PHYSIOLOGICAL OR ABIOTIC DISORDERS OF PLANTS

FACTSHEET

Introduction

This factsheet was developed initially for the ginseng industry, and then expanded to include other outdoor plants. Thus the many references to ginseng in the text. It is also a very brief look at this topic in general.

Physiological or abiotic disorders are distinguished from other disorders in that they are not caused by living organisms (viruses, bacteria, fungi insects etc), but are caused by non-living, abiotic situations and cause a deviation from normal growth. They are physical or chemical changes in a plant from what is normal and generally caused by an external factor. Some non-infectious disorders are easy to identify, but others are difficult or even impossible. Most of them are not reversible once they have occurred. To help in identifying physiological disorders it important to know that:

- Physiological disorders are often caused by the lack or excess of something that supports life or by the presence of something that interferes with life.
- Physiological disorders can affect plants in all stages of their lives.
- They occur with the absence of infectious agents therefore cannot be transmitted.
- Plant reactions to the same agent vary widely, from little reaction to death.
- Dealing with physiological disorders often means dealing with the consequences from a past event.
- There is generally a clear line of demarcation from damaged and undamaged tissue.
- Physiological disorders are serious in themselves but often serve as the 'open door' for pathogens to enter.

Some of the physiological changes that can occur are listed below, but not in order of severity or most likely to happen.

Chemical Injury

Any kind of foreign chemical applied in the wrong dosage or at the wrong time is capable of doing physical damage. Most chemical injury will come from pesticides applied at too high rates, the wrong time, or during very hot parts of the day. Damage from chemical injury may appear as red, yellow or brown spots on the leaves, leaf tips turning brown, stunted or misshapen plants, to overall browning and death of a plant.

Minor herbicide injury on a broad leaf plant has a very typical pattern of elongated and pointed leaf tips with raised veins and may be accompanied by twisted or stunted new growth, to in the worst case scenario, death of the plant.

Tordon injury to potatoes from contamination of farmyard manures.

24D injury to landscape tree from overuse of herbicides on lawn.

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Cold Injury and Frost

Some plants can sustain some frost pressure in the spring or fall, without major damage, while others cannot. Frost injury may cause, browning of leaf tissue, deformed plants, puckered leaves, damaged leaf/flower/& fruit parts, to complete death of a plant, depending on severity. The frost damaged plants or parts will generally show evidence very quickly. It is also felt that very cold but not freezing temperatures for sustained periods will cause puckering or other damage of plant tissue of some plants, especially flower parts and to young seedlings. There is a time/temperature relationship, with less ability in most cases to withstand damage before plants are hardened off properly.

Nectarines with frost damage at flowering time.

It was observed in the ginseng industry that having shade up at the time of the frost gave protection to a substantial degree. We do not know how many degrees of frost shade will protect to but it is at least 3-4 ^{o}C. Shade will only be helpful in certain types of frost, mainly the radiative type where air masses are not moving (calm). Shade is no protection from advective frosts, (windy condition along with cold temperatures).

Row covers are used in the spring to protect from wind and frost but also to warm the plant underneath, giving enhanced growth.

Avoiding areas where late spring frost is a regular occurrence would seem to make sense for susceptible plants. High elevation or marginal areas within a plant's hardiness zone rating are most likely to be affected, though there are some frost pockets in most areas.

Heat Stress / Scorch Injury

This can be a major physiological disorder especially in hot climates and is caused by injury from direct sun exposure/intensity or just simply too hot. When the temperature is extremely hot, a plant needs to bring water from the roots to the leaves stems etc. and out the stomata (small openings) as water vapour, a process known as transpiration. This cools the leaves and plant parts and prevents heat stress injury. If enough water cannot be carried up the plant system, the plant will voluntarily let some of its leaf surface die. If severe enough all the tissue will die. Damage from this stressed condition will appear as a light to dark brown papery areas and will occur very quickly. Some plants will wilt first but eventually show the symptoms. Measurement of this process is called evapotranspiration.

This is common on street trees where the leaves dry up, but they will re-leaf the following year.

Horse Chestnut with leaf scorch damage

Generally when the temp is very high in the interior of BC, the relative humidity is quite low, causing the plant to need more water. If this is combined with inadequate soil moisture, further aggravation may occur. Light soils can also be a factor, as they don't hold as much available water for plants as heavier soils do. To avoid this injury, or try too, you can:

- Make sure when going into a hot period that adequate soil moisture exists
- On very susceptible plants like ginseng or hosta you may be able to use an above ground irrigation as a cooling device, turning it on for short periods of time (10-20 min.) during the heat of the day. A temperature of 35^{o}C seems to be the temperature trigger for this process to start. You may need to do this up to four times each hot day. This will not add any major amount of water to the soil system.

The heat stress factor can also be a concern during the period of blooming and seed formation. This is not fully understood but in plants like ginseng, there can be poor to no seed formation when severe heat occurs during this stage. Pollen grain damage is the most suspected problem, as ginseng is indigenous to a climate area with cooler temperatures and higher humidity at all times during the plant growth cycle. The result of this damage may vary from plant to plant, or even vary in parts of the field because of different flowering times and microclimates.

Mechanical or Physical Injury

This occurs where plants are physically damaged by people, wind, animals, equipment etc. This is important, as every site of tissue injury is a potential entry point for disease. Some plants are much more prone to disease problems from injury than others so

you have to know your crop. There are a number of factors that can reduce this kind of injury.

- Reduce the number of times equipment passes through the garden.
- Have wheel guards on all your equipment for row crops.
- Have proper clearance on all equipment to prevent touching.
- Reduce the number of people around plants and exercise care when you are in them.
- Have windbreak protection if necessary as plants bashing into each other can cause injury.
- Do pruning or other operations at the proper time.

Sapsucker damage to Mountain Ash Tree can cause a trunk or branch to die.

Relative Humidity (Rh)

In this situation we are generally talking about low Rh causing drying problems but high Rh can also cause problems. Low Rh will generally occur as a problem in combination with high or excessive temperatures discussed in the heat stress section earlier. High Rh over long periods of time like in a greenhouse or wet climate areas can also support establishment of certain disease organisms. Ooedema is a blistering of plant tissue and often a result of high Rh.

Atmospheric Conditions

In some parts of the world there are overall atmospheric conditions that play havoc with plants. One of the more notable is acid rain/snow that causes, over time, the water and soil to be too acid for good or any plant growth.

Too much cloud or heavy smog can also have a negative affect on plants causing a low intensity situations.

Levels of CO2 that are too high or low can also affect plant growth. This is common in closed atmosphere places like a greenhouse and must be controlled for proper plant growth.

Where light is supplied either totally or partially, the quality of the source is very important. Too much red or blue spectrum light can affect plants and how they grow, depending on the situation and plant. It is best to consult an expert for this method of plant production.

The duration of light is also very important in the production of plants like the poinsettia, where it must have specific day/night periods with no breaks or they will not bloom.

Unusual growth pattern in ginseng (China) due to air and/or soil pollution.

Physical Soil Problems

The selection of a good site for growing is so important as some plants do not like certain conditions. Soil can have a physiological effect on the plant, which can take many forms. Texts are written on this subject, but briefly the following are important.

- Compacted soil can cause root deformation and difficulty in digging with breaking and bruising of roots tubers etc. Clay soils tend to give the most concern with compaction and the addition of OM will help most situations. Sand added to clay soils, will not often be much help by itself. Compaction can also cause water to percolate slowly into the soil, causing saturated conditions.
- Low organic matter (OM) in many soils can cause conditions where almost any soil becomes extremely compacted and difficult to work. This can be corrected prior to planting but not after so care should be taken to ensure OM is adequate.

Water Stress

As the title implies, this is where the plant gets to much or not enough water to function properly. The following have been observed as causing water stress situations.

- Heat – where the plant cannot take water up fast enough for its needs (see Heat Stress). Wilting would be an indicator but there is a fine line between wilting and actual damage.
- Improper maintenance of irrigation equipment such as plugging of sprinkler heads for prolonged periods of time or breakdown with long repair times.
- Competition from other plants – e.g., large trees. Trees have massive root systems often reaching as far out each direction as the tree is tall. (E.g. a 60 foot tree can have a 120 foot diameter root system).

Not enough water in the soil, making it hard or impossible for a plant to retrieve it.

- Water stress is also caused by too much rain and can be enhanced on sloped sites. This is where water from rain or irrigation runs to a low spot causing super saturated areas or standing water. This creates ideal situations for root rot organisms such as *Phytopthora* to get started.

Examples of growing season water requirements are, Cabbage, 30cm; onion, 40-60 cm; corn, 45 cm; carrots, 40 cm; tomato, 60 cm; and melons, 45-60 cm.

Wind Injury

Wind injury can occur in any area of BC, but is an ongoing problem in some locations. Avoiding windy sites or setting up permanent windbreaks may be permanent solutions.

Wind injury can also aggravate cold injury or winter injury, especially if the humidity is low at the time of the wind/cold period. This is especially hard on buds of tender plants and even some hardier plants like raspberries.

Some of the effects of wind injury are or can be:

- Sandblasting can be a factor where a planting is adjacent to an open field subject to wind erosion. This will or can create entry points for disease.
- Wind damage can be as simple as plant parts rubbing together causing surface scarring which are also entry points.
- Wind injury can also be a factor in seed yield reduction by banging seed heads around, a situation called shattering when the crop is nearing harvest.
- Wind will create more evaporation from the leaf surface on a hot day, possibly aggravating a heat stress factor.
- Wind can also be a help in pollination, drying plants off, and hardening off plants so it is good in moderation.

Winter Injury

This section could be included under frost injury but is substantially different, thus is treated separately. Early prolonged cold temperatures in the fall, or early spring warm spells are the causative factors here.

Early fall freezes can affect roots before they have fully hardened off and are ready for winter. The fall of 1995, in the BC interior, saw temperatures drop to –25^{o}C for an extended period early in the fall. Some damage was noticed the following spring in some areas. Proper mulch depth, if it is used, and quality of mulch will give some protection to a root system.

Some plants have short dormancy requirement so are ready to grow by about January first of a new year. If an early warm spell occurs, some movement of plant sap can occur to the point where a subsequent hard frost can damage buds for the next growth period. Some plants will not form another flower or growth bud for new growth the same year it is damaged, but most plants will, at a minimum, form new leaf buds.
The warm winter weather can also create problems with snow pack melting and cause water to sit in low areas. This should be removed somehow in most over wintering crops to eliminate root damage by diseases later on. Some plants like ginseng will not tolerate wet feet for even short periods (24 hours) without some damage.

Periods of warm/cold/warm/cold are also a potential hazard with many plants, especially combined with poor mulch cover or when it happens at certain times of the year.

Winter injury can also appear on the SW side of tree trunks, where the sun, even on cool but sunny winter days, will warm a dark tree trunk. When the sun sets the tree bark freezes again very quickly causing frost injury to the warmed area.

Low winter soil temperatures can be a factor as well. Injury in the form of slight damage to severe injury or death can occur from excessively low soil temperature. Every plant has its own particular tolerance, which gives it the hardiness zone rating for the species or variety. For example ginseng roots can only stand a winter soil temperature of about –5^{o}C before injury starts to occur.

Winter injury can also occur in the form of ice and/or snow damage. Often you need to go out and remove snow from trees like pyramidal cedars to prevent breaking or permanent bending.

Premature Bud Development (Late Fall)

Under certain conditions in the fall some plants will develop new leaves (and sometimes flowers) from next years bud. This can be extensive but usually is not a problem. The length of daylight or photoperiod, combined with the necessary air temperatures in the fall, creating conditions similar to spring is considered to be the trigger. If August is cooler than normal and September is warmer and sunnier you probably will see more of this condition. Observations of up to 5-8 percent have been seen.

There may be a genetic connection to this problem where certain plants may have more of a tendency to do this. Flowering crab-apple and chokecherry are two plants that do this regularly in the fall.

Reversion

This is a condition where a plant that is variegated grows an all green branch. This is where the plant cells revert back to the all green form of the parent plant. Hosta, variegated maples and variegated dogwood are plants where this is commonly observed.

If this occurs, just prune the green branch off at the point of occurrence. Often the green form is more vigorous and will overtake the plant if this isn't pruned out, spoiling the looks of the plant.

Allelopathy

There are sometimes instances where a plant or a few plants don't do well in a certain location. This may be a soil or shade factor but also could be an affect of one plant on another. There are two situations where this is common and these are with knapweed affecting grass on range and closer to home, growing plants under a walnut tree. Some plants will not grow under walnuts because of a chemical released by the roots of the walnut tree. This is called allelopathy where a chemical from one plant affects other plants. You need to be aware though that walnuts get very large and exhibit a lot of shade so this may be all or part of the problem.

High Salts (EC)

High Salts (Electrical Conductivity) is another area that is not really a physiological factor by our definition but can cause symptoms that appear as physical problems, but actually caused by a chemical imbalance in the soil. Small stunted slow growing plants, or leaf tip burn could be typical symptoms related to this. The only way to determine a high salt problem is to have a soil test done. You should have tests done before planting so corrections can be made or avoid planting the area. Causes of high salts can be too much fertilizer or naturally occurring soil chemistry conditions.

Improper Planting Techniques

There are a number of things that fall into this category, from planting too deep, either as seeds or plants causing poor or no growth, to planting too late in the year. Garlic and onions are good examples of too late planting as they need a certain time to produce tops before the days start to shorten after the summer solstice when bulbs start to form.

Things like girdling roots fall into this category as well and this problem is due to lack of inspections or improper root pruning at planting time. This may not show up for many years when the plant will choke itself in a slow death. Failure to remove poly twine from a root ball can have the same effect as a girdling root.

Nutrient Deficiency or Excess (Imbalances)

Every plant reacts to extreme highs and lows of nutrients, some reactions being quite evident, others less so. Plants can be stunted, deformed or suffer things like leaf tip or leaf margin burn. This injury may look similar to diseases, wind injury, chemical injury or sun scald in various situations. Bitter pit in apples is a calcium problem but looks much like a disease starting.

Different nutrient imbalances will give different reactions and an imbalance in one nutrient can make another one unavailable or un-functional. There are nutrient deficiency charts/pictures for many plants such as strawberry. A soil test at a laboratory is the only way to know what your imbalance is. Some conditions need to be amended before seeding/planting occurs as they cannot be fixed after. If soils cannot be amended as in high boron for example, within reasonable cost, another site selection or different and more tolerant crop would be in order.

Bitter pit in apples is a calcium problem not a disease

Blossom end rot in tomatoes is also a Calcium problem causing collapse of blossom end cells

Genetics/Hereditary Disorders

Although this is an internal factor and not an external cause, plants can do weird things when its own genetic system goes awry. This can cause many factors from variegated plants, twisted plants (epinasty) or distorted stems(fasciation), seed pod colour changes, multiple stems etc. Some of these mutations have been collected and used by scientists, for example variegated strains of plants or contorted willow. If you see an unusual event you may consider saving it for future considerations or showing it to a researcher who may be able to use it.

Some of these genetic factors could look like other disorders and may not be genetic at all but rather chemical or insect injury, disease, poor nutrition, or physical injuries as examples.

Fasciation of plant tissue causing flattened stem

Summary Statement

In the introduction and text, there was mention of many physical things that affect plants. These are often very hard to diagnose and there also may be more than one factor. Situations where there is a period of very hot weather and leaves on horse chestnut for example turn brown, scorch/sunscald is the probable cause as they are susceptible to this. Under watering may also be a contributing factor but not necessarily 'the' problem. If these trees were sprayed for insects on a hot day, a similar result may occur so you need to keep in mind the recent history of activities. Shade loving plants in the wrong place will probably be affected by direct sun, so know your plant materials. Plants in a greenhouse are subject to heat stress and other conditions such as oedema where corky areas occur on the underside of leaves, caused by too much water/humidity. Sometimes damage from insects or a disease looks like a physical problem such as the distorting effect caused by snowball aphids on a *Vibirnum opulus sterile* (snowball) plant. There is much more detailed information available in texts. This is just a quick overview to give you a start to discovering what might be wrong, a case of not 'whodunit' but 'what'.

This short summary of physiological disorders of plants was produced for the InfoBasket program, a BC Ministry of Agriculture, Food and Fisheries (MAFF) web based information delivery system and resides on the MAFF website. Go to http://infobasket.gov.bc.ca/Infoman/communities/community.asp?UserID=2&