Tuber Trauma: Demystifying herbicide, physiological, and other factors

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Tuber trauma

1. Types of tuber trauma
2. Causes
3. What to do

Types of trauma

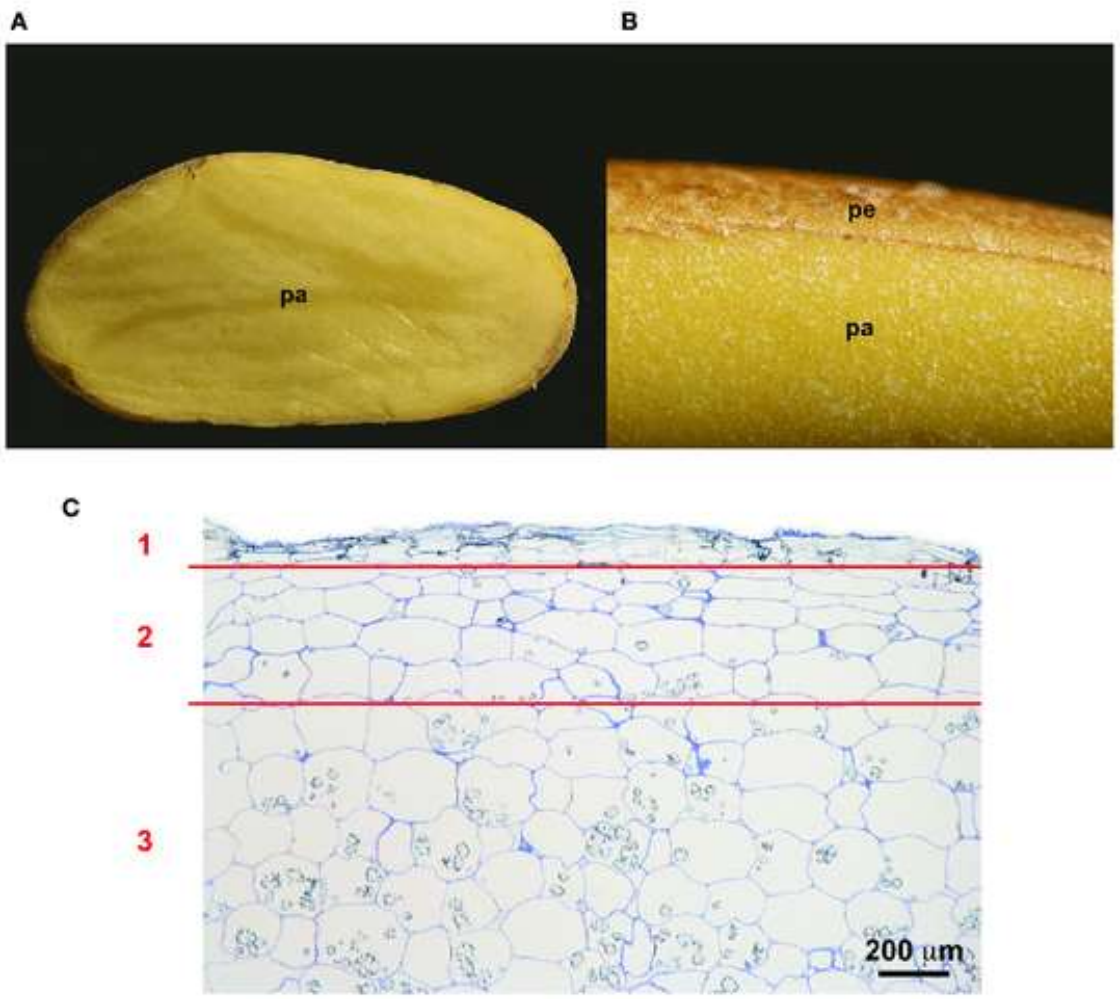
- Skin cracking
- Misshaped tubers

Tuber skin cracking

- Surface cracking (shallow)
- Thumbnail cracks
- Shatter bruise
- Mechanical injury
- Fissures / growth cracks (deeper)
- Extended cracks around stem or bud end

Periderm

- Periderm acts as armor to protect inner tissue.
- Wound periderm forms to heal and protect injured tissues.



(Massana-Codina et. al, 2020)

Periderm & russeting

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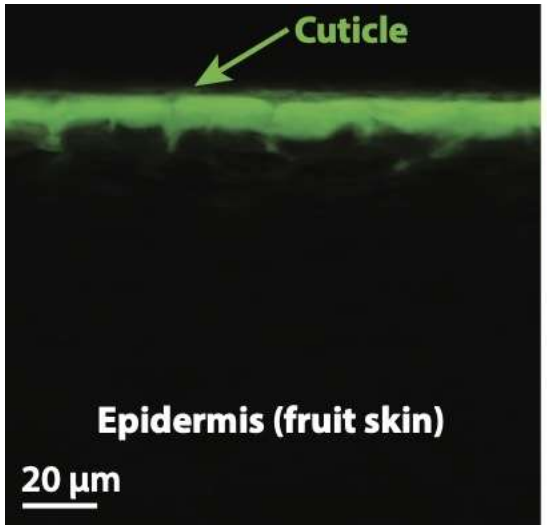
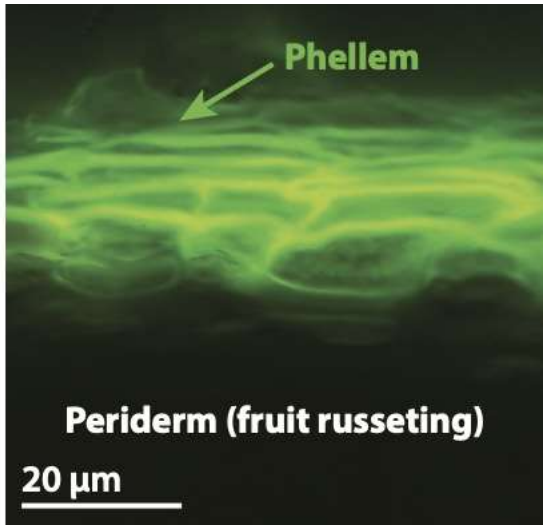
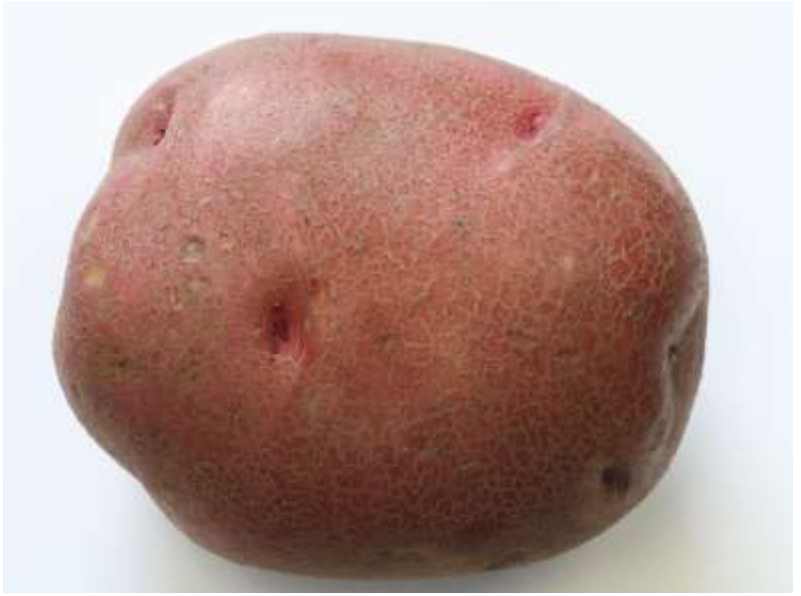




(Serra et al., 2022)

Process of russeting

1. Initiates with growth stress that exceeds a threshold causing microcracks.
2. New periderm originates (russeting).
3. Skin russeting seal microcracks and provides solution for growth stress, water loss, and prevents pathogen entrance.



(Serra et al., 2022)

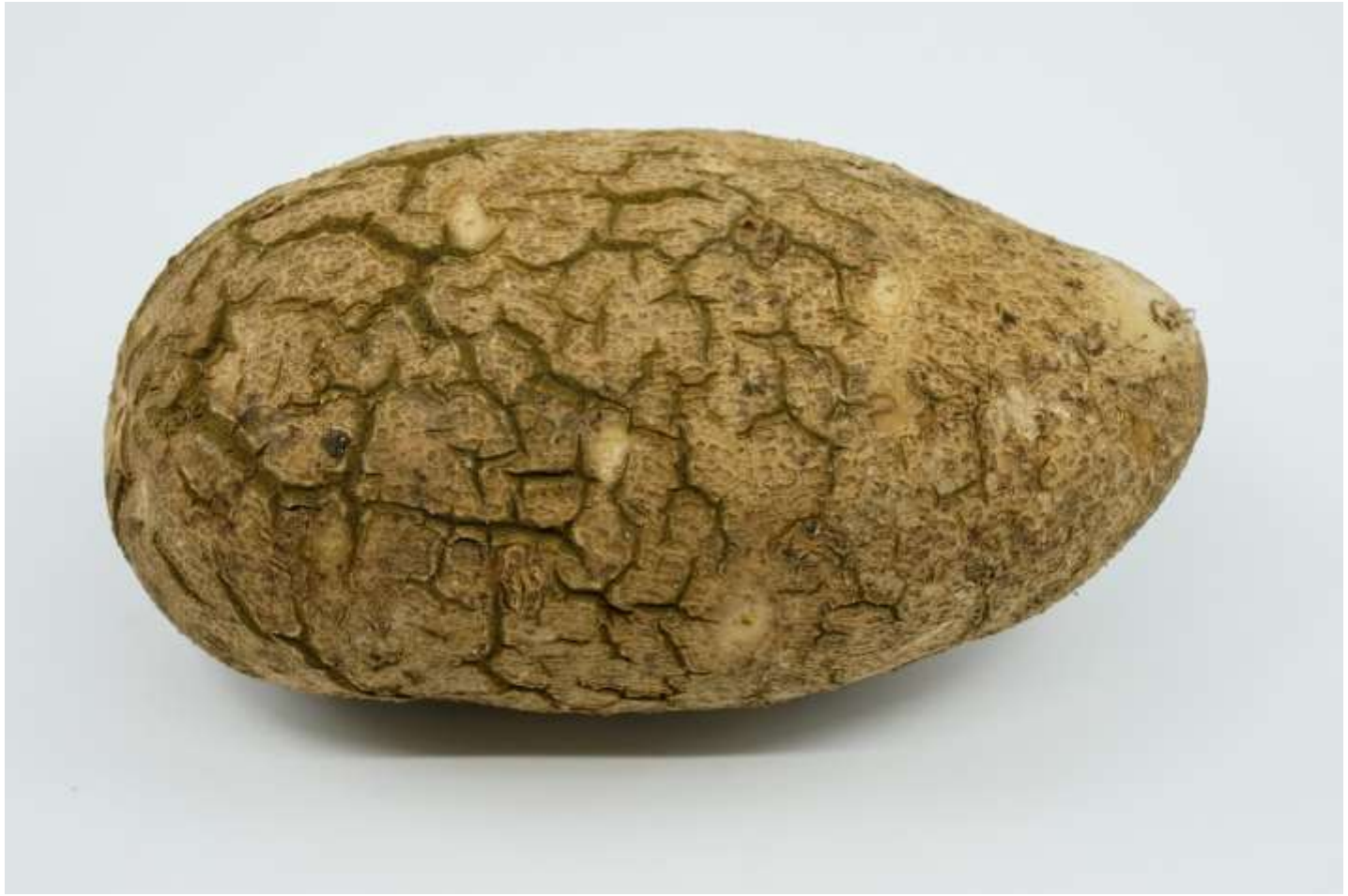
Herbicide induced surface blemishes

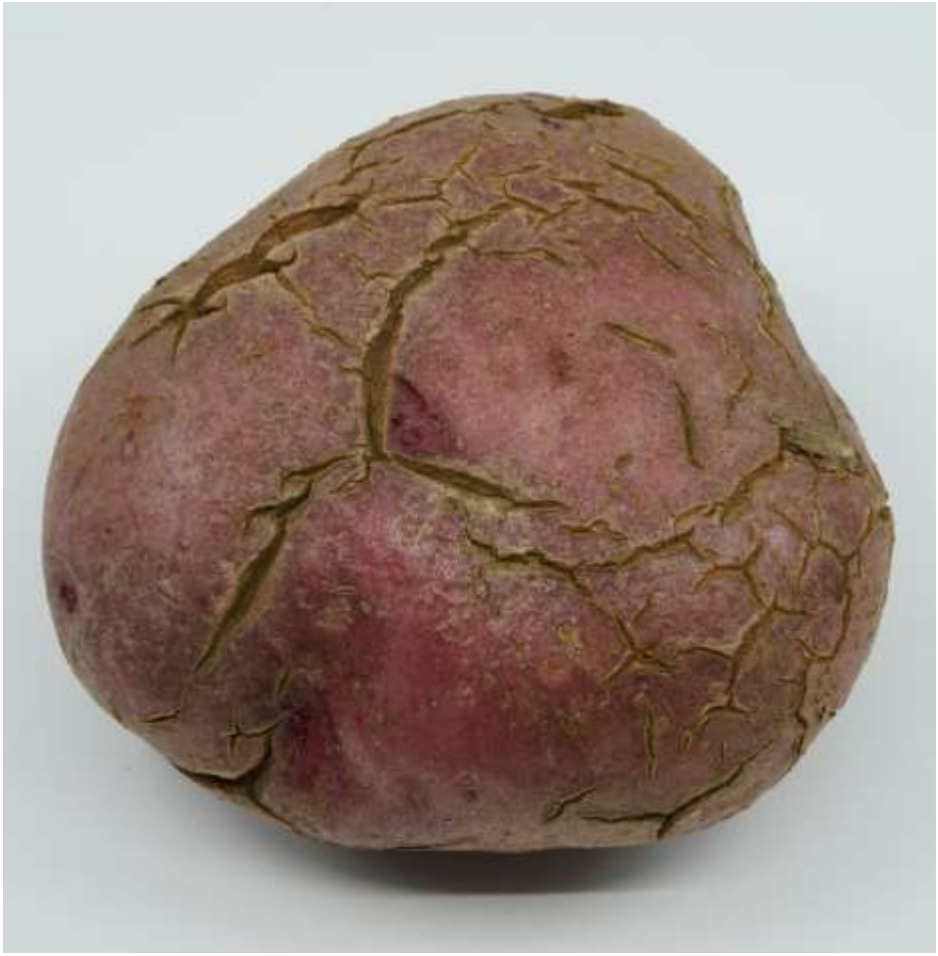
Elephant hide

Elephant hide

- Rough or thick coarse russeting
- Causes:
  - High temperatures, genetic traits, soil fertility, soil moisture or chemical treatments
- Diseases
  - Rhizoctonia and mop-top
- Herbicides
  - ALS chemistry and glyphosate

Herbicide skin shenanigans





Mechanical

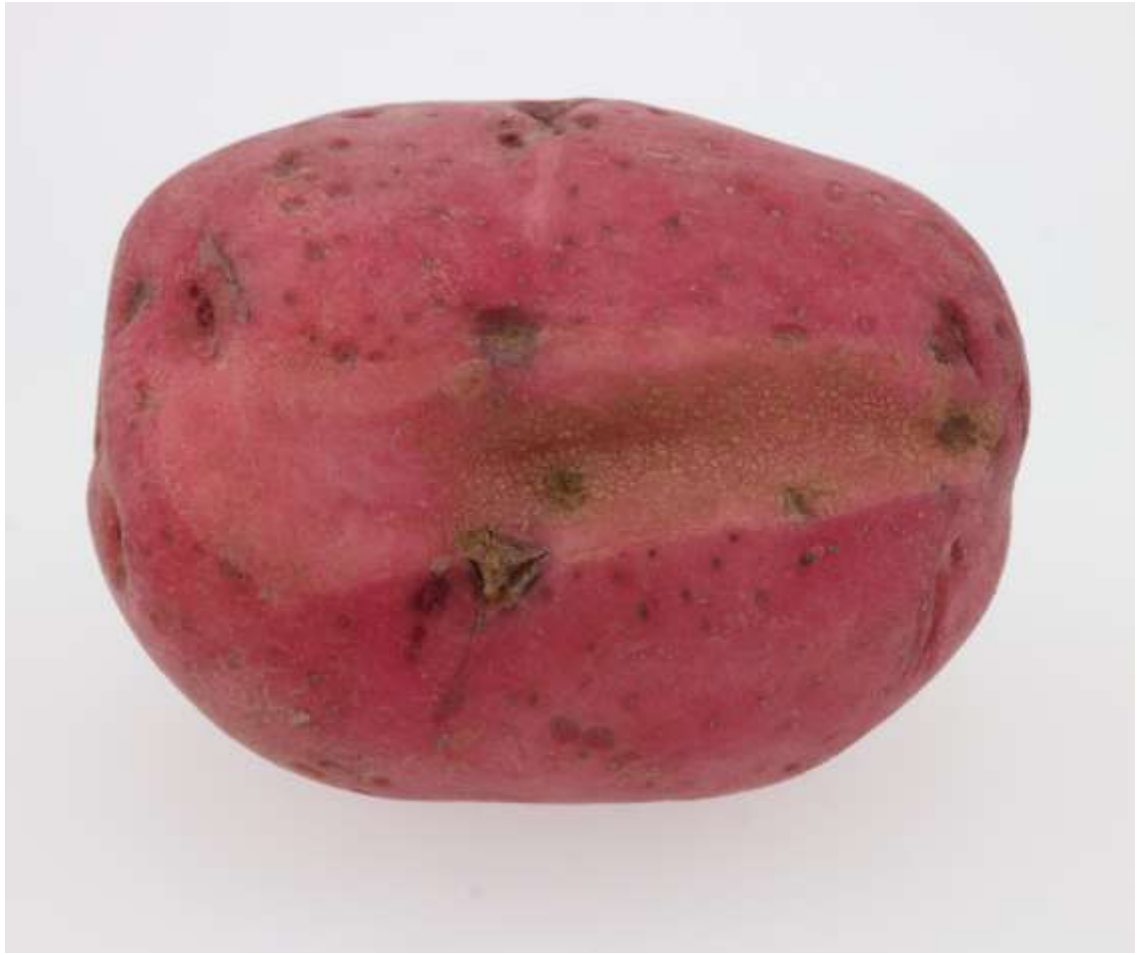
Fissures / growth cracks

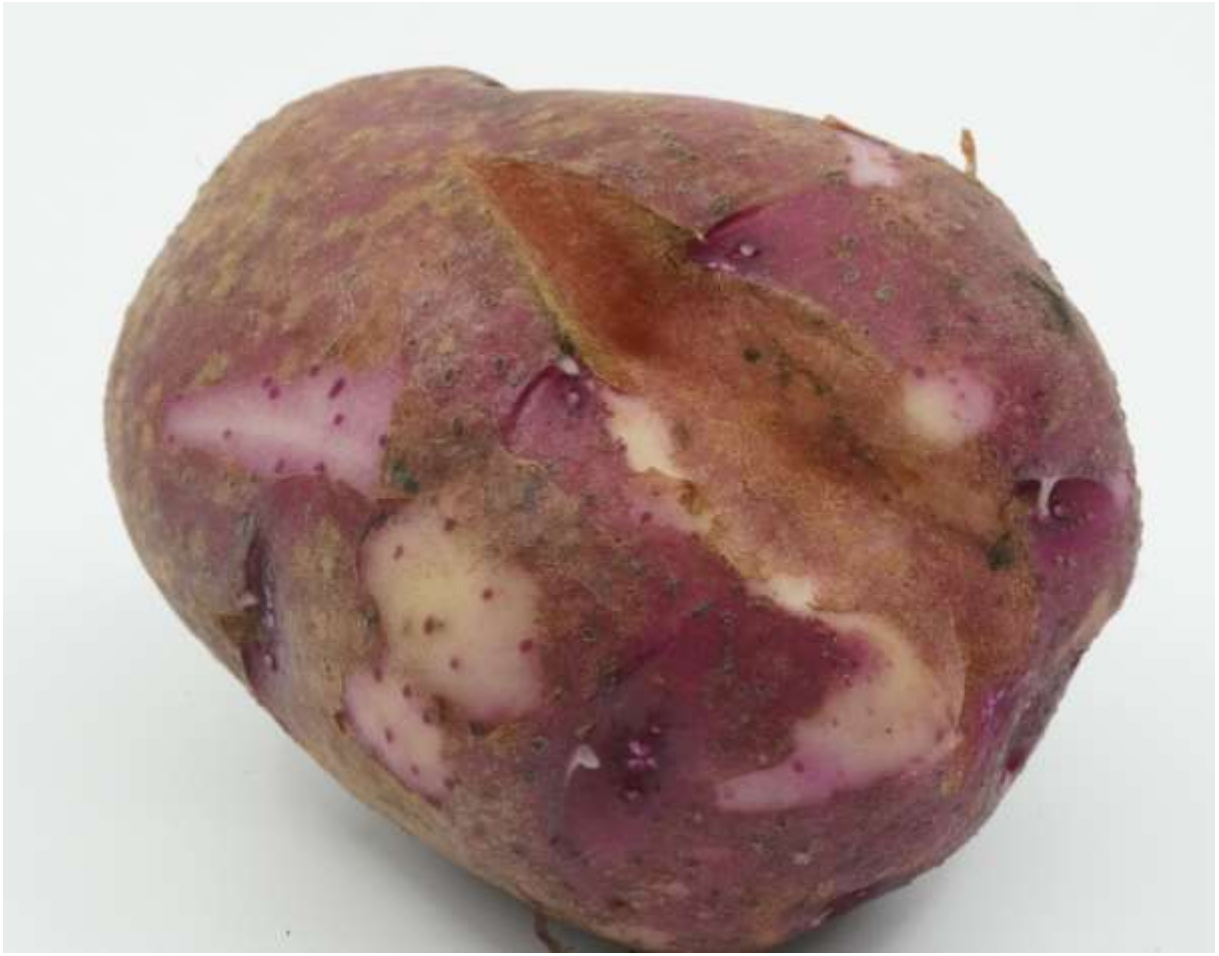
- Internal core tissue grows faster than surface tissue.
  - Occurs frequently in stressed growing conditions.
- Deeper fissures = occurred in early bulking.

Fissures / growth cracks

- Typically occurs at bud-end and goes lengthwise.
- Severity varies by variety.

Growth cracks





Growth cracks

PVY induced growth cracks

- Estima >20% PVY plants had more tubers with cracks.
- PVY^{A} and PVY^{V}
- Variety depend

(Carnegie and McCreath, 2010)

Hollow heart

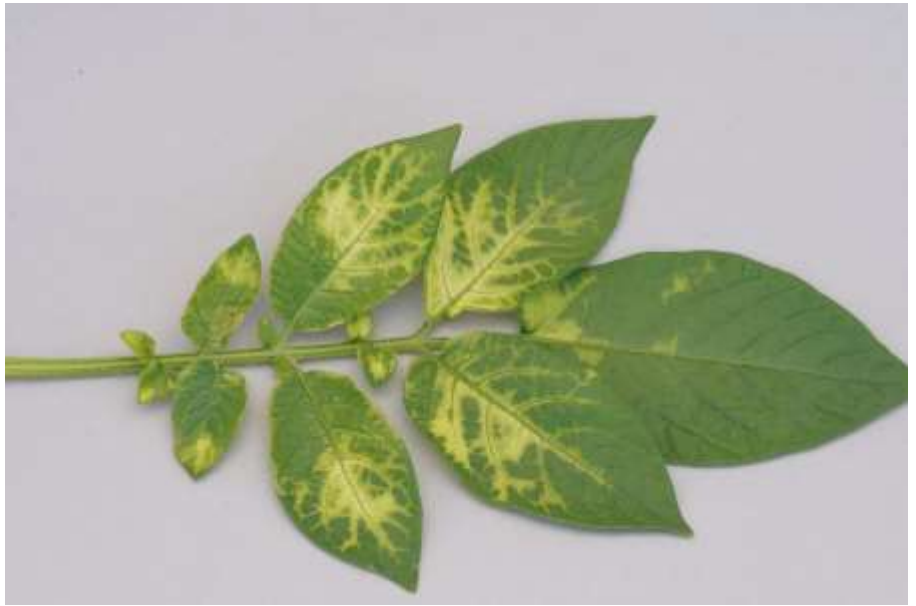
Hollow Heart

- Precursor is brown center and can develop into hollow heart as tuber expands.
- Causes:
  - Stress growing conditions followed by rapid tuber growth.
    - Water stress, heat stress, fertilizer

Herbicides

- Herbicides can result in tuber injury.
  - Soil
  - Foliage contact

- Labelled herbicides misused or applied in unfavorable growing conditions can injure tubers.



Soil carryover

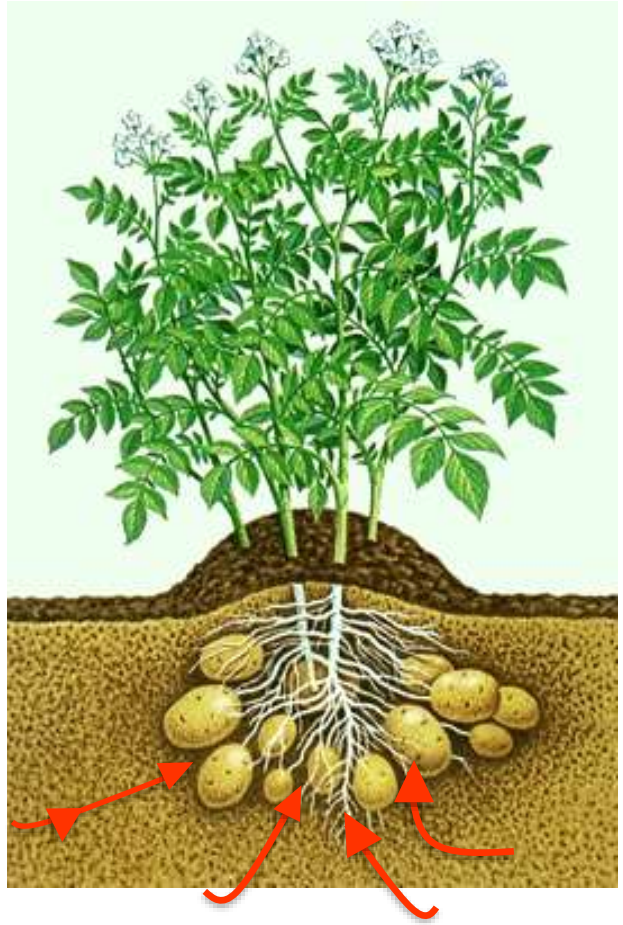
Soil carryover

- Follow the label
  - Pay attention to details, such as precipitation + irrigation and soil pH
  - For example: imazamox 9 months if >18 inch of R+I **AND** soil pH >6.2; 18 months if <18 inch of R+I **OR** soil pH <6.2
- If renting land, know the previous herbicides used for 2 previous years.
- Bioassy soil if in question

Soil carryover

Herbicide movement from root uptake

- Herbicides taken up by roots can enter plant.
- Can be transported to leaves, root/tubers or all areas of plant.
- Some compounds can be stored in tubers.



Foliar injury

Heat crinkle

Heat crinkle

- Sprouts suddenly encounter high temperature
- Can increase stem number
- More common in sandy soils
- Russet Burbank is sensitive
- Not herbicide related

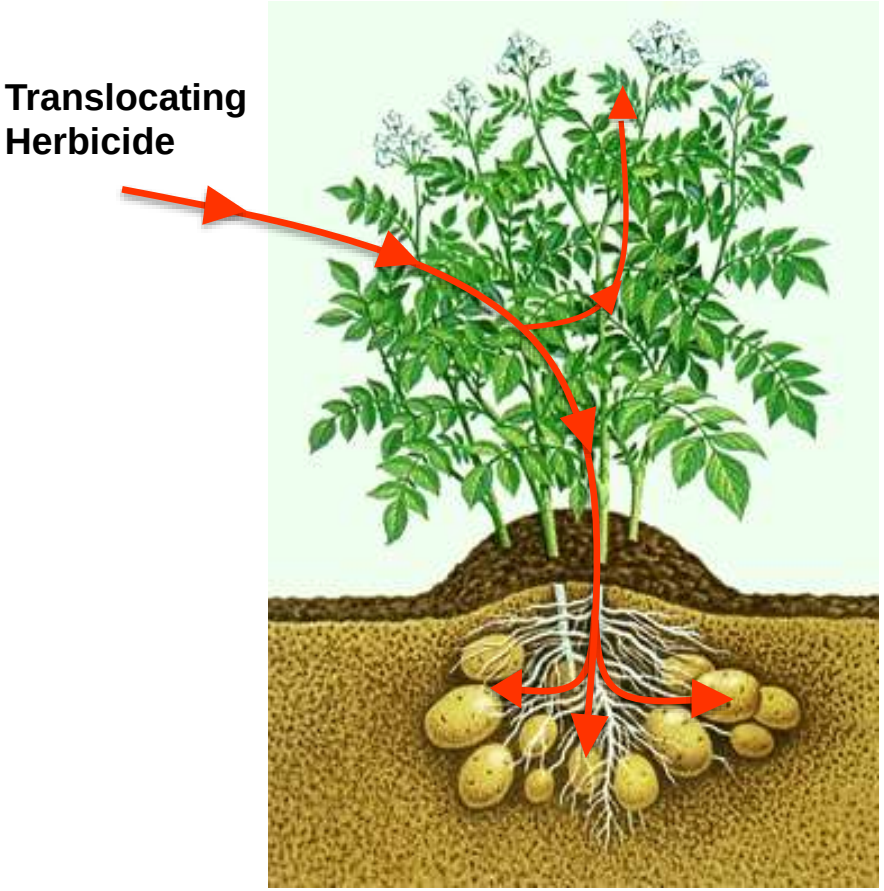
Glyphosate

Exposure by foliage: Where to look

- Leaves and tubers
  - Translocating herbicides affect new growth (leaves/tubers)
  - Contact herbicides injure what it contacts (new & old leaves)

Herbicide movement from foliar contact

- Go to strongest sink
- ALS inhibitors (Group 2)
- Growth regulators (Group 4)
- EPSP synthase inhibitor (Group 9)



Herbicide induced cracks

Clomazone

Fomesafen

Pyroxasulfone

Herbicide induced tuber trauma

Halosulfuron

Glyphosate

Extended cracks around tuber

Variable severity with herbicides

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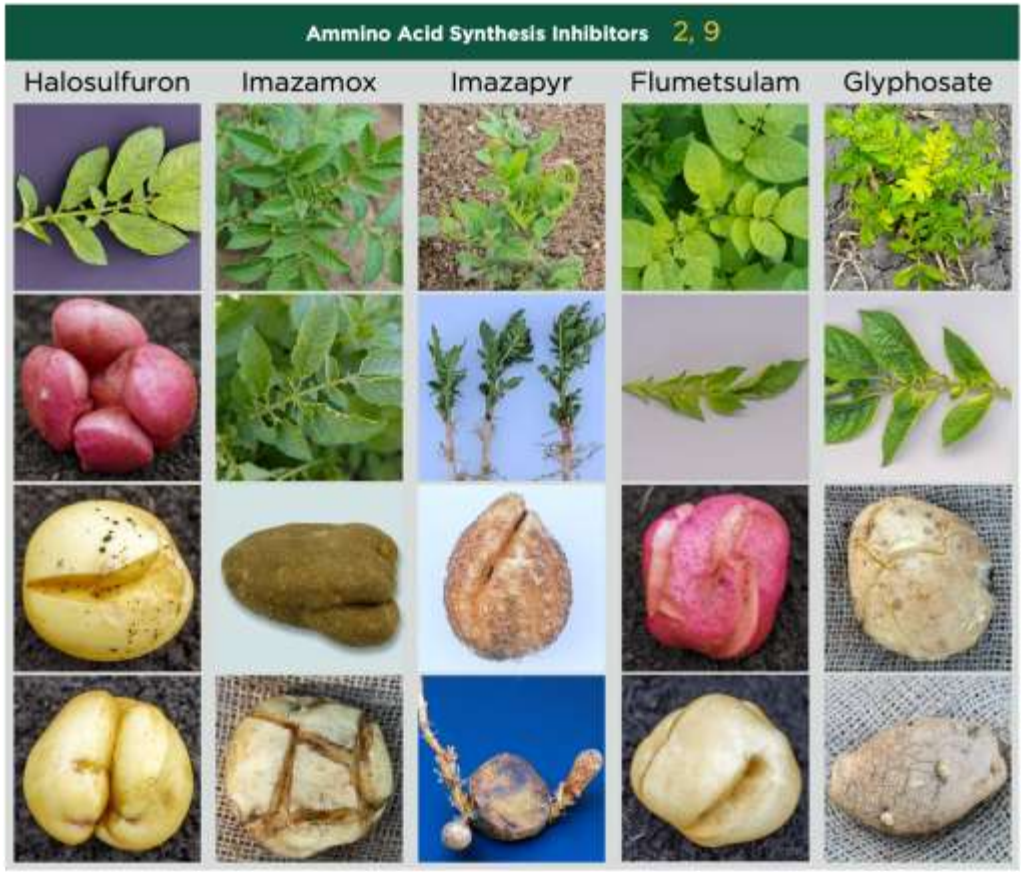
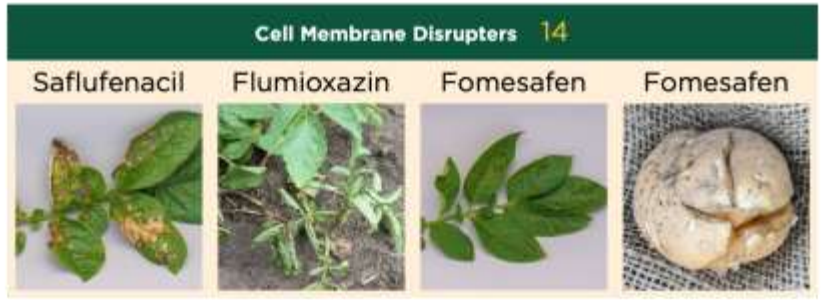
Herbicide Injury on Potatoes

University of Minnesota EXTENSION





z.umn.edu/herbicide

Growth cracks

Misshaped tubers

- Pointed
- Bottleneck
- Dumbbell
- Elongated
- Knobs or protruding eyes
- Jelly end
- Second growth
- Tuber chaining

Tuber malformations

- Result of:
  - Sudden growth interruption, rapid growth following a stress
- Bottleneck, dumbbell, or pointed end appearance, this is indicative of when growth interruption occurred.
- Herbicides can interrupt growth and cause malformations.

A1987

Potato Tuber Second Growth

Andy Robinson, Associate Professor and Extension Potato Agronomist, North Dakota State University/University of Minnesota

Eugenia Banks, Potato Specialist, Ontario Potato Board

Potato tubers are the result of the plant genetics and the environmental conditions in which they are grown. Potato varieties are selected carefully for tubers that have desirable appearance to maximize sales and reduce waste.

However, some years can cause more environmental stress than others, resulting in tuber secondary growth. Secondary growth often manifests as heat sprouts, tuber chaining and tuber malformations. This physiological disorder decreases yield and quality of the tubers in the field.

The most common condition leading to secondary growth is heat stress, specifically soil temperatures. Soil temperature as low as 75 F (24 C) can stimulate this disorder, while soil temperature held at 82 F (28 C) for a month or 90 F (32 C) for one week has resulted in consistent and significant second growth of tubers.

The development of this second growth also can be attributed to other conditions that interrupt or temporally halt growth, such as moisture stress or nutrient imbalance. A combination of stresses, such as heat and moisture stress, will exacerbate plant stress and cause more pronounced second growth.

The size, shape and amount of second growth will depend on the growth stage, variety, and the duration and intensity of the stress. This second growth reduces tuber quality and marketable yield by consuming plant energy for heat sprouts, resulting in misshapen, unmarketable tubers, while not providing any benefit to the grower.

In a stressful period, normal potato tuber growth is interrupted or stopped, and then normal tuber growth resumes. This change in growth can affect how tubers develop. Early bulking stress can constrict stem end growth, resulting in pointy stem end (Figure 1) or bottleneck tubers (Figure 2).

Mid-bulking growth disruption leads to tubers that look like dumbbells (Figure 3), or are kidney-shaped (Figure 4) or elongated (Figure 5). Late-bulking growth disruption can cause pointy bud end tubers (Figure 6).

Tubers with pointy ends, generally those receiving the early bulking stress, may develop jelly end rot (Figure 7) or an accumulation of sugars in the stem end rather than starch that appears translucent. Jelly end rot breakdown results in soft, jellylike and slightly watery ends.

Figure 1. Pointy stem end tuber. (Andy Robinson, NDSU/UM)

Figure 2. Bottleneck-shaped tuber. (Andy Robinson, NDSU/UM)

Figure 3. Dumbbell-shaped tuber. (Andy Robinson, NDSU/UM)

Figure 4. Kidney-shaped tuber with heat sprouts. (Andy Robinson, NDSU/UM)

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ontario potato board

North Dakota State University
Fargo, North Dakota

September 2020

Fusarium can infect jelly ends and appear like dry rot. The affected area may extend up to an inch (2.5 centimeters) or more from the stem end. As the tubers age or dry out, the affected tissue dehydrates, shrivels, and turns light brown and papery. Heat stress also can stimulate growth of lateral buds, resulting in protruding eyes or knobs (Figure 8).

Heat sprouts and chaining of tubers are an outcome of renewed growth following a stress period. Heat sprouts (Figure 9) grow from stolons or tubers and will grow above ground into leafy stems (Figure 10) or below ground as stolons (Figure 11).

Tuber chaining (Figure 12) can occur when stolons set multiple tubers on one stolon. Varieties with short dormancy seem to be more prone to develop heat sprouts and chaining of tubers. This can result in dormancy being broken, causing tubers to sprout prior to harvest. Storing these potato tubers can be difficult because they are physiologically old and often will develop secondary tubers in storage (Figure 13).

Potato second growth is a difficult disorder to avoid because of the strong environmental influence on plant growth and development. To minimize second growth, look for varieties that are less prone to having second growth and try to maintain ideal conditions for uniform plant and tuber growth.

Cultural management practices may include promoting uniform stands, ensuring adequate plant nutrition and promoting uniform soil moisture to meet crop demand. Irrigation can be used to cool the soil, but do not overwater because this can lead to lenticel enlargement and pathogen entry into tubers.

Figure 5. Elongated tuber. (Andy Robinson, NDSU/UM)

Figure 6. Pointy bud end tuber. (Andy Robinson, NDSU/UM)

Figure 7. Jelly end rot. (Andy Robinson, NDSU/UM)

Figure 8. Protruding eyes or knobs. (Andy Robinson, NDSU/UM)

Figure 9. Heat sprouts. (Andy Robinson, NDSU/UM)

Figure 10. Heat sprouts with foliar growth. (Eugenia Banks, Ontario Potato Board)

Figure 11. Heat sprouts with tuber chaining. (Eugenia Banks, Ontario Potato Board)

Figure 12. Tuber chaining. (Andy Robinson, NDSU/UM)

Figure 13. Second tubers. (Andy Robinson, NDSU/UM)

Misshaped tubers



Physiological

Environment

Exposure by foliage: Tubers

- Stress from herbicide exposure can cause extreme tuber cracking, malformations, and disrupt seed tuber growth.

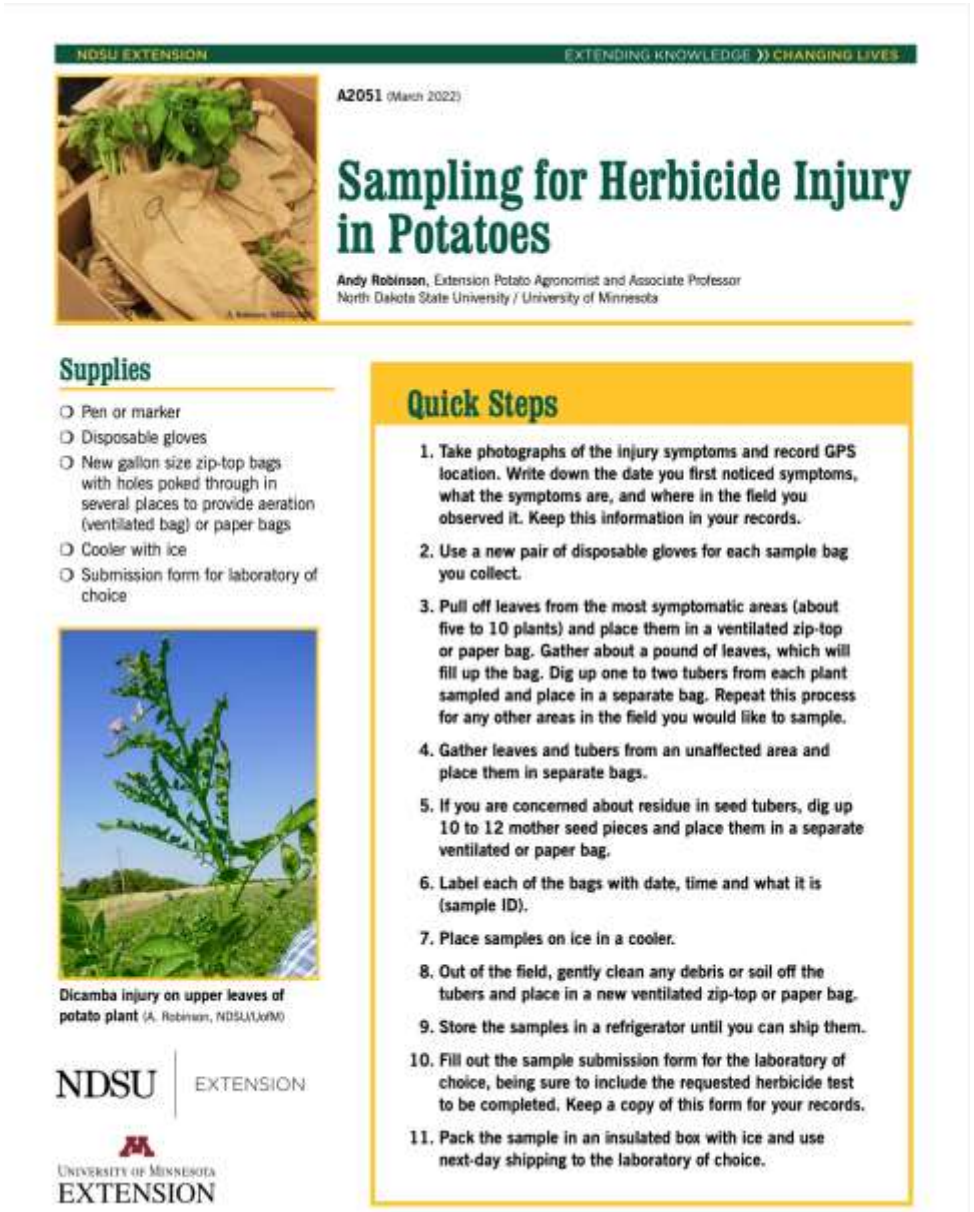
Malformed tubers

Extreme cracking

Sampling procedure

1. Document
2. Sample
3. Chain of custody
4. Clean sample
5. Ship to a laboratory

z.umn.edu/injury



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A2051 (March 2022)

Sampling for Herbicide Injury in Potatoes

Andy Robinson, Extension Potato Agronomist and Associate Professor
North Dakota State University / University of Minnesota

Supplies

- ❍ Pen or marker
- ❍ Disposable gloves
- ❍ New gallon size zip-top bags with holes poked through in several places to provide aeration (ventilated bag) or paper bags
- ❍ Cooler with ice
- ❍ Submission form for laboratory of choice

Dicamba injury on upper leaves of potato plant (A. Robinson, NDSU/UofM)

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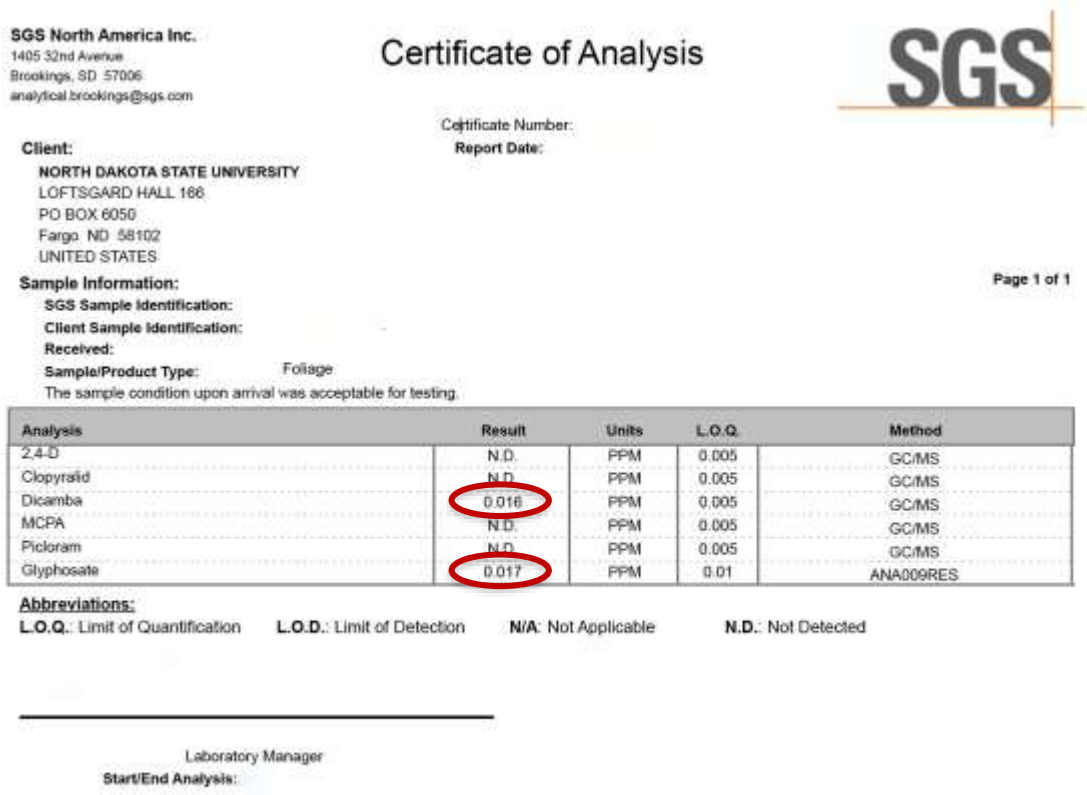
Quick Steps

1. Take photographs of the injury symptoms and record GPS location. Write down the date you first noticed symptoms, what the symptoms are, and where in the field you observed it. Keep this information in your records.
2. Use a new pair of disposable gloves for each sample bag you collect.
3. Pull off leaves from the most symptomatic areas (about five to 10 plants) and place them in a ventilated zip-top or paper bag. Gather about a pound of leaves, which will fill up the bag. Dig up one to two tubers from each plant sampled and place in a separate bag. Repeat this process for any other areas in the field you would like to sample.
4. Gather leaves and tubers from an unaffected area and place them in separate bags.
5. If you are concerned about residue in seed tubers, dig up 10 to 12 mother seed pieces and place them in a separate ventilated or paper bag.
6. Label each of the bags with date, time and what it is (sample ID).
7. Place samples on ice in a cooler.
8. Out of the field, gently clean any debris or soil off the tubers and place in a new ventilated zip-top or paper bag.
9. Store the samples in a refrigerator until you can ship them.
10. Fill out the sample submission form for the laboratory of choice, being sure to include the requested herbicide test to be completed. Keep a copy of this form for your records.
11. Pack the sample in an insulated box with ice and use next-day shipping to the laboratory of choice.

Laboratory analysis example

- 0.016 ppm dicamba
- 0.017 ppm glyphosate
- Will be stored in tubers and affect next crop.



SGS North America Inc.
1405 32nd Avenue
Brookings, SD 57006
analytical.brookings@sgs.com

Certificate of Analysis

SGS

Certificate Number:
Report Date:

Client:
NORTH DAKOTA STATE UNIVERSITY
LOFTSGARD HALL 166
PO BOX 6050
Fargo ND 58102
UNITED STATES

Page 1 of 1

Sample Information:
SGS Sample Identification:
Client Sample Identification:
Received:
Sample/Product Type: Foliage
The sample condition upon arrival was acceptable for testing.

Analysis	Result	Units	L.O.Q.	Method
2,4-D	N.D.	PPM	0.005	GC/MS
Clopyralid	N.D.	PPM	0.005	GC/MS
Dicamba	0.016	PPM	0.005	GC/MS
MCPA	N.D.	PPM	0.005	GC/MS
Picloram	N.D.	PPM	0.005	GC/MS
Glyphosate	0.017	PPM	0.01	ANA009RES

Abbreviations:
L.O.Q.: Limit of Quantification L.O.D.: Limit of Detection N/A: Not Applicable N.D.: Not Detected

Laboratory Manager
Start/End Analysis:

Mitigation

Mitigation

- Dedicated sprayer
- Proper tank cleanout
- Talk to neighbors
- Public map
- Signage
- Scout fields regularly
- Provide good growing conditions

Questions?

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