Relationship Among Seed Size, Planting Date, and Common Root Rot in Hard Red Winter Wheat

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ABSTRACT

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A dryland field study was conducted to determine the effect of seed size and planting date of hard red winter wheat on the severity of common root rot caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker. Seed of cvs. Hawk, TAM 200, TAM 107, Scout 66, and Siouland 89 were separated into three size categories of small, mixed, and large and were planted in the first weeks of September and October 1994 and 1995. Disease ratings for incidence and severity of subcrown internode infections were made in March and at harvest. At harvest, grain yields were collected. In both years of the study, there was no interaction between seed size and cultivars for any of the measured variables. Overall, seed size had no effect on disease severity or grain yield for either year. However, when sorted by planting date, plants from small seed yielded less than plants from other seed. October plantings showed lower disease indices than September plantings at the March evaluation. At the harvest disease evaluation, there were no differences in disease severity between planting dates for the first year but, in the second year of the study, plants from the October planting had lower disease than those from the September planting. There was no significant correlation among seed size, final yield, and disease index. The results of this study suggest that the expense of planting higher-quality certified seed cannot be justified for producing hard red winter wheat in dryland conditions in the Texas Panhandle, considering the current price of wheat and the average dryland yield.

Approximately 2.43 million ha of hard red winter wheat are planted yearly in Texas, 36% of which is planted in the Texas Panhandle (2,20). One of the many diseases affecting the winter wheat crop in Texas is common root rot, caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker. *B. sorokiniana* is a soilborne fungus that infects stems, crowns, and roots of plants, causing infected tissues to become necrotic (1,17). The most obvious symptoms of common root rot appear on the subcrown internode, which becomes dark brown to black when infected. The death of this tissue limits the plant's ability to take up water and nutrients from the soil (9). Infection by *B. sorokiniana* can negatively affect the number of tillers and their ability to produce grain if the plant encounters stress during the tillering to heading stage. Diehl (3), in 1982, estimated that yield losses in winter wheat ranged from 9 to 23% in fields in Brazil. Wildermath reported losses of 6 to 44% for several cultivars tested in Queensland, Australia, and

Verma reported losses of 30, 35, and 30% for 1969, 1970, and 1971, respectively, for spring wheat in Manitou, Canada (22,23).

Although grain is of primary importance, another use of winter wheat in the southwestern United States is as forage for grazing cattle during the late fall and winter. For years, farmers in the Texas Panhandle have planted winter wheat early (August or early September) to produce forage for winter grazing of stocker cattle. In the 1994-95 season, 704,000 ha of wheat were grazed with nearly 900,000 head of cattle in the Panhandle of Texas alone (20). Research conducted by Rush et al. (16) evaluated the effect of differing common root rot levels on forage production and concluded that the disease was not detrimental to production of hard red winter wheat in the Texas Panhandle.

Planting early to maximize forage production raises the question of how this practice affects disease severity and yield of the grain crop. Slykhuis et al. (18) studied planting dates and disease severity for wheat streak mosaic, common root rot, and rust. They found that, in the absence of wheat streak mosaic, the optimum planting dates for winter wheat in southern Alberta were between September 1 and 15. Fenster et al. (4) reported that planting around 10 September was best for reducing disease severity in the Panhandle of Nebraska. Hsi et al. (5) reported that planting winter

wheat in late September and early October was best for maximizing grain yield in the High Plains of eastern New Mexico. Plantings in late August had higher disease severity ratings and more loss to winter kill.

Another factor farmers have to consider when planting wheat is whether to plant cleaned and graded seed or to plant seed from the previous harvest (bin-run seed). Wheat is a self-pollinating crop; therefore, the harvested grain contains the same genetic makeup as the parent. Bin-run seed contains all sizes of seed and may also contain debris and weed seed. The effects of size and quality of wheat seed on agronomic qualities such as early vigor, germination, and yield have been evaluated in the past (10,12,15,21). However, no research has been conducted on the relationship between seed size and common root rot severity in hard red winter wheat. Therefore, a study was initiated with the objective of determining if seed size of hard red winter wheat affected severity of common root rot and whether there was an interaction among planting date, seed size, and common root rot.

MATERIALS AND METHODS

Field plots were located at the Texas Agricultural Experiment Station, Bushland. The field had been planted continuously with wheat for at least 5 years and was naturally infested with *B. sorokiniana*. Five wheat cultivars were used in this study: Scout 66, Siouland 89, TAM 107, TAM 200, and Hawk. These five cultivars of hard red winter wheat have been used in previous studies and found to have different levels of susceptibility to common root rot in the field, with TAM 200 expressing greater susceptibility than Scout 66, Hawk, and Siouland 89 (13,16). Seed of each cultivar were separated into different size categories by using U.S.A. Standard Testing sieves of size numbers 6, 7, 8, and 10, with openings of 3.35, 2.80, 2.36, and 2.00 mm, respectively. The sieves were stacked into a column in order from top to bottom of no. 6, 7, 8, and 10. About 50 g of seed was placed on top of the column and the column was shaken by hand for 20 to 30 s. The seed remaining in the no. 6 sieve were removed and classified as large-size seed. The column was then shaken again for 20 to 30 s and the seed that remained in the no. 7 sieve were discarded. The column was then shaken for an additional 20 to 30

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s and the seed in the no. 8 sieve were discarded. Seed in the no. 10 sieve were removed and classified as small-size seed. Unsieved seed from the same lots of seed used in the sieving process were classified as mixed. Six replications of all seed size-cultivar combinations were planted at two planting dates, using a cone planter, to a planting depth of approximately 4 to 5 cm (1.5 to 2 in.). The plot area was four rows, 4.57 m (15 feet) long with a 30.5-cm (1 foot) row spacing, and 32 g of seed was planted per plot. Planting dates were 6 September and 7 October for 1994 and 12 September and 16 October for 1995. Plots were arranged in a randomized complete block design with a factorial arrangement of treatments within planting date. Before planting, beds were irrigated to guarantee adequate moisture for germination. Approximately 5 weeks after planting, stand counts were taken. Evaluations for disease were conducted in March (MDI) and at harvest (HDI) both years of the study. In March, sampling was conducted by pulling approximately four to five plants having subcrown internodes from each of the four rows in each plot. The samples within a plot were taken at a diagonal from corner to corner. Harvest sampling was accomplished by collecting plants from 50 cm of row in each of the two center rows of a plot. Plants were gently pulled so that the

subcrown internode remained attached, and roots were then washed to remove remaining soil and to expose the subcrown internode for visual inspection. Cleaned internodes were analyzed and graded as previously described (16) on a scale from 0 to 4, with plants rated as 0 having no visible symptoms on the subcrown internode, 1 having up to 25% discoloration, 2 having 26 to 50% discoloration, 3 having 51 to 75% discoloration, and 4 having more than 76% discoloration. A disease index (DI) was then calculated using the rating system described by Ledingham et al. (11). After samples for disease determination were taken, plots were harvested using a small-plot combine, and grain weight per plot was determined.

Data were analyzed by analysis of variance and significant treatment differences were separated by Duncan's multiple range test for each dependent variable. If an interaction was found between two dependent variables, data were sorted by these variables and analyzed for mean separation. Yield and yield components also were correlated to seed size and disease index and Pearson's correlation coefficients were evaluated for significance.

RESULTS

Due to severe disease pressure by *Wheat streak mosaic virus* (WSMV) and high

plains disease (HPD) in plots planted in September, plot yields were not determined for the September planting in the 1994–1995 season. Outside sources of stress were different during the 2 years of the study; therefore, data were analyzed separately by year. Analysis of variance for all variables analyzed for the 1994–1995 and 1995–96 growing seasons is summarized in Tables 1 and 2, respectively.

Seed size categories. Weights of seed among each size category were significantly different. The average 100-seed weight for the three seed sizes were 1.6, 2.9, and 3.8 g for small, mixed, and large, respectively, in 1994 and 1.5, 2.5, and 3.4 g for small, mixed, and large, respectively, in 1995.

1994–95 season. Plots sown with small seed had the greatest number of plants and October sowings had denser stands than September sowings.

Regardless of seed size, common root rot was more severe in the September planting than in the October planting (Table 3). Seed size had no effect on HDI at both planting dates; however, planting date had a significant effect (Table 1).

1995–96 season. A drought began in October 1995 and lasted until June 1996. By March 1996, it was necessary to furrow irrigate the plants to keep them alive. Seed size and planting dates had a significant effect on stand counts and a seed size-planting date interaction was found (Table 2). In September, there were no significant differences among seed sizes (Table 4). In October, wheat grown from small seed had higher stand counts than that grown from mixed and large seed (Table 4) and, in every case, the October planting had higher stand counts than the September planting.

Seed size had no effect on MDI or HDI. Planting date did have a significant effect, but no interaction between seed size and planting date was found for MDI or HDI (Tables 2 and 3). As in the 1994–95 growing season, the September planting had significantly higher MDI than the October planting, regardless of seed size.

Overall seed size did not have a significant effect on grain yield. However, there was an interaction between planting date and seed size and planting date and cultivars (Table 2). Grain yields from wheat planted in October from large seed had the highest yield, which was 105 g (18%) more than wheat planted from small seed (Table 5).

No significant correlation was found among yield, seed size, planting date, and DI for either growing season.

DISCUSSION

Previous research on seed size has dealt mostly with the agronomic characteristics of growth and final yield. Main and Nafziger (12) found that there was no interaction between seed size and water stress with regard to germination. In this study,

Table 1. Analysis of variance (ANOVA) for the 1994–95 growing season for stand count, March disease index (MDI), harvest disease index, (HDI) and yield^v

	Stand count ^w	MDI	HDI	Yield
Planting date ^x	***	***	***	...
Cultivar ^y	**	***	**	**
Seed size ^z	***	NS	NS	NS
Replication	NS	NS	NS	NS
Seed size × planting date	***	**	NS	...
Seed size × cultivar	NS	NS	NS	NS
Planting date × cultivar	NS	***	NS	...

^v **, *** = Significant differences at $P = 0.05$ and 0.01 respectively; NS = nonsignificant differences; ... = not applicable.

^w Number of plants per meter length of row.

^x September and October. ANOVA for yield is for is for the September planting only.

^y Scout 66, Siouxland 89, TAM 107, TAM 200, and Hawk.

^z Small, mixed, and large seed. Small seed stayed above a no. 10 sieve but passed through a no. 8 sieve, mixed seed were not sieved, and large seed were seed that stayed above a no. 6 sieve.

Table 2. Analysis of variance for the 1995–1996 growing season for stand count, March disease index (MDI), harvest disease index (HDI), and yield^v

	Stand count ^w	MDI	HDI	Yield
Planting date ^x	***	***	***	***
Cultivar ^y	**	***	**	**
Seed size ^z	***	NS	NS	NS
Replication	NS	NS	NS	NS
Seed size × planting date	***	**	NS	***
Seed size × cultivar	NS	NS	NS	NS
Planting date × cultivar	NS	***	NS	***

^v **, *** = Significant differences at $P = 0.05$ and 0.01 respectively; NS = nonsignificant differences.

^w Number of plants per meter length of row.

^x September and October.

^y Scout 66, Siouxland 89, TAM 107, TAM 200, and Hawk.

^z Small, mixed, and large seed. Small seed stayed above a no. 10 sieve but passed through a no. 8 sieve, mixed seed were not sieved, and large seed were seed that stayed above a no. 6 sieve.

during the 1994–95 season, small-seed plots always had a higher stand count than large-seed plots (Table 4). However, this was due to the fact that planting was done by weight of seed per plot instead of number of seed per plot and the ratio of the number of small seed planted to large seed planted was between 1.9 and 2.5 to 1.0. Planting by weight is a standard practice in the Texas Panhandle and typical planting rates range from 65 to 100 kg ha⁻¹ (60 to 90 lb acre⁻¹). Even when planting is on a volume basis (bushels acre⁻¹), a 60-lb bushel is assumed. In the 1995–96 season, only stand counts from the October planting of small seed were significantly greater than the stand counts from large seed. The fact that stand counts were lower overall as compared to the previous year was probably due to the severe drought that began in October 1995. However, this does not fully explain why seed size did not influence stands, even though plots receiving small seed were planted with almost twice the seed per plot as those receiving large seed. These results suggest that, under adverse environmental conditions, small seed do not emerge as well as larger seed. In most years, it is unlikely that many farms in the Panhandle of Texas have optimum conditions for growing wheat. Furthermore, it is generally accepted that, in the Texas Panhandle, October planting is more conducive for grain production than planting in September (24).

Several studies (6–8,19) have been conducted in which seed size had no effect on final yield measurements when plots were planted by seed weight. Seed size did not show any effects on plot yield in the 1994–95 and 1995–96 seasons (Tables 1 and 2). However, in both years, yield from large seed was significantly higher than yield from small seed, but no different from the yield from mixed seed at the October planting. These results support previous reports (7,8,19) with regard to seed size and final yield.

The main objective of this study was to determine the effect of seed size on disease severity of common root rot in the field. When MDI was analyzed for seed size effects in the 1994–95 and 1995–96 seasons, we found no consistent differences (Table 3). Furthermore, HDI was unaffected by seed size in either season. The fact that there was no significant correlation between seed size and disease severity supports the conclusion that seed size had minimal effect on disease severity in this study. Furthermore, even though MDI values for large and small seed were different in 1995, the differences probably were not biologically significant to yield (14).

DIs showed large differences between planting dates in both years of the study, with plants from the September planting having a higher DI than plants from the October planting (Table 3). The fact that

differences in disease severity were not present at the harvest evaluation but were present at the March evaluation suggests that, when trying to identify a seed treatment effect on disease severity, one should evaluate for disease differences not later than jointing.

With regard to seed size, effects on disease or yield are dependent on planting date. For both years of this study, the October planting from large seed yielded significantly more than the planting from small seed (Table 3). However, seed size did not consistently affect disease severity. In fact, when evaluating the effects of seed size on common root rot severity, disease ratings of plants from different size seed usually were not significant, and the significant differences that were observed probably were not biologically significant because they had no correlation with yield. This conclusion is supported by the similar response of the five cultivars analyzed in this study at two planting dates and for two consecutive growing seasons.

The Texas panhandle has an average dryland wheat yield of approximately 1 Mg ha⁻¹ (15 to 18 bushels acre⁻¹) (20) and the selling price of wheat for the last few years has been around \$2.00/bushel. In this scenario, growers gross about \$30/acre. The cost of certified seed is approximately \$9.00 per 60-lb bushel and, at a seeding rate of 90 lb/acre, typical for an October planting (24), the cost of certified seed (\$13.00 to 14.00/acre) is not economical for growers, when they can acquire cleaned noncertified seed or “bin-run seed” for about \$4.00/bushel. Therefore, because there is no consistent effect of seed size on common root rot or yield, the expense of planting higher-quality certified seed cannot be justified for hard red winter wheat dryland production in the Texas Panhandle. This conclusion is supported by previous studies that showed common root rot severity was not related to drought tolerance or yield of several wheat cultivars grown in the Texas Panhandle (14) and that it had no detrimental effect on wheat forage production (16).

Table 3. Effect of planting date on March disease indices by planting date in the 1994–95 and 1995–96 growing season for all cultivars combined^y

Seed size ^z	1994–95		1995–96	
	September	October	September	October
Small	2.0 A a	1.4 A b	2.3 A a	1.2 A b
Mixed	1.8 A a	1.4 A b	2.3 A a	1.1 A b
Large	1.8 A a	1.1 A b	2.3 A a	1.2 A b

^y Disease indices are for samples collected in March. Approximately 20 subcrown internodes from each plot were rated. Index range is from 0 to 4, with 0 being clean and 4 having from 75 to 100% discoloration. Means within a growing season followed by the same uppercase letter within a column are not statistically different. Means followed by the same lowercase letter within a row of a growing season are not statistically different.

^z Small seed stayed above a no. 10 sieve but passed through a no. 8 sieve, mixed seed were not sieved, and large seed were seed that stayed above a no. 6 sieve.

Table 4. Effects of planting date on stand counts by seed size in the 1994–95 and 1995–96 growing seasons for all five cultivars combined^y

Seed size ^z	1994–95		1995–96	
	September	October	September	October
Small	45.0 A b	79.6 A a	21 A b	41 A a
Mixed	32.9 B b	56.1 B a	23 A b	30 B a
Large	26.9 C b	46.5 C a	20 A b	31 B a

^y Stand counts = number of plants per meter length of row. Means within a growing season followed by the same uppercase letter within a column are not statistically different. Means followed by the same lowercase letter within a row of a growing season are not statistically different.

^z Small seed stayed above a no. 10 sieve but passed through a no. 8 sieve, mixed seed were not sieved, and large seed were seed that stayed above a no. 6 sieve.

Table 5. Effect of seed size on plot yield (g) by planting date in the 1994–95 and 1995–96 growing season for all five cultivars combined^y

Seed size ^z	1994–95		1995–96	
	September	October	September	October
Small	...	681 B	476 A b	591 B a
Mixed	...	741 AB	402 A b	693 A a
Large	...	762 A	421 A b	696 A a

^y Plot yield = weight of grain threshed from the entire plot; ... = not applicable. Means followed by the same uppercase letter within a column are not statistically different. Means followed by the same lowercase letter within a row in the 1995–96 growing season are not statistically different.

^z Small seed stayed above a no. 10 sieve but passed through a no. 8 sieve, mixed seed were not sieved, and large seed were seed that stayed above a no. 6 sieve.

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