Application of SCI Ideas to Orchard Management / Intensification

An orchardist's choreography of space x timing x pruning x fertility

– Mark Fulford (draft)

It turns out that the principles for the ***System of Crop Intensification*** (SCI), which have been extrapolated from the more specific ***System of Rice Intensification*** (SRI) www.sririce.org, may be applied (*mutatis mutandis*, to use a Latin expression that economists love – changing those things which need to be changed) to woody orchard crops.

One needs to start with the recognition that orchard crops, being perennials rather than annuals, can benefit from changes in the timing of longer-term crop cycles. Catching and capitalizing on opportunities to feed and prune fruit trees, synchronizing this with their periodicity, is a different challenge than managing annual crop cycles, something all-important. When the fruit buds for next year's crop will start to develop depends on the plant's nutritional supply at the time when the trees are already carrying this year's crop (unless one has a strongly alternate-year-bearing variety -- I have a number of these in my orchard).

The alternate-bearing habit of some late-ripening fruits, usually heirloom varieties, can be partly overcome with some SRI-like changes in management methods as the nutritional status of the later fall- or winter-storage cultivars is linked to their demand for much greater reserves of photosynthesized sugars and greater mineral density than are needed by most annual-bearing summer apples. This is not an iron-bound rule because nature has given us an incredible range in fruiting habits. But this is the general trend for tree habits in northern orchards.

Quality

If nutritional density can be fairly evaluated, it appears that some vertebrates, particularly rodents, know unerringly which varieties have the densest and longest-lasting, high-flavor fruit without reading any book description. Their revealed preferences in an unprotected root cellar, as observed by this author, clearly favor the alternate / late-bearing winter fruit. The flavor and texture when these apples are well-grown is also what the human tongue seems to like best, as judged in the nearby market place, which is supplied with over 40 varieties grown here.

I have loads of data and written or dictated comments from orchard growers that support the fact that soil quality and tree spacing/timing together produce more desirable fruits to sell. Soil quality can be improved with bioavailable mineral and fertilizer applications, so this is not a fully-fixed factor and can be adjusted within a tree's life span. Management in terms of timing and spacing of trees is something that tree farmers can modify at all stages of orchard crops.

Planting

The affordable practice of planting bare-root trees is now how almost all orchards are established. The mortality can be rather high in new plantings, however, if a few things are not observed right from the start. Most young fruit and nut trees and berry bush fruits do not do well when in with competition of grass sod.

There are several reasons for this, but the main considerations may be allelopathic exudates, from grasses in particular, and the fact that grass rhizospheres are much more bacterially-loaded in nature than what fruit trees, and especially nuts and berries, prefer for their biological soil balance. As an example, rock dusts such as granite and basalt are preferably placed on the surface of a wide area around the newly-planted tree, 6-8 feet in circumference, to set the stage for the first several years of a tree's young and impressionable life.

A fruit tree's growth pathway is affected probably not as much by the chemistry and chemical interactions involved, as by the tree's preference for a more fungal-dominated soil community; and for berries, ericaceous / mycorrhizal support is preferred by many of the the vaccinium species; (blueberries, huckleberries, lingons and cranberry). Having fungal and ericaceous symbionts is often the deciding factor for survival and thrive-ability in new tree and berry plantings.

Without tilling the surface, a grower can use the technique of pre-loading first rock minerals, then topped with a deep layer of woody / leafy composts on a tree site. This is best done in the fall before spring planting, to create a matching woody soil biology mulched deeply over top of the necessary mineral supply for a 'bio-tenderized,' well-fed, non-competitive zone. This neutralizes the effects of bacterially-dominant and non-compatible grass sod, with woody organic matter that nurtures a fungal-dominant support system. Whether in temperate

conditions or in the tropics, the same conditions can be encouraged in a mulch zone. When a layer of organic matter that harbors fungal symbionts has been built up on the soil surface, competing with grass sod, the need for watering will be greatly reduced, and the bearing age and cropping maturity will be moved forward compared to plantings that are plugged into unprepared sod.

Transplant orientation is also another under-appreciated factor which changes the survival outcome of any size or species of tree, both bare-root or ball-and-burlap alike. It is advisable to mark the trunks of nursery liners if possible to show the north direction so that the trees can be planted with the same geomagnetic orientation as they were originally grown in.

Nurserymen and tree-farmer experimentation with many empirical observations as well as my own nursery and orchard management experience show this to be a significant factor. This is not a new piece of knowledge by any means. An orchard -planting trial conducted at UC Davis demonstrated this some years back. Paying attention to directional orientation contributes to more intensified management of the orchard, acknowledging inherent biological potentials in trees rather than treating them like interchangeable fruit-producing machines.

Improving cropping efficiency in orchards is much like working with rice in SRI practices as spacing is seen to be a crucial factor. Plants, both perennial and annual, benefit from fully-bioavailable food reserves within easy reach of their root systems. These reserves are enhanced by having a loose but protected, untilled, preferably mulched surface, extending well beyond the canopy, with fungal-colonized woody materials in place to promote weather-tolerance as well as water and mineral reserves.

This is not a place for tillage equipment as we are dealing with a long-term perennial root systems running horizontally in the aerobic zone, often quite shallow. This zone is ideally dominated with complex fungal communities, actinomycetes, earthworms, and insects of much greater diversity than is found in annual crop soils. This accumulation may be likened to an *orchard soil banking account* (my analogy). Both short-term checking and long-term savings accounts (humic / mineral escrow) are evident in healthy orchard soil systems.

The need for space is just as critical for a productive tree as a thriving rice plant, or for that matter almost any crop. Acutely visible in overcrowded orchards is the loss of lower limbs, dying off from shading and nutrient shortfalls related to the constraints on photosynthesis. This is something that growers need to view as a two-way street, epitomized in the phloem/xylem juxtaposition. As above the ground, so below. The factors limiting growth and health mount in dense plantings, and one should expect premature die-off when plants are crowded too closely together.

All leaf surfaces need as much full sunlight during the day length as is possible to achieve. Where orchards have been densely planted, even on semi-dwarf rootstocks, the lack of 'elbow room' to grow in all directions, above and below ground, becomes a severely, but not-often-recognized limiting factor.

It can be determined that if the limbs of neighboring trees are overlapping and shading each other, their management above ground becomes cumbersome -- for spraying, mowing and picking.

The trees naturally abandon their lower and older limbs if sunlight and soil-derived exchanges of nourishment are reduced relative to the more vegetatively-inclined top growth. This results in a loss of lower limbs as trees are efficient energy-economizers and translocate reserves to areas of greater photosynthesis as a survival mechanism. This is much like the premature yellowing and abandonment of the seed leaf and the oldest true leaves typical of crowded and undernourished annuals.

For example, the typical spacing for mid- to semi-dwarfing apple rootstocks is 12-20 feet. Maybe up to 25 feet for semi-standards like the very common M7and M106 apples established in New England. There are no problems with crowding until limbs begin to touch freely. At this time, the growth of production flattens out and begins to drop. Cull rates rise, and weaker trees falter first.
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The bold practice of cutting out half of the trees in an orchard in a single season, counter-intuitively, can release the remaining trees so much that overall crop yield is not lost, and indeed the quality and fruiting potential of the remaining trees is realized at a much higher grade. Thus the benefits of wide spacing that SRI shows for rice are seen also with perennial and woody crops.

A better distance between semi-dwarfs and semi-standard (apple) sized trees is 30-40 feet. Alternatively, one can plant every other tree with a very short-term dwarf rootstock until cutting-out time becomes apparent.

Tissue and sap testing r**eveals nutritional pathway efficiency.** This inside look at plant metabolism can be monitored in close to real time to make soil and crop fertility decisions during the season, same as for annual crops, by leaf petiole tissue analysis which is done by a number of independent labs and agriculture departments of some universities, including http://cnal.cals.cornell.edu/ More immediate information can be had by using real-time, in-the-field plant sap testing using instruments from such sources as www.pikeagri.com.

The instruments typically used for plant sap assays are: refractometer (digital or prismatic), conductivity meter, sap /soil pH meter, calcium meter, and a nitrates meter. Many of these are made by the Horiba Company. When the oldest and lower limbs of leaves of trees (or any crop) lose critical elements for growth and photosynthesis, such as translocation of potassium and poor accumulations of slower elements such as phosphorus and calcium, then those limbs or leaf scaffolds become unfruitful and the quality of the fruits are substandard compared to those developed on more robust locations of the tree. These limbs and leaves are also more prone to malnutrition-related infections, mainly fungal, but also including bacterial, viral and pest insect habitation.

The leaf tissue and sap monitoring exercises can be quite revealing when compared to soil test results since the monitoring often shows that soil elements may be present but unavailable to whatever crop is being grown. This should be a significant alert in that it signals the soil biology is impaired. This condition surfaces most frequently if not predominantly in soils where herbicides, fungicides and excessive tillage have been used, even in the more distant past.*

Underground, the unseen overlap between trees' growing domains is reflected even more in the competition between their root systems. These systems will, in many cases, extend as far as twice beyond the canopy drip line if allowed to do so. The inherently frequent traffic of tractor tires on road beds in crowded orchard settings creates a compaction zone that limits lateral feeding of the root systems and their associated mycorrhizae .

More critical to these communities is the fact that the complex extensions of obligate and non-obligate fungal colonies and other organism communities in the potential orchard rhizosphere will get compacted, or killed outright, by heavy fungicide use, typical of common orchard practices

**Systemic herbicides should all be eliminated as it is now known that they are far more destructive to the long-term health and yield of an orchard let alone all soils.*

Spacing out the trees to allow full sunlight and easy traffic flow between them, without having to prune off limb ends frequently, is a prerequisite for tree comfort above ground. The same, yet mostly invisible effect is in play below the surface. This principle applies without exception for any tree or shrub fruit planting on full-sized standard or semi- dwarfing, and even dwarfing rootstocks of apple, pear, plum, citrus, etc.

Doing vegetable or grain intercropping and managing livestock ranging within these plantings, provided the animals do not browse on the young trees, is an effective way to make a good return from the land area while long-term trees develop to fill it.

Pruning / feeding periodicity

Usually fruit trees are pruned in the late winter dormant season in northern temperate orchards. There can be a lot of brush to contend with, but the dormant canopy is easy to see clearly and to assess for decision-making on pruning. No interference with spraying or harvest is going on, so it makes sense from a management point of view to do your pruning at this time. Yet, from a tree's nutritional and cropping-cycle perspective, we can do a lot better at other times.

1) Feeding minerals like igneous-parent rock dusts with some calcium and phosphorus- bearing elements placed underneath woody / leafy mulching materials when the soil is warm and active is a highly effective woody crop program. In the New England area, this can be anywhere from early May until late August.

It is suggested to not use heavy applications of fresh manure(s) or strong soluble nitrogen fertilizer sources as these promote rapid, unstable vegetative growth,

from un-complexed nitrates in the sap, leading to higher incidence of disease and poor-quality fruit (Chaboussou 2004). This practice attracts sap-feeding insect pests and sets of non-hardy buds. It also can shift the soil biology into highly bacterial conditions, and this is not suitable for good tree health. It is best to feed new and young woody perennials on the surface, protected by a mulch, not putting much in the actual planting hole, especially not nitrogen inputs since this leads to a 'lazy' tree, i.e., one poorly-anchored, with a simple root structure that is uninspired to venture forth and explore new food potentials with symbiont soil organisms.

2) Prune small diameter vegetative wood in the mid to late summer as this will divert photosynthesis to fruit-filling and to the next year's fruit bud determination. Cease the summer phase pruning in September to allow cuts to heal well before dormancy. This is also a good window of opportunity for providing foliar-sprayed mineral supplementation and for applying dry minerals under a mulch surface made of freshly-chipped leafy brush.

The summer pruning activity within the trees is also an ideal time to combine hand fruit thinning to avoid competition within overly tight fruit clusters as this allows for a better grade of finished crop. Sunlight and spray penetration within the canopy are also improved with the cutting out of small vertical sucker wood. Insect- or disease-damaged fruits can be culled out before they interfere with the final value of the harvest. This close-to-the-tree, hands-on work is critical for pest and disease scouting, which is so important to decision-making about the use of pesticides.

3) Avoid using soluble N as much as possible. The overuse of soluble nitrogen fertilizers is a crop-limiting practice in orchards. Instead, let fungal-decomposed woody mulch over pulverized rock minerals be standard orchard practice, thereby letting associated soil biology do the desired balancing. Do not use sawdust or raw manures, especially late in the season. Use chipped brush of mixed species and leaves as compost feed stocks to support the fungal-dominated soil biology of a woody crop.

Mulching fruit trees with straw or hay is not a very good idea as this encourages

more rodent incursion and is less effective as a builder of soil fungi. In the tropics it was noted that layers of spent banana and palm leaves or other woody mulches greatly protected the often arid, sandy, low-capacity soils or the acidic, iron- and aluminum- and magnesium-saturated tropical ferrisols and oxisols which can stunt crops and make it hard to establish young orchards where the soil is left bare.

4) Keep perennial plant diversity on the orchard floor healthy for pollinators and for sustaining the predators of insect pests. In the north, this means mowing later in the season as fruit- picking commences to facilitate harvesting and reduce nesting zones for rodents that set up abodes and cause potential winter damage. In the hotter southern areas and with water resources more likely limited and limiting, this is a soil protection practice.

5) Keep orchards clean. Dropped fruit should be removed whenever they occur, to help interrupt the pest insect cycles. Prunings should be chipped or composted and reapplied as mulch to be returned to humus unless they are diseased. Remove all diseased wood remains before chipping and mulching. Breaking disease and pest- insect cycles with orchard hygiene, use of free-ranging poultry, and other briefly yet densely-pulsed livestock grazing has proven beneficial to overall tree health. If herbivores spend too much chronic time in an orchard, tree browsing usually occurs as animals can sense a higher comparative nutrition (flavor / palatability) value in the leaves twigs and buds of mineral-dense woody plants over grasses.

6) Grafting can allow you to recover a solid tree of poor variety by top-working a new variety onto the existing planting with about a three-year recovery time to fruiting for a new crop. (This is relevant in temperate / deciduous orchards in particular.) Bridge grafting can also be used to repair rodent- and mechanically-damaged trunks. It works much like arterial bypass surgery, reconnecting the interrupted cambium and resealing sap transport routes.

The temptation to employ grafting as a ‘fix’ on older, run-down trees in low vegetative-energy, diseased, or well-aged and non-productive condition, often backfires, due to the tree’s lack of vitality to heal. Younger trees are more suited to this practice, and all ages of trees should be fertilized (with restraint on nitrogen) with focus given to enhancing minerals and biological actors and

processes to support cell wall integrity in preparation for the shock of so much wood removal.

A woody compost with mineral feeding during the mid-growing season prior to grafting is far more likely to ensure success. Older trees can be grafted in stages, replacing the top 50% first, then lower, newly reinvigorated limbs in the second season. More grafts placed in the cambium interface of smaller cuts will heal much better with less die-back.

In some cases where a mix of pollen donors is needed to get good cross-fertilization, two or more varieties of a given compatible species may be used within the same tree to improve fruit set. There are even a few interspecies grafts that are possible and offer some advantages beyond the scope of this article.

8) Harvest and post-harvest. For the smaller grower of tree fruits, it may be wise to sort and grade the fruit as soon as possible, even directly in the field, if the crop will head to market in the near future, and as well for long-term stored crops, which can easily be spoiled with a few bad fruits unsorted within the boxes or bins. Some of the more damaging oversights for fruits is bruising and denting / scratching during harvest as these fruits cannot repair once removed from the trees.

Picking fruit when cool but not wet nor frosted and then immediately placing it in cold storage (e.g., apples and pears) can prolong the overall useable qualities of the fruit by a month more than if allowing the freshly-harvested fruits to heat up in the sun and endure temperature and humidity fluctuations.

Once in a cellar or storage room, good air circulation is critical to prevent stagnation. Apples, for example, can be stored much colder than many other fruits, but going below freezing point by even one degree is significant for their longevity.

In the tropics, some fruits may do best when simply hung in animal-proof screen shelters, out of the sun and in deep shade to prevent fluctuation of temperature.

Berries generally need to be picked dry and cool to give ideal conditions for shelf life.

9) Preventive Steps. Many post-harvest decay and mold issues can be prevented by managing how a crop is grown, with special emphasis on the natural management in the field or orchard that focuses on reducing fungal spore and unseen disease colonies on the trees and fruits in the first place. Much of this goes back to wide spacing, mineral dense soil, and/or foliage feeding and timing for all aspects of the cropping system.

The use of micronized silica, fulvic and humic acids, vitamins and enzymes as foliar-misted or sprayed-on aids are less-known tools in the management kits for effective, non-toxic tree management. In many cases, an abrupt discontinuation of the usual chemical fixes is less effective and more risky than steadily decreasing the toxic dosing with something of nutritional advantage.

Often the conventionally-managed orchard soils are so lacking in supportive life. The supposed mineral and trace-element components, while shown as present on test results, may not be accessible to the tree, for lack of a thriving soil community to trade with. The reliance on fungicides in orchard crops worldwide has in many ways compromised the soil/crop immune systems of many of the crops we seek to grow. Meanwhile, many wild or 'unkempt' closest relatives of these crops are seen to flourish, in spite of the presence of pathogens in both the cultivated and uncultivated environments.

Much of the needed re-establishment of soil health can be done without expensive input products and with a healthy respect for bio-mimicry to guide us. Setting the stage for success in biologically-managed orchards is very much like the SRI/SCI successes achieved for rice, wheat and other crops.

10) Selection. Probably this should have been mentioned up front, at the beginning and prior to any orchard plantings. The choices made by the fruit grower of the cultivar (varieties) to be planted will make a very significant difference in the long-term outcome on a fruit farm. This is somewhat different than for growing annual crops.

The orchard grower, regardless of the possibility of doing grafting to improve existing trees, is well rewarded by researching the alternatives as much as

possible to ensure the thrift and reliability of both the root stock and the varieties chosen for planting. No matter how glamorous a name may be, there should be some evidence of the regional suitability of a variety selected, knowing how it will probably perform in the farm's location. This attention to selection is more critical for organic-labeled practices than for some other agricultural constraints.

REFERENCE:

Chaboussou, F. (2004). *Healthy Crops: A New Agricultural Revolution*. Jon Anderson, Charnley, U.K. (English translation of book published in French in 1985) [Available in paperback from Amazon]