

# POTATO EYES

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## Biopesticides

Biopesticides are anything that kills a pest and is biological in origin as opposed to being synthesized in a laboratory. In the potato industry, the best known biopesticide is referred to as Bt, *Bacillus thuringiensis*. This is an example of a microbial biopesticide. *B. thuringiensis* is a soil bacterium, toxic to many insect larvae. There are several Bt-products registered on potatoes for foliar applications such as DiPel, Du-Ter and Javelin. Insect-killing genes of *B. thuringiensis* have also been introduced into the genome of several crops including potato, for example the New Leaf clones of several cultivars. As such, Bt has shown to be most effective.

There are also biochemical biopesticides. These are structurally related to natural substances and function identically to them. Their actions are non-toxic, so in a literal sense they are not pesticides. Examples are pheromones used to attract (trick) insects into thinking that they are with a mate thereby confusing their mating cycle or to attract them into traps.

Generally, all biopesticides exhibit the following characteristics:

- narrow target range
- highly specific mode of action
- suppress pests, not eliminate
- critical timing of application
- limited field persistence
- short residual effect
- safer to environment
- safer to people

Their use is best as part of an Integrated Management Program (IPM).

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## Tuber External Growth Defects

In 1999 (Nebraska Potato Eyes 11-4), the development and symptoms of various physiological tuber disorders were reviewed. These were: brown center and hollow heart, jelly or glassy ends, internal heat necrosis, non-pathogenic vascular discoloration, chilling and freezing, and blackheart. All of these are primarily internal defects. The following continues the review focusing on growth disorders that show primarily external defects.

### Deformations

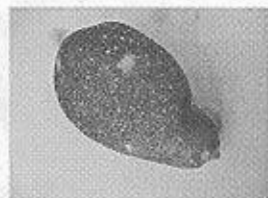
There are several types of tuber deformations or malformations such as dumbbell, kidney, pointy end, and hot dog (elongated). Tubers with these defects are also referred to as "being rough." They are due to problems associated with apical buds and longitudinal growth. Harvest quality or grade is affected and tubers are discarded as culls.



Dumbbell tuber



Kidney tuber



Pointy end tuber

### Development and Appearance

During a period of stress, longitudinal growth slows or may even stop. When favorable conditions return, tuber growth resumes, "stop and go" growth. Therefore, appearance is due to irregular longitudinal growth, often because of a constriction. Pointy stem-end or Bottleneck: Growth disruption occurred during early bulking and the constriction is at the stem end. Dumbbell and Elongated (hot dogs): Growth disruption occurred at mid-bulking. Dumbbells have a constriction in the middle. Kidney-shaped tubers tend to have a slighter mid-section constriction and tend to cure, giving the kidney-shape appearance. Elongated tubers show little lateral growth; they also tend to be gnarled and cured. Pointy bud-end: Late-season growth disruption resulting in a slight constriction at the bud end. Often dumbbells and pointy bud-ends are associated with jelly end rot or glassy end (Nebr Potato Eyes 11-4, 1999).

### Causation

These deformations are primarily due to high temperature stress in the field often but not necessarily exacerbated by water stress. Note, water stress or drought alone does not cause these deformation. The severity of the deformation increases with higher temperatures and longer high-temperature periods. Basically high temperatures, above 80°F, decrease cell division and lower the supply of carbohydrates available to the tuber. Other factors that exacerbate temperature-induced deformation are excessive nitrogen application before a high temperature period, uneven nutrient or moisture supply, hail and frost.

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# Tuber External Growth Defects

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## Susceptibility

Potato varieties vary considerably in their sensitivity to high-temperature field stress. The rule of thumb is that longer-tuber varieties are more susceptible than rounder-tuber varieties. For example, long whites such as Kennebec are more susceptible than round whites as Atlantic. Russet Burbank is one of the most sensitive of all varieties.

## Cultural Practices

Since weather cannot be controlled, when planting susceptible varieties choose areas with cooler climates. Irrigate adequately during early bulking. Field capacity should be maintained higher than 80%, closer to 90%, during tuber growth (Potato Production Stages: Scheduling Key Practices, Univ. Nebr. Coop. Ext. Circ. # 95-1249). Avoid exacerbating stresses such as excessive nitrogen.

## Knobbiness

Knobbiness is due to stimulated growth of lateral buds in one or more eyes. Protruding eyes is a similar defect. The size and shape of knobs depends on the growth stage of the tuber when stress occurs. As with the deformations reviewed above, high-temperature stress is the cause for stimulating this abnormal, lateral-bud growth. Susceptibility to knobs varies with varieties. Practices to lessen knobbiness are the same as for deformations. Unlike pointy end and dumbbells, there are no internal defects or rots associated with the formation of knobs. Knobby potatoes are considered culls, lowering marketable yield.



## Growth Cracks

These large cracks are due to desynchronized growth between inner and outer tuber tissue. Sometimes this is referred to as bursting. Cracked tubers are culled unless the cracks are shallow enough that the tubers could be used for processing.



## Development and Appearance

Longitudinal fissures develop when the core tissue inside the tuber grows faster than the outer tissues, the periderm. In other words, the internal pressure of the tuber is greater than the tensile strength of the skin or surface tissue. The resulting fissure or crack can extend the entire length of the tuber and may be shallow or a half inch deep. Growth cracks undergo wound-healing and show a characteristic suberized appearance. When healed, they seldom become infected with a pathogen. Growth cracking can also be associated with plant infection by a few relatively uncommon viruses such as yellow dwarf virus and spindle tuber viroid. More importantly, growth cracking can be caused by exposure to members of two new herbicide families, imidazolinones such as Pursuit and sulfonylureas such as Ally and Accent (NPE 11-3, 1999).

## Causation

The sudden and rapid growth of internal tuber tissue or growth cracking is primarily due to an uneven availability of soil moisture and rapid, uneven uptake of water. This occurs when heavy rain or excessive short-term irrigation is followed by a period of dryness. Growth cracking is exacerbated when plants are spaced widely apart or when tuber set is unusually low. Uneven fertilization placement worsens the cracking. This is also true of excessive nitrogen or poor timing of nitrogen fertilization especially during the mid-bulking period. Low soil boron may also worsen the amount of cracking.

## Susceptibility

Varietal susceptibility to growth cracking is not well documented or understood. It may be related to the speed of tuber growth during mid-bulking and to root growth.

## Cultural Practices

Three cultural practices to minimize growth cracking are uniform plant spacing, adequate soil moisture with consistent irrigation scheduling and uniform fertilization especially avoiding excessive and late applications of nitrogen.

## Harvest Cracking

Thumbnail cracking is shallow and random. Appearance is that of semi-circular breaks, half-moons, and are associated with exposure of very turgid (hydrated) tubers to very dry conditions. Surface splitting or air cracking is a slight separation of the skin. This is associated with exposure of very turgid tubers to sudden cold temperatures. Both these types of cracking are associated with harvest but should not be confused with shatter bruise which has a distinct appearance and is caused by impacts. Thumbnail and air cracks heal slowly and are subject to infection and dehydration in storage.

## Tuber Chaining (Gemmation)

This disorder affects harvest yields. The small tubers formed compete with the primary tuber for nutrients and thereby lower the weight of the marketable tuber. There is no effect on fresh market quality of the primary tuber except for reduced tuber size. For processing, the texture and starch content may not be desirable. Tuber chaining may also interfere with harvest separation of the primary tuber from stolon.

## Development and Appearance

Tuber chaining refers to the initiation followed by limited growth of tubers at the nodes of a stolon after the apical tuber at the end of the stolon was initiated and has begun growing. The disorder's name refers to the chain appearance of the series of little tubers along the stolon. The development or initiation of these is due to a break down of apical dominance of the primary tuber. This is a hormonal phenomenon associated with auxin (IAA) concentrations basipetal from the primary tuber. The sizing of the primary tuber is inhibited due to the lessened carbohydrate (sucrose) taken in because of competition with the secondary tubers. The primary tuber, in severe cases, can have a glassy or soft texture and have a low specific gravity making it undesirable for processing.

A related phenomenon is sprouting from buds on the nodes of the stolon. The sprout does not affect quality but will compete for nutrients much like tuber chaining, and is also related to loss of apical dominance.

## Causation

The cause of tuber chaining is high soil temperature. Soil temperatures around the daughter tubers that are above 75°F, especially early to mid bulking or tuber growth (Potato Production Stages: Scheduling Key Practices, Univ. Nebr. Coop. Ext. Circ. # 95-1249), will promote tuber chaining. Once this disorder has begun, the return of cooling soil temperature around tubers will not overcome the disorder. In other words, the chaining and nutrient competition will continue for the rest of the season, thereby yields are lowered. On a physiological level, once apical dominance is lost by the primary tuber, it does not return. Note, low soil moisture does not cause this disorder but is usually associated with high soil temperature.



# Tuber External Growth Defects

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## Susceptibility

Varieties, in general, are susceptible but round tuber varieties, most white chipping and red varieties are particularly prone to tuber chaining.

## Cultural Practices

Since air temperature cannot be controlled, the best practices to avoid over-heating of the soil is to plant deep, to hill and to maintain a good trapezoidal structure to the row. Seed pieces should be at least six inches below the surface; eight inches would not hurt. In severe hot weather, cooling the ground with irrigation may be necessary.



## Heat Sprouting and Hair Sprouting

Premature sprouting of tubers late in the season or early in storage affects quality of the harvested tubers. Besides appearance, the sprouts soften the tuber by taking up its nutrients and lowering the starch content. The taste of the tuber is uneven with a sweeter taste near the sprout. This makes the tuber unacceptable for processing since frying will turn this area dark.

## Development and Appearance

Sprouts appear from the eyes of the primary tuber. The heat sprout may remain underground, or emerge and become green and leafy. The hair sprout is very thin, hair-like, and is too weak to emerge or grow much. Tuber sprouting is a hormonal phenomenon involving the lack of development of tuber dormancy, related to abscisic acid (ABA).

## Causation

The cause of heat and hair sprouting is high soil temperature. The conditions for this disorder are similar to that for tuber chaining (see above) except that exposure to high soil temperature is toward the end of the growing season, late bulking or plateau stages (Potato Production Stages: Scheduling Key Practices, Univ. Nebr. Coop. Ext. Circ. # 95-1249). Once sprouted, the sprouts will grow under good conditions. In other words, tuber dormancy does not develop. Hair sprouting is also a symptom of infection with *Colletotrichum atramentarium*, related to black dot, and associated with aster yellow carried by leafhoppers and psyllid yellow carried by potato/tomato psyllids.

## Susceptibility

Varieties, in general, are susceptible but varieties with short tuber dormancy periods may be more so.

## Cultural Practices

Practices to minimize this disorder are the same as for tuber chaining. Since air temperature cannot be controlled, the best practices to avoid over-heating of the soil are to plant deep, to hill and to maintain a good row structure. In severe hot weather, cooling the ground with irrigation may be necessary.

## Little Tuber Disorder

When many tubers form off the seed piece before sprout emergence, the disorder is called little tuber disorder. Small tubers develop at the same time as the seed piece sprouts. This disorder will affect plant growth and reduce yields.

## Development and Appearance

Little tuber disorder develops in storage due to ageing of seed tubers. Upon planting little tubers are initiated directly at the eyes of the seed piece or on very short stolons while the seed piece is

sprouting. This can also occur in storage prior to planting. Physiologically, it is induced by a break down of apical dominance of the eyes on the tuber and of sprouts on the stolons. The mechanism is similar to that for tuber chaining.

## Causation

This disorder is due to physiological ageing of seed tubers as a response to high late-season storage temperature. It occurs when seed piece temperature is greater than 68°F and is planted in soil that is less than 50°F. Little tuber disorder can also occur when sprouted seed tubers or pieces are placed in cold storage and then planted. Elevated concentrations of the gases carbon dioxide (CO<sub>2</sub>) and ethylene (C<sub>2</sub>H<sub>4</sub>), a gaseous hormone, may induce little tuber disorder as well as be involved in tuber chaining and heat sprouting. All of these disorders are due to changes in hormone levels.

## Susceptibility

No difference in varietal sensitivity to this has been reported.

## Cultural Practices

Since the disorder is caused by seed tuber ageing in warm storages, the key practice is storing seed potatoes at less than 40°F, but above temperatures causing chilling or freezing damage (NPE 11-4, 1999). Avoid long storage of seed tubers. Avoid physiologically ageing seed such as rough handling (bruising), poor ventilation or elevated temperatures. Do not plant in cold (<50°F), dry (<60% FC) soil.

## Internal Sprouting

Internal sprouting occurs in storage and is characterized by the sprout growing into the tuber, ingrowing. This can occur from a sprout from an eye on the underside of the tuber growing up and penetrating it or from deep eyes when the sprout grows sideways into the tuber. The tip of the internal sprout is commonly necrotic, brown. When it occurs, it usually is from an eye with multiple sprouts (rosette). This disorder occurs primarily with physiologically aged tubers and occurs when storage temperatures are above 55°F. The two major causes associated with internal sprouting are application of below effective levels of CIPC, a sprout inhibitor, and high pile pressure late in the storage season.

## Swollen Lenticels

Lenticels are pores in the skin of tubers; botanically, they are stomates. They are involved in gas exchange of oxygen and carbon dioxide during respiration and photosynthesis. Besides giving an unmarketable appearance to the tuber, the major problem is that an entrance to pathogenic organisms, bacterial soft rot, pink rot and leak, is created (NPE 9-5, 1997; 10-4, 1998).

## Development and Appearance

Swollen or enlarged lenticels (water spot, water scab) develop when tissue below the lenticel swells and bursts through the protective covering of the lenticel. This forms a corky mass around the lenticel. The disorder is somewhat reversible if the wet period is short.

## Causation

This disorder is caused by exposure of the tuber to very wet conditions in the field or in storage. The swelling seems to be related to oxygen deprivation by the watery film covering the lenticel.

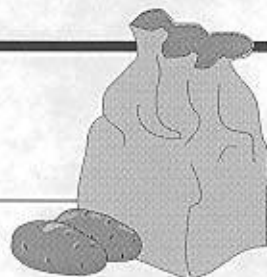
## Susceptibility

All varieties are susceptible.

## Cultural Practices

Avoid over-watering. Avoid harvesting low, swampy spots in the field. Pick fields with good drainage. Avoid condensation in storage. Keep storage well ventilated.

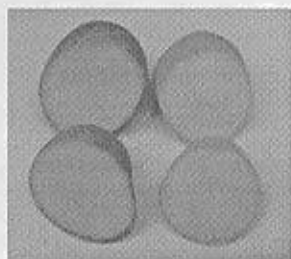
# NEBRASKA POTATO EYES



## Elephant Hide

This disorder is called elephant or alligator hide on russet varieties and fish skin or turtle back on red and white varieties. It is characterized by a thick russet appearance to the skin due to furrowing or cracking of the skin. Causes and practices to control it are not known. Russet Burbank seems to be especially susceptible.

## Greening



Greening of tubers is a result of light exposure and sun-scalding, a similar disorder, is due to light exposure at high temperatures. Greening is a major source of culls at harvest and market and has been dealt with in detail earlier (NPE 12-4, 2000; Potato Education Guides web-site).

## **Summary Table: Causes of External Defects**

| <u>Defect</u>    | <u>Primary Cause</u> | <u>Occurrence</u> | <u>Market Effect</u> |
|------------------|----------------------|-------------------|----------------------|
| Deformation      | heat*                | bulking           | quality              |
| Knob             | heat                 | bulking           | quality              |
| Growth Crack     | wet/dry soil*        | bulking           | quality              |
| Chaining         | hot soil             | mid-bulking       | yield (size)         |
| Heat Sprout      | hot soil             | late-bulking      | quality & yield      |
| Swollen Lenticel | wet soil             | bulking-harvest   | storage rots         |
| Greening         | light                | bulking-storage   | quality              |
| Thumbnail Crack  | very dry soil        | harvest           | storage rots         |
| Air Crack        | sudden cold          | harvest           | storage rots         |
| Internal Sprout  | CIPC, piling         | storage           | quality              |
| Little Tuber     | seed ageing          | storage           | yield (stand)        |
| "Hides"          | ?                    | ?                 | (quality)            |

\*May also be caused by certain newer herbicides

Check out the Nebraska Potato Eyes on the WWW at:  
<http://www.panhandle.unl.edu/peyes.htm>