Carbon Fever, Prescriptions, and Home Remedies for Our Carbon Addictions©

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The dawning of the 21st century has more than brought to our attention the need to look beyond where the nursery industry has habitually been. Worries of global warming and its uncertain ramifications are simultaneously coupled with the anxiety that our energy needs will increasingly become more and more expensive. The reality is that our carbon-based economies will still be with us for some time yet to come and it is a certainty that we will have to make significant adjustments to cope with increased costs in the future.

The hard and cold facts (no pun intended) are that the energy and raw material needs of most nursery operations are largely carbon based and in many cases these raw materials are not renewable. It is interesting that the original text of this missive was written on notebook paper that is derived from sugar cane residue. When joined with the digital miracle of the computer, the carbon foot print to produce this dialogue at least at the beginning is negligible. Plastics in the form of film and slides were eliminated and replaced by electrons. Even the transmission of this "paper" to the editor will be electronic and will side step gasoline or diesel induced transportation.

However it is a far cry from the transportation revolution for words and the transportation needs for trees, shrubs, perennials, and annuals. Electrons put to work for heating purposes for plants is unrealistically expensive so alternatives and creative thinking are the order of the day to overcome the carbon road blocks we all will have to face. In looking to the future we have to develop ways to reduce our dependence on many of our nonrenewable carbon resources.

The big KAHUNAS of our energy usage, motor fuels and heating fuels, will be with us for awhile until we have a significant breakthrough with respect to energy management. We may not be able to implement an effective strategy to do without these necessities, although the economic times are forcing us to re-evaluate just what exactly we are doing with what seemed to be a limitless energy source. We all need trucks, tractors, deliveries to our door, and deliveries of our products to someone else's door. We as propagators and producers all know that once the cutting is rooted or the finished plant is grown, only half of the job is done. We still need to ship it "Danno" for therein lies our life blood. No plant is worth anything unless it is on someone else's truck.

It should not be lost on us that one of the key reasons that many of the third world countries stay perennially poor is that they lack the basics of a sound transportation system. They do not have the roads, trucks, or capacity to handle freight and that stymies their progress. Without transportation and its ability to get our plants to the hands of the consumer, we all would be at a loss. Since we may well not be able to get a grip on our transportation costs, how else can we save expenses so that we can continue to use the state of the art freight systems that we depend on so heavily?

One starting place is to study how we specifically do things. Can we discover that there are areas where we can cut our expenses and reallocate those funds to our energy needs? Can we literally "lighten the load," which can translate directly to fuel savings in the long run?

In studying balled and burlap trees, it is obvious that surplus weight is a continual problem for shipping of these plants. Many balls are not shaved properly nor are the bottoms of the earth balls removed sufficiently. There are no roots there so why are we hauling the extra earth around? Excess weight goes along for the ride but not without a cost. A bit more fastidiousness in the digging production cycle can be quite effective in reducing this extra weight that not only affects transportation but also the person handling in it who is involved in dealing with these extra heavy earth balls.

One fairly recent trend is the movement away from earth balls for trees and they are being replaced by extra large containers. This is happening because the container trees are significantly lighter in weight and are more user friendly to women and others who cannot handle the extra heavy typical B&B tree. The lighter weight of the container plants also means that more of them can be shipped on the same truck without incurring department of transportation weight limits.

What about the growers of seedlings and rooted cuttings, can weight savings be found there as well? The answer is yes. A block of cardboard or plastic with significant holes in it can still do the job as spacer or filler and yet will contribute greatly to weight reductions. A block of Styrofoam with holes in it that removes 25%–30% of the material normally found in a nonperforated block will not only save on overall weight for that shipping box but will also result in savings of raw material. Cardboard can be fashioned into solid shapes that can be hollow and yet remain strong. Many perennial plug growers use shredded newspaper as a shock absorber for their plants. It is effective and is cheap to obtain, but it is not light in weight and does represent a significant disposal problem on the other end. Styrofoam beads and bulbs, however, unless recycled are not any significant improvement and are potentially worse because at least paper comes from renewable resources.

Bigger boxes do offer some cost savings if they are properly designed to hold a maximum of 1020 trays and not have an excess of unused space. In the world of UPS and Fed Ex more material in a box to be shipped results in cost savings.

THE PROPAGATION PROGRAM

Can money be saved by a new look at the rooting cutting program? In a short and brief analysis the answer is absolutely. But where to begin?

Several things come immediately to mind. Labor tops the list followed by heating and energy costs. Second would be cooling costs and the third measure would be to take a strong look at nonrenewable materials, such as plastic films and pots.

Labor costs are the number one factor in propagation costs and that can be improved somewhat, but due to the amount of variation and seasonality labor can be a hard issue to refine. Heating costs either directly to reduce cold damage or to be used for bottom heat can be managed after some study.

Overwintering costs associated with using heat will invariably continue to rise and yet technology that was initially brought to the forefront at IPPS meetings seems to be forgotten or, at the least, ignored. While applied heat will prevent plants from freezing, it is not generally freezing that affects cold hardy plants. What really kills rooted cuttings and seedlings in winter is not freezing but rather desiccation associated with freeze drying. While applied heat can stop root balls from freezing and thereby allowing the uptake of water, a more practical energy saving method is to use thermal blankets as protection such as the ones made from microfoam or bubble pack. Either application can be used repeatedly and once paid for do not incur additional expense as opposed to propane that delivers a single punch but must be renewed continuously when needed. If propane is the only alternative, one way to increase its effectiveness is to have a steam generator used in conjunction to the propane heat, often they can be one and the same. Highly humid environments hold more ambient heat than those arenas that only have dry air.

Another energy consuming activity of propagators is to use bottom heat and in many cases it is absolutely necessary, but what isn't necessary is the origin of such heat. Traditionally bottom heat has been obtained from multiple sources such as using electric heat mats or applied hot water systems using fossil fuels as the heat source. Little can be done to replace electrically operated systems unless they are replaced by hot water systems that can in turn be augmented with alternatives that have little energy consumption.

Solar energy is abundant and readily available but far too often money is spent to remove solar heat rather than to capture it and use it. But it can be used for bottom heat. A 15 ft × 100 ft double-inflated clear polyhouse can be fitted with a series of racks to hold several thousand feet of black poly filled with water and recirculated and stored in a large storage tank. On a given July day in Pennsylvania, prime cutting rooting season, the temperature in a sealed poly house as described above at 9 AM is 90 °F, by 3 PM the temperature is 135 °F. Water at 135 °F is sufficient for an effective bottom heat system set at 80 °F. A 300- to 500-gal storage tank holds enough hot water to carry the heat to the system during the night. During the day the hot water would circulate under the cuttings then to the polyhouse heat system, then to the storage tank and back out to the cuttings. Cost of the house and plastic for an average of 5 years is $210 a year. Cost to run the recirculation pump which must be used as well in a fossil fuel system remains the same. Cost to run the system with conventional propane at current market rate of $1.50–$2.00 per gallon is substantial and will easily surpass the $200 per year level.

Another cost saving measure for propagation is to pay close attention to the timing of the taking of cuttings. If the timing is wrong, several things can come into play. One is that the subsequent rooting of these cuttings will be poor. A second factor is that applied bottom heat might offset the inappropriate timing but there is a substantial energy cost. If the timing is right then the amount of applied bottom heat might be small or none. Also, cuttings taken past the optimum time will often take longer to root and thereby use more over all energy. Many cuttings can be rooted out of doors in full sun if there is adequate wind protection to prevent drift of the applied mist. Very few propagation nurseries root plants in full sun but the potential is there. The use of the ultra fine greenhouse construction to root perennials or woody plants is the energy equivalent of using a back hoe to do the work of a small shovel which begs the question, are the really big hard-to-heat, hard-to-cool greenhouse all that cost effective?

In Tennessee for example cuttings are often rooted in very low-statured poly tunnels which are equipped with mist. Such tunnels are filled with trays of cuttings, they trays are watered in, the mist is turned on and the whole structure is then covered with white poly and sealed completely. Cuttings root in about 14 days and can then be hardened off and removed. In China both cuttings and seedlings are raised in similar type tunnels but without mist. To save space the cutting and seedling propagation tunnels are placed in the tree rows of a balled-and-burlap nursery. In Europe, cuttings are placed in trays, watered in, and placed in small tunnels as in Tennessee but the tunnels are often inside of a much larger unheated greenhouse. The system depends upon the larger greenhouse to generate heat by solar heating which in turn supplies the heat to root the cuttings.

Cutting Production. Another aspect of timing and energy consumption is that in many species, such as perennials in the Composite family, the inappropriate timing for the cuttings will often result in "blind cuttings." Blind cuttings are cuttings that overtly appear to be normal and they will root but they will not give rise to functioning plants. If they do not die during the winter time, and many of them do die, those that survive will give rise to flowering shoots that then subsequently die after flowering. In the case of *Scabiosa*, blind cuttings are morphologically different than vegetative cuttings and can be readily ascertained. Blind cuttings in *Scabiosa* have indented leaf margins and those cuttings that root well to produce fully functioning plants have entire leaves. It should be obvious that if blind cuttings are taken there can be a significant loss of applied heat energy.

Cost Savings for Heat. In the last 5 years or so there has been an increased interest in using outdoor waste-fuel-fired furnaces. Waste wood chips, whole logs, and pallets often go begging for someone to take them. Such potential fuel sources are being utilized to heat water which is then pumped into greenhouses and used to ambient air heating or bottom heating. Such systems are now commercially available and have a pay back period of 5 years. Interestingly, home-made systems can be built to burn a range of fuels that are locally available such as bark strips from saw mills. Such systems often make use of "free" or low-cost scrap for fuels and are quite energy efficient. With regards to global warming such systems also are carbon neutral. One propagation operation in Quebec uses scrap-wood pallets. A similar operation in Ohio stock piles wood chips from trimming operations. In both cases there is a fossil fuel back-up system, but the scrap heat systems cover over 90% of the heat needs. The Quebec system, while homemade, can fend off cold temperatures as low as -30 °F.

Fertilizers and Growth. Few of us realize that fertilizers are major components of a negative energy flow. It is perhaps realistic to consider fertilizer as a supplemental energy source for plants but one that has to be continually replaced, unlike the sun which is prevalent at least 12 h a day.

The jest of this problem is that all nitrogen fertilizers are made in a round-about way from natural gas and that is a significant energy usage. Costs for the nitrogen fertilizer, ammonium sulfate, have risen from $200 per ton in the year 2000 to over $800 per ton in 2009. This trend will continue and costs are expected to rise even further. What can be done about this situation?

One option is to look at what the actual nitrogen requirements are for an acceptable saleable plant. Researchers in Denmark at the Danish Institute of Horticulture have shown that an applied nitrogen reduction of 50%–75% can still produce a readily salable plant. The truth is, much of the nitrogen applied to plants is rapidly flushed out the drain holes of containers. Not only is this a significant loss of valuable material, it is also a potential pollutant and often readily attracts the interest of the EPA and state departments of environmental protection. By reducing nitrogen consumption major dollar costs can be saved, the pollution potential is reduced and there is a subsequent reduction in the total amount of carbon that is consumed.

Reducing the amount of nitrogen for container plants ideally is not hard. The Danish researchers have discovered that by increasing the cation capacity of manufactured soils very small amounts of fertilizer are required to achieve the same result compared to soils that have not been modified. High organic mixes have a poor cation exchange capacity and fertilizer readily pours through. Fortunately the ingredients needed to increase cation capacity are not expensive.

Cation capacity of most soils, be it sawdust, peat, or rice hulls can be readily increased by the addition of calcined clays; read this as kitty litter, a readily available calcined clay. Bentonite, if of the right polarity, can also be used as a cation exchange booster. Unpublished research at Barnes Horticultural Services has shown that the addition of 10%–75% commercially available kitty little resulted in a high retention of cations, such as K^+, Ca^{++}, and Mg^{++} and a good retention of nitrates as well.

Fertilizer usage can also be curtailed by modifying application methods. For instance, a non-growing plant will use sparingly little fertilizer but in many commercial operations fertilizer is supplied whether it is needed or not. In some cases this will lead to nitrogen toxicity and the eventual death of the sensitive plant. Part of the problem of over fertilization is encouraged by the myth that fertilizer will actually induce a plant to begin growing. There is no evidence that fertilizer of any kind will initiate plant growth when there is none. If fertilizer is applied to *Euonymus alatus* or *Syringa vulgaris* after the 1st day of summer, absolutely nothing will happen in the way of growth. The plant may become greener but it will not begin growing again until passing through a normal winter sequence. To be fair, a good nutrient level is essential for the overall health of the plant and to supply a basis for future growth and for the formation of flower buds, but the amount to do this is substantially less than that required to promote an actively growing plant.

To be really effective, fertilizers should be applied to plants when they are actively growing or just before they naturally begin growing. Excess fertilizer on woody plants is largely wasted as the plant finishes it natural growth cycles.

When it comes to the application of liquid fertilizers it is readily known, but perhaps not considered, that most plants cannot use a fertilizer solution that contains more than 400 ppm N. Anything beyond that point is also wasted. However a continuous dose of fertilizer at 400 ppm N often leads to salt accumulations which are toxic and can lead to the problem of nitrogen toxicity. A moderate level of fertilizer application at 150–200 ppm N is utilized far more effectively by the plants than what occurs with a dosage of 400 ppm N.

Liquid fertilizers can also be affected by the chemistry and pH of irrigation waters and those waters should be checked frequently so that they will not interfere with the action of the fertilizer.

Organic fertilizers are often better for the long-term supply for a plant as opposed to some so-called time-release fertilizers. The inorganic chemical versions are prone to release via a variety of mechanisms and environmental conditions can alter those mechanisms. Sometimes time-release fertilizers can suddenly release their load and create a phenomenon known as " quick release" which can be damaging to plant systems. Quick release can also occur in the early parts of spring and can create a detrimental situation if, following the quick release due to warm weather, a subsequent drop in temperatures coincides with a flush of new growth by the plants. Organic fertilizers while much slower will not create a "quick release" circumstance in the early spring.

In field operations cover cropping is preferable to solely applying a chemical fertilizer. Sometimes the two can be utilized together to boost both the chemical status of the soil as well as its tilth and porosity to air. A soil with a build up of organic matter also retains a greater amount of applied nutrients and water. It is generally considered that an acre of grass is the equivalent to 1 ton of applied nitrogen to that ground. Legumes such as soy bean, clover, vetch, or peanuts can add even more nitrogen to a field soil.

Since it is prudent to add fertilizer to a growing plant, it is also sensible to understand what it is that actually promotes plants to grow. Heat is a critical but ineffectual if there is not a significant level of light of the correct wavelengths or photoperiod duration that promotes a long-day situation. Plants respond to light changes far more quickly than they respond to heat changes, although in some situations heat will mimic light in triggering plant responses. The phytochrome response is responsible for the induction of new growth or seed germination upon exposure to light in the red region of the spectrum. In a greenhouse environment, both heat and light have to be in a particular balance in order for plant growth to be optimal. Once that is achieved then the addition of fertilizers to further growth is acceptable.

Light can also be used to keep plants in a vegetative state and reduce that incidence of plants, particularly perennials, from slipping into the flowering mode. Different wavelengths of light will also affect what types of growth will occur. Some lights strong in the red spectrum will advance stem and shoot growth. Sodium lights, strong in yellow and being almost monochromatic will induce flowering and limit shoot growth. The fertilizer needs for shoot growth are significantly different that those needed for floral formation.

Applied lights of the proper wavelength will keep plants growing provided that sufficient heat is available but the light response is more powerful than that of the heat response and plants will try to keep growing in spite of falling temperatures. This can lead to problems if the applied light is not removed in sufficient time for the plants to acclimate to the change of the seasons.

To keep plants growing two things are needed. One is a light source with a spectrum that contains red light and two is the use of the light to create a situation known as a "short night." Even though many texts refer to the benefit of a long-day cycle to keep plants from going dormant it is not really a long-day cycle that is doing the job, but rather it is a short night that does the triggering.

It is customary to split the night into two parts by having lights come on from 10 PM to 2 AM. This creates a situation of two short nights in the same 24 h. Plants keep growing. To save energy costs the lights can be made to flash 10 sec every 10 min during the 4 h intervals. The same results can be achieved by the flashing lights as opposed to the continuous lights which use far more energy. If fertilizer is applied during the short night cycles plants will grow substantially.

Soils — Soils Are No Longer Dirt Cheap. One of the problems for nursery and greenhouse growers is the high cost of artificial soils. Also, such soils often fail to meet the needs of a grower and additives must be incorporated to augment soil qualities. Even more of a concern is that in some quarter's peat moss is considered to be nonrenewable. Germany has already outlawed the use of peat moss in potting soils. Even if the scarcity of peat is not a questionable issue, the cost of producing peat and hauling it from the more remote areas of the globe to where it is used will continue to rise. Transportation costs of peat will eventually make the use of peat moss prohibitive.

Another key component of most container plant soils is bark and in many cases it has been readily available, but this is changing. Power companies have taken a keen interest in bark and much of what was once available is now being used to generate electricity. It is easier for the power companies to use bark, as is, than the tailored bark products that the nursery industry requires; hence bark producers are taking the easy way out and selling to the power companies first. Like peat, bark is also experiencing increased freight costs and they will not be going away. The coupled increased demand from power companies and freight costs are driving the costs of bark up to the point that it will not be a good source of substrate for potting soils. Are there alternatives?

Yes, and much of it is regional, however efforts are being made to farm raw materials for potting soil substrates and this should keep costs and freight charges to manageable levels. Some examples of alternatives are coir, composted chicken feathers, rice hulls, composted ground up whole softwood trees, noncomposted whole ground up softwood trees, composted ground up hardwood trees and some experimental use of ground up plastics instead of perlite.

Soil constituents all have pluses and minuses, here are a few:

- Coir is renewable and serves to increase aeration of soils. Being organic it will eventually degrade and lose its effectiveness. Not readily available yet but it can be farmed and might become more accessible with time.
- Composted chicken feathers are renewable and serve to reduce a difficult waste management issue. It acts as a slow-release nitrogen source but is subject to compaction in containers. This is a regional product and distribution may be limited.
- Rice hulls are renewable, regional, cheap, and offer a light-weight component to soils both for aeration and texture.
- Softwood trees are renewable and farmable, can be composted to produce a peat-like substance, or used raw. Raw trees though do consume more nitrogen than a composted product, however.
- Hardwood trees are renewable and farmable, but hardwood trees often contain high levels of toxins not present in softwood trees. Also hardwood trees have much higher pH residues in the compost.
- Ground-up plastics are not renewable but readily available as a waste product. It does not degrade and will linger in the environment and overall affects for the long-term are not known. It is cheap and readily increases porosity of soils.

Plastic Containers — Are Their Days Numbered? Plastic pots have been a staple of the North American nursery trade for about 50 years now. They are ubiquitous and can be found in almost any nursery producing plants from containers. However, they have two draw backs that might limit their presence in the future.

- One is the difficult issue of disposal and it is a significant issue.
- Two is that these containers are plastic and are derived from oil and petrochemicals.

Both limitations of plastic pots will inevitably contribute to continual price increases in the future.

Some 30 years ago nursery containers were available that were made from paper and from recycled tires. During the late 1970s and early 1980s these products appeared and then subsequently disappeared. Now, after being refined and modified they are making a come back. Other things finding their way into pot manufacture are polylactate plastics that are derived from corn. Chances are good that we will all have to adapt to using new products that are not linked to the oil/petrocarbon sources and will be developed from renewable resources.

SYNOPSIS

In synopsis, costs of many of our raw materials are rising; this has both a positive and negative component. However the increased costs are also stimulating new ideas on how to produce competitive raw materials that can be used in the same way as the old stand bys. The new products coming our way may even result in a decrease in costs as the production and development issues are resolved. We all should understand that the initial cost of a particular item is not the entire cost and hidden costs such as disposal, limitations on raw materials, and freight bills all contribute to lessening the bottom line. We, as an industry, must reevaluate what our priorities are, initiate research and development programs to solve problems, and abandon old tired ways for the greater good. The survival of the nursery trade will depend on moving forward and not looking back too long.