

FROST INJURIES IN WHEAT AND ITS PROTECTION



Introduction

Wheat is subjected to adverse weather conditions during much of its growth period. Low temperature injury during winter and spring can be particularly destructive. The winter hardiness of most varieties when combined with good management practices have reduced winter killing of wheat.

Wheat has little resistance to low temperatures after it begins growing in the spring, therefore, injury from freezes at this time can occur.

The dew point is the temperature at which the relative humidity reaches 100% as the air cools. At this point, water vapor in the air condenses into fog or dew, which gives off heat, slowing the temperature drop. Freeze injury occurs when the plant tissue temperature falls below a critical value where there is an irreversible physiological condition that is conducive to death or malfunction of the plant cells. The risk of having a frost becomes greater as the dew point becomes lower. If the dew point is below freezing, so that condensation and heat release does not take place until below freezing, temperatures can drop to damaging levels extremely rapidly. In this case, the white crystals typically seen in a frost or freeze may not form, a condition sometimes referred to as a "black frost".

Injury usually occurs whenever low temperatures coincide with sensitive plant growth stages. The amount of injury may be large or only a few fields or parts of fields. It is most severe along river bottoms, valleys, and depressions in fields where cold settles. Early-maturing wheat is more likely to be injured by

freeze than is late-maturing wheat. Susceptibility to freezing temperatures steadily increases as maturity of wheat advances during spring. Some varietal difference in resistance to spring freeze injury has been reported, but it is mostly caused by differences in plant growth stages when freezes occur. There is little difference among wheat varieties at the same growth stage and, therefore, little opportunity to increase freezing resistance.

Wheat that has had good growing conditions and high soil fertility, particularly nitrogen, is more sensitive to freeze injury because of its lush growth and high moisture content. Sandy soils dry out more quickly than clay soils and can be more frost-prone as a result. Drought stress, on the other hand, tends to harden plants to cold and decreases their water content and the severity of freeze injury. Ample soil moisture, cool temperatures, and high soil fertility slows plant maturity which reduces its potential for injury as compared to plants that have had less favorable growing conditions and are in more advanced growth stage when freezing occurs.

Injury Symptoms of Wheat Resulting from Freezing Temperatures

Growth Stage	Approximate Injurious Temperature (2 hours)	Primary Symptoms	Yield Effect
Tillering	12 F° (-11 °C)	Leaf chlorosis, burning of leaf tips, silage odor, blue cast to fields	Slight to moderate
Jointing – Stem elongation	24 °F (-4 °C)	Death of growing point, leaf yellowing or burning, lesions, splitting, or bending of lower stem, odor	Moderate to severe
Heading	30 °F (-1 °C)	Floret sterility, white awns or white heads, damage to lower stem, leaf discoloration	Severe
Flowering	32 °F (0 °C)	Floret sterility, white awns or white heads, damage to lower stem, leaf discoloration	Severe
Milk	28 °F (-2 °C)	White awns or white heads, damage to lower stems, leaf discoloration, shrunk, roughened, or discolored kernels	Moderate to severe
Dough	28 °F (-2 °C)	Shriveled, discolored kernels, poor germination	Slight to moderate

TEMPERATURE THAT CAUSE FROST INJURY

Damage occurs when water in the plant cells freezes, thus causing the cells or cell parts to rupture. The temperature at which this occurs depends on the water content and concentration of water vs. solutes in the plant tissue. Therefore, the temperature at which damage occurs varies with the crop and growth stage.

Wheat is most sensitive to freeze injury during reproductive growth, which begins with pollination during late boot or heading stages. Temperatures that are only slightly below freezing can severely injure wheat at these stages and greatly reduce grain yields.

FREEZING INJURY AT BOOTING STAGE

Freeze injury at this stage, when the heads are enclosed in the sheath or the flag leaves, causes a number of symptoms. Freezing may trap the head inside the boots so that they cannot emerge normally. When this happens, the heads will remain in the boots, split out the sides of the boots, or emerge base-first from the boots.



Sometimes spikes emerge normally from the boot after freezing, but remain yellow or even white instead of their usual green color. When this happens, the heads have been killed.

Frequently, only the male parts (anthers) of the flowers in the head are killed. Since wheat is self-pollinated, sterility caused by freeze injury causes poor kernel set and low grain yield. Injury can be detected soon after freezing by examining the anthers inside each floret. Anthers are normally light green and turgid when young and become yellow about the time they are extruded from the florets after anthesis or flowering. The anthers, still green, become twisted and shriveled within 48 hours after a freeze but



they turn white to whitish-brown quickly and may not be extruded from the florets. The female parts (stigma, style, and ovary) may be damaged, but if they are, the anther also will be injured. The stigma normally has a greenish-white, feathery appearance. A damaged stigma becomes off-white to brown and will not open. The ovary will also turn off-white to brown. Use of a hand lens will be helpful in detecting symptoms.

FREEZING INJURY AT HEADING STAGE

Wheat heads usually emerge from the boots; most symptoms of freeze injury at this stage are sterility, leaf desiccation or drying. Lesions on lower stems have symptoms that are similar to those at earlier growth stages. The most apparent symptom, however, is usually chlorosis or bleaching of the awns ("beard") so that they are white instead of the normal green color. Freezing temperatures that injure the awns will usually kill the male flower parts.



Grain produced by wheat injured after the flower stage frequently is of poorer quality than usual. Test weight may be low, kernels may be shriveled or discolored, and the grain may be a mixture of kernels of different sizes and maturities.

The germination percentage of grain from a freeze – injured plant that is to be used for seed should be checked before planting. Grain of most wheat varieties has a natural dormancy that causes low germination for several weeks after harvest. The grain should be given a cold treatment before testing, or germination tests should be delayed for almost four weeks. If germination is slow and germination percentage is low for four weeks or more after harvest, the wheat should not be used as seed. Shriveled seed should not be used in any case because field emergence is poor even if germination percentage is high. In addition, shriveled seeds produce less vigorous seedlings that usually yield less grain than seedlings from good quality wheat seed.

FROST INJURIES AT FLOWERING (ANTHESIS) STAGE

Wheat usually flowers about one week after the heads appear. Symptoms of freeze injury at the flowering and heading stages are nearly similar.

The flowering stage is the most freeze-sensitive stage in wheat. Small differences in temperature, duration of exposure, or other conditions can cause large differences in amount of injury.

Exposure to freezing temperatures at the flowering stage kills the male parts of the flowers and causes sterility as described for the boot and heading stages. After freezing, the anthers are white and desiccated or shriveled instead of their normal yellow color.

Freeze injury at the flowering stage causes complete or partial sterility, and void or partially filled heads because of the extreme sensitivity.

Flowering proceeds from florets near the center of wheat heads to florets at the top and bottom of the heads over a 2 to 4 day period. This small difference in flowering stage when freezing occurs may result in no grain being set in the center or one or both ends of the head (Figure 21). This lack of grain set may have resulted from male flowers in those florets being in a sensitive growth stage when the freeze occurred. Grain might develop in other parts of the spikes, however, because flowering had not started or was already completed in those florets when the freeze occurred.



SUMMARY

Frost is very hard to predict in terms of damage potential in the crop as there are so many factors that affect the tolerance. In general -2 to -3 °C frost over a period of at least an hour is expected to cause damage to crops, -1 °C for an extended period such as 3 to 4 hours can also cause similar damage. Evaluating the damage is difficult and should be done approximately 24 to 48 hours after the frost for initial symptoms and up to a week to ten days for full extent of damage. A white appearance to the crop is a good early indicator of some frost damage. Heavily damaged crops will quickly show signs of frost injury including discoloration, darkening, water soaked appearance of fleshy tissue and pods. Slightly damaged pods or heads may show very little symptoms but the seeds within the heads may be damaged. Seed harvested from crops exposed to frost must be vigor tested prior to using the seed for next year's crops.

FROST PROTECTION MEASURES

Although frost and freeze damage to crop plants can be negative and irreversible, there are some measures which can be taken in order to protect high-value crops. While there is not one solution that is guaranteed to protect crops, farmers have developed ways to increase the chance of plants not getting harmed by cold weather.

1. Sprinkler Irrigation

- i) Frost protection with sprinklers is a proven method to help protect crops from damage caused by freezing weather. For areas prone to freeze events, installing and operating a sprinkler system designed for frost protection.
- ii) It is important to recognize that this method only prevents the temperature of the protected plant from falling below the freezing point. It does not warm the plant parts nor does it raise the air temperature appreciably.
- iii) Sprinkling maintaining a thin film of water on plants prevents temperatures beneath the film from dropping below freezing, even though ice may form. Irrigation is a much cheaper method to use for frost control. When water freezes and turns into ice, it releases latent heat. Then, the ice that builds up on the plant will insulate it from the colder surrounding air temperatures. Because of this, some growers choose to spray their crop with water before the freeze occurs.

2. Heating - heaters or open fires to counteract radiation heat loss, a large number of small heaters works better than a few large ones. Mostly the straws are burned in different places with such distance to avoid frost damage.

3. Change in planting dates - Selecting planting dates for wheat crop after the probability of freezing lessens in the January – February. Before sowing weather must be considered and temperature range should be 4 – 25 °C if the temperature is more than it sowing can be delayed for few days. If the temperature is high and crop is cultivated, plant shoots remain single and rapidly goes to heading. Early growing crop has more chance to frost damage.

GHULAM NABI ARAIN
CROP MANAGER – AGRONOMY
VALLEY IRRIGATION PAKISTAN (PRIVATE), LIMITED