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Wheat:

Freeze Injury in Wheat May Impact Management Options

Since May 11 fields in southwestern North Dakota may have experience three freeze events which may have damaged wheat growth and development. The most recent freeze occurring Friday morning, May 25 could very well have severely damaged winter wheat that was in the boot stage to early stages of flowering. NDAWN on that day recorded low temperatures of 29^{o}F at Beach and Mott and 30^{o}F at Bowman and Dickinson. Some producers in low lying areas reported temperatures as low as 20 to 25^{o}F. Tonight and tomorrow night, other areas of the state could experience freezing conditions. Whether freeze injury will cause damage to the wheat crop (winter or spring) depends on several factors including plant growth stage, plant moisture content, freeze type, duration of exposure and lowest temperature reached. Determining if a wheat crop has been injured and how severely it has been injured will help the producer decide if another fungicide or nutrient application is required or if the crop should be hayed or terminated. Freezing normally does not kill the entire plant and the roots may continue to absorb nitrates from the soil. With no grain to use the nitrates, the plant may accumulate nitrate in the forage.

Susceptibility to freezing temperatures steadily increases as maturity progresses through the flowering stage then decreases slightly as seed develops. All cereals are most sensitive to freeze injury during reproductive growth, beginning at jointing and continuing through the boot, heading and pollination stages. A light freeze (28^{o}-32^{o}F) can severely injure cereals at these stages and greatly reduce grain yields.

Mechanical disruption of cells by ice crystals that enlarge both within and between cells will injure plants. Cereals grown under good growing conditions and high soil test nitrogen levels are more susceptible to freeze injury. Drought and other stresses tend to harden plants to cold.

The degree of injury is influenced by the duration of low temperatures as well as the lowest temperature reached. Prolonged exposure to a given temperature can cause much more severe damage than brief exposures. Topography can affect the extent of freeze injury. Also the temperature that is recorded at a particular site may not reflect the actual temperature experience by the plant in the field. These factors make it difficult to make general statements about the extent of damage caused by a freeze event. Extensive scouting of a field will help in defining severity and area affected by freezing.

A table below summarizes freeze injury symptoms and yield loss by growth stage. Diagnosis of freeze injury requires knowledge of plant parts most vulnerable at each growth stage, their location and their appearance as well as when they are normal.

Emergence to tillering – Zadoks 10-25. During seedling to early tillering stages the growing point is below the soil surface and protected from freeze injury. Most damage occurs to leaves which may have distinct light-yellow bands and which become chlorotic or necrotic and usually twisted.

Jointing – Zadoks scale 31-39. Leaves of freeze-injured plants develop damage symptoms similar to those of the tillering stage. The most serious injury can occur to the growing points. The growing point in a stem is located just above the uppermost node you can feel when you run the stem between your thumb and forefinger. To observe the growing point, split the stem lengthwise with a

sharp blade to expose the developing head. Normal uninjured growing point is bright pearl white to yellow green and turgid. Freeze injury causes the growing point to turn dull white or brownish and water soaked. Injury to growing point can occur in plants that appear to be otherwise normal because the growing point is most sensitive to cold. When the growing point is inured, stem elongation stops but later uninjured tillers continue to grow masking the damage. Expect normal and late tillers, uneven maturity and decrease in grain yield. Stem discoloration is associated with reduced metabolite transport through the nodes.

Boot – Zadoks scale 41-49. Freezing may cause heads to be trapped inside the boot so that they cannot emerge. The heads may remain in the boot, split out the side or the boot or emerge from the boot base first. Often the peduncle or stem supporting the head continues to elongate normally, causing crimps in the stem that can inhibit normal transfer of photosynthates. The result is low test weight grain. Often the head appears normal from the outside even though the anthers are dead. Because wheat (barley and oats) are self-pollinated, male sterility causes poor seed set and low grain yield. Anthers are more sensitive to freezing temperatures than female flower parts. Normal anthers are light green, full of developing pollen grains and turgid. They turn yellow when they mature and shed pollen. Freeze injury causes anthers to turn white and shrivel. It usually prevents them from shedding pollen and extruding. Anthers should be examined during this stage as leaves and stem may appear normal.

Heading – Zadoks scale 51-59. Most symptoms of freeze injury at this stage are similar to those of earlier growth stages – sterility, leaf burn and stem lesions. The most apparent symptom is chlorosis or bleaching of awn tips. White tipped awns usually indicate that floral parts have been injured. Awn tips may have a purple cast before turning white. A light-green or white freeze ring may encircle the stem below the head several days after exposure to freezing temperatures. This ring marks the juncture of the stem and flag leaf at the time of the freeze.

Anthesis – Zadoks scale 61-69. Flowering stage is most sensitive to freeze injury. Light freezes at this stage will result in the amount of injury. Usually light freezes at this stage will result in the appearance of more random damage than at other stages. More severe freezes usually cause the entire head to be sterile. Awns of damaged plants will bend to nearly 90 degree angles from the rachis as they mature.

Milk and Dough – Zadoks 71-89. Freeze injury can occur in grain during the milk and dough stages. Usually grain will grow to normal size but then produce light, shriveled grain at maturity. Cereals frozen at milk stage often shatter easily at maturity and germination percentage is usually reduced as a result of the freeze injury. Cereal kernels frozen during the dough stage will have slightly reduced test weights and appear shriveled. Seed germination may be reduced.

Spring freeze injury to cereals at various growth stages.

Growth stage	Primary symptoms	Yield effect
Tillering (Zadoks 12-25)	Leaf chlorosis, burning of leaf tips, silage odor, blue cast to fields.	Slight to moderate
Jointing Zadoks 31-39)	Death of growing point; leaf yellowing or burning; lesions splitting or bending of lower stem; odor	Moderate to severe
Boot (Zadoks 41-49)	Floret sterility, head trapped in boot, damage to lower stem, leaf discoloration, odor	Moderate to severe
Heading (Zadoks 51-59)	Floret sterility, white awns or white heads, damage to lower stem, leaf discoloration	Severe

Flowering (Zadoks 61-69)	Floret sterility, white awns or white heads, damage to lower stem, leaf discoloration	Severe
Milk (Zakoks 71-77)	White awns or white heads damage to lower stems; leaf discoloration; shrunken, roughened or discolored kernels	Moderate to severe
Dough (Zadoks 83-89)	Shriveled, discolored kernels; poor germination	Slight to moderate

Source: Paulsen, G.M., E.G. Heyne and H.D. Wilkins. 1982. Spring freeze injury to Kansas wheat. Kansas State University Cooperative Extension Service C-646.

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