A PHOTOSYNTHETIC STRESS - TRANSLOCATION BALANCE CONCEPT RELEVANT TO STALK ROT OF CORN

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I. Stalk rot of corn is associated with several pathogens, host and environmental variables.

A. Pathogens

1. many species found in rotten stalks (2,24,48,52).
2. isolates often are "virulent" in specific geographic areas or during certain years (29,56).
3. most isolated species have cellulolytic and pectolytic enzymes capable of digesting cellulose and lignin in corn (2,6,9).
4. all are ubiquitous, soil inhabiting organisms.
5. populations of these soil organisms increase in the soil as plants approach maturity, especially near "susceptible" genotypes (22).
6. none are aggressive pathogens of vigorous host cells.

B. Hosts

1. can be almost any genotype.
2. development of rot is correlated with pith cell senescence (4,16, 26,34,43,45).
   a. pith cells senesce in upper internodes first (8,26,45).
   b. stalk rot "susceptible" genotypes senesce more rapidly than "resistant" genotypes (4,11,34,45).
   c. rate of senescence is correlated with reduction in concentration of reducing sugars (11,12,39).
   d. root and leaf injury increases rate of senescence in stalk pith cells (17,43,44).
   e. senescent cells no longer have fungi static compounds (5).
3. destruction of leaf tissue increase amount of stalk rot (17,43)
4. high yielding hybrids or inbreds tend to have more stalk rot.
   a. barren plants rarely have stalk rot (38).
   b. artificially decreasing grain fill reduces amount of stalk rot (7,36).
   c. inbreds with poor silking emergence often have good stalk rot "resistance".
5. a sudden increase of pH in corn stalks occurs earliest in susceptible genotypes. Living cells have a pH of 5-6 but this suddenly changes to 8, presumedly with death of the pith tissue (30).
6. plants with rotten stalks almost always have rotted roots also (20,51).
7. resistance studies show complex inheritance (28).

C. Environment

1. Higher incidences of stalk rot are associated with:
   a. high plant populations (38,54)
   b. droughts (10).
   c. wet August and September weather (10,13,50).
   d. early frosts.
   e. high nitrogen, low potassium, fertilizer ratio (1,23,46).
   f. high or low soil pH - affects mineral uptake (25).
   g. cloudy weather.
   h. artificial shading.

Cont. Page 2

II. All or most of these associated phenomena are consistent with a photosynthetic stress - translocation balance concept: When a corn plant has less than normal photosynthesis during the grain filling period, the resulting carbohydrate shortage causes a lowered grain-fill and/or an increase in the rate of senescence in root and lower stalk cells. If the senescence occurs before or shortly after completion of grain-fill, stalk rotting fungi will decay the roots and the stalk. The senescence, therefore, is dependent upon two main variables: the amount of photosynthate produced and the translocation of the photosynthates.

A. Photosynthesis in corn

1. Photosynthetic rate is directly related to light intensity.

a. corn is a C_4 plant.

b. CO_2 is not generally a limiting factor in the field (41).

c. P.R. increases with light intensities up to 10,000 ft. candles. (40,41,3)

d. the high population - increased stalk rot relationship is mostly caused by shading (14,37).

e. cloudiness represents reduced light and therefore reduced photosynthesis (41).

2. Photosynthetic rate is also reduced by:

a. moisture stress (41).

b. destruction of leaf tissue (diseases, frost, leaf removal).

c. potassium deficiency (15).

B. Translocation in corn

1. directed by cytokinins produced in roots, meristems, and embryos.

2. before pollination, carbohydrates flow from leaf into stalk, root, and newest leaves (19).

3. with embryo formation, carbohydrates flow into grain and roots (?). Reducing the number of embryos by interfering with pollination reduces total amount to ear.

4. varieties with low yields under shade conditions often are slow to silk under shade (42).

III. Each plant in a field has slightly different environments. If all the plants are under photosynthetic stress during the season because of high plant population, unusually cloudy weather, fertilizer imbalance, or moisture stress, the slight disadvantage of certain plants, because of slow or weak emergence, or fertilizer dispersion or unequal plant distribution may cause senescence of roots before completion of grain fill. Some genotypes, however, will probably have reduced yield, but no early senescence. Saprophytic fungi quickly invade and decay the senescing root or stalk cells if the temperature requirements for the isolate are adequate. Destruction of root cells and plugging of xylem vessels results in the sudden wilting symptom commonly referred to as premature dying. Given adequate environment for the fungal growth and sufficient time before harvest, the pith of the stalk will be destroyed and the rind will begin decaying. The strength and/or flexibility of the rind, the size of ear, the height of the ear, and the wind now determine whether the stalk lodges.

IV. Genotype variations in stalk rot resistance can be determined, therefore, by photosynthetic, or possibly total energy, efficiency and by translocation patterns. If photosynthetic efficiency is improved by selection methods, theoretically the plant should be able to withstand photosynthetic stresses without reductions in yield or increases in stalk rot. If photosynthetic efficiency is not improved, then stalk rot resistance must come from the change in translocation pattern to the root and therefore, with some reduction in grain yield when photosynthetic stresses are present. Most plant breeders will opt for improvement of photosynthetic efficiency if adequate methods are devised.

Cont. Page 3

V. Stalk Rot studies, stalk rot resistance evaluations, and breeding selections must consider the relationships between photosynthetic stress and translocation patterns if meaningful, practical improvement of stalk rot resistance in corn will be made.

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See next page

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See next page

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See next page

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