Cereal Rust Epidemiology Studies Using Roadside Trap Plots in the Southeastern United States

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ABSTRACT

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Cereal rust trap plots were planted along a 2,687-km route using interstate and federal highways in the southeastern United States. The technique was developed and evaluated to study the oversummering and overwintering biology of four major cereal rusts: leaf and stem rusts of wheat, and crown and stem rusts of oats. The interstate highway system was selected to provide ease and speed of access for planting and monitoring, and for general safety reasons. Markers placed at 20-mi (32-km) intervals were selected for the trap plot sites to conform to established cereal rust survey techniques. Susceptible, well-adapted cultivars were preplanted in the greenhouse for subsequent transplanting at the sites and/or seeded directly to increase the likelihood of plot survival. The trials were conducted over a 7-yr period, 1986–1993, with 3 yr used to study oversummering (planted in July and sampled in November) and 4 yr to study overwintering biology during the normal growing season (planted in November and sampled in April). Severe droughts limited survival in 1986 and 1987. In 1988, several plots along the Gulf Coast were flooded and died. Planting and culturing techniques were modified each year to improve survival. Oversummering data indicated this method is useful for monitoring cereal rust survival during the summer, but plot survival rates under extreme stress may limit the effectiveness of the technique. Trials during 1990–1993 were promising, supplying both incidence and virulence data to supplement USDA-ARS Cereal Rust Laboratory annual surveys. The technique is not only effective for cereal rust research, but is also suitable for detecting other windborne pathogens, cereal and peanut viruses, and insect pests at a reasonable cost.

Additional keywords: *Puccinia coronata, P. graminis, P. recondita*

Cereal rusts, caused by *Puccinia recondita* Roberge ex Desmaz. f. sp. *tritici* and *P. graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn. on wheat (*Triticum aestivum* L.), and *P. coronata* Corda f. sp. *avenae* W.P. Fraser & Ledingham and *P. graminis* f. sp. *avenae* Eriks. & E. Henn. on oats (*Avena sativa* L.), are major yield- and quality-reducing pathogens of these crops worldwide. As such, they have been the subjects of extensive epidemiological surveys to monitor disease severities and pathogen population virulences (2–4,7,8). Annual surveys in the southeastern United States utilize standard sampling techniques in which commercial fields are inspected with stops selected at 20-mi (32-km) intervals along routes in cereal production areas. These sampling stops are supplemented by visits to trap plots and research nurseries that provide an opportunity to evaluate local rust populations in reference to a diverse group of cultivars and experimental hybrids (6). These surveys are conducted during the spring growing season, moving north with the epidemic and the crops' maturity.

Young et al (10) discussed several types of trap plots which have been used to detect and/or forecast diseases. Plantings of susceptible cultivars at several locations provided information on the presence and potential severity of cereal rusts and other diseases. To study the oversummering biology of the pathogen, Tu and Hendrix (9) used seedlings susceptible to stripe rust (caused by *Puccinia striiformis* Westend.) during the off-season to monitor disease activity in the absence of a field crop.

Our research developed, evaluated, and implemented a nontraditional and relatively rapid method of surveying wheat and oats for rust incidence, development, and virulence. A preliminary report of this research has been presented (5).

MATERIALS AND METHODS

Portions of the interstate and U.S. highway systems in the Southeast were selected to provide easy access for workers to plant and monitor a series of cereal rust trap plots. Mileposts served as reliable location markers, and the highways made rapid access of a large area possible. The route selected consisted of a 1,670-mi (2,687-km) oval from Griffin, Georgia, to Interstate (I) 75, then south to I-10, west to U.S. 171, north to I-20, and east returning to Georgia (Fig. 1). Plots were located at mile markers evenly divisible by 20, to be consistent with established survey techniques (6). This route enabled sampling in several different environments, including the Gulf Shore, lower and upper Coastal Plains, and the Piedmont.

Two rust-susceptible wheat cultivars, McNair 701 and Coker 916, were used the first 3 yr. The late summer through early winter period was selected to provide information on the oversummering biology of the rusts. During these periods, no commercial cereal fields were available to provide inoculum. The cultivars were preseeded in peat pots and allowed to soak for 3 days prior to planting the first year. During the second and third years, plants were seeded in presoaked Jiffy Pots just prior to planting. Also, Hunter wheat was planted by direct seeding the second and third year to improve the probability of successfully establishing a stand of susceptible wheat. All three cultivars are susceptible to regionally predominant races of *P. recondita* and *P. graminis*. They are also very well-adapted for growing in the Southeast. Saluda wheat and Simpson oats were added to the trap plots the last 4 yr to broaden the sampling possibilities. Ten to 15 seeds each of Coker 916, McNair 701, Hunter, and Simpson were preplanted in 15-cm plastic pots for transplanting at the sites during the last 3 yr. They were planted early enough to allow for root establishment, to increase the probability of survival. Simpson and Saluda were seeded directly at the sites.

Sites were chosen in most cases outside the "mow line" on a line perpendicular to the highway from the milepost. Some plots were planted at the base of the milepost, a location somewhat protected from mowers. When it was necessary to skip a milepost that was near an interchange ramp, bridge, or other potential hazard, the next suitable milepost was used. Each site was prepared for planting by hand-tilling an area of 2,800 cm^2 and 15 cm deep to provide seed beds into which the preplanted peat pots or plants from the plastic pots were transplanted. Shallow furrows (2 cm deep and 25 cm long) were used for direct seeding and covered with soil. To facilitate locating plots at sampling time, red spray paint

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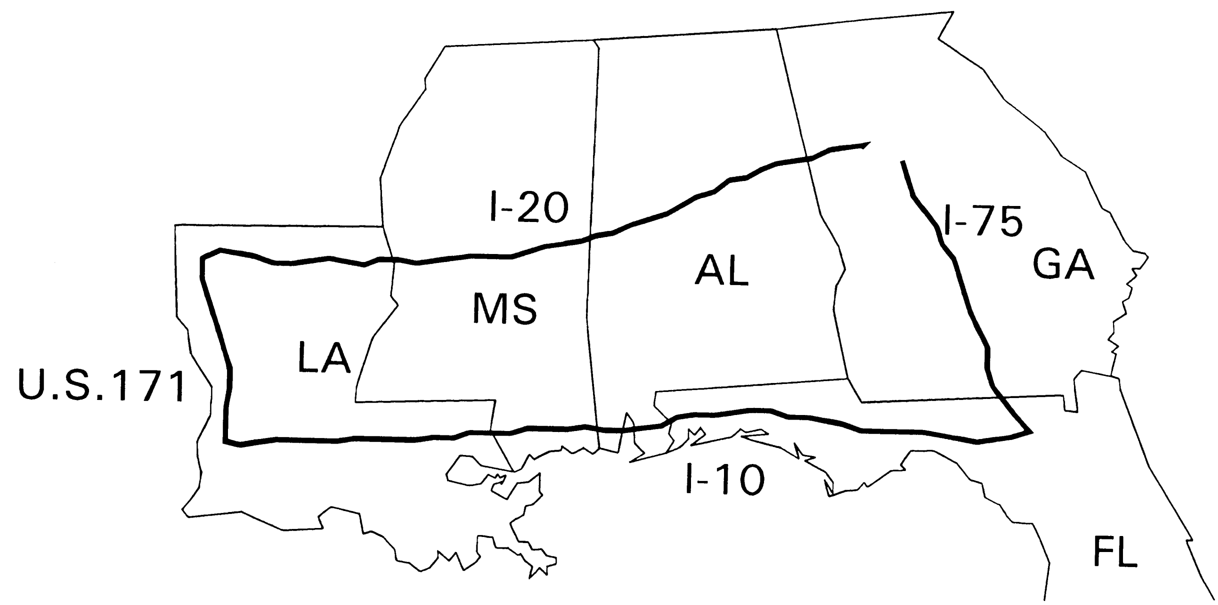

Fig. 1. Cereal rust trap plots were located at mile markers evenly divisible by 20 along the interstates and U.S. highway shown.

was used to mark the area, either on a nearby fence post or tree, or surrounding the area itself. Small (15 cm) white plastic stakes were used the last 2 yr to mark the sites. Twenty grams of 10-10-10 fertilizer was applied at planting and supplemented with an additional 20 g by topdressing the last 4 yr during a midwinter trip to inspect plots and replant as necessary. Rates were recommended based on commonly used rates for establishing grass along highways (Fred C. Boswell, *personal communication*). Approximately 79 sites were established each year.

Planting trips were made in late July or early August, well after wheat harvest (oversummering trials), and in mid-November for the normal season plantings. Each trip required three working days. Sampling trips were made in early or late November, before fall-seeded wheat could become an inoculum source, or during the regular spring growing season, in mid to late April. These trips also required 3 days.

Samples of rust were collected from trap plots and submitted to the Cereal Rust Laboratory for culturing, classification, and inclusion in the annual virulence survey.

Prior to planting, highway department officials in Georgia, Florida, Alabama, Mississippi, and Louisiana were contacted about our intended activities. Each was quite helpful and suggested certain safety practices and potential hazards related to herbicide use and pending construction activities.

RESULTS AND DISCUSSION

The first 2 yr of this experiment were plagued by severe droughts. In spite of adverse conditions, about one-third of the plots had live plants at sampling time (Table 1). Many plants had some leaf rust, and two plots each had a single small stem rust pustule. No patterns based upon location were evident for either plant survival or rust presence.

Table 1. Interstate cereal rust trap plot summary during 1986–1993

	Trap plot survival		Leaf rust incidence		Crown rust incidence		Other diseases	
Year[a]	(No.)	(%)	Obs.[b]	Coll.[b]	Obs.	Coll.	PM[c]	BYDV[c]
1986	19	24	13	7	...	...	...	...
1987	24	30	11	6	...	...	...	...
1988	25	31	4	2	...	...	2	...
1990	57	73	17	9	4	2	3	...
1991	61	76	15	9	7	3	4	4
1992	68	86	7	6	3	3	4	31
1993	52	65	7	6	23	15	...	6
Total	306	...	74	45	37	23	13	41

[a] Off-season, oversummering trials, 1986–1988. Normal growing season trials, 1990–1993.
[b] Obs. = rust present but not collected; coll. = rust present and collected.
[c] Powdery mildew (PM) collections submitted to Steve Leath at Raleigh, NC; barley yellow dwarf virus (BYDV) samples submitted to Anna Hewings at Urbana, IL.

Several hazards resulted in missing plots. Dry conditions caused the most damage the first 2 yr. The preplanted and soaked peat pots the first year promoted germination and early growth. The ensuing drought killed many of these small plants. Highway mowing crews eliminated some plots, even though we tried to place the plots outside the normal mow line. Modifications of the planting methods each season resulted in successively higher survival rates (Table 1). Changes incorporated included the use of an inconspicuous marker to facilitate locating plots so they could be moved farther beyond the mow line, to reduce the losses from mowers. Fence building and other construction activities also destroyed some plots. Because animals dug up and/or ate plants in some plots, moth balls were distributed near the plants to discourage grazing. A few plots were under water or inaccessible because of high water at sampling time. Losses related to maintenance and construction were greater along interstate highways than along the U.S. highway. Access, speed, and safety were much better along the interstate highways. Portions of U.S. 171 have only two lanes, making it somewhat risky to pull over and off the road for planting and sampling.

The entire experiment covered over 31,000 mi (51,000 km) during the 19 round trips and required 57 long working days or approximately 1,000 man hours. Pretrip information supplied by officials of the highway departments of the five states aided us in making the trips and completing the 1,440 planting, fertilizing, and sampling stops without incident.

Since we were able to increase the survival percentage each year through modifications of our methods (Table 1), we feel this means of rust epidemic monitoring has promise. The rust collections were submitted to the Cereal Rust Laboratory and included in the annual rust survey. Nearly all collections submitted were viable (39 of the 45 leaf rust collections, for example) and contributed virulence and incidence data for the survey (Table 2). Virulences determined from trap plot samples are treated as field samples for the survey database, since

Table 2. Leaf rust virulences detected in five states using conventional and interstate survey techniques during 1986–1993

Year	Nursery	Field	Interstate
1986	KBG, MBG, NBG, PBG, TBB[a]	NBG, TBB	...
1987	CBG, FBM, KBB, MBB, MBG, MBL, MDB, NBG, PBG, TBB, TBH, TLG	CBD, CBG, KBB, MBB, MBD, PLM, TBB	...
1988	CBG, MBB, MDB, PBG, TBB	MBG, MFB, TFB	...
1989	CBG, CGB, FBM, MBB, MBG, MFB, PLR, TBB, TBD, TBG, TLG	CBG, MBG, MFB, TLG, TBG	...
1990	BBB, CBG, CBT, FBM, FBR, KBB, KBG, LBB, MBB, MBG, MDB, PLR, PMB, TBB, TBG, TBJ, TCB, TFB, TLG	CBB, CBG, FBM, FBR, KBB, KBG, LLG, MBB, MBG, TBB, TBG, TLG	CBG, KBG, MBG
1991	CBG, DBB, FBM, KBG, KFB, MBB, MBG, MFB, PLM, TBB, TBG, TCB, TBJ, TDB, TLG	MBG	KCG, KFB, MBG, MFB
1992	BGB, KBG, KFB, MBB, MBG, MBJ, MCB, MFB, TBG, TBJ, TBQ, TLG	KCG, MBB, MBG, MBJ, TBG, TLQ	MBG, MDG, TBG, TDB, TFB, TLG
1993	CLG, MBG, MBJ, MBR, MFB, PLR, PNM, PNR, TBG, TLG	MBG, MBR, PNR, TLG	TLG, MBG

[a] Virulence designations are from Long and Kolmer (1).

we feel they more nearly represent field sources than do those collected from within a genetically diverse breeding or test nursery.

Although fewer samples were collected from interstate trap plots than from the conventional nursery and field, it is important to note that conventional sampling involved from seven to 12 collectors over 17 to 39 dates. The interstate samples were collected on only three to five dates by one collector. Also, the virulences detected by the interstate plot samples represent large percentages (43–69%) of the total in the five states during 1990–1993.

Negative results also contributed to the data here as evidence of lack of rust. Both plot size and location are highly suited for sampling wheat leaf rust and oat crown rust, but not well-suited to detecting stem rust of either crop. This may be due to sampling time. Wind turbulence from passing traffic did not interfere with infection. During sampling stops, it was often possible to collect rusts on naturally occurring grasses right at the roadside. A few areas featured volunteer cereals from highway mulching operations, which were often infected with leaf or crown rusts.

To evaluate the potential of this technique for monitoring other crop pests, two preliminary trials have been conducted to detect small grain viruses and peanut (*Arachis hypogaea* L.) viruses. Of 31 small grain leaf samples submitted for barley yellow dwarf virus enzyme-linked immunosorbent assay (ELISA) in February 1992, 11 were positive for the PAV strain and one for the RPV strain. Three of the 79 peanut samples collected 29 May 1991 were positive for peanut mottle virus (PMV). Twelve of 79 samples collected 1 mo later were positive for PMV. No other viruses were detected from either set of samples. Having known plant cultivars available at preset locations, easy to access and requiring minimum time to sample a large area, could be useful for many plant disease monitoring programs.

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