EFFECT OF SEEDING DATE OF WINTER WHEAT ON INCIDENCE, SEVERITY AND YIELD LOSS DUE TO CEPHALOSPORIUM STRIPE

by

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INTRODUCTION

Cephalosporium stripe (Cs) of winter wheat (Triticum aestivum L.) is a severe systemic disease caused by the soilborne fungus Cephalosporium gramineum Nisikado & Ikata (= Hymenula cerealis Ell. and Ev.) (Cg). Cs is widely distributed in the United States (8) and can be a yield reducing factor in a continuous cropping system (2) or under summer fallow conditions (4). First reported in Kansas in 1972 (18), Cs has increased in importance so that there has been an estimated 136 million kg loss each year from 1976 through 1981 (15).

The most effective controls for Cs are crop rotation (4,7) and the proper management of residue (2). Although effective levels of resistance to Cs have been reported (10,11), there are currently no popular commercial cultivars in Kansas with high levels of resistance. No chemicals are registered for Cs control.

Another reported control for Cs is delayed fall planting. Bruehl (4), working in Washington, stated that losses due to Cs were more severe in early seeding date trials as a result of increases in percentage Cg infection. He observed more severe stunting and more complete systemic invasion of the host plant in infected early-seeded plants. Likewise, Pool and Sharp (14), demonstrated that early fall planting in Montana allowed for the development of a more extensive root system which resulted in higher Cs incidences than late plantings. The higher incidence of Cs was due to higher average soil temperatures 14 days after seeding which they hypothesized provided more potential infection sites as a result of root injury causing during soil heaving (1,4) and root freezing (1). In a 4-yr study conducted in Michigan, Wiese and Ravenscroft (17) also reported reduced Cs incidence in late planted winter wheat.

This study was undertaken to determine the effects of delayed seeding of winter wheat on: 1) incidence of Cs under Kansas conditions; ii) yield loss due to Cs; iii) crop yield potential in the absence of Cs; iv) resistance reaction of cultivars to Cs; v) the effect of Cs on host ontogeny; and, vi) the rate and degree of systemic spread of Cg in infected tillers.

MATERIALS AND METHODS

A 2-yr field experiment was conducted at Rocky Ford Experiment Field near Manhattan, KS, in a Chase silty clay loam soil (pH = 6.2) which had not been cultivated to wheat for 2 yr and was not infested with Cg. Four planting dates were staggered 2 wk apart in both years, beginning at the end of September and finishing during the first week of November.

For the 1980-81 season, three hard red winter wheat cultivars were selected based upon their agronomic characteristics and host reaction to Cs: 'Sturdy' (CI13684), an early maturing semidwarf cultivar highly susceptible to Cs; 'Newton' (CI17715), a medium maturing semidwarf grown extensively in Kansas for its soilborne wheat mosaic virus resistance, moderately susceptible to Cs; and CC1078-4, a tall, late maturing breeding line with a relatively low susceptibility to Cs.

Inoculum consisted of autoclaved oat kernels infested with six isolates of Cg (9). Twenty grams of inoculum were mixed with 7.8 g of wheat seed at the time of planting and introduced into the furrow. An equal amount of autoclaved oats not colonized by Cg was used in control plots.

Experimental design was a randomized split plot with five replications. Each cultivar was hand planted on a given seeding date in single 3.85 m rows with the inoculated treatment paired with the control. Those treatments were separated from each other by single rows on noninoculated wheat, and all rows were spaced 0.3 m apart. The cultivar/planting date made up the main plot while the treatment comprised the subplot.

During the 1981-82 season, the three cultivars used were 'Sturdy', 'Arkan', and Crest Line Row Component (LRC) 40 (MT 7579). Sturdy is susceptible while Arkan and Crest LRC 40 (11) are moderately susceptible to Cs.

The experimental design was a randomized split plot with five replications with the main plot being the treatment (inoculated/control) and the subplot being the planting date and cultivar. Each cultivar was planted in a single row 3.85 m long and separated by single border rows spaced 0.3 m apart. The inoculum consisted of 5.7 kg of infested oats rototilled to a 10-cm depth in each of five 10 m^2 areas. An equivalent amount of noninfested autoclaved oats was rototilled into the soil in five separate areas to serve as controls.

Infection percentages were estimated in the late spring from heading through flowering [growth stages (gs) 13-18] (16) by counting the number of symptomatic tillers in a population of 50 randomly chosen tillers in each plot.

Observations of disease severity were made every 3 to 4 days on each plot starting at gs 9 and continuing up to harvest. Twenty-five randomly chosen tillers expressing Cs symptoms were tagged at the end of jointing (gs 9) (16) and scored periodically for disease severity based upon the degree of systemic symptom expression caused by the pathogen (3). Since this system of measuring disease severity utilizes only infected tillers, the severity score has been termed systemic spread index (SSI).

The effect of planting date and Cs infection upon host ontogeny was assessed by estimating the gs (16) of each plot every 3 to 4 days. All plots were hand harvested when mature and yields adjusted to 12% moisture. Heavy rain and hail shortly before harvest prevented yield determinations for the 1981-82 season. Yield loss was calculated by subtracting the yield of a given cultivar/planting date from the approximate control yield and represented as a percentage.

RESULTS

During the 1980-81 season, infection percentages did not differ among planting dates (Table 1). However, a significant decrease in percentage infection was observed with delayed fall planting during the 1981-82 season (Table 2).

The presence of Cg significantly reduced yields relative to non-inoculated treatments; however, the percentage yield reduction for each planting was not significantly different (Table 3).

During the 1980-81 season, the yield of the noninoculated plots for the 3 November planting date was severely reduced relative to the yields of earlier planting dates (Table 3). Combining the three cultivars, an average 13.7% yield reduction resulted for every week delay in planting past the optimum planting date (7 October). The highest yields for the

Table 1. Influence of planting date on percentage infection of winter wheat by *Cephalosporium gramineum*, 1980-81.

	Percentage infection[x]			
	Cultivar			
Planting date	Sturdy	Newton	CC1078-4	Mean
September 23	69.2 a[y]	56.0 abc	29.2 c	51.5 d[z]
October 7	63.6 ab	45.2 ab	42.4 abc	50.4 d
October 21	69.6 a	36.4 bc	31.2 c	45.7 d
November 3	79.8 a	45.6 ab	33.6 bc	50.0 d
Mean	68.3 e[z]	45.8 f	34.1 g	

[x]Percent infection estimated from heading to flowering.

[y]Values with the same letter are not significantly different (P=0.05) using Duncan's multiple range test.

[z]Row and column means followed by the same letter are not significantly (P=0.05) different according to Duncan's multiple range test.

Table 2. Influence of date of planting on percentage infection of winter wheat by *Cephalosporium gramineum*, 1981-82.

	Percentage infection[x]			
	Cultivar			
Planting date	Sturdy	Arkan	CLR40	Mean
September 27	99.6 a[y]	96.4 ab	85.2 cd	93.7 a[z]
October 12	98.0 a	89.2 bcd	82.4 d	89.9 a
October 26	91.6 a	79.8 e	69.2 e	77.2 b
November 4	69.2 e	62.4 ef	58.8 f	63.5 c
Mean	89.6 g[z]	79.7 h	73.9 i	

[x]Percent infection estimated from heading to flowering.

[y]Values with the same letter are not significantly different (P=0.05) using Duncan's multiple range test.

[z]Row and column means followed by the same letter are not significantly different (P=0.05) using Duncan's multiple range test.

Table 3. Influence of planting date and Cephalosporium gramineum inoculated on winter wheat yield, 1980-81

		Yield[w]				
		Cultivar				Yield
Planting date	Treatment	Sturdy	Newton	CC1078-4	Mean	reduction (%)
September 23	Control	242 b[x]	486 b	393 a	374 ab	
	Inoculated	109 cd	264 cd	203 bc	192 c	49 a
October 7	Control	375 a	506 a	428 a	436 a	
	Inoculated	63 d	222 cd	182 b	155 c	64 a
October 21	Control	472 a	307 bc	277 b	352 b	
	Inoculated	42 d	153 de	201 bc	132 cd	62 a
November 3	Control	184 bc	138 e	271 b	198 c	
	Inoculated	15 d	56 e	122 c	64 d	67 a

[w]Average yield for five replicates in g/plot.

[x]Values within a column followed by the same letter are not significantly different ($\underline{P}$=0.05) using Duncan's multiple range test.

inoculated plots came from the earliest planting date (23 September) with an 11.1% reduction in yield for each week delay in planting past that date (Table 3).

In neither year did delayed seeding significantly change cultivar reaction to Cs with respect to percentage infection and the ranking of cultivars remained the same (Tables 1 and 2).

Date of planting had a marked effect on the growth and development of the host in all plots although only the data for the cultivar Sturdy collected during 1980-81 are presented (Fig. 1). There was a considerable lag in development of late planted wheat compared with early planted wheat so that heading date (gs - 15) was delayed an average of about 3 days for every 2-wk delay in planting (Fig. 1). The inoculated plots exhibited a retardation of growth and development when compared to the control plots of the same planting date from the vegetative stages up to kernel development (gs = 25). This was followed by accelerated maturation of the caryopsis in Cs infected tillers (Fig. 1).

Combining data obtained for all three cultivars during 1980-81, the planting date did not significantly affect the systemic development of symptoms (SSI) (Fig. 2). The small scatter between different planting dates at a particular growth stage supported a hypothesis that they represented one line with a common slope and y-intercept. The alternative hypothesis was tested for and rejected ($\underline{P}$=0.05). Although not presented here, similar data was generated for the 1981-82 season.

DISCUSSION

Delayed planting significantly reduced percentage infection in one

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Fig. 1. Influence of planting date and *Cephalosporium gramineum* inoculation on development and maturation of the winter wheat cultivar Sturdy where growth stage (gs) 15 = heading 95% complete, gs 26 = late milk, gs 29 = late dough, and gs 31 = harvest ripe. Each point is the mean of five replicates.

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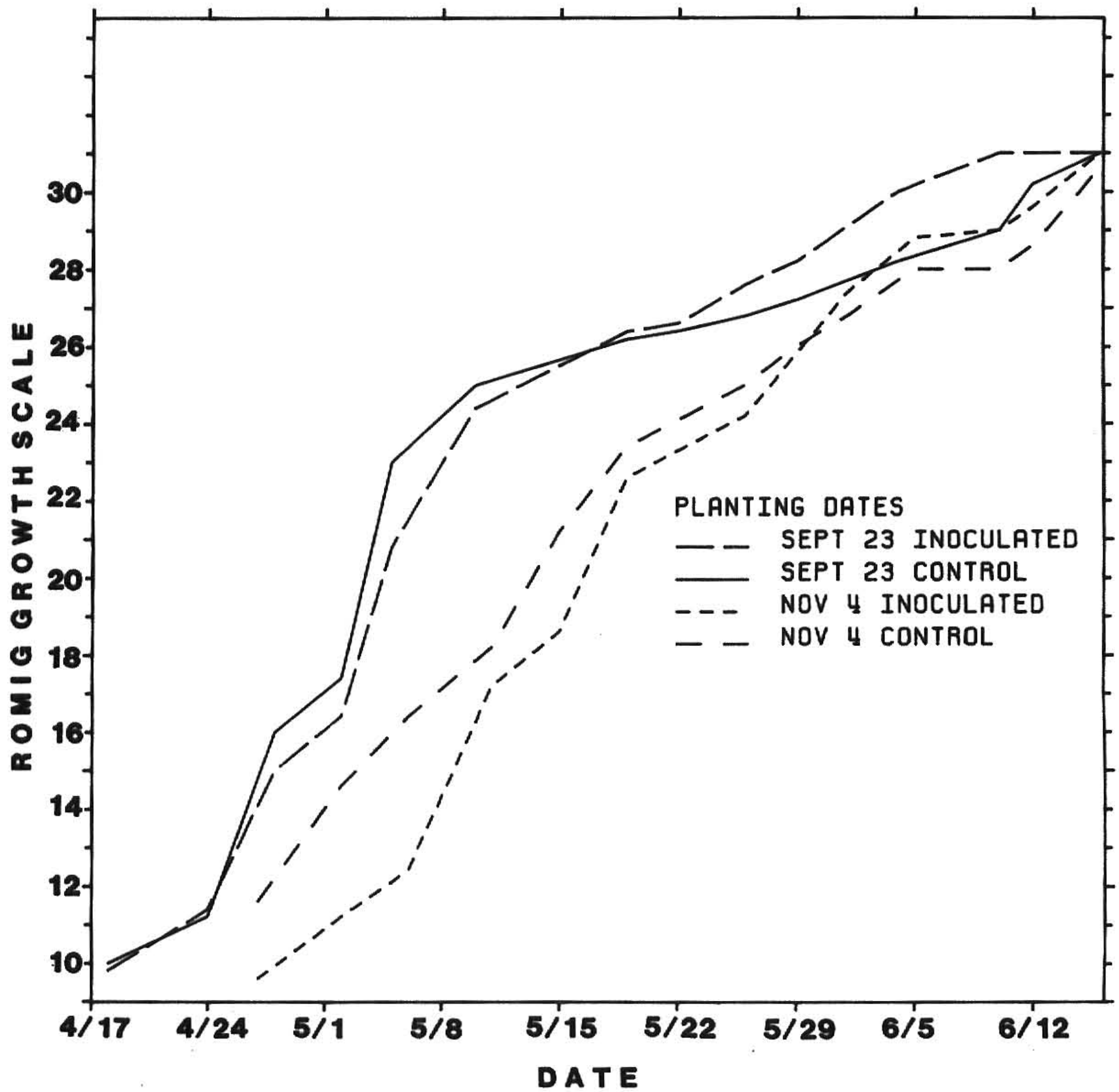
ROMIG GROWTH SCALE
30
28
26
24
22
20
18
16
14
12
10
4/17
4/24
5/1
5/8
5/15
5/22
5/29
6/5
6/12
DATE
PLANTING DATES
SEPT 23 INOCULATED
SEPT 23 CONTROL
NOV 4 INOCULATED
NOV 4 CONTROL

Figure 1.

Fig. 2. Effect of planting date of winter wheat on systemic development of Cephalosporium stripe symptoms at various host growth stages (gs) where gs 15 = heading 95% complete, gs 26 = late milk, gs 29 = late dough, and gs 31 = harvest ripe. Systemic spread index determined by rating the four leaves of infected tillers for symptoms where 4.0 = flag leaves showing symptoms, 3.0 = flag leaf healthy, penultimate leaf showing symptoms, 2.0 = top two leaves healthy, penultimate leaf showing symptoms, 1.0 = top three leaves healthy, fourth leaf showing symptoms, and 0.00 top four leaves healthy. Each observation represents the mean rating from 375 infected tillers.

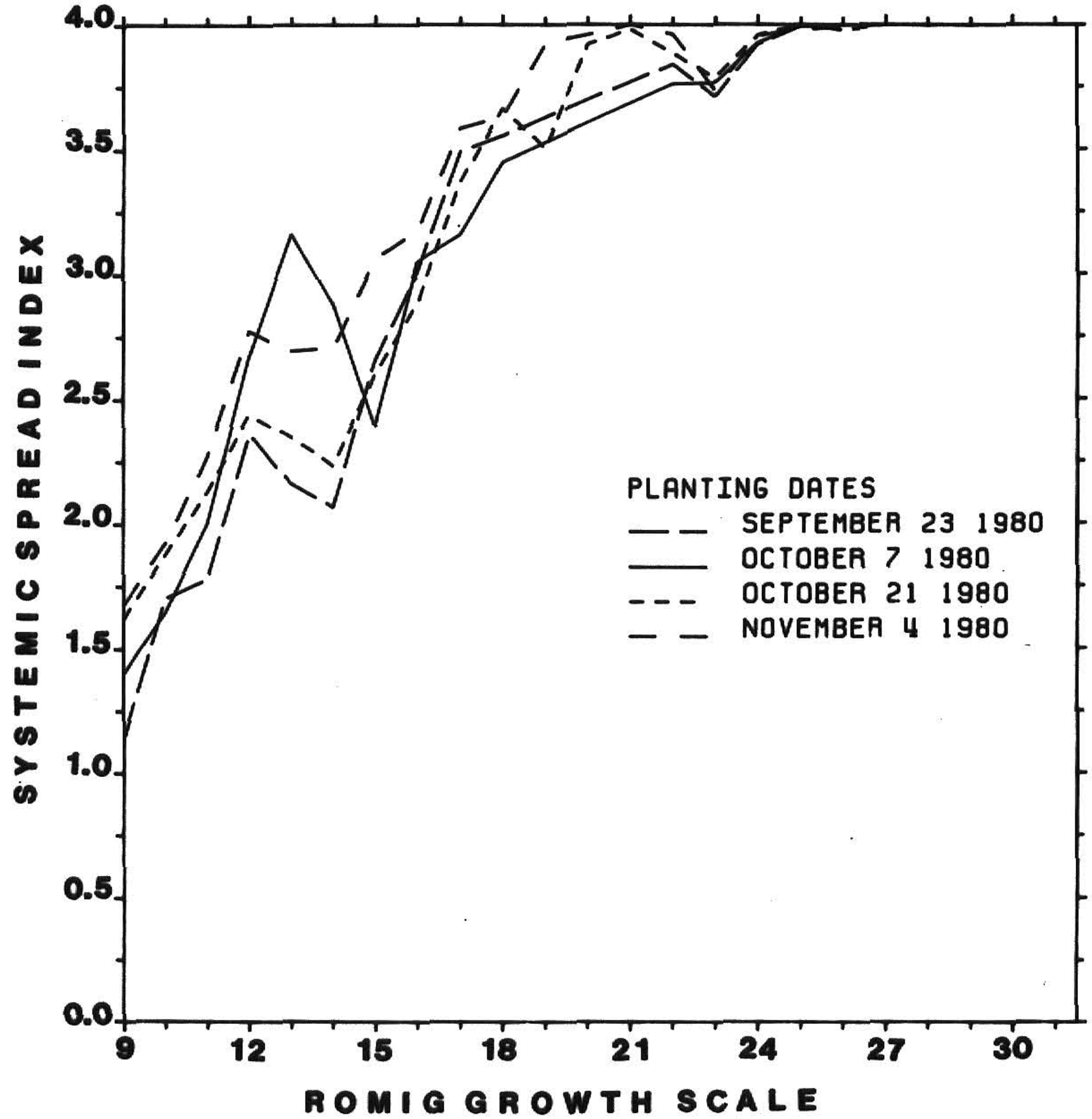
SYSTEMIC SPREAD INDEX
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9
12
15
18
21
24
27
30
ROMIG GROWTH SCALE
PLANTING DATES
SEPTEMBER 23 1980
OCTOBER 7 1980
OCTOBER 21 1980
NOVEMBER 4 1980

Figure 2.

of the 2-yr studied. This reduction has been attributed to reduced root growth associated with cooler soil temperatures in late fall (4). Less growth in the fall could result in a reduction in potential infection sites caused by root breakage during winter or spring soil freezing (14) or root freezing (1).

The planting date of winter wheat greatly affects yield potential under Kansas conditions. Data collected over a 9-yr period at Manhattan, KS, showed an 11% reduction in yield for every week delay past the optimum planting date (6). This is in agreement with work done in Canada where planting date also has a large influence on the performance of winter cereals (5). Results from our study also showed a large (13.7%) loss in yield for every week delay past the optimum planting date. Thus, the benefit of delayed fall planting of winter wheat, for whatever reason, should compensate for the loss in yield associated with this practice. Yield loss due to Cs was not reduced with any of the planting dates for the 1980-81 season (Table 3). Furthermore, in the presence or absence of severe Cs, the highest yield during that year was obtained with the earlier planting dates. Even though a reduction (30.2%) in the percentage of Cs infection was experienced in the 1981-82 season, this reduction would not compensate for the loss in yield potential (54.8%) due to a 4-wk delay in planting past the optimum date. Thus, the decision to delay planting of winter wheat to partially control losses due to Cs is not seen to be as effective in Kansas as it might be in other states (7,14,17).

Nevertheless, successful crop management must take into account other pressures that may limit crop productivity. Hessian fly, Wheat streak mosaic virus and Take-all are examples of diseases where yield losses also are reduced by delayed seeding of winter wheat (16). These and other pests along with Cs in a producer's field may make delayed planting more economical in Kansas than in fields infested with Cg alone.

Since the ranking of cultivar reaction of Cs with respect to percentage infection and yield loss will not change with different planting dates, breeders and plant pathologists screening germplasm for resistance to Cs will not need to consider this.

Results of this study indicate that for investigations involving different planting dates, Cs incidence and/or severity should be collected at the same growth stage and not the same calendar date. Late planting significantly delayed crop maturity with approximately a 3-day delay in heading for each 2-wk delay in planting. Thus, since the extent of systemic spread has been closely linked with host ontogeny and xylem maturation (13), data for Cs incidence and severity will be biased toward later planting dates if collected on the same calendar date.

At all planting dates Cg infection delayed host development until grain maturation where rapid development occurred. This is in agreement with the premature ripening associated with Cs (16) and points to the 'most severe effects of pathogenesis' expressed by Morton et al (12) as reduced carbohydrate synthesis and disrupted transport of assimilates to the caryopsis during the reduced grain filling period. In our study, planting date did not affect the rate of systemic symptom development when observed at particular growth stages, corroborating the correlation of host ontogeny with symptom expression (13). Thus, the benefits of delayed planting with regard to Cs are apparently due to reduced disease incidence and not reduced systemic spread of the pathogen once it has entered the host.

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ABSTRACT

A 2-yr field trial was established to study the effects of delayed planting of winter wheat on Cephalosporium stripe (Cs) incidence, severity, and yield loss. There was a significant reduction in Cs incidence with delayed planting in one of the years; however, in the other year, incidence, disease severity and percentage yield loss due to Cs were not significantly affected. Furthermore, there was a 13.7% yield reduction for noninoculated plots with each week delay beyond the optimum planting date. Thus, in some years under Kansas conditions, reduction in Cs incidence can be expected with delayed seeding, but this benefit is negated by loss of crop yield potential associated with this practice. The influence of planting date on host resistance reaction to Cs, host ontogeny, and rate of systemic symptom expression also were determined.