A Trip up the Calcium Highway

The Next Chapter

Spring 2011 GVGO Science News
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Most of us know the most frustrating events in growing the Atlantic Giant Pumpkin (AGP) can occur usually in the dog days of August. Blindsided growers are left empty handed by the affects of a simple diminutive tiny atom on the periodic table of elements. The event can play a cruel an extremely doubtful havoc on a plant's single fruit. So traumatic it can force a grower to abandon the hobby for much more benign chores around the yard.

Consider that each plant requires an hour a day of care or more from spring through to fall including prep time. It becomes easy to understand the investment that a grower places with each seedling placed into the patch.

A mere lack of small a quantity of this lowly common atom can very easily destroy the best of fruit within the blink of an eye. The misshapen fruit often sends the grower reeling and wanting for another opportunity to grow a big pumpkin.

This pesky substance known as Calcium (Ca) for centuries is really rather ambiguous. Ca is slivery, grey and dull in colour with little value to mankind. It is easy to see why it never gained acceptance adorning a cavewomen's appendages. However Ca is the fifth most abundant element in the earth's crust. Found mostly as limestone and gypsum Ca was quickly put to use by plants as they colonized the earth's early land masses.

Cavemen first noticed it as icicle looking stalagmites and stalactites which are formed of calcium carbonate. It is also an essential component of animal's bones, teeth and sea shells. Ca is an alkaline metallic mineral know to moderate and neutralize acids. Not considered a major plant element required for growth it is essentially a macro element in the giant competitive growers pumpkin patch. Truly this obscure mineral holds the super power of kryptonite in the gardens, giant pumpkin patch.

However Ca is highly susceptible to localized restrictions that prevents uptake into the roots. This can be caused either by poor soil moisture levels, displacement of competitive cations or lock up caused by bicarbonate molecules. Highly soluble Ca moves within the soil solution around the root zone awaiting transport up into the plants calcium highway we call the xylem.

Taken in by the plants roots it is transformed into calcium pectate. Distributed amongst plant in the xylem flow it accumulates within the plants vascular systems including the leaves and fruits cell walls. Sadly for those who have faced its ugly wrath an unhealthy portion of Ca results in a smiling pumpkins distal cellular walls.

Krytonitic power is of course an understatement for a grower of Atlantic Giants. Most are keenly aware of the balance of power that Ca plays in the soil. Firstly it helps to nullify the affects of soil acids by lowering pH. Secondly it competes with other cations in the soil and helps to maintain an appropriate balance within the soils elemental substructure. The discovery of Ca's importance in the role of growing an AGP is not new. Related vegetable growers and scientists alike have understood its presidential role and function in plants for many decades.

The pumpkin community often begs for a greater understanding and investigation. Exploring the correct soil proportions of Ca but also to the science of its uptake and induction into the living plant is necessary. If Fruit Sinks (FS) of rapidly expanding cucurbita maxima are to surpass 2000 pounds these two questions must be answered.

The main causes for concern are reduced Ca uptake resulting in blossom end split (BES) and low fruit weights. Most soils are readily abundant in the alkaline mineral and often at very high levels. However, much of the calcium in your soil is often tied-up in insoluble compounds and is unavailable to be absorbed by plant roots. Ca is usually very mobile in the soil and is easily absorbed into young unsuberized roots. It is transported within the plants main highway known as the xylem through a process called transpiration. Fresh supplies of water and Ca are carried up this one-way highway within the transpiration stream to the more dominate evaporative parts of the plant. Often this happens to be the leaves which tend to transpire larger amounts of water and thus receive the lion's share of Ca.

The most critical time for the fruit is in early stages of development when the fruit develops its internal distribution network. It is at this time when young developing blossoms and fruit suffer during periods of evaporative or uptake stress, setting the stage for a growers blossoming demise.

Low fruit weights and BES often begin to develop during the first few days before and after pollination setting the stage for rigid blossom end walls of seasoned fruit. Related to BES, Dill Rings, Sag Lines and internal wall cracks are latter stage effects of water supply and Ca uptake stress.

Trying to identify some of the more popular theories and ideas surrounding the cause of these events is often the most misunderstood of pumpkin deformities. Here are a few of the causes and tips I have referenced over the past several years from hundreds of research journals and articles I have reviewed.

Low fruit weights, Blossom-end splitting, Dill Rings and internal cracking are not caused by a parasitic organism. The conditions are caused by physiologic disorders associated with low concentrations of water, Ca and nutrient products in the xylem flow. The effects can be triggered by environmental factors that surround the roots and or the leaf canopy.

Calcium is required in relatively large concentrations for normal cell growth. When a rapidly growing fruit is deprived of necessary water and Ca, the tissues degrade. BES, Dill Rings and internal wall case cracks are induced when demand for plant water exceeds supply. Split event dates are often proceeded by a prior periods of water supply stress. Even with an abundance of calcium in the soil, inadequate calcium levels in the plant and fruit can occur under these conditions.

This may also result from a host of conditions including high amounts of competitive cation's in the soil, high organic matter, drought stress, excessive soil moisture or wide fluctuations which reduce uptake. Evaporative leaf canopy stress contributes by increasing the demand for xylem flow and Ca when it may not be available in larger quantities for transportation to the fruit. Therefore reduced movement of Ca into the plant are major concerns.

Incomplete Conclusions

- The myth of increased photosynthesis or accumulative and sudden carbohydrate production was often thought to result in BES. Increased deposits enlarge a fruit deprived of calcium placing stress on the ever expanding cell walls. Although this may be the final result of Ca deprivation it is not the cause of such a calamity.

- Genetic disposition is also thought to play a major role. Certain genetic strains may be better suited to foster adequate root uptake or reduce canopy transpiration. Distribution pathways in the peduncle stem leading to the fruits distal end maybe more vigorous and prevalent in some strains. Genetic heavy walled fruit may therefore often provide a larger comfort range for developing young fruit. It is also probable to assume that certain genetic combinations may assist in the appropriate production and storage of photosynthesis by products.

- Foliar applications of calcium, which are often advocated, are of little value because of poor absorption and movement to fruit where it is needed. Drs. Hodges and Steinegger, Extension Specialists with the University of Nebraska, Lincoln, report calcium does not move from leaves to the fruits. Thus, foliar canopy sprays of calcium won't correct blossom end split problems. It is thought that pumpkin fruits do not have openings in the epidermis (skin) through which calcium can be absorbed. Contrary to past grower belief, direct application of calcium by wet towels, is ineffective. A secondary cause being slowed fruit transpiration by the towelled enclosure. A third opinion states that towels may be trapping in the ripening gas ethylene. Topical Ca sprays during fruit formation from golf ball to basketball stages may be of benefit but this is still largely unproven.

Leading Causes of BES

- **Unsuitable irrigation water** is a leading cause of Ca nutrient deficiency in fast growing AGP plants and soils of modern day patches. Ca-bicarbonate sequesters Ca cations in a tightly held grip. A common occurrence in irrigation water supplies this bond can be moderated by treating water with acids to 5.5 pH. Analysis of water for irrigation should include the *cations*: calcium, magnesium, and sodium, and the *anions*: bicarbonate, carbonate, sulfate, and chloride. Determining water quality can assist the grower in raising water solubility of Ca within the rhizoshere thereby increasing uptake.

- **Environmental factors** enter into the equation by affecting the availability of nutrients and may hasten reduced uptake of Ca. These include a wide range of conditions from weather induced evapo-transpiration to rhizospheric drought and or anoxia (lack of oxygen).

    1. **Soil moisture content** plays a critical role in the movement of calcium in the soil and its uptake by roots. Without sufficient soil moisture, calcium mobility will be lost and not move to the roots. If the soil is too wet, oxygen can be unavailable for new root growth. Anaerobic conditions cause low absorption by root tips in which the cell walls of the epidermis become suberized. Once a suberin layer develops in these cells, water and calcium can no longer be absorbed. Suberin is a waxy cork like substance through which water and nutrients cannot move.

    2. **Drought stress** and wide fluctuations in soil moisture in poor irrigation. Even brief soil water deficits can disrupt water and nutrient flow in the plant. If this occurs while fruits are developing, blossom-end splits or Dill Rings will likely develop. Plants generally need about one inch of moisture per week from rain or irrigation for proper growth and development. If the irrigation of any kind is available, it should be used during periods of low humidity and hot, drying winds. Start to irrigate at the beginning of the dry spell.

- **Rapid, vegetative growth** due to excessive soil applied ammonium or nitrate nitrogen fertilization can cause fruit splits. These forms of nitrogen do enhance growth, photosynthesis and fruit quality. However the ammonium ions compete with calcium and significantly restrict its uptake. AGP plants have evolved for years in environments that normally contained less than 5% OM. Plenty of nitrogen is usually available for plant uptake in most of today's patches containing levels in excess of 10% or more.

- **High patch concentrations of OM** and the sudden influx of ammonium nitrates by release of decaying beneficial micro organisms accelerate the release of competing cations of ammonium. This condition begins to hasten green growth and reduces Ca uptake as the soil warms. Avoiding fertilization of ammonia-cal forms during and prior to fruiting stages is prudent. Calcium nitrate or calcium chealated supplements with a soluble nitrogen sources high in nitrate nitrogen should be used in only small quantities. If desired ammonium nitrogen should be used foliar at low rates only.

- **Larger leaf canopies**, a primary effect of increased nitrogen released into the soil are another of the competing factors affecting the demand for Calcium away from the developing sink.

- **Drenches of Ca mixes** combined Humic Acid and Fulvic acid is especially important at this time to enhance solubility in the soil solution. Ca mixed together with phosphites and or micro nutrients can be soil applied and new evidence is revealing transportation in the phloem is possible with nano particle brews.

- **Mulching**, can serve to maintain an even level of soil moisture, should be practiced where feasible. Caution is required as mulches containing high ammonium should be restricted. Leaves and straw that are high in carbon make the best vine mulches. Plastic mulches are not recommended as they are more difficult to manage and maintain soil moisture. They also have the disadvantage of trapping in soil gases and ethylene ushering in maturity.

- **Weather**, specifically thunderstorms and excessive rainfall can trigger the effects of a plant and fruit low in Ca that is already susceptible to BES. Firstly in fostering growth spurts hastened by sudden expansion of the non flexible fruit sink (FS). Secondly by removing oxygen from the soil and creating anaerobic, suberin building conditions.

- **Bright sunny days** with high temperatures and low humidity drive the leaf engine faster. This causes high transpiration rates out of the leaves and directs more mass flow up the xylem river to the leaves and away from the FS. Leaves become the plants radiator as water energy is directed to the plants elephant ears for cooling. This diversion is also one of the primary results of Dill ring formation during later stages of growth. Combine this with speedy growth of a young fruit during large sink storage periods or dry soil just before such an event and your fruit is now left starving for calcium and unable to cope with increased quantities of sink storage.

Example..... In Ontario 2006 we had a period of nearly no growth for several days in early August right after the passage of a severe cold front. Numerous growers reported slow to no growth at all during this period. A lot of major problems sprang up shortly after this time caused by low humidity and high transpiration allowing for lower rates of Ca importation to the fruit. Deep rib splits, sag lines and blossom end splits suddenly begin to appear on the fruits external skin. When compared with hot humid days the sunny low humidity day plays an uncertain havoc with your plants. This is especially true if the plant is not accustomed to the sudden change a new weather front brings with it. The severe dry cold front I mentioned was preceded by one of hottest humid string of days in Ontario history. Slowing down sudden transpiration by shading the plant or misting at frequent intervals on such days may reduce risk somewhat.

- **Growing a backup secondary FS** just in case you suffer the blight of a water Ca starved offspring often leads to little success. The secondary FS will begin to compete for the available water and Ca resources. This tactic could however work in soils that produce lesser amounts of ammonium. Soils, near in natural background OM levels may be better able to sustain adequate Ca availability and uptake into the plant. The main advantage to the grower allows for of control excess FS storage during low transpiration and high photosynthesis events. Under such conditions sudden sugar production can result in plants that are better able to distribute the influx of leaf export.

- **Keeping an area of plant shoots** that are actively growing provide a new source of young unsuberized roots and a good flow of Ca and nutrient products into the plant. This can be enhanced by applying sparingly foliar ammonium nitrogen and phosphorus to only the new growing plant sections. Nitrogen will aid in green growth as phosphorus assists young root formation. It is possible to stimulate root development with hormone products. Under good conditions grower can maintain new vine sections and roots well into September.

Despite doing plenty of homework and studying the cause and effects of BES for many years there are still unknown factors. Most growers will again be haunted by the prospect of having a smiling fruit in 2011 and beyond. Much is yet to be learned about the role of Calcium in the Atlantic Giant Pumpkin. I hope we now have a better basic knowledge and some of the tools required to combat the frustratingly deadly season ending fruit calamity.