FREEZE DAMAGE EXPERIENCE AND RESULTS

The Easter freeze of 2007 was an unusual freeze that resulted in severe damage to wheat at a time (late in season) that made it difficult to make a decision on whether to keep the wheat or plant to an alternative crop. Recommendations were made and some were right and some were wrong. All the decisions were tempered by the price of the wheat crop and alternative crops. In an effort to record this experience and the results of the wheat that was kept, the following articles look at what was learned in an effort to preserve the information and provide a base for future decisions when a freeze of this type and magnitude occurs in the future.

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Historical Aspects of Wheat Freeze Damage

Spring freeze damage to wheat in Kentucky is not an annual occurrence, but the possibilities exist for it to occur more frequently than it actually does. Freezing temperatures are achieved every spring in Kentucky, but the actual temperature, when it occurs, and the susceptibility of the wheat crop are all factors that determine if and to what extent damage may occur. Past experience has shown us that freeze damage to the wheat crop can be minor to severe or occur regionally or statewide.

Three basic conditions must be present for significant freeze injury to occur to the wheat crop. These are: 1) The wheat plant must be at a sensitive stage of growth; 2) Temperatures must drop to a certain critical level; and 3) The temperature must remain at or below the critical level for at least 2-3 hours. The wheat plant becomes extremely sensitive to freeze injury after it joints (Feekes growth stage 6) when the growing point (developing wheat head) elongates above the soil surface. The most serious freeze damage (yield loss) occurs as a result of death of the growing point/wheat head and damage to the stem. Also, the more advanced the wheat growth stage, the less the critical temperature level has to be to cause damage. Table 1 gives a summary of injury-causing temperatures, symptoms, and yield effects of freeze injury at various stages of growth.

Freeze damage to the 2007 wheat crop was a reminder that spring freezes can cause considerable damage. Will freeze damage occur to the 2008 wheat crop? This cannot be predicted since Mother Nature is so fickle. Spring Freeze injury occurs when low temperatures coincide with

sensitive plant growth stages (i.e. in 2007). The risk of spring freeze injury is greater when wheat initiates growth early due to higher than average temperatures in late winter (January/February) and/or early spring (March/April) and advances through its developmental stages more quickly than normal or when an unusually late freeze occurs (late April/early May) after the wheat is further advanced. Both of the previously mentioned scenarios have occurred in the past in Kentucky and resulted in freeze damage.

Historically, how often do significant wheat freeze damage events occur in Kentucky? Over the past 38 years (1970-2007), records indicate that moderate to severe freeze damage (yield loss) to the wheat crop occurred regionally or statewide in eight of the years. These years included: 1973 (mid-April); 1976 (late April and early May); 1982 (early & mid-April); 1986 (late April); 1990 (early April); 1998 (mid-March); 2002 (mid-May); and 2007 (early April). Two significant freeze damage events occurred each decade and averaged almost one every five years since 1970. However, the time interval between significant freeze damage events (from 1970-2007) ranged from only 3 years (1973 and 1976) to eight years (1990 and 1998). Also, on a calendar basis, these freeze damage events occurred as early as mid-March to as late as early-mid May. Mother Nature determines when and how frequent wheat freeze damage occurs. In addition to the eight significant freeze damage events that have occurred since 1970, there have been years that marginal freeze damage conditions occurred resulting in only minor damage with minimal, if any, yield loss. Minor freeze damage conditions occurred in 1974, 1983, 1985, 1989, 1992, and 2000.

Table 1. Freeze Injury in Wheat

Growth Stage	Approximate Injurious Temp (2 hrs)	Primary Symptoms	Yield Effect
Tillering (1-5)[a]	12°F	Leaf chlorosis; burning of leaf tips; silage odor; blue cast to fields	Slight to moderate
Jointing (6-7)	24°F	Death of growing point; leaf yellowing or burning; lesions, splitting, or bending of lower stem; odor	Moderate to severe
Boot (10)	28°F	Floret sterility; spike trapped in boot; damage to lower stem; leaf discoloration; odor	Moderate to severe
Heading (10.1 - .5)	30°F	Floret sterility; white awns or white spikes; damage to lower stem; leaf discoloration	Severe
Flowering (10.51 - .54)	30°F	Floret sterility; white awns or white spikes; damage to lower stem; leaf discoloration	Severe
Milk (11.1)	28°F	White awns or white spikes, damage to lower stems; leaf discoloration; shrunken, roughened, or discolored kernels	Moderate to severe
Dough (11.2)	28°F	Shriveled, discolored kernels; poor germination	Slight to moderate

[a]Numbers in parentheses refer to the Feekes scale.

Wheat Yields 2007: What Happened?

Winter wheat was much more resilient following the spring freeze than anyone predicted. Average yields for Kentucky are estimated to be near 51 bushels/acre, not the best yields, but far better than we predicted. Some fields that we thought would not be suited to harvest yielded 30 to 50 bushels/acre. So, why did we miss it so badly?

This was the most freeze damage on wheat any of us had witnessed. We have seen wheat freeze before, but the wheat was not as mature when the freeze hit. Many wheat fields had dead growing points on the primary tillers. Surviving tillers produced about 30 heads per square foot, well below the ideal 50 heads per square foot. The low number of heads can provide good yields if all growing conditions are right. If there is any disease, lodging or bad weather the yields will drop.

In some fields as much as 80% of the surviving tillers had damaged stems near the soil surface, often between the first and second joint. Usually, damaged stems will fall over once the wheat head adds weight. Also, diseases often occur in the stems at the site of freeze damaged. Previous experience tells us to assume that these heads on damaged stems will not produce adequate seed. If all damaged stems do not make a head, then final stands are close to 6 heads per square, well below what is needed for adequate yield.

The death of the primary tillers normally means a delay in growth and development and harvest. This harvest delay would delay double-crop soybean planting, which would reduce their yield.

This was the picture we all saw during April. What happened next…or what did not happen… changed that picture entirely.

Kentucky experienced about six weeks of dry weather following the freeze event. The dry weather prevented wheat from falling over. It discouraged disease development that normally occurs on damaged stems. No heavy rains occurred to knock down the wheat. The dry weather encouraged faster development and most wheat matured within a few days of normal. This was absolutely the best possible weather conditions for wheat recovering from freeze damage. None of us expected perfect weather conditions.

To contrast our experience in Kentucky, Arkansas had wheat freeze damage at similar growth stages this year. Arkansas experienced several rainfall events while Kentucky experienced none. Arkansas wheat yields were very low (about 40 bu/acre) and grain quality was low. Kansas was similar to Arkansas in that final yields were less than what was expected (32 bu/acre).

In unusual weather events (such as a week of temperatures in the 80 s in March, followed by three to five days of freezing temperatures the first of April in Kentucky) unusual things happen. The science behind our predictions on wheat freeze damage was sound. One thing we all have learned, and continue to do so, is that it is extremely hard to outguess Mother Nature.

Summary of Impact of Freeze Damage on Wheat Diseases

The majority of wheat acres in Kentucky were badly hurt by the spring freezes that occurred in early April, 2007. Many fields were subsequently destroyed by the producer and planted to other crops. However, many acres were taken to yield for grain and many fields were retained for seed purposes.

In my 23 years on the job, I had not seen wheat subjected to multiple, consecutive hard freezes, so I really did not know what to expect. Many wheat growers apparently had the same uncertainty. Consequently, I received numerous questions about the need to spray retained fields with a fungicide. Obviously, grain yields were already seriously compromised by the freezes and, if left unchecked, diseases could have taken even more yield out of the crop. Plus, there was no sense in retaining a field for seed purposes if seed quality was not protected. Thus, it made some sense to me that some producers should consider applying a fungicide to a damaged crop.

I realized that the weather between the time the last freeze occurred and late grain fill would ultimately determine which diseases develop and to what extent. Based on limited experience with prior freeze events, I reasoned that delayed emergence of secondary tillers could result in enhanced Fusarium head blight (FHB)/deoxynilalenol (DON) if the weather was wet during and immediately after head emergence. Conversely, if the weather was hot and dry, I knew FHB/DON would probably not be a problem. As it turned out, FHB was not a significant problem in Kentucky this spring. The weather turned dry during May and unseasonably moderate temperatures favored grain fill. Folicur and Orius were granted a section 18 label for FHB/DON suppression in Kentucky, but very little of either fungicide was used for FHB or DON suppression. DON levels are not always linked to FHB symptoms in the field, and because wheat is just now being harvested, it is too early to say for sure that DON will not be a problem. This said, I would be very surprised if DON was a problem in many harvested fields in Kentucky since the weather leading up to harvest has been generally dry and crop lodging minimal (despite significant stem damage due to the freeze).

In addition, I expected to see greater incidence and severity of Stagonospora leaf and glume blotch. The latter disease can really hurt seed quality, so where maximized seed quality was a goal, I anticipated that many of those acres might need to be treated to control glume blotch. I reasoned that harvest may be delayed due to the large number of secondary tillers formed following the freeze kill. As it turned out, neither leaf nor glume blotch were much of a concern because of the dry weather during grain fill. In fact, no single fungal disease was serious in any field I looked at this year. Many common foliar fungal diseases (stripe rust, leaf rust, powdery mildew, speckled leaf blotch, Stagonospora leaf and glume blotch, and tan spot) were present at minimal levels in many fields, but the freeze damage did not seem to exacerbate the disease situation in any field I observed.

In summary, the consecutive nights of hard freezes in early April significantly damaged a majority of wheat fields in Kentucky. The extent of the freeze was unprecedented and, as a result, many fields were destroyed and replanted to other crops. There was concern that common wheat diseases, especially Fusarium Head Blight and Stagonospora leaf and glume blotch, could become a problem and further compromise yields and grain/seed quality. This situation never materialized, apparently due to the dry weather from early May to mid-June.

Effect of Freeze Damage on Herbicide Activity

Much of the early planted wheat in Kentucky was developing rapidly and in Feekes 6 and 7 growth stages when the April freeze occurred. As a result of the freeze damage, approximately 104,000 acres of wheat were either harvested for hay or silage or treated with a burndown herbicide to convert damaged fields to full season soybeans or corn. A section 18 label was issued to allow wheat growers to harvest their crop for hay or silage where thifensulfuron or the premix of thifensulfuron plus tribenuron were applied. There was some concern that stem damage from the freezing temperatures would limit translocation of glyphosate; consequently, paraquat was discussed as the preferred burndown treatment to control of wheat where corn or soybeans would be planted. A study initiated on April 20 compared glyphosate and paraquat for controlling freeze damaged wheat. Results showed that control was better with glyphosate than with paraquat, but activity was slow. Label restrictions limited the opportunity to rotate to corn in freeze damaged wheat that was treated with mesosulfuron.

Nitrogen Effects on Wheat Damage and Recovery

Nitrogen added before the freeze had two different effects on the wheat and on its susceptibility to the amount of damage sustained during the freeze:

1) High rates of nitrogen added early to the wheat in late winter or early spring increased the growth rate of the wheat which resulted in an advanced stage of growth. The more advanced the stage of growth, the more susceptible the plant was to the freeze damage. So early nitrogen increased the amount of damage due to the more advanced stage of growth

2) Late nitrogen applications seemed to have the opposite effect. Some Kentucky wheat fields looked much better than others following the freeze. Part of the reason may be due to nitrogen application timing. We noticed that wheat treated with fertilizer nitrogen about two weeks before the freeze did better than wheat treated at other timings with fertilizer nitrogen. We assume that this timing, this year, allowed wheat to have good uptake of fertilizer nitrogen. Concentration of nitrogen in the leaves was at a high level and acted as anti-freeze to the cold temperatures. Wheat with nitrogen applied either before or after this two-week timing did not have high enough nitrogen concentrations to serve as anti-freeze. The timing of fertilizer nitrogen application depended on temperatures, soil moisture and wheat growth, so it would be extremely difficult to predict whether such timings would have similar results in future events.

Nitrogen availability is important to the plant in its recovery process from the freeze damage. The following guidelines may be helpful in making decisions on the use of nitrogen during this process:

1) ***Nitrogen uptake into the wheat plant takes place mainly between Feekes 5 and Feekes 7.*** So most of the N was in the plant at the time of the freeze.

2) ***Wheat with little or no lower stem and head damage, but considerable leaf burn.*** In this case, the wheat needs nitrogen to be readily available to it for the regrowth of the leaves. If all the nitrogen has not been added, it should be added soon. The amount of nitrogen should be applied at the full recommended rate and sometimes an extra 10 to 15 lbs/ac of N is helpful to the crop. If leaf burn is minimal, then the extra 10 to 15 lbs/ac of N may not be needed.

3) Wheat with some lower stem and head damage, but still has a good yield potential.

If nitrogen has not been added, it should be added soon at the full rate of recommended nitrogen. This would help recovery and the yield may be greater than the projected yield at this time. If all the nitrogen was added before the freeze, then an additional 30 to 40 lbs/ac of actual nitrogen would be needed to stimulate new growth and replace the nitrogen that will be released slowly.

4) Wheat with considerable lower stem and head damage.

It would be questionable in most cases if this stand should be kept. If a farmer wants to gamble, nitrogen at the full rate could be applied soon to help recovery, realizing that this may be throwing good money after bad. If all the nitrogen was added before the freeze, then an additional 30 to 40 lbs/ac of actual nitrogen would be needed to stimulate new growth and replace the nitrogen that will be released slowly. The other possibility would be to delay any nitrogen application until a clear decision can be made on whether to keep the crop. The farmer may sacrifice yield because of a slower recovery, if the ultimate decision was to keep the wheat crop, but would reduce the economic risk of a bad decision.

5) Nitrogen applied to abandoned wheat for corn and soybeans.

Corn:

Assuming there are no monsoon rain storms, one could possibly count on 50 percent of the N applied to the wheat to be available to the following corn crop. Most of this would be immediately available with some coming available with decomposition.

Soybeans:

Any nitrogen applied to the wheat should not be a consideration for the planting of soybeans. The soybean plant will compensate for any or no nitrogen previously added and it will have almost no effect on it except for a little faster growth the first 2 to 3 weeks after emergence.

Summary:

Nitrogen has a definite influence on the amount of freeze damage a wheat crop will sustain and its ability to recover. Early nitrogen will usually increase the chance for damage due to accelerated plant development while nitrogen added shortly before the freeze will reduce the amount of freeze damage. Nitrogen availability during the recovery stage is quite important.