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Flooding Impacts on Corn Growth and Yield

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Recent rains have caused flooding and ponding in many cornfields. Growers are concerned about corn growth and development and any yield effects that might occur from short periods of flooding. The extent to which flooding injures corn is determined by several factors including: 1) timing of flooding during the life cycle of corn, 2) frequency and duration of flooding, and 3) air-soil temperatures during flooding (Belford et al., 1985).

Respiration is the plant physiological process most sensitive to flooding. Flooding reduces the exchange of air (oxygen) between soil and atmosphere eventually leading to decreased total root volume, less transport of water and nutrients through the roots to the shoot, and formation of sulfides and butyric acid by microorganisms that are toxic compounds to plants (Wesseling, 1974).

Soils contain pores filled with gas and/or water. The two main gases important for respiration are oxygen and carbon dioxide. The pathway for oxygen into the plant is from the atmosphere through soil pores to a thin water film surrounding plant root hairs. It is relatively easy for oxygen to diffuse into soil when pores are filled by air, but oxygen does not easily diffuse in water so the main constraint to oxygen movement is the thin water film surrounding root hairs. This boundary is magnified in flood/pond conditions. Carbon dioxide rarely accumulates to toxic levels in soil (Wesseling, 1974).

Roots are injured if the soil remains waterlogged. Continued poor aeration causes cell death and even death of roots. Measurable short term reductions for root and leaf growth rates begin immediately within 1-12 hours, but tend to recover quickly within 2-3 days (Wenkert et al., 1981). Almost immediately leaf elongation ceases and N, P, and K concentration in leaves decrease, but in roots N, P and K concentrations increase (Ashraf and Rehman, 1999). Flooding restricts root growth in the upper 18 inches of soil, but root elongation continues in deeper horizons. Soil compaction and flooding will restrict root growth more severely than either factor separately (Klepper, 1990).

All biological processes are influenced by temperature (Wesseling, 1974). Wet soils have a large heat capacity and considerable amounts of heat are required to raise their temperature. Thus, usually wet soils are cold and corn growth is slower. Drainage lowers the moisture content of the upper soil layers so air can penetrate more easily to roots, and transport carbon dioxide produced by roots, microbes and chemical reactions to the atmosphere. Lowering soil moisture content also leads to higher soil temperatures and faster growth.

Evaluating damage from flooding

The growing point of corn is metabolically active and is near or below the soil surface prior to V6 (6 visible leaf collars). Within about 48 hours the oxygen supply in a flooded soil is depleted (Purvis and Williamson, 1972; Fausey and McDonald, 1985). Without oxygen, the growing point cannot respire and critical functions are impaired. If temperatures are warm during flooding (greater than 77 degrees F) plants may not survive 24-hours. Cooler temperatures prolong survival. If flooding in corn is less than 48 hours, crop injury should be limited.

To confirm plant survival, check the color of the growing point. It should be white to cream colored, while a darkening and/or softening usually precedes plant death. Also look for new leaf growth 3 to 5 days after water drains from the field. Once the growing point is above the water level, the chances of survival improve greatly.

Things to look for later during the growing season

Even if flooding doesn't kill plants, it may have a long-term negative impact on crop performance. Excess moisture during the early vegetative stages retards root development (Wenkert et al., 1981). As a result, plants may be subject to greater injury later during a dry summer because root systems are not sufficiently developed to contact available subsoil water.

A considerable amount of oxygen is required in the soil for mineralization of nutrient elements from organic matter by microbes. Oxygen deficiencies reduce microbe activity, decreasing the rate at which ammonium and nitrate are supplied to plants resulting in nitrogen deficiency in waterlogged soils (Wesseling, 1974). Additionally, flooding can reduce the activity of mycorrhizae essential for symbiotic phosphorus uptake (Ellis, 1998). Flooding can also result in losses of nitrogen through denitrification and leaching. Where estimated nitrogen loss is significant in fields not yet tasseling and yield potential is reasonable, corn may respond to additional applied fertilizer.

Flooding causes greater crop yield losses when it occurs early in the season (Meyer et al., 1987; Kanwar et al., 1988; Mukhtar et al., 1990; Lizaso and Ritchie, 1997). When six-inch corn was flooded for 24, 48 and 72 h corn yields were reduced 18, 22, and 32% at a low N fertilizer level. At a high N level, these reductions ranged from 19 to 14% one year and <5% in another year (Ritter and Beer, 1969). When corn at a height of 30 inches was flooded for 24 and 96 h, yields were reduced 14 to 30%. With a high level of N in the soil, very little yield reduction occurred even with 96 h of flooding. When flooded near silking, no reduction in yield occurred at a high N level, but yield reductions up to 16% occurred with 96 h of flooding at the low level of N.

Mud and sediment caking leaves and stalks could damage plant tissue and allow development of fungal and bacterial diseases not typically seen. Due to early season stress the plant may be predisposed to root and stalk rots later and harvest timing of fields may need to be adjusted accordingly. A disease problem that may become greater due to flooding and cool temperatures is crazy top, a fungus that depends upon saturated soil conditions to infect corn seedlings. With warmer, wet or humid conditions Pythium can reduce stands despite fungicide seed treatments. There is limited hybrid resistance to these diseases and predicting damage is difficult until later in the growing season.

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