Pointers for Assessing Freeze Damage in Wheat—Texas High & Rolling Plains
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Consult additional resources including “Wheat Freeze Injury in Texas” (2014) at http://wheatfreezeinjury.tamu.edu

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Wheat & Freezing Temperatures

- Wheat is a cool-season grass, but once it begins spring growth, it is much more susceptible to cold temperatures.
- Absolute temperature {Air temperature vs. down in the canopy}, for younger wheat, especially before early boot stage.
  - If light winds only, lower areas of field (playa basin, a draw) tend to have more injury; but winds (e.g., April 10, 2013) circulate the cold more—increased potential damage in the canopy, less relative damage in low areas.
- Duration of cold—a standard is typically injury at a certain temperature at 2 hours of exposure.
- Growth Stage
- Variety of Wheat?—Probably not (I do notice that triticale seems to lay down more readily).
Not Meant to Be “Waffle Words”

- 2 hours at (XYZ) temperature is the point at which “we anticipate significant freeze injury potential on wheat” (especially for grain)
- That is how I state it. We just don’t know for about a week, sometimes more, what kind of damage might have been incurred
- March 25 freeze in Texas High Plains didn’t cause that much problem overall but in a few fields
- There is a lot of uncertainty, and I don’t often state the wheat freeze injury in blunt words, unless it is pretty obvious
Growth Stages

- Early maturing wheat more likely to be injured than late maturing wheat
  - Late 1999-2004: freeze injury 90% of the time involved early maturing, greenbug-resistant TAM 110 (replaced by TAM 112); or Jagger, which tended to break dormancy early

- Lush, high moisture, high nitrogen wheat: more sensitive

- Exception in 2013: northeast Panhandle freeze April 10 hit later wheat harder; we believe younger tillers present on the plant near jointing were especially sensitive, and they just collapsed, with no indication of standing back up within 8-10 days

- Grazed wheat is delayed sometimes by 2 weeks or so (and this can be used to hold back wheat that was planted early or is early maturity)

- In 2013 it appears in the Texas High Plains that wheat jointing was up to 2 weeks later than what I normally expect thus reducing freeze injury potential
Different stages of small grains growth. Plot in the foreground is late joint to early boot. Plot to the right is rye, which is headed out.
Dryland field, Hale Co., TX, April 4, 2013. Field must have received a decent rain early on to have grown this well, but now the March 25 freeze has hit, and most growing points are dead so growth essentially has ceased (except for small tillers) even if rains occurred.
Dryland field on verge of dying from lack of rain then additional damage from a freeze. Dark green spots are likely blowing snow accumulation from road to the right.
Why is the older portion of this plant apparently damaged, but there is head that looks green and healthy? We normally expect greater freeze damage potential on tissue more advanced in growth stage.

In this case the middle stem may have been damaged some time ago, and the left stem, which was smaller, continued growth.
“Drives-Me-Nuts” Symptoms

- I will never be completely comfortable with assessing freeze damage in wheat, largely because there is the interpretation of ‘What does it mean?’ involved. This is OK.

- Sometimes you may encounter symptoms that don’t make sense, and the previous slide is an example, which I think we saw repeated in the 4/17/2013 wheat freeze clinic in O’Donnell.

- In this Lynn Co. example, there were boot and late boot stage heads, but many smaller tillers that had dead growing points (I now believe from the 3/25/2013 freeze). This is evidence that once the growing point dies that stems stop all growth. In this case the younger stems that were not damage continued to grow, and are now booting.
Spikelet number and seeds per spikelet are being determined in this growing point shortly after jointing. This is very important as potential yield for this stem will be determined by what happens later: weather, irrigation, rainfall, disease incidence, etc.
Wheat growing point differentiation more advanced than in previous slide (possibly nearing completion, now at 2\textsuperscript{nd} hollow stem): a small head down in stem. Spikelet number & seeds per spikelet mostly already determined. If grazing and then going to grain cattle should have been off about 7-10 days ago.
Key Temperatures (~2 hours)

- Tillering, time duration can be quite wide, as low as 12° F
- Jointing, 22-24° F
- Boot, 28° F; this can vary (possibly lower) as early boot might still have some canopy protection, but later boot begins to emerge above the canopy
- Heading, 30° F
- Flowering, 32° F
  - These are potentially the worst…
- Milk & dough, 28° F
For foliage, top damage can look bad from the road—lots of damaged tips (March 25 freeze was a good example), but in reality only 1-2% of the total foliage.

Other needed information about the status of a wheat crop, unfortunately, requires some effort—cutting plants, parting the foliage to look for split stems, or examining the anthers with a hand lens.

We may not be able to wait for damage to become obvious in case the producer needs to change course (graze or hay).

An example is when a producer has bearded wheat that is about to head (diminishing its value for hay due to beards).
Tillering Stage

- Burned foliage and leaf tips
- Injury slows growth and may damage some young existing tillers, but as conditions warm, growth of new leaves and tillers resumes
- We are usually not too worried about this stage of growth as jointing has not yet occurred
Jointing Stage

- Our literature in “Freeze Injury on Wheat” says this occurs in Texas late March through April
- I think it comes before that. I have often regarded jointing around Lamesa (60 miles south of Lubbock) around March 1-7 for typical for initiation of jointing
  - Earlier in much of Rolling Plains
  - And of course 2 weeks later in the Panhandle
- Jointing can vary ± 2 weeks
- **Wheat Management Reminder:** all topdress N should be applied by the time the field is jointing
Checking the Wheat—*Let’s Begin*…

- Start with a clump of plants.
- There are many plants bound together by soil and roots.
- Work them apart and separate out the plants to reveal…
Select a typical plant then identify the largest stem (likely the oldest; there may be a second stem, which was the first tiller emerging 4 weeks or less from planting).
- Observe for any stems where the most recently emerged leaf is dead. No need to assess those stems further.
- Pick a larger stem and assess the growing point by cutting.
- To find the growing point, find the node on the stem that is visible, then using thumb and forefinger, run up the stem feeling other node(s) underneath; then cut from above that point downward. If this older stem is OK, then younger stems probably are, too (but check a few).
More about Jointing

- Growing point has become much more sensitive to injury.
- Dead leaf might appear in the “whorl”
  - This means that particular stem (not the whole plant) will add no more forage (though compensation from other tillers can be high) and will not produce any grain
- Stems can collapse (they feel rubbery, “flat” between thumb and forefinger) and lodging is an issue. I see a fair amount of triticale go down with good freeze. Young tillers under the forage can be trapped and die (if early joint, flash graze?)
- Discoloration or splitting of lower stems or brown in the lower nodes will diminish but not necessarily stop water & nutrient uptake
The most recently emerging leaf below is green and healthy, but the above emerging leaf is turning yellow to tan, indicating a dead growing point.
The most recently emerged leaf on the left stem is dead, meaning the growing point is dead. There will be no more head development and no further leaf area added on this stem.

The emerging leaf on the right stem is good.
The growing point below is brown in the base of the small head on top of the node (3 days after freeze). It will not grow. Same plant with side view to right.
The head on the left is healthy, and the segmentation of the spikelets is readily seen. The head on the right is tan, e.g. dead.
Assessing Very Small Heads

- Sometimes when the head is very small you can’t tell very well if it has been damaged. It is usually white in appearance after a few days (≤ 3/16” long). I ask myself: “Is the head more white or tan?” or “Is the head more yellow/green tint than white?” You need good light to determine this if you are looking at samples inside.

- If head is light tan (let alone a medium tan) it is dead.

- If the head has a green tint that is good—alive and growing.

- If you can see the segmentation of the spikelets on a small head when it is about 1/4” that is a good sign.

- If you just aren’t sure, reassess overall in a few days.
½ inch long head is dead, and has no development of spikelets. (Note that most recently emerged leaf is still green, but it will not grow any more.)
Small growing point of head only 3 days after freeze, Hale Co., Texas, 2013. Head is dead.
Examining the base of the plant for injured or collapsed stems. Stems above and to the right of fingertip were softened, but not completely collapsed, by a freeze.
Split stem at base of otherwise healthy plant. This type of freeze response can hinder full stem and grain yield potential, but growth probably continues (water & nutrient translocation are reduced; disease infection might occur).
Triticale for hay/silage that has collapsed due to freeze injury. May or may not stand back up (a lot of triticale does not).
Same spot in field of triticale as in previous pic. Stems are weakened by the freeze, and will not likely stand back up, nor will younger tillers be able to push through. Silage or hay harvest will likely need to cut one-way into the leaning forage and ‘dead-head’ back.
Topmost externally visible node on an individual stem. Growing point is somewhere above this visible node.
Two different growing points on the same plant. Bottom brown growing point is dead, the top is good—light green tint is visible in the small head, and the segmentation (developing spikelets) is visible.
Stem damage on left between 1\textsuperscript{st} node (under right finger) and 2\textsuperscript{nd} node (pinkie fingertip) is damaged (softened, but not completely collapsed). At least the internode is not brown to dark brown which would suggest more severe damage.

In right pic, the stem (left) is more damaged, and the brown color in the node indicates an increased level of potential damage that may restrict or stop movement of nutrients and water to head.
Good growing point (above) with light green tint. Two stems below it are damaged with near complete collapse, and are mid-brown indicating a greater degree of deterioration.
Triticale and winter wheat varieties that demonstrate differing responses (especially leaf burn) to cold temperatures. One spring triticale, left of top-center, has not survived due to winterkill.
Boot Stage

- Early boot may be still on the edge of the canopy vs. fat boot just prior to head emergence which is at the top of the canopy and moving above it.
- Anthers (male, later produce and eject pollen) may show damage later after heading—shriveled, don’t become yellow, turn tan or brown.
- Heads may emerge from the side of the boot, and if the heads in the boot or at emergence are yellow or white or just look limp, they are damaged. Little grain.
- This might be only on main stems, if secondary and tertiary tillers trail the main stem by a few days—they can escape injury.
For freeze assessment, I like to sample along a pivot track, where plants are exposed on the top and the sides. If I don’t find damage here the rest of the field is likely in good shape (fewer spot checks needed to confirm).
Heavy aphid damage in wheat that was also subjected to freeze damage (28% dead emerged leaves among stems).
Underneath foliage where massive infestation of greenbugs, some Russian wheat aphids have killed foliage. Note the high number of casks (skins) from different stages (instars) of aphids. Some live aphids visible (darker ones are RWA?).
Conflicting Symptoms, Jointing & Later

- Russian Wheat Aphid is very injurious, at much lower numbers than greenbugs, due to the toxicity of the injected toxin
- White striping on leaves, sometimes white and purplish leaf sheaths
- Not related to freeze
- If you look at fields, note aphid presence. Have they been sprayed?
- RWA tend to feed often above the collar on the leaf blade, and the leaf blade curls or rolls up around them for protection
Characteristic Russian wheat aphid damage symptoms on stems: white, longitudinal (lengthwise) striping, often will turn purple.
Heading Stage

- Sterility the main concern
- Bleached awns (beards)—white in appearance. If they are white all the way down to the floret (where the seed will develop from the ovary, if fertilized), the individual floret will likely not produce a seed
- “Frost Ring” from the stem/collar intersection at the time of freeze moves further up as the stem elongates
Heads with white color are freeze damaged and will not develop further. Green heads may still have issues with freeze injury (need to check floral structures, wait to see if normal; ultimately check to see if grain develops).
Flowering Stage

- Usually flowering about 1 week after heads emerge
  - Most sensitive stage (32° F)
- Early Rolling Plains concerns in 2013, none south of Lubbock through April 17 (though rye has been headed out for up to two weeks)
- Anthers (male, pollen source) are normally yellow. Pollination actually occurs in wheat largely before the anther is extruded.
- Damage to anthers could have occurred earlier (boot) and may not emerge at all.
Flowering Stage 2

- Wheat heads flower in the middle of the head first (then up & down, 2-4 days)
- Anthers a few days before emergence are light green, become **yellow** (sometimes with an orangish tint) by the time they are extruded. If killed earlier, the anthers may be white. Normal emerging anthers turn tan or brown after a few days and fall off.
Male anthers (an) of the flower provide pollen. The female stigma (fs) is light and feathery, and receives the pollen. Good anthers void of freeze damage are initially green, eventually plump, and not shriveled. On the right, anthers are nearing extrusion from the floret, now a yellow in color. Pollination in small grains actually occurs before the anthers pop out (right).
Pollination in wheat where pollen grains have been released.
View of seed growth at 24 and 48 hours. In my experience you can normally see the initial formation of the seed 2 days after pollination, just a little bump (1 mm) at the base of the floret, and within a day it looks like above. The wheat seed grows from one end to the other (not expansive in all directions like a watermelon).
Freeze injury after pollination results in shriveled seed.

Seed that confirms initial pollination occurred (A) shows the formation of a kernel at the base of the floret. When there is doubt about whether pollination has been harmed by a freeze this is the first sign to find for assurance of fertility and that anthers/pollen were not rendered sterile. As seed grows it elongates (upward in the floret) from B to E in about 3 or 4 days.
Milk & Dough Stages

- Not relevant at this time (April 24, 2013) in the Texas High Plains. Have got to get through flowering first.

- The position of the grain within the spikelet and the floret structures that enfold the grain (glume, palea, lemma) are in the next slide.
Spikelet ~30 days after pollination. Most wheat normally has 2 seeds per spikelet, and as conditions become more favorable (weather, rain/irrigation, good fertility) 3 and 4 (and even 5) seeds can develop in a spikelet. When assessing freeze injury on wheat just in advance of flowering you may have to find the anthers inside the palea/lemma (sometimes hard to do).
Possible Changes in Outcome

- Converting grain fields to forage?
- Not until we have handle on the grain yield potential
- The earlier stage of growth (e.g., younger or later wheat) a freeze occurs the less potential reduction in grain yield
  - That’s in most cases: in 2013, younger wheat in the northeast Texas Panhandle was hurt worse we believe due to the sensitivity of young tillers to the freeze
- And plants do compensate. Example: a field that is found to have 20% damaged grain heads (dead) does not necessarily experience a 20% decline in yield, maybe 10%. Compensation from tillers—a tiller that may have been unproductive now produces 8, 10, 12 harvestable grains
  - May be of lower quality, lower test weight
“Wheat freeze injury is never as bad as it looks.”

- This frequent statement from a former colleague has been repeated many, many times.
- In general, it this is very much the case.
- However, I (Trostle) just can’t comfortably make that statement without inserting ‘usually,’ hence “Wheat freeze injury is usually never as bad as it looks.”
- Sometimes, wheat freeze injury IS as bad as it looks, and on rare occasion, worse. The later in season the less time the wheat has to compensate.
“Wheat freeze injury is never as bad as it looks.”—The 50% Guideline?

- AgriLife Extension has often estimated that “about half” of the current damage will translate into actual yield loss. Perhaps this is too simplistic, but we do state it often…
- That is, if a field was found to have 40% loss of growing points then there would be perhaps a 20% decrease in actual realized yield.
- Might not be reliable much of the time. If a field is early in development tillering to early or mid-jointing, then perhaps there is better compensation (e.g., 10-15% yield loss), but if later in development with less time to compensate, then greater actual losses in yield (e.g., 25-30%)
- Just be aware of the possible issues with this general statement.
Tips for Field Assessment 1

- After a freeze, especially if the night was not windy, damage is more likely in lower areas of a field (tapering into a playa bottom, a draw). If you don’t find damage there, it won’t likely be on higher areas of the field (assuming similar growth stage across the field).
- This likely doesn’t hold up on windy nights as colder air can’t settle into low areas and remain there.
- A good assessment normally needs to wait about 7 days after a freeze to allow symptoms to express themselves.
Tips for Field Assessment 2

- To begin assessment, pick a representative area of the field, and plan to assess the opposite end of the field.
- Choice of stems needs to be random and representative (discard any exceptionally large or advanced stems or those stems that are very small, especially if in your estimation you don’t believe they would contribute to grain yield).
- Sometimes it is best to “Let Your Fingers Do the Walking” by selecting every 5th stem for assessment (don’t look at the stems as you choose which ones to assess).
- This decreases visual influence over what stems you might be biased to choose.
Tips for Field Assessment 3

- Choose 20 stems for assessment. If the most recently emerging leaf is dead, no need to check the growing point.
- Continue by assessing the growing points with cutting of the stems.
- If 18 growing points are good (2 dead), or 4 good/16 bad, you get a pretty good picture of the condition at that site; now move to another area.
- What if you have 13/7 good/bad, or 9/11? That is inconclusive, so select another 20 stems until the status becomes clear; then go to another area.
- Also, evaluate the stem integrity (if stem is badly damaged then don’t count a good head).
Tips for Field Assessment 4

- Write down your observations in case you need to assess the field again to see if any further damage becomes evident.
- Total up your observations for a field.

- PATIENCE! It may take you an hour or more to adequately assess a field, especially if there are questions.

- Sometimes you never really know what the outcome was. When you assess field, choose a few to go back to and see if your estimate of further growth were on target.
Common Question/Mis-understanding

- Across the numerous freeze injury clinics in 2013 and in e-mails and phone calls: “If the growing point is dead, will I still get some growth (including forage) in the stem and leaf?”

- No. There is one growing point per stem. Yes, the most recently emerging leaf may be green, but if the growing point is dead that leaf will not grow any more. Nor will the stem elongate any more as the stem increases length generally from the top. So for an individual stem the growth ceases.

- Other stems on the same plant, however, can continue normal growth and in fact can compensate more for the dead growing point.
Possible Changes in Outcome 3

- Grain may still be the best option for rotation, etc.
- What role does crop insurance have?
- Many dryland fields are already stressed and without rain have little to no potential
  - They should be grazed if animals are available (unless you don’t want hoof compaction)
  - They aren’t tall enough to justify swathing
- Feed quality is still good for freeze-damaged wheat, just like we have always known for forage taken at earlier stages of growth
Possible Changes in Outcome 3

- If a crop is held for forage now, but is bearded wheat, then the forage crop cannot readily be taken past late boot stage waiting for additional forage compensation.
- The emerged of bearded heads necessitates forage harvest.
- What about nitrate accumulation? I have not heard this being a past issue in the TX High Plains (maybe we weren’t paying attention), but in theory if a wheat crop can’t make grain but nitrate-N accumulation continues and has no place to go (no developing grain) then nitrate conc. could increase.
- But there is usually additional tiller growth now.
- Not a concern in forage for silage as the ensiling/fermentation process will destroy up to half of the nitrate.
Common beardless wheat variety (others are TAM 401, Deliver, WeatherMaster, etc.) that enable a grower to wait a little longer for compensatory forage growth after a freeze.
Since We are Talking Wheat... (1)
As you help discuss and assess freeze damage with farmers

- Ask producers if they are aware of or have access to our Texas High Plains (multi-site, multi-year regional averages reported) and Rolling Plains variety trial results
  - Statewide report:  
  - More detailed High Plains results, with regional multi-year/multi-site averages, including our “Pick” varieties:  
Since We are Talking Wheat... (2)
As you help discuss and assess freeze damage with farmers

- **Timing of topdress N** on wheat by the jointing stage
- Not “Spring” topdressing, but think “Later Winter” topdressing
- If you see a little wheat **starting to joint**, then the growing point on the rest of the field’s mainstem is starting to differentiate (key component for yield, e.g. spikelet number and seeds per spikelet): “If you haven’t already topdressed your wheat, do it now.” (vs. ‘once you see jointing then topdress your wheat’)

- **Observation**: the further south in the TX High Plains the more likely producers are late with topdress N
Since We are Talking Wheat... (3)
As you help discuss and assess freeze damage with farmers

- Examine their planting dates to suggest against too early/too late grain planting dates:
  - Northern & Southwest Texas Panhandle, ~Oct. 1-7 optimum
  - Northern South Plains, Southeast Panhandle, ~Oct. 10-15
  - Central South Plains, Oct. 20
  - Lower South Plains, Oct. 25 (at least single digits of November)

If dryland, then moisture affects planting date
- Some producers this year in the lower South Plains planted wheat for grain (no grazing) in September: Not Needed!
- But on the other hand, wheat can’t often make up grain potential with tillering & high seeding rate if planted late
Additional Contacts (2014)

These Texas A&M AgriLife Extension Soil & Crop specialist colleagues are potential resources for wheat and small grain injury assessment & education:

- Dr. Clark Neely, state small grains specialist, College Station, cneely@ag.tamu.edu, (979) 862-1412
- Dr. Jourdan Bell, extension agronomist, Amarillo, jourdan.bell@ag.tamu.edu, (806) 677-5600
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- Dr. Travis Miller, associate Soil & Crop Sciences head for Extension, College Station, (979) 845-4008
- Dr. Calvin Trostle, extension agronomist, Lubbock, ctrostle@ag.tamu.edu, (806) 746-6101
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