

PATTERNS OF CELL DEATH IN ELONGATING CORN STALKS

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ABSTRACT.—The rate of elongation of the 10 internodes above the uppermost brace roots in six inbred lines of corn (B2, B14, C103, R130, 38-11, and Os420) was not related to the pattern of cell death in the internodes. In general, death of cells in the pith tissue occurred in upper internodes earlier than in lower internodes. Death of cells in the lower internodes occurred earlier and in greater numbers in stalk rot susceptible than in stalk rot resistant lines.

Recent studies have indicated that the nature of resistance to spread of *Diplodia zeae* (Schw.) Lev. and *Gibberella zeae* (Schw.) Petch in stalk tissue of corn is related to the death of cells in stalk tissue (Pappelis, 1965; Pappelis and Smith, 1963). All varieties of corn appear to be resistant to naturally occurring stalk rot prior to silking but differ greatly in the time they become susceptible after that time (Koehler, 1960). Michaelson (1957) has indicated that some varieties are susceptible to stalk rot if inoculated prior to silking. Pappelis (1965) recently demonstrated that the death patterns in inbred lines varied greatly and that death of cells in the lower internodes occurred in stalk rot susceptible lines earlier than in resistant lines. The study was conducted after all internodes had elongated. The purpose of the present study was to determine when cells of the lower internodes died, especially in relation to stalk elongation.

Materials and Methods.—Six inbred lines of corn were planted May 21, 1962, in a three-replicate experiment on the Southern Illinois University Agronomy Farm, Carbondale. Plants were grown one foot apart in rows 13 feet long. Each variety subplot consisted of 10 rows with 40 inches between rows. The height measurements of the 10 internodes were made for internodes above the ground in young plants and inter-

nodes above the uppermost brace roots in elongated stalks. Internode death patterns were determined by cutting the stalks longitudinally through the central axis and rating the 10 internodes with the following system: 0.0, no dead cells in the internode surface appearing white or fluffy; 0.1, less than 1% of the surface showing dead cells; 0.5, 2-12% dead; 1.0, 13 to 25%; 2.0, 26 to 50%; 3.0, 51 to 75%; 4.0, 76 to 100%; 5.0, as 4.0 with dead cells in the internode linking the areas of dead cells with those in the lower internode; and 6, like 5 with plant dead.

Results and Discussion.—In general, elongation of the 10 internodes in the stalks of all six varieties occurred before late July. The patterns of cell death in the six varieties were similar in that the death of most of the cells occurred in the middle internodes of the stalk, followed by rapid death of cells in the elongating upper internodes. The greatest differences between the six inbreds appeared to be the time when extensive areas of cell death were observed in the first internode.

The cell death patterns for each inbred are presented in Table 1. In B2, dead cells were first observed in the third, fourth, and fifth internodes when only 6 internodes had elongated. The 10 internodes at that time had reached about one-half of the maximum height.

Similarly, dead cells were observed in the stalk of B14, C103, 38-11 after the 10 internodes had elongated to one-half their height. In R130, dead cells were not observed until the 10 internodes had elongated to over one-half the height, while in Os420, this had occurred as soon as the lower three internodes had elongated to about one-quarter of the height that the 10 internodes would achieve.

With regard to death of cells in the first internode, the most rapid rate of death was noted for Os420 and the least

TABLE 1.—Pith condition ratings and height of ten internodes of corn inbreds B2, B.14, C103, 38-11, and Os420; 1962, 3 replicates, 5 plants per replicate per sample date.

Date	Internode										Height (inches)
	1	2	3	4	5	6	7	8	9	10	
Inbred B2											
7-6....	0.0	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	0.0	0.0	8
7-13...	0.0	0.0	0.3	0.3	0.1	0.0	0.0 ¹	0.0	0.0	0.0	20
7-20...	0.0	0.5	2.3	3.0	2.7	2.2	1.3	0.5	0.1	0.0 ¹	30
7-27...	0.1	1.1	2.8	3.4	3.4	3.2	2.9	2.4	2.1	1.7	37
8-3....	0.8	1.7	2.9	3.4	3.4	3.4	3.2	3.1	2.9	2.5	37
8-10...	0.6	1.6	3.3	3.9	4.0	4.0	3.9	3.7	3.4	3.3	38
8-17...	1.1	2.9	3.5	3.8	3.9	3.9	3.8	3.7	3.6	3.6	.....
8-23...	0.7	2.0	3.1	3.9	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-30...	1.5	2.9	3.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
9-6....	1.1	2.3	3.5	3.9	4.0	4.0	4.0	4.0	4.0	4.0	.....
Inbred B14											
7-6....	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	0.0	0.0	0.0	9
7-13...	0.0	0.2	0.1	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	20
7-20...	0.0	1.2	2.7	3.5	3.1	2.7	2.0	1.2	0.5 ¹	0.2	31
7-27...	0.0	1.3	3.1	3.7	3.8	3.7	3.5	3.4	3.0	2.5	38
8-3....	0.0	1.7	3.3	3.8	4.0	4.0	4.0	4.0	3.9	3.8	37
8-10...	0.1	1.6	3.4	3.9	4.0	4.0	4.0	4.0	4.0	4.0	38
8-17...	2.2	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-23...	1.9	3.3	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-30...	3.0	3.6	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
9-6....	2.1	3.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
Inbred C103											
7-6....	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	0.0	0.0	0.0	12
7-13...	0.0	0.0	0.1	0.3	0.0	0.0 ¹	0.0	0.0	0.0	0.0	24
7-20...	0.0	0.4	1.8	3.0	2.9	2.3	1.3	0.7	0.1	0.0 ¹	37
7-27...	0.3	1.5	2.2	3.3	3.2	3.4	3.4	3.0	2.3	1.9	44
8-3....	0.0	0.3	1.8	3.3	3.6	3.8	3.9	3.7	3.6	2.9	46
8-10...	0.2	1.3	2.3	3.2	3.6	3.9	4.0	4.0	4.0	4.0	47
8-17...	1.3	2.0	2.7	3.4	3.8	4.0	4.0	4.0	4.0	4.0	.....
8-23...	2.2	3.2	3.7	3.9	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-30...	3.6	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	.....
9-6....	3.6	4.0	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	.....

¹ This and the upper internodes not elongated more than 1 inch.

TABLE 1.—Continued.

TABLE 1. Continued.

Date	Internode										Height (inches)
	1	2	3	4	5	6	7	8	9	10	
Inbred R130											
7-6....	0.0	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	0.0	0.0	11
7-13...	0.0	0.0	0.0	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	25
7-20...	0.0	0.0	0.4	0.5	0.4	0.1	0.0	0.0	0.0	0.0 ¹	40
7-27...	0.0	0.5	1.9	2.5	2.4	2.1	1.6	1.0	0.7	0.5	45
8-3....	0.0	0.5	2.1	2.6	2.6	2.6	2.7	2.3	2.0	1.7	51
8-10...	0.3	1.1	2.3	3.0	3.0	2.9	2.7	2.5	2.3	2.2	48
8-17...	0.6	2.0	2.7	3.2	3.5	3.6	3.6	3.6	3.6	3.7	.....
8-23...	0.6	2.3	3.3	3.5	3.6	3.7	3.7	3.7	3.7	3.7	.....
8-30...	2.0	2.7	3.0	3.1	3.4	3.4	3.3	3.3	3.4	3.4	.....
9-6....	2.2	2.8	3.4	3.6	3.6	3.5	3.6	3.7	3.8	3.8	.....
Inbred 38-11											
7-6....	0.0	0.0	0.0	0.0 ¹	0.0	0.0	0.0	0.0	0.0	0.0	12
7-13...	0.0	0.6	0.7	0.1	0.0 ¹	0.0	0.0	0.0	0.0	0.0	19
7-20...	1.7	2.9	3.5	3.5	2.9	1.6	0.4	0.0	0.0 ¹	0.0	32
7-27...	1.8	3.0	3.6	3.6	3.5	3.1	2.4	1.7	1.0	0.7	39
8-3....	2.3	3.4	3.9	4.0	4.0	4.0	3.8	3.5	3.0	2.8	42
8-10...	2.7	3.5	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	41
8-17...	3.1	3.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-23...	3.7	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-30...	4.0	4.1	4.1	4.0	4.0	4.0	4.0	4.0	4.1	4.1	.....
9-6....	4.0	4.0	4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
Inbred Os420											
7-6....	0.1	0.3	0.2	0.0 ¹	0.0	0.0	0.0	0.0	0.0	0.0	11
7-13...	1.7	3.0	2.3	1.2	0.4	0.1 ¹	0.0	0.0	0.0	0.0	21
7-20...	2.3	3.6	3.8	3.9	3.7	3.2	2.7	1.9	1.1	0.8	39
7-27...	2.9	3.8	3.9	4.0	4.0	4.0	3.7	3.5	3.4	2.5	48
8-3....	2.7	3.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.9	44
8-10...	3.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	45
8-17...	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	.....
8-23...	3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.....
8-30...	4.6	4.6	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	.....
9-6....	4.7	4.7	4.5	4.4	4.4	4.5	4.5	4.6	4.7	4.7	.....

rapid for B2. On 3 August, the varieties could be grouped according to the amounts of dead cells in the first internode as follows: R130, B14, and C103 rating 0.0; B2 rating 0.8; and 38-11 and 0s420 rating about 2.5. On 23 August the grouping would be: R130 and B2 lowest with ratings about 0.5; B14 and C103 rating about 2.0; and 38-11 and 0s420 rating about 3.8. On 6 September, the varieties would be grouped as follows: B2 lowest with a rating of 1.1; B14 and R130 rating about 2.1; C103 and 38-11 rating about 3.8; and 0s420 rating 4.7.

The internodes in which cell death in the pith tissue apparently occurred first differed in the varieties: in the first through third internodes in 0s420; second and third in 38-11 and B14; third and fourth in C103; third through fifth in B2; and third through sixth in R130. When fully elongated and ears formed, there was no relationship between cell death patterns in internodes and the location of the ears (0s420, two ears generally at internodes 5 and 6; B2 and B14, one ear generally at 6; C103, one ear generally at 7; 38-11, two ears generally at 7 and 8; and R130, one ear generally at 8). The fastest rate of cell death indicated by the change in rating in all varieties appeared in the fourth through sixth internodes after mid-July. The pattern of cell death in pith tissue of the nodes did not occur in a similar pattern in the three lines in which this was observed; 38-11, C103, and 0s420.

The trait of cell death in pith tissue appears to be uniform in the plants of each inbred and confirms the earlier work of Pappelis (1965) indicating wide

differences in the patterns in susceptible and resistant inbreds. From these studies, it now appears likely that cell death patterns may prove helpful in detecting stalk rot susceptibility at a very early stage of stalk development. This should be helpful in genetic studies on the nature of stalk rot resistance in which the characteristic patterns of cell death in inbreds can be studied in various genetic combinations.

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