HANDLING CORN DAMAGED BY AUTUMN FROST

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Corn plants are sometimes exposed to low temperatures during autumn that kill plant tissue before physiological maturity. When an early frost occurs, corn producers need to know the impact of the damage on maturation and yield, and what to do with the frosted crop. This publication provides information on the effect of frost on grain development, describes options for handling the damaged corn, and discusses ways to reduce the risk of frost.

CONDITIONS CONDUCIVE TO FROST DAMAGE

Severity of frost damage depends in large part upon the duration and extent of sub-freezing temperatures. For example, substantial frost damage of leaf, stalk, and husk tissue will occur when temperatures remain below 32ºF for 4 to 5 hours or when temperatures decline to 28ºF or lower for even a few minutes before increasing above 32ºF. Frost damage due to rapid heat loss from radiational cooling can occur when air temperatures are several degrees above 32ºF if the air is clear and still. Under these conditions, leaf temperatures can drop below the actual air temperatures.

When air temperature is close to freezing, slight variations in terrain result in frost damage in low-lying areas, with no damage only a few feet higher in elevation. Thin plant stands and plants at the edge of the field are more likely to freeze because of more radiational cooling and less heat contained within the crop cover.

EFFECT OF FROST DAMAGE ON GRAIN DEVELOPMENT AND YIELD

The influence of frost damage on final grain yield depends on how much leaf tissue is killed and the stage of development when the frost occurs. The effect of plant defoliation on grain yield becomes smaller the closer the plant is to physiological maturity (Table 1). Redistribution of sugars from stalks to ears, despite complete leaf death, will increase kernel dry weight beyond that present on the frost date and reduce yield loss, unless the freeze is severe enough to kill stalks, husks, and kernels. If any leaves, especially above the ear, or even the stalk and husk are still green after a frost, grain dry weight will increase until the black layer forms at kernel tips. However, several days of cool temperatures (daily highs of 45 to 55/F) during grain fill may result in premature black layer formation, ending further grain yield increases even if another frost has not occurred.

Table 1. Corn Grain Yield Losses Following Plant Defoliation and Immediate Harvest at Three Stages of Kernel Development, Compared to Losses When Defoliated at Same Stages and Left in the Field to Mature.

Stages of kernel development	Harvested at Defoliation	Harvested at Maturity
	- - - - - % yield reduction - - - - -	
Soft dough	51-58	34-36
Fully dented	39-42	22-31
Late dent	11-12	4-8

Source: Afuakwa J. J., and R. K. Crookston. 1984. Using the kernel milk line to visually monitor grain maturity in maize. Crop Sci. 24: 687 -691.

When green, very immature (milk to dough stage) corn plants have been frosted, leaves quickly dry, giving the appearance of rapid whole plant dry down. But leaves comprise a small portion (10 to 15%) of total plant weight and lose moisture rapidly compared to stalk and ears. Numerous studies have shown no evidence of increased whole-plant drying rates following frost.

Many corn growers perceive that kernels from early - frosted corn dry very slowly or not at all in the field. Minnesota studies simulating frost damage at early dent stage (approximately 55% kernel moisture) indicated that corn killed immaturely by frost dried normally when environmental conditions favored kernel drying. Dry-down of the frosted corn was temporarily delayed immediately following frost, however, resulting in 4 to 9 more days needed to reach the acceptable grain harvest moisture range (22 to 30%) compared to non-frosted corn. Besides delaying harvest, this could increase field and harvest losses and limit fall tillage operations. Drying rate for ears with loosened husks (simulating light frost damage) was more rapid than with normal ears. This suggests that a mild frost which only kills husks could increase rate of kernel moisture loss.

HANDLING FROST-DAMAGED CORN

Options for handling frost-damaged corn depend on the plant stage when frost occurred and whether the farming operation involves silage or only cash grain production.

Milk Stage

Silage. Optimum silage fermentation occurs when whole-plant moisture is 62 to 68%. When corn plants are ensiled immediately after a frost at milk stage, the silage will be wet and sour. Nutrients will be lost in silo seepage, and livestock consumption will be low. Options are to green chop and feed or to let corn dry in the field and ensile at less than 70% whole-plant moisture in upright silos or 75% moisture in horizontal silos or stacks. Field losses will increase with time-, therefore, producers must balance harvest losses against fermentation losses and quality problems with wet silage. Addition of absorbent materials such as ground grain or straw can be used to reduce moisture by 1% for each 30 Ib. of dry material applied per ton of silage. Livestock will eat less green-chopped corn, but dry matter and crude protein digestibility may be equal to or higher than for more mature corn silage. Test corn silage harvested at immature stages for percent moisture and feed value before feeding. A procedure for testing whole plant moisture and further information on harvesting corn silage are described in NCH-49, "Corn Silage Harvest Techniques."

Grain. Yield potential for corn frozen during the milk stage will be low, and grain will be very chaffy. Therefore, green-chopping or ensiling whole plants will likely be the recommended options for handling the damaged corn.

Dough Stage

Silage. When corn is frozen at the dough stage of kernel development, it should be allowed to field-dry until whole-plant moisture reaches at least 70 to 75% (refer to guidelines described above for immature silage). Test silage for moisture and feed value before feeding.

Grain. Yields will be reduced by at least one-half unless stalk, ear, and some leaves survived frost (Table 1). Test weight will be low, probably less than 50 lb./bushel.

Grain will be very wet (Table 2) and will need to be dried in the field for a long period to a maximum of 35% kernel moisture before combining. This extended drying period will increase field losses, because frosted, immature corn tends to have more stalk breakage than mature corn. Ear molds may develop when field-drying conditions are slow.

Table 2. Whole-Plant and Kernel Moisture of Corn at Four Stages of Kernel Development.

Stage of kernel development	Moisture Concentrations: Kernel	Whole plant
	- - - - -%- - - -	
Soft dough	60-62	- -
Fully dented	54-55	73-76
Late dent	40	68-69
Mature*	23-30	58-64

* Maturity indicated by black layer formation and/or milk disappearance from kernel under normal development. Premature frost or extended cool temperatures may cause black layer formation at earlier stages and wetter moistures.
Sources:
(Kernel moistures) Afuakwa, J. J., and R. K. Crookston. 1984. Using the kernel milk line to visually monitor grain maturity in maize Crop Sci. 24:687 -691.
(Whole-plant moistures) Kurle, J. E., and R. K. Crookston. 1986 A visual indicator of when to harvest corn for silage. Agron. Abstr. American Society of Agronomy, Madison, Wl p. 116.

During combining, grain will be susceptible to breakage, and the wet cob may break into small pieces, increasing dockage due to broken corn and foreign material (BCFM). Reduce cylinder speed as low as possible if immature - frosted corn has dried below 30% kernel moisture. If corn is wetter than 30% kernel moisture, cob breakage may occur and a higher cylinder speed and closer concave setting may be helpful to clean-shell kernels from cobs.

High temperature drying could cause immature kernels to darken or turn brown; however, with natural-air or low-temperature drying systems it will be difficult to adequately dry corn wetter than 26% grain moisture. Corn harvested wet should be dried to kernel moisture 1 to 2% lower than the normal 13 to 14% for long-term storage. This is due to greater variations of moisture content within the grain mass and increased physical kernel damage and broken cobs, which could magnify mold problems. Screen corn to remove fines and foreign material if possible, Once corn is stored, be certain to maintain aeration cycles. In extreme northern regions, in areas where sub-zero temperatures occur frequently during the winter, wet corn at 30 to 35% kernel moisture could be harvested frozen, put in bins, kept cold until the weather warms, and then dried.

Wet corn could be stored in a silo as high-moisture ear-corn or shelled grain if field-dried to 28 to 32% kernel moisture before harvest. Corn dried below 30% moisture could be husked and cribbed, but adequate air circulation is important to prevent spoilage.

Dent Stage

Silage. With frost-kill at the beginning of the dent stage, whole-plant moisture will still be greater than the optimum 62 to 68% (Table 2), so plants must be allowed to dry to these moisture levels before ensiling.

Beginning at the late-dent stage (kernel endosperm milk line positioned halfway between the base and tip of the kernel), whole-plant moisture percentage is ideal for ensiling (Table 2). Because physiologically mature corn dries rapidly in warm, dry weather and heavy frost may hasten leaf loss, ensile immediately (for more information, see NCH -49).

Grain. Corn that is frost-killed during the early- to mid-dent stage will contain more than 50% kernel moisture (Table 2) and can be harvested for grain or ear-corn after a long field-drying period, Grain yields will be reduced (Table 1), and test weights will be below normal. Follow the guidelines for handling wet corn described under "Dough Stage" above.

If only a portion of the plant tissue is killed and/or if the grain was in the late dent stage before the frost, yield loss will be small (Table 1) and test weights will be close to normal.

Severe frost will not affect grain yield or quality after physiological maturity, and drying rate is influenced by hybrid and environment. Kernel moistures will be less than 40% (Table 2), and harvest can occur following the normal fall drying period.

REDUCING THE RISK OF FROST DAMAGE

To reduce the risk of frost damage, corn producers need to match hybrids to expected seasonal growing degree days, based on planting date and average first autumn frost dates. Corn hybrids should reach physiological maturity before the average date when freeze risk is greater than 50%. Timely early planting is vital for frost avoidance, and hybrids with earlier maturities should be planted when delays occur. Planting hybrids with a range of maturities will decrease the risk of damage to the entire crop if an unusually early frost occurs.

In northern areas, some full-season hybrids with high yield potential may be killed by frost at the late dent stage, but still produce more silage and/or grain than short-season hybrids that do reach maturity before frost. However, high drying costs may negate the value of small yield increases from full-season hybrids. This indicates that the importance of avoiding frost-kill before physiological maturity depends on crop use. If intended use is whole-plant silage or high-moisture grain, occurrence of frost damage during late grain-fill may not be detrimental.

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