripening, preharvest drop, and poor storage quality. Thus, B treatments need to be made with great care, since either too little or too much can be very harmful.

Potassium (K) and Magnesium (Mg)

K is an important element in fruit quality. Fairly high K levels in fruit are often reported to increase red color and to raise fruit acid level, which can improve fruit taste. We have never worked with K treatments, so have no personal experience to add to what is said in the literature. However, K is a difficult element to manage. It is present in fairly high concentrations in the fruit, so a large crop can deplete a tree's K reserves. In a low-crop year, however, the K in leaves is released to the soil as leaves decay, and is quickly recycled to the tree. Thus, K applications should be done judiciously and be based on annual leaf analyses.

Mg is an element frequently deficient in Northeastern apple orchards, so it is often applied. There appears to be little direct relationship of fruit Mg levels to fruit quality, so applications should be based on tree needs, as shown in leaf analyses
.

Interaction of Elements

The above discussion has considered mineral element effects as direct responses. However, there is a great deal of interaction among these elements that greatly influences their effects.

High N probably worsens the effects of deficiencies of all the other elements. The fruit are "weaker" and so more susceptible to other problems. However in the case of Ca, the consequence is clear: high N increases fruit size, and as fruit size increases fruit Ca directly decreases. Anything that increases fruit size will likely decrease fruit Ca and increase storage losses.

K and Mg can directly interfere with the ability of Ca to slow down fruit deterioration. It has often been shown that the ratio of K + Mg : Ca is more closely related to fruit quality than is Ca level alone. This means that if either K or Mg is excessively high in fruits, the impact of low Ca will be increased. This makes it very important that K and Mg only be applied if leaf analysis calls for it, and then only at the rate indicated by the levels in the leaves.

Both P and B also interact with Ca. P apparently works with Ca to maintain quality, so if it is low, Ca is less effective in maintaining quality. B is somehow involved in movement of Ca to fruit on the tree, so if B is low, it can cause fruit Ca deficiency to occur.

Conclusion

Today's market demands high quality fruit. Mineral levels in the fruit as it grows and after it is harvested are highly significant factors in producing fruit that will satisfy this market and maintain financial viability. Clearly, N and Ca demand careful management by fruit growers to achieve high fruit quality. B must be maintained within an adequate range also. Mg and K are important for tree productivity, but fruit quality may be damaged if excessive treatments are applied. P level in fruits does not appear to be related to postharvest quality in Northeastern fruit.

Growers today must produce larger sizes of fruit to satisfy market demand. Larger fruit have lower Ca and are inherently more at risk of quality loss after harvest. Futhermore, the longer fruit is stored before marketing, the physiologically older they become and the more susceptible to disorders they are. A slow market makes it harder to maintain fruit quality.

The challenges don't seem to get easier!

Bill Bramlage is an emeritus professor at the University of Massachussets who specializes in factors that influence postharvest fruit quality. Dr. Sarah Weis is a research technician with Dr. Bramlage.

Calcium Nutrition and Control of Calcium-related Disorders

Chris Watkins[1], Jim Schupp[2], and Dave Rosenberger[2]

[1]Department of Horticulture, Cornell University, Ithaca, NY
[2]Cornell's Hudson Valley Laboratory, Highland, NY

This work was funded in part by the New York Apple Research and Development Program.

Adequate Ca in the fruit is essential to minimize bitterpit and other Ca-related disorders of the fruit. Many varieties need foliar calcium sprays to control these disorders. This article details the essential steps in a successful foliar calcium spray program and compares many of the common calcium spray products.

The role of calcium nutrition in fruit quality has been well established, and all growers are aware that maintaining adequate calcium levels in fruit is important for minimizing the risk of calcium-related physiological disorders. The most obvious of these is bitter pit, but disorders such as cork spot, Jonathon spot and senescent breakdown are also associated with low fruit calcium. Other disorders that have been related to low calcium include watercore, and susceptibility to low oxygen injury during storage. In addition, because of the importance of calcium in cell walls and membranes, claims are often made that increased levels of this mineral delay senescence and affect fruit firmness. Usually, however, these effects can be observed only when fruit has been stored beyond meaningful storage periods for saleable quality (Table 1), or when highly sophisticated postharvest treatment techniques such as vacuum or pressure infiltration have been used to increase calcium levels well above those that can be achieved in the field.

Calcium levels in fruit are affected by at least four factors:

1. The balance between fruit and vegetative material on the tree,
2. Calcium availability in the soil,
3. Calcium sprays on the tree,
4. Postharvest calcium treatments.

Factors 1 and 2 should be your first line of defense against calcium deficiency. Indeed, an important aspect of calcium management is that protocols to ensure good nutritional balance with calcium are the same as for all other nutrients; and they should be based on soil and leaf analyses and good horticultural practices. A preharvest calcium spray program will be necessary on those orchard blocks with special problems, such as excessive N or Mg fertilization, low crop load, or low soil pH, and in blocks containing varieties that are highly susceptible to bitter pit or senescent breakdown.

Traditionally these varieties have been Cortland, Jonagold, Mutsu and Northern Spy. As growers strive to increase fruit size, the risk of calcium-related disorders increases, even in varieties that are not usually susceptible to low calcium-related disorders. For example, bitter pit is not a disorder usually documented on McIntosh, but 80 ct. Macs in the Champlain have developed this disorder. Also, increasing experience with Honeycrisp has demonstrated its susceptibility to bitter pit and the need for effective calcium management programs in the orchard.

This article provides an overview of the current recommendation for maintaining optimum calcium nutrition in the orchard.

The Balance Between Fruit and Leaves

Calcium is an immobile nutrient in plant systems. It moves from the soil to the leaves and fruit, along with water, via the passive xylem transport system, but movement from leaves to fruit is restricted. The flow of calcium into plant parts is driven by demand of the tissues. Leaves compete more effectively than fruit for available calcium. Thus a program to maximize fruit calcium levels should involve cultural practices to manage this competition. The balance between leaves and fruit can be affected by tree vigor and fruit density. Appropriate tree vigor should be maintained by avoiding excessive pruning or nitrogen application. Tree spacing recommended for the rootstock should be used to avoid overcrowding of trees. The goal is uniform, moderate tree vigor.

TABLE 1

Effect of calcium tree sprays and dips on the condition of McIntosh apples after removal from CA storage plus one week at room temperature, March 1981. (Blanpied, unpublished).

Treatment	Flesh firmness(lb)	Senescent Breakdown (%)
Control	7.3a	30a
Ca tree spray[x]	7.5a	14b
Postharvest $CaCl_2$ dip (25 lb/100 gal)	8.4b	4c
Ca tree spray plus dip	8.4b	2c

[x]5 summer sprays of Stollar CaB @ 2 pints/acre + early fall spray of $CaCl_2$ @ 2 lb acre.

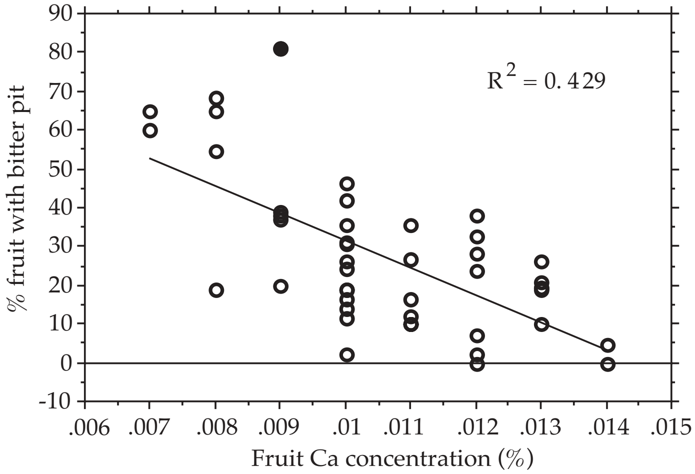

Figure 1. Percentage bitter pit in Honeycrisp apples in relation to calcium concentration of the flesh.

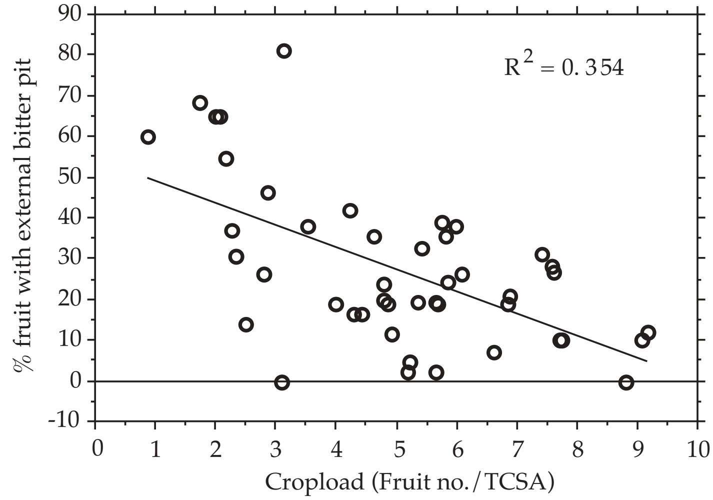

Figure 2. Percentage bitter pit in Honeycrisp apples in relation to cropload.

Crop load should be adjusted to obtain optimum size (i.e., the size required for maximum profitability) and annual bearing. Biennial bearing can be a major factor influencing calcium concentrations in fruit because low calcium levels and increased susceptibility of fruit to bitter pit and breakdown are associated with large fruit on light- cropping trees. Examples of the effect of calcium content as influenced by fruit size and crop load on bitter pit on Honeycrisp are shown in Figures 1 and 2. Table 2 contains a list of factors that should be considered for maintaining appropriate vigor and fruit density in the orchard.

Soil, Leaf and Fruit Analysis

The Cornell recommendation for preharvest calcium application principally involves soil nutrition. While development of visual symptoms of disorders in the orchard or in storage may alert you to the existence of problems, your program should be based on leaf and soil analyses. The important aspects of a calcium analysis program are outlined by Stiles and Shaw (1991):

Soil. Low levels of calcium in the soil are usually associated with low soil pH and low cation exchange capacity, particularly in subsurface soils. If properly limed, the soil should have an abundant supply of calcium, and surface applications of lime should be made to maintain a pH of 6.5 in the topsoil and at least 6.0 in the subsoil.

Leaf. The calcium content of leaf samples is considered adequate if in the range of 1.3 to 2.0%. Values above 1.6% are generally required to minimize low calcium-related fruit problems. Low calcium levels in leaves is often associated with low soil pH and calcium supply, but can result from boron and/or zinc deficiency. High magnesium and potash levels in soils or excessive foliar applications of Mg and K can also interfere with the uptake of calcium. Reduced uptake of Ca impacts all tissues.

Fruit. Correlations between storage disorders and fruit mineral content have been demonstrated in the US and other countries, and are sometimes utilized commercially to eliminate high-risk fruit from storage. In many of these studies, fruit calcium is usually correlated to storage disorders. There is no recommendation for the optimum range of fruit calcium content for New York, although Bramlage et al. (1985) developed a regression equation based on calcium that successfully predicted breakdown in McIntosh grown in Massachusetts. Development and use of such schemes has been limited in the US, however, probably because bitter pit and other disorders that cannot be solved by preharvest strategies have been rare. Therefore the coordination and costs required for implementation of mineral analysis schemes for fruit has not been justifiable. In addition, proper attention to harvest maturity, and modern postharvest management methods such as rapid cooling and controlled atmosphere storage, together with shorter air storage periods have reduced the extent of commercially relevant problems with the exception of varieties with high incidences of disorders on fruit while on the tree.

Calcium Spray Treatments

The recommended preharvest calcium spray program is to use low calcium concentrations during the early part of the growing season because of greater susceptibility of young foliage to salt damage. This is followed by higher concentrations once foliage is mature (Stiles and Reid, 1991).

1. Beginning 7 to 10 days after petal fall, apply 3 to 4 cover sprays of 1 to 2 lbs of calcium chloride (78% $CaCl_2$), or its equivalent per 100 gallons (dilute basis) at 14-day intervals.
2. At four and two weeks prior to harvest, apply 2 additional sprays of 3 to 4 lb per hundred gallons. These rates provide 27-48 lbs of $CaCl_2$ (7.5-13.4 lbs of actual calcium) per acre for orchards that require 300 gallons of dilute spray per acre.

Basic principles of a calcium spray program. The basic principles of a good calcium spray program are based on the following facts:

1. Complete coverage of fruit is essential because calcium spray deposits on leaves do not benefit the fruit.
2. Frequent applications are more important than exact spray timing. No selected stage of fruit growth is more important than another.
3. Effectiveness of calcium sprays increases with increasing concentration, but concentrations are limited because high calcium concentrations cause damage to the fruit and leaves.

There are a number of additional issues to consider when applying calcium sprays. The first is a reminder that the initial pH of technical $CaCl_2$ in water is about 10.3, and this high pH may reduce the effectiveness of some pesticides. Adding 2/3 oz. of vinegar (5% acid content) per lb. of $CaCl_2$ will neutralize the alkalinity and

TABLE 2

Causes of excessive vegetative growth that may compete for available calcium, their modes of action, and corrective measures. (Modified from the 2002-2003 Pennsylvania Tree Fruit Production Guide)

Cause	Mode of action	Corrective measure
Excessive pruning	Over-invigoration of tree	1. Reduce tree vigor so that moderate pruning can be used to maintain tree size 2. Maintain an annual, moderate pruning program
Excessive nitrogen	Overly vigorous trees	Maintain a nutritionally healthy tree so that a minimum level of N can be used to maintain moderate tree vigor
Inadequate spacing	Trees planted too closely can develop a cycle of excessive pruning followed by excessive vigor	Integrate variety, rootstock, soil type, and your management intentions into plant spacing considerations
Low fruit load	Light cropping trees generally have excessive vegetation	Maintain a system of annual cropping to avoid excessive tree vigor

TABLE 3

Maturity of McIntosh and Empire apples after a calcium spray program in the Champlain, Western New York (WNY) and Hudson Valley regions (1995 season)

Variety	Growing region	Internal ethylene concentration (ppm)		Firmness (lb)		Starch index (1-8)	
		- Ca	*+ Ca*	*- Ca*	*+ Ca*	*- Ca*	*+ Ca*
McIntosh	Champlain	5	40	15.3	14.6	5.8	6.7
	WNY	81	82	14.2	14.3	6.4	6.3
	Hudson V.	38	71	13.6	13.2	6.3	6.6
Empire	Champlain	2	4	16.9	16.8	4.8	5.9
	WNY	10	6	18.1	17.9	5.8	5.6
	Hudson V.	3	19	16.9	16.9	4.7	5.0

Modified from Watkins (1997)

bring the spray solution to about pH 6.0. Addition of vinegar does not affect uptake of Ca by the apples. Materials that will buffer the solution to about pH 6.0 may also be used as an alternative to vinegar. Since $Ca(NO_3)_2$ does not raise the pH of the spray solution, vinegar is not required when this form of calcium is used.

$CaCl_2$ is a caustic salt that will corrode sprayer parts, so sprayers must be washed thoroughly after each spray. Newer sprayers made of stainless steel, fiberglass, or various plastics are rust resistant and are therefore preferable for making calcium applications.

Calcium applications should be avoided when temperatures are above 80ºF, particularly when the humidity is also high. Also, do not re-apply calcium unless it has rained since the last application. Residues left from earlier sprays may increase the risk of leaf burn when no rainfall occurs between applications.

There is limited information and some disagreement about the compatibility of $CaCl_2$ with apple pesticides. Potential problems include physical incompatibilities of various mixtures, inactivation of pesticides by $CaCl_2$ sprays, and increased phytotoxicity of some mixtures. However, grower experience indicates that $CaCl_2$ can be tank mixed with many pesticides. Growers can test compatibility by mixing materials in a jar and looking for precipitates, but this may not always be a reliable indicator of a reduction in pesticide efficacy. Consult the manufacturers of proprietary calcium products to determine their compatibility with pesticides. If $CaCl_2$ is applied apart from pesticides, a non-ionic wetting agent should be added. The wetting agent may reduce the potential for leaf injury and increase uptake. Since most pesticide formulations include wetting agents, none should be needed when $CaCl_2$ and pesticides are combined.

Calcium chloride is incompatible with Epsom salts ($MgSO_4$). It is generally recommended that $CaCl_2$ should not be tank mixed with plant growth regulators. Calcium inactivates the growth regulator Apogee (Schupp et al. 2001). Additionally, Ca should not be mixed with captan. In New York, considerable fruit spotting occurred on Empire fruit during the 1998 in orchards where calcium sprays were tank mixed with captan (Rosenberger, 1999). The captan burn was most severe where liquid calcium formulations were used, or where adjuvants were included in the tank mix. These likely enhanced the uptake of captan into fruit. Fruit were especially susceptible in 1998 because of the cloudy, cool summer weather which resulted in less cuticular development on fruit. To be effective, fruit must absorb calcium, and liquid formulations of calcium often include adjuvants that enhance absorption. With captan, enhanced uptake will almost always cause phytotoxicity. Lastly, some problems (increased foliar burn) have been reported in Michigan when $CaCl_2$ was mixed with either azinphos, or basic coppers.

Agitation must be sufficient to maintain thorough mixing during application. Risk of damage is greatest on weak trees and injured foliage. Under cool, moist conditions, use caution when applying foliar calcium as part of a complex tank mix. Slow drying may increase absorption and increase the risk of injury.

Calcium injury appears as a burn at the margins of the leaves. In most cases this injury is thought to be associated with inaccurate sprayer calibration, since the injury is not as prominent when dilute applications are used. Concentrations up to 10X have been very effective, but any inaccuracy in calibration is magnified when applications are made at higher concentrations. These errors can result in leaf burn. To reduce the risk of injury to the fruit and foliage, Washington State Cooperative Extension recommends applying $CaCl_2$ with at least 100 gallons of spray water per acre. $CaCl_2$ should be mixed in a pail of water and be added last, when the sprayer tank is nearly full, to ensure thorough mixing.

We have found that $CaCl_2$ can cause advanced fruit ripening in McIntosh and Empire fruit in some regions of New York in some years (Table 3). It is likely that the calcium sprays caused stress on the trees in the Hudson Valley and Champlain even though sprays were applied as recommended. This could be serious if weather that promotes poor fruit color-

CENTENNIAL FRUIT FIELD DAYS 2004

at the Geneva Experiment Station

July 27

Tree Fruit

- Fruit thinning; sensor technology, etc.
- New apple varieties for NY
- Zonal chlorosis of Honeycrisp leaves
- Reducing fruit safety risks
- Serenade biofungicide for management of apple diseases
- Managing fungicide resistance in apple
- Stone fruit breeding at Geneva
- Update on internal worm management research
- Simulation research and cybernetic technology for apple growers
- Apple and tart cherry germplasm collections
- Choosing a sweet cherry planting system
- Protecting sweet cherries from cracking and birds
- Mature management of sweet cherries
- Training and pruning of young sweet cherries
- Sprayer testing: Rising to the challenge of EUREPGAP
- Sprayer demonstrations

July 28

Grapes

- Grape disease management
- Biology & epidemiology of powdery mildew
- Spore production in powdery mildew
- What's new with downy mildew
- Beneficial mites for powdery mildew
- Lure & trap to monitor grape berry moth
- Management of grape berry moth
- Sprayer nozzle orientation
- Sprayer demonstrations —10 manufacturers
- Viticulture Research at Fredonia
- Simulation research and cybernetic technology for grape growers
- Winter hardiness in NY hybrid wine grape varieties/breeding program selections
- Root growth & respiration in grapes
- Managing grape crown gall
- Water & nitrogen management to reduce ` atypical aging of white wine
- Grape Improvement Research at USDA
- The *Vitis* germplasm collection at PGRU

Small Fruits

- Weed control in strawberries
- Alternative production practices
- White pine blister rust control on *Ribes*
- Equipment demonstrations
- Bird control in blueberry
- Food safety in berries
- Strawberry and raspberry varieties
- Alternative berry crops
- Grower contributions
- Berry rot management options: Anthracnose & gray mold
- Strawberry sap beetle management
- Integrated pest management options
- Organic pest control options

For more info:
http://www.nysaes.cornell.edu/hort/fieldday2004/index.html
Or contact Nancy Long: 315-787-2288 or NPL1@cornell.edu

CORNELL CALS 1904-2004 CENTENNIAL A Century of Leadership

CELEBRATING **THE PAST** SHAPING **THE PRESENT** INSPIRING **THE FUTURE**

TABLE 4

Calcium materials for use on apples. (From the 2002-2003 Pennsylvania Tree Fruit Production Guide)

Product Name	Elemental Ca (%)	Pounds Ca per Gallon or Pound	Manufacturer	Amount Product per Acre per Spray (min-max)	Pounds Ca per Acre per Spray (min-max)
CaB	6	0.60	Stoller, Inc.	3-6 pt.	0.22-0.45
CaB'y	10	1.19	Stoller, Inc.	2-4 qt.	0.58-1.19
Calcium chloride (77-80% $CaCl_2$)	27.8	0.28	many	1.8-6.2 lb.	0.50-1.74
Calcium chloride (35% $CaCl_2$)	12.6	1.42	many	0.35-1.24 gal.	0.50-1.76
Cor-Clear Dry	34.5	0.34	SEGO Intl.	4-8 lb.	1.36-2.72
Foliar Ca. Folical	10	0.96	Agrimar Corp.	1 gal.	0.96
Fung-Aid	10	1.19	Stoller, Inc.	2-4 qt.	0.58-1.19
Link Calcium 6%	6	0.62	Wilbur-Ellis Co.	2-4 qt.	0.31-0.62
Mora-Leaf Ca. (94% $CaCl_2$)	34	0.34	Wilbur-Ellis Co.	4-8 lb.	1.36-2.72
Nutri-Cal 8% Calcium Solution	8	0.89	CSI Chem. Corp.	1-2 qt.	0.22-0.44
Nutra-Phos 10	10	0.10	Leffingwell Div.	3-10 lb.	0.30-1.00
Nutra-Phos 12	11	0.11	Leffingwell Div.	3-10 lb.	0.33-1.10
Nutra-Phos 24	20	0.20	Leffingwell Div.	3-10 lb.	0.60-2.00
Nutra-Phos Mg	10	0.10	Leffingwell Div.	3-10 lb.	0.30-1.00
Nutra-Plus Cal-Gard	6	0.60	Custom Chemicides	1-3 qt.	0.15-0.45
Pit-Stop Dry Con. Foliar Cal. 32.5%	32.5	0.32	Ag-Chem, Inc.	4-8 lb.	1.28-2.56
Pit-Stop Foliar Calcium 12%	12	1.35	Ag-Chem, Inc.	1.5 gal.	2.02
Sett	8	0.91	Stoller, Inc.	1 gal.	0.91
Sorba-Spray Cal	8	0.86	Leffingwell Div.	1-4 qt.	0.21-0.86
Sorba-Spray CaB	5	0.50	Leffingwell Div.	1-4 qt.	0.12-0.50
Stopit Ca. Conc.	12	1.28	Shield-Brite Div.	2-4 qt.	0.64-1.28
Tracite Ca. 6%	6	0.60	Helena Chem Co	3-6 pt.	0.22-0.45
Traco Pit-Cal Liquid Calcium	12	1.40	Traylor Chem Co	0.5-2 gal.	0.7-2.80
Wuxal Calcium	10.7	1.42	Aglukon Div.	3-4 pt.	0.53-0.71

ing occurs before harvest. Growers who apply calcium need to aware that advanced ripening is a possibility and that early harvest might be anticipated.

There are many calcium formulations available (Table 4), often claiming greater calcium uptake, effectiveness in reducing disorders, or reduced risk of injury to leaves and fruit. We recommend $CaCl_2$ because of its proven effectiveness. It also is less expensive than most other sources. Other formulations often have lower than recommended rates of calcium application. Regardless of the product used, follow the manufacturer's recommendations for rates and timing.

$Ca(NO_3)_2$ may be substituted for $CaCl_2$. In Massachusetts they have tested $Ca(NO_3)_2$ only on McIntosh, and have experienced no fruit injury; however, there are reports that $Ca(NO_3)_2$ causes fruit spotting on Delicious and Golden Delicious. No increase in leaf nitrogen level results when the recommended dosage of $Ca(NO_3)_2$ is applied.

Determining the amount of elemental calcium in a commercially formulated product

Because of the number of different calcium formulations and associated cost effectiveness of each, it is important to compare them to determine actual prices per pound of calcium being purchased. The following guide and examples are available in the Pennsylvania Tree Fruit Production guide, 2002-2003.

1. Look for, or determine, the percentage of elemental calcium in the product. This should be listed somewhere on the label.
2. For a liquid formulation, multiply the percentage by the weight of the material per gallon. For a solid, multiply the percentage by the weight of material you will add to the tank. Result equals the pounds of calcium per gallon or pound of formulated product.
3. Determine the rate of formulated material you intend to apply per acre per application. For a specific calcium product this is usually listed on the label.
4. Multiply the amount of material per acre by the number of applications to be made during the season. Remember to adjust rate per acre for the last two applications of the season if higher rates are used in late-season applications. Result equals the amount of total product per acre per season.
5. Multiply the amount of total product per acre per season (from Step 4) by the pounds of calcium per gallon or pound of formulated product (from Step 2). Result equals the total amount of elemental calcium per acre per season.
6. Compare the result from Step 5 with our recommendation of 7.5 to 14 pounds of elemental calcium per acre per season for orchards that require 300 gal/A of dilute sprays.
7. Compare the season-long cost of materials. Multiply the amount of material used per season times the cost of the material.

Example: Product A sells for $6.50 per gallon and is a liquid listed as containing 15% elemental calcium. The weight per gallon is 12 pounds. The label recommends 2 to 4 quarts per acre per application with eight applications suggested per season. You decide to apply 2 quarts per acre per application.

Step 1: You determine that the product contains 15% elemental calcium.

Step 2: 12 lb x 0.15 = 1.8 lb of elemental calcium per gal.

Step 3: You choose to apply 2 quarts (or 0.5 gal) per acre per application.

Step 4: 0.5 gal per acre per application x 8 applications per season = 4 gal of material
per acre per season.

Step 5: 4 gal x 1.8 = 7.2 lb of elemental calcium per acre per season.

Step 5: Our recommendation is 7.5 to 14.0 lb of elemental calcium per acre per season.

Step 7: 4.0 gal x $6.50 per gal = $26.00.

Comparing costs. You wish to compare the cost per pound of elemental calcium in two products. For Products A and

B we can determine which is less expensive.

1. Determine the number of pounds of elemental calcium per gallon or pounds of formulated product for each product you are considering. (Same as in Step 2 above).
2. Determine the cost per pound of elemental calcium in each product.
3. Compare the cost of the two materials.

Compare the two products to determine the rate needed to achieve 14 pounds of elemental calcium per acre per season assuming that you will be making eight applications during the season:

1. Divide the number of pounds of elemental calcium desired per season by the number of applications. Result is the pounds of elemental calcium needed per acre per application by the amount of elemental calcium per gallon or pound of material.
2. Divide the pounds of elemental calcium needed per acre per application by the amount of elemental calcium per gallon of pound of material. Result is the gallons or pounds of formulated material needed per acre per spray.

In summary, to effectively evaluate materials other than dry $CaCl_2$, the cost per pound of actual calcium must be determined for the formulation in question and the label must be examined to determine if the formulation will allow application of the recommended 7.5 to 14 pounds of actual calcium per acre per season.

Postharvest Calcium Dips

Postharvest dips or drenches of $CaCl_2$ can be used to increase the calcium content of apples, and will sometimes reduce the incidence of storage disorders related to calcium deficiencies, but we believe that they should be used only as the last resort. Postharvest application of calcium will not control development of bitter pit if growing conditions, early harvest, or slow cooling after harvest have predisposed the fruit to severe bitter bit.

Materials containing $CaCl_2$ are the only sources of calcium that may be used. Dry $CaCl_2$ at 94% purity or higher may be used, and it should be used at no more than 12 lbs./100 gallons of water, since damage to the fruit may occur at higher concentrations. Vinegar (5%) at 8 to 10 oz. per 100 gallons can be used to counteract the alkalinity of the calcium chloride solution. Two commercial liquid formulations of calcium chloride are also labeled for use. "STOPIT" liquid calcium concentrate (Shield-Brite Corp.; 12% calcium) is labeled for use at 1 gallon per 74 gallons of drench water. "Decco Calcium Chloride-EC 405" (12% calcium) is labeled for use at 1 gallon per 79 gallons of drench water. Both of these labeled rates result in markedly lower calcium concentrations in the solution than does 12 lbs. of dry calcium chloride (94%) per 100 gallons. However, the liquid formulations are easier to use than 94% calcium chloride pellets.

All of these calcium materials may be combined with scald-inhibiting chemicals. No postharvest dip or drench should be used without inclusion of fungicide to control postharvest decays.

References

Bramlage, W.J., Weis, S.A., Drake, M. 1985. Predicting the occurrence of postharvest disorders of 'McIntosh' apples from preharvest mineral analyses. *J. Amer. Soc. Hort. Sci.* 110: 493-498.

Pennsylvania Tree Fruit Production Guide, 2002-2003. http://www.cas.psu.edu/docs/CASDEPT/Hort/TFPG/

Rosenberger, D.A. 1999. Don't burn the fruit! Scaffolds Fruit Journal 8(16): 4-5. (http://www.nysaes.cornell.edu/ent/scaffolds/1999/7.6_diseases.html)

Schupp, J. R., T. L. Robinson, J. Norrelli, and H. Aldwinkle. 2001. Apogee: A New Plant Growth Regulator for Apple. *N. Y. Fruit Quarterly* 9(2): 19-21.

Stiles, W.C., Reid, S. 1991. Orchard Nutrition Management. *Cornell Cooperative Extension Information Bulletin* 210.

Watkins, C. 1997. Update on calcium and DPA research. In *Proceedings from the Harvesting, Handling, and Storage Workshop*, Ithaca, NY. NRAES-112. pp65-73.

Chris Watkins is a research and extension professor in the department of horticulture who specializes in postharvest physiology. He leads Cornell's postharvest extension program. Jim Schupp is an associate research and extension professor at Cornell's Hudson Valley Lab who specializes in orchard management and growth regulators. Dave Rosenberger is a research and extension professor at Cornell's Hudson Valley Lab who specializes in pre and postharvest diseases of apple.

Groundcover Management Effects on Orchard Production, Nutrition, Soil and Water Quality

Ian A. Merwin
Dept. of Horticulture
Cornell University, Ithaca, NY

Our long-term studies on orchard soil management show that season long bare soil treatments from either residual herbicides or tillage do not give the highest long term yield. The use of post emergent herbicides such as Roundup maintained better soil physical condition and resulted in less runoff and leaching of nitrogen. The most important time to control weeds is during May and June.

The systems used to manage weed competition for nutrients and water in orchards influence not only the growth, physiology and yields of trees, but also soil and water quality in the surrounding ecosystem. With intensive use of mechanized tillage equipment and residual herbicides, it is possible to eliminate surface vegetation beneath fruit trees year-round, and this has become a common practice in many orchards. Because fruit-growing regions are often located on well-drained soils and upland slopes near lakes and rivers, there is a substantial risk of soil erosion and runoff or leaching of pesticides and fertilizers into water resources. A good fruit-growing site is also likely to be replanted to fruit crops many times over. This makes the long-term conservation of soil fertility and favorable soil physical conditions especially important from horticultural, economic and environmental perspectives.

For the last 15 years my research group at Cornell University has been studying the complex interactions of fruit trees, surface groundcovers such as weeds and mulches, soil physical conditions and fertility, the movement of fertilizers and pesticides, and soil-borne pathogens in orchard soils (Merwin, 2003). Our approach in these studies has been comparative and systems oriented. We establish different long-term groundcover management systems (GMSs), and then observe and compare how these systems affect above and below ground outputs and processes in orchards. In this article I will describe three of our studies and what we have learned about orchard nutrition and productivity, and soil and water quality through these experiments.

1986 Ground Cover Experiment

In 1986, Warren Stiles and I started an orchard GMS study at Cornell's research farm in Ithaca, NY. We planted 'Empire' and 'Jonagold' trees on MM.111 rootstock, at 3 x 6-m spacing, into six replications of different GMSs established within 1.5 or 2.5-m wide strips in the tree rows. The GMS treatments were as follows: (1) Post-emergence applications of glyphosate (RoundUp™) herbicide in May and July each year (Post-Herb); 2) Pre-emergence applications of norflurazon (Solicam™), diuron (Karmex™), and paraquat (Gramoxone™) herbicides in May each year (Pre-Herb); 3) A regularly mowed turfgrass of *Lolium perenne* and *Festuca rubra;* 4) Mechanical soil tillage each month throughout the growing season (Tilled); 5) A legume cover crop of *Coronilla varia* (Crown Vetch); and 6) A 10-cm deep layer of hay-straw mulch, renewed each May (Mulch). We continued this study from 1986 to 1994, publishing our results in a series of reports (Merwin et al, 1992, Merwin and Stiles, 1994; Merwin et al, 1994; Merwin et al, 1996, Merwin et al. 1999).

This study showed that GMSs have important effects on orchard soil quality, as well as on fruit yield and tree physiology. During six years of observations, soil organic matter degraded and bulk density increased in the Pre-Herb and Tilled GMSs compared with Grass or Post-Herb systems (Fig. 1). Water infiltration rates were greatly reduced in the continuously bare soil of the Pre-Herb treatment, and there was substantial soil erosion and herbicide runoff in that weed-free GMS. Soil was drier most summers and tree N supply was lower under the Grass and Vetch groundcovers. Cumulative yields were lowest on trees in GMSs with grass or vetch groundcovers; but we also noted that fruit color, firmness, and flavor were best in those treatments, especially for 'Jonagold.' Interestingly, cumulative yields were as good in a 1.5-m (5 ft) wide herbicide strip as in 2.5-m (8 ft) wide strips, and there were

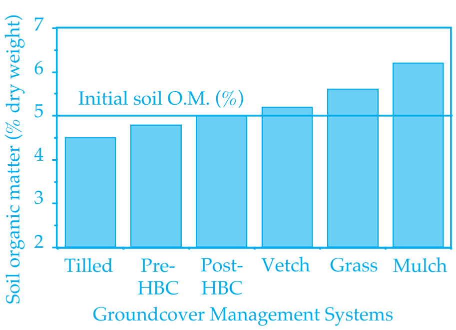

Figure 1. Change in orchard soil organic matter after six years under different GMSs.

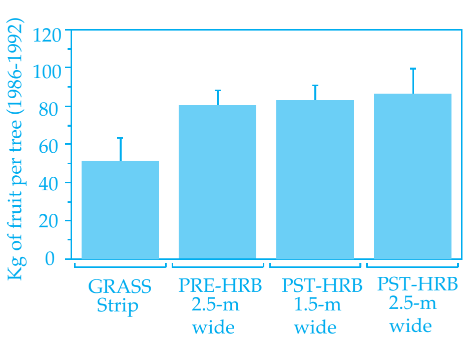

Figure 2. Groundcover management impacts on cumulative fruit yield (kg/tree) after six years.

no significant differences in yields from completely weed-free Pre-Herb treatments compared with the two Post-Herb glyphosate treatments, that were quite weedy throughout the dormant season (Fig. 2). About 25% of the trees growing in the Mulch plots died either from Phytophthora root infections and/or meadow vole damage (*Microtus* sp.) during the 3rd and 4th years of the study. When we studied the below-ground movement of nitrate-N and pesticide analogs under different GMSs at this orchard, we observed different patterns of runoff and leaching of these agrichemicals, indicating a greater potential for off-site movement of fertilizers and pesticides in the herbicide treatments (Merwin et al, 1996).

This first study demonstrated both the negative aspects, and the long-term benefits of maintaining groundcover vegetation to protect the soil beneath trees. Groundcovers help to conserve soil and water quality. They can increase or maintain soil organic matter, which improves soil structure and fertility. They protect soils from compaction and damage by foot and machinery traffic. There is also evidence that groundcover vegetation can improve biological control of some pests. So the surface vegetation that we often view as competitive or nuisance weeds can actually be beneficial for soil fertility conservation. If "weeds" have both positive and negative impacts on the orchard agro-ecosystem, then we need to determine the optimal balance between groundcover benefits for soil and fruit quality, and groundcover interference with soil water and nutrient availability. To do this, we need to understand the damage thresholds for weed competition in apple orchards. For this purpose, in 1992 we began another study to evaluate spatial and temporal thresholds for groundcover competition with apple trees.

Figure 3. Soil erosion sediment in irrigation tail water from a clean- cultivated California apricot orchard.

1992 Weed Damage Threshold Experiment

Damage thresholds are defined as the level of pest infestation or population where yield loss or damage will probably occur to the crop if that pest is not controlled. The economic damage threshold is a somewhat higher pest level where the costs of control measures will be offset by the expected economic benefits of controls. This is a fundamental concept for Integrated Pest Management (IPM) that is essential for biological control of arthropod pests such as mites and other foliar pests, and for preventing or delaying the development of pesticide resistance. At present, not much is known about damage thresholds for weeds in orchards. With a powerful arsenal of machinery and herbicides to control weeds, most researchers and growers have assumed that effective weed control means complete year-round eradication of weeds in the tree rows. This Wild-West "shoot first and ask questions later" approach, is apparent in the trade names—for example Ambush, Lasso, Roundup, Ramrod, Spike, or Fusillade—used to market herbicides in the USA. Such an approach ignores the potential benefits of orchard groundcovers and may encourage the overuse of herbicides and so-called "clean" cultivation (Fig. 3).

Our field experiment to determine weed damage thresholds involved factorial combinations of weed-control timing and space. We assumed that the main threshold factors would be the spatial area and temporal period in which weeds were suppressed within the tree rows. Other researchers such as Atkinson in the UK, or Glenn and Welker in the US had reported increased fruit yields, nitrogen uptake, and yields as the weed-free area beneath apple or peach trees increased, peaking at around 8 to 10 m^2 per tree. Since our planting was irrigated, we reduced the weed-free areas to a range of 0, 2, 4, and 6m^2 per tree, assuming that trickle irrigation would compensate partially for weed proximity. In the absence of any previously published studies on critical weed-free periods for orchard weed competition, we decided to test 0, 1, 2, or 3-month periods of weed suppression, in monthly combinations from May to August during the growing season. In April 1991, we planted 'Gala' apple trees on M.26 rootstocks at 3 x 6-m spacing with three trees per experimental plot. Paraquat herbicide was applied on the first day of each month to suppress weed growth for the designated 30-day periods and areas in each treatment combination.

During the next five years we measured tree growth, nutrient uptake, and fruit yields in this orchard. Contrary to previous studies done in non-irrigated orchards (Atkinson and White, 1976; Welker and Glenn, 1989), we observed no significant benefits to trees as the weed-free area increased from 2 to 6 m^2 per tree, although tree growth and yields in all three weed-free areas were much greater than in the mowed check treatment (Fig. 4). We attributed these results to the below-ground effects of trickle irrigation, which apparently concentrated the roots of our trees into a narrow volume not much wider than the 0.7-m width of the 2 m^2 per tree treatments.

The observed response to weed-control timing in this study was also remarkable. The trees responded best to early summer

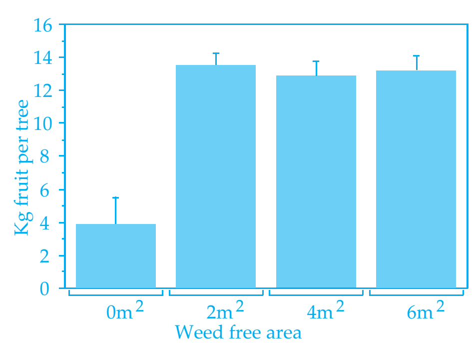

Figure 4. Yield vs weed control area in 1994.

(May and June) weed control, with decreasing tree growth and yields as weed suppression was delayed until August. This trend continued for five years, and was reflected in cumulative fruit yields as well (Merwin and Ray, 1997). When we plotted cumulative yield efficiency (kg fruit/cm^2 trunk cross-sectional area) vs. weed-control timing after five years, the typical curvilinear response of a pest damage threshold was evident. We concluded that weed-free strips could be narrowed substantially to 1 m or less in similar orchards with drip irrigation, and that the first 60 days of the growing season were the critical period for weed suppression, providing the most benefits per weed-control costs in New York orchards.

Other researchers have since repeated this experiment on tart cherry (Al Hinai and Roper, 2001) and strawberry (Pritts and Kelly, 2001) with similar results. Moreover, research with apples and grapes in Europe has confirmed that moderate weed competition with fruit crops during the latter part of the growing season can improve fruit quality. We need to learn more about the cost/benefit relationships for orchard groundcover vegetation in different climates and soil types, but it appears likely that complete eradication of orchard groundcover in the tree rows is neither necessary nor desirable. For similar reasons the use of non-residual post-emergence herbicides is recommended in European and New Zealand IFP (Integrated Fruit Production) protocols.

1991 Nitrogen and Pesticide Leaching Experiment

The third study I will describe is an ongoing experiment investigating the relationship between orchard GMSs, soil physical conditions, tree physiology and yield, agrichemicals leaching and runoff, and nitrogen uptake and retention. In 1991 we installed a field-scale (2 acre) replicated drainage lysimeter system beneath an experimental apple orchard to monitor agrichemicals movement and other important impacts of four different tree-row GMSs: 1) Pre-emergence herbicides (norflurazon, diuron and glyphosate); 2) Post-emergence herbicides (glyphosate); 3) Mowed Sodgrass (red fescue); and 4) A shredded hardwood (mixed *Quercus*, *Fraxinus*, *Acer*, *Fagus*, and *Juglans spp.*) bark mulch. In 1992, we planted 20 trees per replicate (four rows of five trees), with a buried drainage line beneath trees in each plot to intercept water that infiltrated through the GMS treatments, enabling us to sample

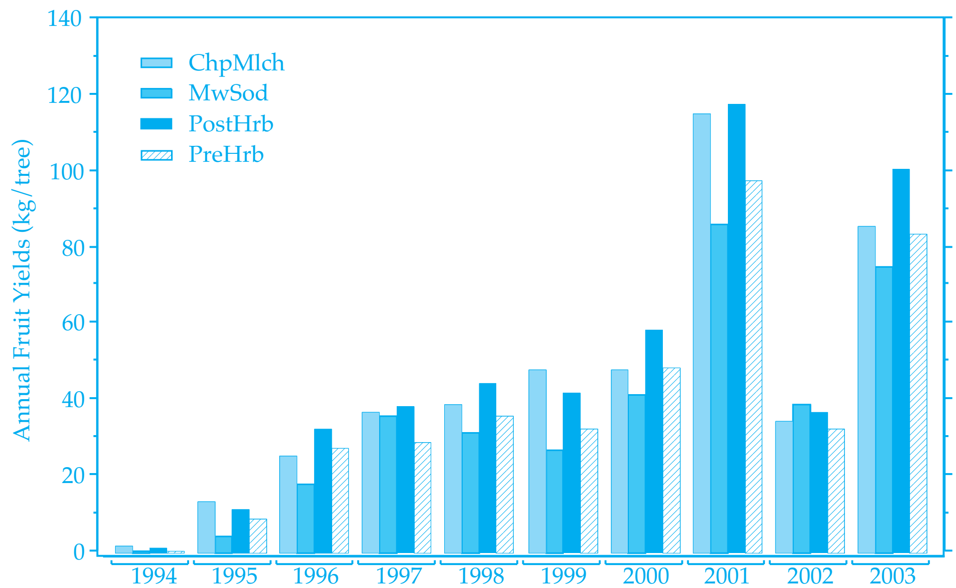

Figure 5. Cumulative annual fruit yields (kg/tree) in each GMS treatment from 1992 to 2003.

the outflows of nutrients and pesticides. Two surface weirs in each plot enabled us to sample and analyze runoff water. The trees were 'Empire' on M.9/MM.111 rootstocks, planted at 3 x 6 m spacing, with microsprinkler irrigation. The entire site was datalogged to provide continuous records of soil moisture and temperature. Suction lysimeters were used to extract retained water samples from the tree root zone. The site sloped gently toward nearby Cayuga Lake, and the soil was a silty clay loam that averaged about 4.5% organic matter concentrations when GMS treatments were first established in 1992 (Merwin et al, 1996).

The following trends have been observed in this study during the past decade. From 1992 to 1997, and cumulatively through 2003, trees in the Post-Herb (glyphosate) treatment have produced the most fruit (Fig. 5). The best tree growth and second highest cumulative yields have been in the BarkMulch GMS. Trees in the MowedSod plots have been the smallest and least productive, while trees in the bare-soil Pre-Herb treatment ranked third—similar in growth with slightly more yield than the MowedSod treatment. Considering that the ground surface beneath trees in the Pre-Herb treatment is almost completely weed-free year-round, while the tree rows of Post-Herb and BarkMulch treatments have sparse weed coverage (a low biomass of weeds covering about 40% of the soil surface) during the dormant season (Fig. 6), it appears that total weed eradication in the Pre-Herb GMS has been detrimental not only to soil quality, but also to tree growth and yields after 12 years. It is worth noting in this regard that most orchard weed-control studies have involved time-spans of only 2 to 4 years—the establishment period in typical orchard production cycles. Looking over the cumulative trends in our study, one could draw different and contradictory conclusions about which GMSs treatments were best from years 1 to 4 vs. years 5 to 9 (Fig. 5). Orchards are a perennial crop system with production cycles of 10 to 50 years. Over such time-spans fruit trees can adapt to varying soil conditions and nutrient supply, with the result that short- and long-term responses to groundcover and nutrition management practices are dynamic and variable from year to year.

Nitrogen and pesticide retention and losses from this orchard have also been influenced by GMSs. Using various sampling systems to extract soil water samples from the root zone, we have observed higher concentrations of nitrate-N and fungicide leaching and runoff from the two herbicide GMSs over successive years (e.g. Fig. 7). Although there are relatively few runoff events from this orchard because there is almost 1000 m of drainage installed beneath the 0.8-ha site, when runoff does occur during spring thaws and summer downpours, the greatest losses of nitrogen are usually in Pre-Herb plots where the soil surface structure has degraded so that infiltration is reduced and erosion increased, causing passive transport of suspended or adsorbed agrichemicals (N, P and benzimidazole fungicide) in runoff water.

During 12 years of observations, there has been a clear trend of greater agrichemical leaching and runoff from the two herbicide GMSs compared with the Bark Mulch and Mowed Sod treatments. However, in recent years as the trees matured and nitrogen fertilizer applications were reduced or eliminated, the losses of Nitrate-N from this orchard to surface and groundwater have remained very low in all GMS treatments—well below the EPA drinking water health standard of 10 ppm.

The actual nitrogen content of the BarkMulch applied biennially in this orchard represents a very large annual input of 300 kg of N per ha. This N input was evident in the total soil-N values determined by combustion analysis, which averaged two-fold greater under the BarkMulch than other GMSs (Fig. 8). Why didn't we see greater leaching or runoff losses of N from this treatment, considering that it has more than doubled soil N content over ten years? One reason is that much of the N in this mulch is contained in lignins and humic substances that degrade and release N much more slowly than mineral-N fertilizers. Another probable factor is that the topsoil carbon content (organic matter) has doubled under the BarkMulch treatment during the past 12 years. This high carbon input fuels a greater microbial activity in the BarkMulch plots, which tends to stabilize much of the soil N in microbial biomass and organic forms. At some point when the mulch plots become fully saturated with N, they may begin to lose N through leaching and runoff; but this has not occurred yet after 12 years of treatments.

To study the dynamics of N uptake and partitioning within this orchard, from 1999 to 2001 we used small amounts of a non-radioactive ^{15}N isotope to trace the movement of fertilizer N within soil and trees in each GMS. By comparing the ratio of ^{14}N (the naturally abundant form of this element) vs. the rare isotope ^{15}N, it is possible to trace the pathways and estimate the

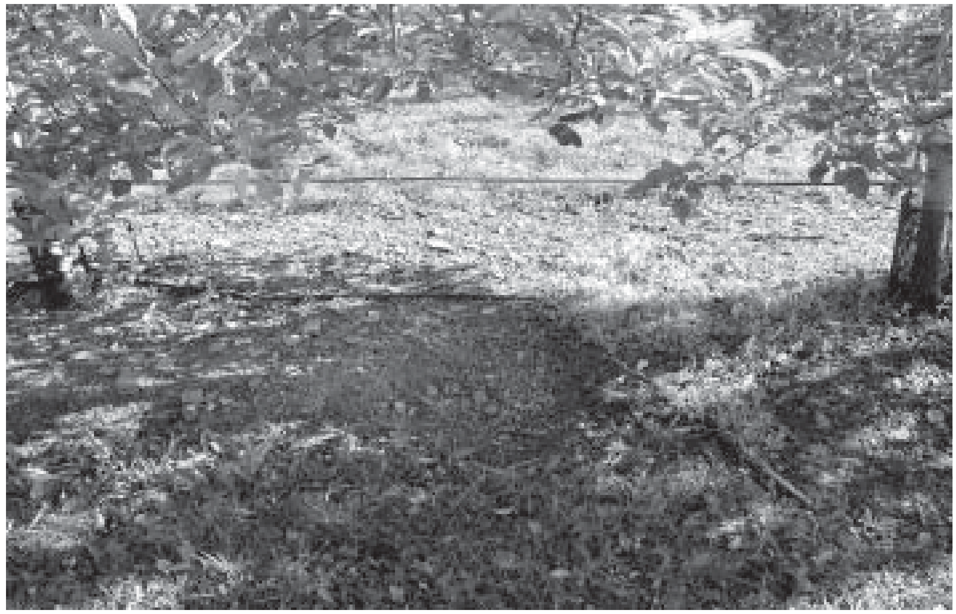

Figure 6. Tree-row surface conditions in weed-free Pre-Herb (left) vs. the sparsely weedy Post-Herb (right) treatments in late autumn.

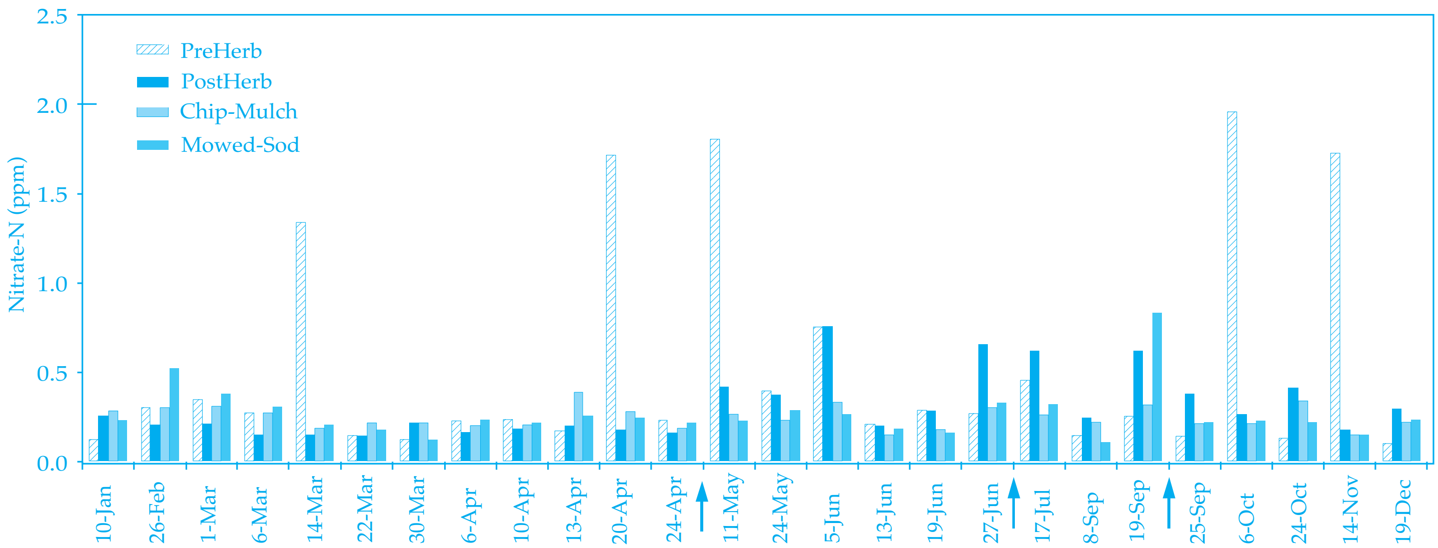

Figure 7. Mean nitrate-N concentrations (ppm) in drainage water outflows from four GMS treatments during 2000. Black arrows indicate dates of three N tracer applications.

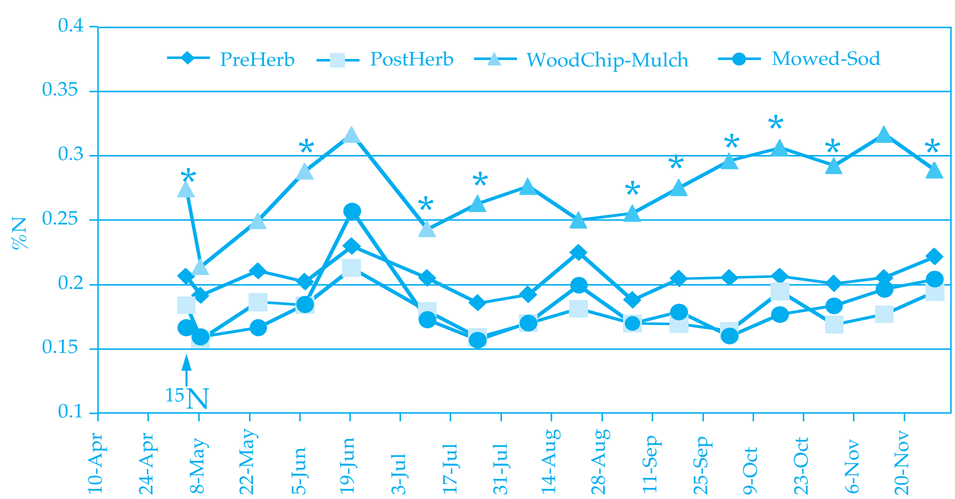

Figure 8. Soil N content (% drt wt basis) in several GMS treatments. Asterisks denote significant (P=0.05) differences on sampling dates during 2000. the N tracer was applied May 15.

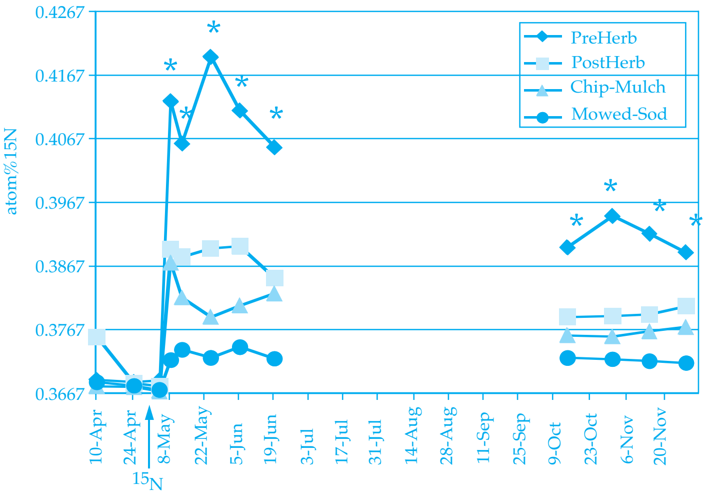

Figure 9. Fruit spur cluster atom % ^{15}N by treatment during 2000. Asterisks denote signifincat differences. N tracer was applied May 5, 2000.

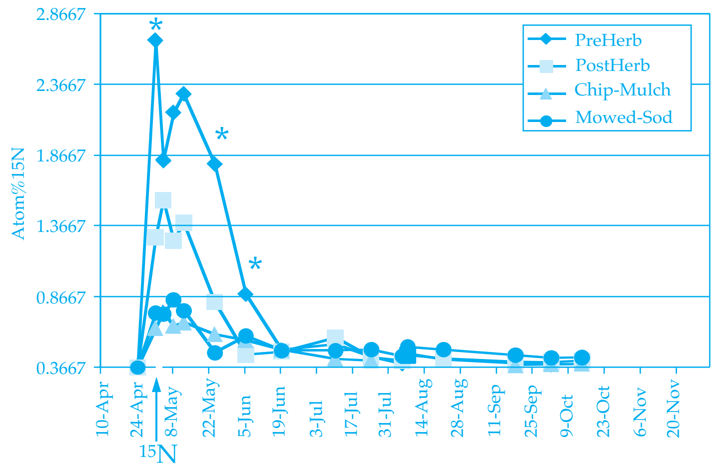

Figure 10. Ggroundcover vegetation atom % ^{15}N by GMS treatments in 2000. Asterisks denote significant differences. The N tracer was applied May 5, 2000.

amounts of N moving from soil N supply into water, weed groundcovers, and different parts of the apple trees. The naturally occurring ratio of $^{15}N/^{14}N$ is 0.3667%, so any elevation above that ratio represents ^{15}N derived from our potassium-nitrate fertilizer treatments that were enriched to 99% ^{15}N. Previous researchers using this technique in orchards have applied large amounts of N-labelled fertilizers to soil beneath trees in weed-free plots that had received large annual doses of N fertilizer, and then studied the uptake efficiency and recycling of nitrogen within those trees. Since our trees had not received any nitrogen fertilizers from 1995-1999 (based upon leaf analyses that indicated sufficient N supply), we chose to apply a very small amount of ^{15}N (< 0.2 g per tree) to serve as a tracer for N uptake and allocations in trees adapted to low soil-N supply.

Unlike previous studies in California and Oregon, the N tracer applied in this orchard was quickly taken up and appeared throughout the trees (Fig. 9). Even the trace amounts of ^{15}N applied around bloom-time quickly appeared in flowers and spur leaves of trees in our study, and remained detectable for the rest of the growing season. Among the GMS treatments, soil-applied N was more available to trees in the two herbicide treatments, because weeds and grass groundcovers had a greater affinity for soil N than the trees. When we sampled groundcover vegetation where the N fertilizer had been applied beneath trees, it contained about four times more ^{15}N than the spurs or leaves of the trees (Fig. 9 vs. Fig. 10). This shows that surface vegetation has a greater affinity for soil N than fruit trees, an observation with several different implications for orchard management. On the one hand, trees obviously need effective weed suppression to obtain enough soil N during critical periods of the growing season. On the other hand, groundcover vegetation can provide an effective reservoir for N (known as N-relay cover crops in agronomic systems) in orchards during times when trees are not taking up soil N, such as late autumn or early spring when trees are dormant but cover crops are actively growing.

Conclusions

What practical conclusions can be drawn from these three experiments? First, they indicate that eradicating weeds in the tree rows throughout the growing season or year-round is probably not necessary in the short-term, and may not be desirable in the long-term. Second, they reveal some of the trade-offs between costs and benefits in various orchard groundcover and soil management systems, and third, these results are helpful to understand these trade-offs in devising the best GMS for each grower's situation.

References

Al-Hinai, Y.K and T.R. Roper. 2001. Temporal effects of chemical weed control on tart cherry tree growth, yield, and leaf nitrogen concentration. *HortScience* 36(1):80-82.

Atkinson, D. and G.C. White. 1976. Soil management with herbicides: The response of soil and plants. *Proc. of British Crops Protection Conf*. p. 873-883.

Merwin, I.A. 2003. Orchard Floor Management Systems. Pp. 303-318 in: *Apples: Botany, Production and Uses* (D.C. Ferree and I. Warrington, eds.) CABI Publ., Wallingford, UK.

Merwin, I.A. P.D. Curtis, and J.A. Ray. 1999. Orchard groundcover management systems affect meadow vole populations and damage to apple trees. *HortScience* 34(2):271-274.

Merwin, I.A. and J.A. Ray. 1997. Spatial and temporal factors in weed interference with newly planted apple trees. *HortScience* 32(4):633-637.

Merwin, I.A., J.A. Ray, T.S. Steenhuis, and J. Boll. 1996. Groundcover management systems influence fungicide and nitrate-N concentrations in leachate and runoff from a New York apple orchard. *J. Amer. Soc. Hort. Sci.* 121(2):249-257.

Merwin, I.A., and W.C. Stiles. 1994. Orchard groundcover management impacts on apple tree growth and productivity, and soil nutrient availability and uptake. *J. Amer. Soc. Hort. Sci.* 119:216-222.

Merwin, I.A., W.C. Stiles, and H.M. van Es. 1994. Orchard groundcover management impacts on soil physical properties. *J. Amer. Soc. Hort. Sci.* 119:209-215.

Merwin, I. A., W.F. Wilcox, and W.C. Stiles. 1992. Influence of orchard groundcover management on the development of Phytophthora crown and root rots of apple. *Plant Disease* 76:199-205.

Pritts, M.P and M.J. Kelly. 2001. Early season weed competition reduces yield of newly planted matted row strawberries. *HortScience*. 36(4):729-731.

Welker, W.V. and D.M. Glenn. 1989. Sod proximity influences the growth and yield of young peach trees. *J. Amer. Soc. Hort. Sci.* 114:856-859.

Ian Merwin is an associate research and teaching professor in the Department of Horticulture who specializes in orchard groundcover management and environmental effects of orchard management.

Mineral Nutrient Management for Organic Fruit Production

Jim Schupp
Department of Horticultural Sciences
Hudson Valley Lab
New York State Agricultural Experiment Station
Highland, NY

Organic apple production offers a niche market which may be of interest to some growers. Organic soil management requires a holistic approach to agricultural ecosystem management. Because of the perennial nature of apple orchards, this is not a great departure from conventional orchard management, except that corrective techniques are limited primarily to naturally derived materials.

Many apple growers are currently seeking to increase profitability through market diversification. One way that growers can distinguish their product from others is by describing and promoting the process by which it is produced (O'Rourke, 2002). Examples of "process-driven" market alternatives include Integrated Fruit Production, Integrated Pest Management, Sustainable, Organic, and Biodynamic. The most widespread and established of these is organic production, a label that provides an alternative for affluent socially conscious consumers who prefer fewer chemicals in their food (Fresh Trends, 2002).

Although mineral nutrition is an important component of organic orchard management, there are other factors more critical to the success of an organic orchard. These include: good market demographics, grower commitment, and a workable pest management strategy. Demand for organic produce is higher in metropolitan areas, (especially those with nearby college campuses) than in rural areas (Fresh Trends, 2002). While some consumers are willing to pay a modest premium for organic produce, the extreme complexity of apple pest management with its limited organic management options and higher production costs requires great dedication on the part of the grower. Only growers who are committed to making the system work will remain organic in the long run.

Organic Regulations

Organic production has a regulatory component which typically involves a third-party certification that only approved practices and products were used in the production and handling of the crop. The USDA National Organic Program (NOP) established national standards for organic labeling in 2002, and these regulations are interpreted by accredited state or private certification agencies. The certification agency has the final word on whether the crop can be certified as organically produced. Although the NOP should result in uniform, consistent standards, certification agencies can vary considerably in fees, documentation required, and sometimes the products that are restricted or the practices required. Make sure you have read and understood the criteria for certification, and make sure your intended customer accepts the same practices and products as the certifying agency.

Farms with less than $5000 in annual sales of organic products can be exempted from certification, but still must abide by NOP standards. A person who knowingly sells or labels a product that fails to meet NOP standards as organic can face a civil penalty of up to $10,000.

The Organic Material Review Institute (OMRI) is an organization that evaluates proprietary products to determine if they meet the standards for organic production under the NOP. OMRI lists brand name products, such as blended fertilizers with more than one ingredient. They also provide a "generic materials list" for single-ingredient products, such as ground limestone or peat moss, which can be used regardless of brand name provided the product is pure. Not all manufacturers are willing to pay the fees to have their products listed by OMRI. It is possible that an unlisted product may be organically acceptable, however the grower must determine whether all of the product's ingredients and its manufacturing process are organically acceptable.

Mineral Nutrition and Groundcover Management

Groundcover management and mineral nutrition are integrally linked. While it is beyond the scope of this paper to present an in-depth description of organic groundcover management, some discussion of this topic is necessary to help the reader envision the type of groundcover system into which the mineral nutrient management practices are being integrated.

Orchards are typically planted on slopes where erosion is a concern. A permanent fescue sod between the tree rows will prevent erosion and reduce soil compaction from the operation of farm equipment in the alleys. Hard or red fescues are slow growing, reducing the need for mowing, and are poor alternate hosts for apple pest organisms. Because fescues are slow to establish, it is best to apply the seed at the high end of the recommended seeding rate to establish a full ground cover as rapidly as possible and prevent weeds from becoming reestablished. A seeding mixture of annual rye and fescue is sometimes used to speed the rate of groundcover establishment.

Apple is a weak competitor for water and nutrients. A three- to four- foot-wide weed-free strip under the trees should be maintained to reduce this competition. This is particularly important during the first several seasons of the orchard. Newly transplanted trees have impaired root systems and this further weakens the ability of the trees to compete with weeds. An effective weed management program fosters rapid early tree growth and early fruit production, resulting in a faster return on investment. Weed management is among the biggest challenges in organic apple production (Jim Bittner, Singer Farms, personal communication).

The primary weed control options for organic blocks are cultivation, burning or mulches, and each option has its pros and cons. Cultivation provides immediate and effective weed control, but must be reapplied several times each season, resulting in increased labor and fuel costs (Schupp and McCue, 1996). Long-term use of cultivation reduces soil organic matter. To minimize the negatives, cultivation should be limited to monthly treatments in May, June and July, followed by a cover crop of canola or vetch in late August.

Mulches can provide adequate weed control if renewed every one or two years, but are expensive, and create a favorable habitat for voles. The decomposition of mulches contributes organic matter to the soil in the long term, but ties up mineral nutrients in the short term, especially nitrogen (N). Nitrogen deficiency can contribute to limited tree growth and low productivity. Coarse shredded bark or woodchip mulch will decompose more slowly than finer materials and is less favorable to voles (Merwin, 1995). Bark or woodchip mulch should be supplemented with hand or flame weeding when the trees are young.

Site Selection & Preparation

The primary strategy of organic mineral-nutrient management is building and maintaining a soil that is biologically active and high in organic matter. Orchard sites are typically selected for climatic conditions, slope, elevation, location relative to other producers and markets, and of course, availability of the real estate. Soil characteristics of a prospective orchard site are often a secondary consideration. Selecting an orchard site with good soil properties is essential when planning an organic block.

Modifying soil characteristics is a long-term process and correcting soil problems in an established orchard is difficult. Furthermore, there are few rapid rescue options available to the organic grower. Starting out with soil that has adequate depth, drainage, texture, water and nutrient holding capacity, pH and mineral nutrient content is always advisable, but with organic production, it is vital.

Once an appropriate site has been selected, pre-plant soil preparations to correct any deficiencies, and to increase organic matter and biodiversity of the soil should begin. Ideally one should plan on spending two years on site improvement before planting the orchard.

Soil testing is used to establish the baseline values of soil acidity, organic matter content, nutrient holding capacity, and mineral nutrient content. Liming to increase soil pH and measures to increase organic matter and mineral nutrients are best addressed prior to planting. This way lime and organic matter can be incorporated deeply into the soil with cultivation so that soil properties are optimized throughout the root zone. This is also the time to tile poorly drained parts of the site and eliminate existing weeds.

Lime should be added to raise the soil pH to 6.5. If the soil test indicates a need for magnesium (Mg), dolomitic, or high mag lime should be used. One or two annual applications of 20-25 tons per acre of cow or chicken manure can also be beneficial for increasing organic matter and adding mineral nutrients to the soil. Horse manure should be avoided, as it is low in nutrient value relative to other animal manures. Furthermore, weed seeds often survive the inefficient digestion of a horse's gut and can contribute to the introduction of new weed species.

Animal manure must not be stockpiled prior to use, as it can cause severe problems with neighboring residences due to both odor and flies. Manure should be tilled in promptly after spreading to incorporate it and prevent loss of N due to volatilization. Typically, seeding a green manure or cover crop such as buckwheat or Sudex follows manure applications. These crops are mowed down before going to seed and then tilled down. The manure application and cover crop are repeated, followed by seeding the permanent ground cover in late summer the season before planting.

Pre-plant Compost

Organic matter is often low in many existing orchard soils, and increasing it improves soil water and nutrient holding capacity. This enhances root regeneration and promotes overall tree vigor. Adding compost as a source of organic matter to planting holes has been demonstrated to have beneficial effects on young apple tree growth in experiments in Massachusetts and Maine (Autio, et al., 1991). The effects of planting-hole treatments are most visible during the year of planting. As root growth extends beyond the volume of the planting hole, the effects of planting-hole treatments diminish. If organic matter amendments were broadcast throughout the orchard soil, perhaps the beneficial growth response could be sustained for a longer period.

For pre-plant compost to be a feasible management practice, an economical, local source of compost must be available. University of Maine Cooperative Extension developed an apple pomace composting project in cooperation with Chick Orchards in Monmouth, Maine. Apple pomace from Chick's cider operation was mixed with leaf waste from the local waste transfer station, and chicken manure from a local egg farm at a 2:6:1 ratio by volume. Wood ash was used to adjust the pH to 5.8 prior to composting. Composting reduced the volume of apple pomace waste by 50 percent, and converted it into an organic soil amendment with highly desirable characteristics. A study was initiated in Maine in 1998 to determine if pre-plant incorporated apple compost or synthetic phosphate (P) fertilizer, either alone or in combination, would improve early apple tree growth and precocity.

The results of this study indicated that pre-plant compost incorporation was more effective than P fertilization for increasing tree growth during the establishment years (Schupp and Moran, 2002). Soil-incorporated compost resulted in increased tree growth and flowering into the third year after planting. Greater tree growth with compost was most likely due to improved N and K status of the trees, and through improved soil aeration and water holding capacity. These results suggested that trees planted in soil amended with apple pomace compost would potentially fill their space more quickly and be able to support more fruit growth in the first years of cropping.

Mineral Nutrient Maintenance

Harvesting an apple crop doesn't remove large amounts of minerals from the soil, compared to many crops (Stiles and Reid, 1991). Apple trees are deciduous perennials with mechanisms for remobilizing essential minerals and storing these in the perennial organs prior to leaf abscission in the autumn. The result is a production system that requires relatively modest mineral nutrient inputs to maintain optimal production. Potassium is the one mineral that is removed in significant amounts with the harvested crop and more significant inputs are required.

Selecting soils with good nutrient holding capacity, maintaining optimal soil pH, and maintaining high (3-4%) soil organic matter will result in most of the orchard's nutritional needs being met by natural cycling, provided weed control is adequate to prevent competition. Still, some supplementary fertilizer application is usually necessary to maintain optimal yield and fruit quality.

The primary method of providing both organic matter and mineral nutrients is the application of compost. The availability of mineral nutrients from compost usually occurs at a slower rate than that from inorganic salts. For this reason, compost is often applied after harvest in autumn or at bud break in early spring. The compost application rate is often based upon the amount of available N relative to that required by the block. For example, if one were applying compost with 5 percent N to an orchard requiring 40 lb actual N per acre, the rate of compost would be 800 lb. By comparison the rate of compost with two percent N for the same block would be 2000 lb per acre.

Composts can vary greatly by ingredients, nutrient value and cost. Make sure you select composts that originated from approvable ingredients and processes; they should be ones that provide adequate amounts of the nutrients needed, and that provide good value relative to the cost. One way to reduce both the purchase price and transportation cost of compost is to use farm waste to produce you own. Apple pomace is one potential source of high carbon waste available to many apple growers, and can be combined with other ingredients to produce high quality compost, as previously described. See Edwards (1998) for detailed information about on-farm composting.

Under NOP regulations, products - including fertilizers- are listed as "allowed" or "not allowed," "not prohibited" or "prohibited." Only those materials that are listed "allowed" and "not prohibited" may be used on organic crops. In some cases the origin of a substance affects its status. Gypsum from a mined source is non-synthetic and is not prohibited, while gypsum by-products, such as scrapped dry wall is synthetic and not allowed. Always check with the certifying agency to make sure that the products you intend to use comply with organic standards.

Adequate mineral nutrients must be available in order for the trees to assimilate large amounts of carbon, partition those assimilates into fruits, and then for those fruits to maintain premium eating quality until consumed. Organic nutrient sources are lower in nutrient concentration and generally more complex than non-organic salts. Organically derived nutrients may not be readily available until decomposition. This slower process requires management with a long-term perspective.

Tracking the trends in mineral nutrient levels in annual leaf samples over several years is the single best way to monitor orchard fertilizer needs. The annual leaf sample should be supplemented with a soil sample every third year. Steps can then be taken to begin corrective measures when a macronutrient shows a trend toward becoming sub-optimal, rather than waiting for an actual shortage to develop. Conversely, foliar sprays of micronutrient fertilizers are permitted under NOP guidelines only when there is a documented shortage. In either case, leaf analysis is necessary to assess the situation.

The principal nutrient required to maintain adequate tree vigor and productivity is N. Organic N sources include manure, fish emulsion/meal, bone meal and blood meal.

Animal manures should be applied pre-bloom in most cases, as NOP regulations prohibit use of animal manures within 90 days of harvest to prevent possible *E. coli* contamination of the crop. Manures can provide higher concentrations of mineral nutrients, especially N, compared to compost; however much of the N value of manure can be lost to volatilization unless it is soil incorporated. For this reason, manures are better suited to groundcover management systems utilizing cultivation.

Matching nutrient needs with those provided by alternative sources allows the grower to provide the best fit of nutrient supplements. Manures provide multiple nutrients besides N. Chicken manure for example is high in phosphorous.

Fertilizers containing soluble forms are more expensive, but are more quickly available, thus they are useful for correcting a deficiency. Sodium nitrate (Chilean nitrate) is listed as not prohibited as long as use is restricted to no more than 20 percent of the crop's total N requirement. Organic standards in the UK prohibit the use of blood and bone meals, so these N sources should not be used on fruit grown for export.

Harvest removes 60-100 lb per acre of potassium (K) annually, while most orchard soils in the northeastern U.S are naturally low in potassium and magnesium (Mg) (Stiles and Reid, 1991). Compost can provide meaningful amounts of these minerals (Schupp and Moran, 2002). In addition to organically derived sources, Sulpomag, a mined material, is frequently used as a source of both K and Mg. Magnesium sulfate (Epsom salts) is allowed as a soil amendment if there is a documented soil Mg deficiency.

Ca deficiency is often associated with low soil pH. Lime is the primary material for maintaining soil Ca. Mined gypsum may be applied when it is desired to increase soil Ca without raising pH.

Bitter pit is an apple disorder associated with low fruit Ca (see the preceding article by Watkins, et al.). Nutritional imbalances such as excessive N, K, or Mg, and deficient B, as well as non-nutritional factors, such as variety, excessive fruit size/low crop load, or drought can contribute to low fruit Ca, even when soil Ca is adequate. In such instances, foliar sprays of calcium chloride ($CaCl_2$) are permitted to reduce the incidence of bitter pit. Under NOP regulations, the $CaCl_2$ used in organic orchards must be extracted from brine.

Deficiencies of boron and other micronutrients may be corrected using synthetic foliar fertilizers, if a deficiency is documented by soil or leaf analysis. In general, micronutrient chelates and sulfates are allowed. Those made from nitrates or chlorides are not allowed.

Summary

Organic production requires a holistic approach to agricultural ecosystem management. Because of the perennial nature of apple orchards, this is not a great departure from conventional orchard management, except that corrective techniques are limited primarily to

TABLE 1

Information Resources for Organic Apple Production

Organic Certification:	
	National Organic Program (NOP): http://www.ams.usda.gov/nop/
	Organic Material Review Institute: http://www.omri.org/crops_generic.pdf
Organic Apple Production Manuals:	
	Edwards, Linda. 1998. Organic Tree Fruit Management. Certified Organic Associations of British Columbia, Keremeos, BC, Canada. ISBN 0-7726-3615-X
	Swezy, S.L., P. Vossen, J. Caprile, and W. Bentley. 2000. Organic Apple Production Manual. Univ. Calif. Agric. and Nat. Resources Publ. 3403. Univ. Calif. Agric. and Nat. Resources Commun. Serv., Oakland, CA. ISBN 1-879906-48-1
Organic Apple Web Sites:	
	http://www.attra.org/attra-pub/apple.html
	http://www.attra.org/attra-pub/fruitover.html
	http://www.attra.org/attra-pub/ipm.html
	http://www.caf.wvu.edu/kearneysville/organic-apple.html
	http://www.canr.msu.edu/vanburen/appleweb.htm
	http://www.canr.msu.edu/vanburen/organasp.htm
	http://orchard.uvm.edu/uvmapple/pest/#Organic Pest Management

naturally derived materials. It is very challenging to produce apples organically, because of the need to maintain the planting over many years without rotation, the vast pest complex, and the exacting demand for high quality, unblemished fruit in the fresh apple market, where much of the growth potential for organic fruit lies.

Organic mineral nutrition management hinges on two principals: 1) practices that lead to the buildup and maintenance of soil that is biologically active and high in organic matter; and 2) supplementing the mineral nutrients provided by the soil with fertilizers from approved sources. Organic orchards should be sited on land with superior soils and pre-plant soil preparation to increase organic matter and correct any sub-optimal soil characteristics. Weed management is critical to reduce competition for nutrients and water.

Soil and leaf analysis provide the basis for correcting mineral nutrient deficiencies or imbalances, and with organic production, changes should be tracked over several years. It may be necessary to use a number of strategies to supply mineral nutrients over the life of the orchard. The slower, natural methods require a management approach that is simultaneously patient and dynamic. The organic approach may increase crop value, however as with most premium market niches, the value is balanced with higher production costs and more management inputs. Personal satisfaction has to be considered part of the reward in order to sustain the energy required to manage an organic orchard.

References

Autio, W.R., D.W. Greene, D.R. Cooley and J.R. Schupp. 1991. Improving the growth of newly planted apple trees. *HortScience* 26: 840-843.

Edwards, Linda. 1998. Organic Tree Fruit Management. Certified Organic Associations of British Columbia, Keremeos, BC, Canada. pp. 198-201.

Fresh trends. 2003. Organically speaking. *The Packer*, Lenexa, KS. p. 5.

Merwin, I. 1995. IPM systems for orchard soils: Groundcover management vs. weed control. *Proc. New Engl. Fruit Mtg.* 101: 43-49.

O'Rourke, D. 2002. Major trends in U.S. and world apple markets. *N.Y. Fruit Quarterly* 10(4): 10-18.

Schupp, J.R. and J.J. McCue. 1996. Effect of five weed control methods on growth and fruiting of 'McIntosh'/M.7 apple trees. *J. Tree Fruit Prod.* 1(1): 1-14.

Schupp, J. R. and R. E. Moran. 2002. Testing pre-plant monoammonium phosphate and apple compost for improving the growth of newly planted apple trees. *N. Y. Fruit Quarterly* 10(1):5-7.

Stiles, W. C. and W. S. Reid. 1991. Orchard nutrition management. *Cornell Coop. Ext. Bul.* 219.

Acknowledgements

The author wishes to thank Mr. Brian Caldwell, Farm Education Coordinator for the Northeast Organic Farming Association of New York, and Dr. Ian Merwin, Associate Professor of Pomology, Department of Horticulture, Cornell University for their helpful suggestions in the preparation of this manuscript.

Jim Schupp is a research and extension associate professor of horticulture who specializes in orchard management. He was previously with Cornell's Hudson Valley Lab and is currently at Penn State University's Biglerville Lab.

ERRATUM

for the New York Fruit Quarterly

VOLUME 12 • NUMBER 1 • SPRING 2004

The figure below is a correction for the figure which appeared on page 11 in the article **"Adjusting Soil pH for Optimum Nutrient Availability"** written by Lailiang Cheng and Warren Stiles, Department of Horticulture, Cornell University, Ithaca, NY.

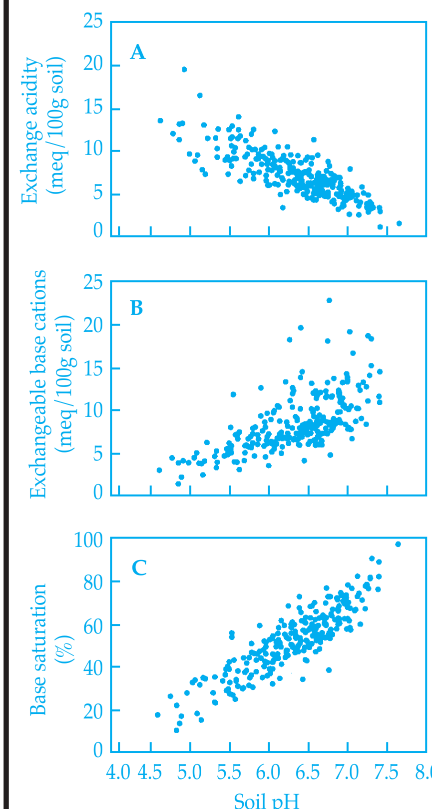

Figure 1. Exchange acidity (A), exchangeable base cations (B), and base saturation (C) in relaiton to soil pH in 250 Hilton soil samples from Western New York apple orchards.

Join the New York State Horticultural Society

Become a part of our Society.
Yearly membership includes
HortSense Newsletter, Hort Flash Updates,
and the New York Fruit Quarterly.
Join us today and support the NYSHS mission to educate, promote and protect the NY fruit industry!
Fill out and mail the Membership Application below.

Mission Statement

The mission of the New York State Horticultural Society, founded in 1855, is to foster the growth, development and profitability of the fruit industry in New York State. It accomplishes this by:

1) Supporting educational opportunities for members
2) Promoting the industry
3) Representing the industry in matters of public policy

New York State Horticultural Society Membership Application

Become a part of our Society. Yearly memberships include HortSense Newsletter, Hort Flash Update, and the New York Fruit Quarterly.
Join us today!

Please Print

NAME ______________________________

FIRM NAME ______________________________

STREET ADDRESS ______________________________

CITY ______________ COUNTY ______________

STATE ______________ ZIP ______________

PHONE __________ FAX __________ E-MAIL __________

PLEASE FIND THE ENCLOSED DUES FOR THE FOLLOWING:

$__________ NYS Horticultural Society Membership Dues

$__________ $20 per year NY Fruit Quarterly Subscription ONLY

$__________ TOTAL

PLEASE MAKE CHECK PAYABLE TO:
New York State Horticultural Society

MAIL TO: New York State Horticultural Society
PO Box 462 • Hedrick Hall
Geneva, NY 14456

Questions? Call the NYSHS office at 315-787-2404

NYSHS Membership Dues

NY Fruit Growers (Individual membership)	$95
Additional (Voluntary Contribution)	$__________
Industry Professionals	$95
Academic Professionals	$45
Out of State	$45
Fruit Industry Sponsors	
NYSHS Supporter	<$500
Bronze	$500
Silver	$1250
Gold	$2500
Platinum	$5000+

NYSHS Issues

Pesticide Registrations
Food Quality Protection Act
Integrated Pest Management
Agricultural Labor and Immigration
Fruit Industry Economic Development
Cornell Research and Extension
Educating Public Officials
Educating Industry
Food Safety

For non-NY residents: Are you interested in the latest research news from New York?

Subscribe to the informative

NEW YORK FRUITQUARTERLY

for $20* per year.

Please use the subscription form at left.
***Membership** in the NYS Horticultural Society **includes** a subscription to the New York Fruit Quarterly.