Three Suction-Type Spore Samplers Compared

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Contribution No. 1245, Division of Biology, Kansas Agricultural Experiment Station and Contribution No. 627, Department of Plant Pathology. Cooperative investigations of the Kansas Agricultural Experiment Station, ARS, USDA, and the Department of Health, Education and Welfare, National Center for Air Pollution Control (Grant No. 5R01 AP00080).

Accepted for publication 3 July 1975.

ABSTRACT

Collecting efficiencies of the Hirst, Kramer-Collins (K-C), and 7-Day Drum samplers were compared using results from wind-tunnel tests. Urediospores of *Puccinia graminis* were used with a wind speed of 18 kph. Stationary rods and Rotorod samplers were used to monitor the homogeneity of the spore cloud in the wind tunnel. Results showed no significant difference among samplers when a rotary intake tube was used on the K-C sampler.

Phytopathology 66:62-64

Additional key word: epidemiology.

During the past 25 years, several different spore traps have been used by plant pathologists and aerobiologists for a variety of research problems. Among them are the Hirst trap, developed by J. M. Hirst (5), and the Kramer-Collins Spore Sampler (8).

All spore traps described here have advantages and disadvantages. The Hirst trap's size and bulkiness limits its use; generally it is used to study air-spore populations at ground level. It is a suction-type trap that operates continuously, impinging particles from the air in a continuous deposit on an adhesive-coated glass microscope slide. The slide moves at constant rate past the orifice and can accomodate a 24-hour deposit. Collections can be time related. The entire body of the sampler rotates to keep the intake orifice facing into the wind. The Burkard 7-day trap (Burkard Manufacturing Co.) is similar to the Hirst trap except for its trapping surface consisting of a drum that rotates past the intake orifice, making one revolution in 7 days. Both are commercially available.

The Kramer-Collins (K-C) spore sampler, also a suction-type trap, impinges airborne particles on an adhesive-coated glass microscope slide. A spring-wound clock motor moves the slide forward each hour so that particles are deposited in discrete hourly bands. The clock motor also operates a microswitch that turns the vacuum pump on and off. Although a variety of cams are available, depending on needs, a four-point cam generally is used to turn the vacuum pump on and off four times each hour for a total operating time of 10 minutes per hour with all four samples deposited in a single hourly band. However, its operating time also can be varied, again depending on needs. The intermittent operation reduces the load of spores in each band, which aids counting and conserves battery power when 12 V DC vacuum pumps are used. A fully charged automobile storage battery will operate the vacuum pump 3-4 days, depending on the time it is operated each hour and the size and age of the battery. For use near a source of line electricity, 115 V AC vacuum pumps also are available.

Although the K-C sampler was designed originally to use in the field and laboratory to study circadian rhythms of spore release by individual specimens or developments of fungi (3, 7, 9, 12), it is equally useful for studies of the air spora of a particular site as over a wheat field (1) or prairie, or woodland site (10). When used for such studies, it requires a rotary intake adaptor to keep the intake orifice facing into the wind. Studies like those of Wallin and Loonan (13) on *Helminthosporium maydis* race T without an adaptor resulted in much lower spore counts than those made with a Rotorod sampler.

To better understand comparative sampling efficiencies of some commonly used volumetric spore traps, we undertook a series of wind-tunnel tests using the Hirst trap, K-C sampler, and the new 7-Day Drum sampler (6) manufactured by G. R. Manufacturing Co., Manhattan, Kansas.

MATERIALS AND METHODS.—The wind tunnel used was 15-meters long with inside dimensions of 92×92 cm (14). Air was circulated at 18 kph through the closed system by a large fan operated by a stationary gasoline engine.

A Hirst trap, a K-C sampler with a 15-cm-high rotary-intake tube, and the new 7-Day Drum sampler were placed equidistant from each other and from the inside walls of the tunnel. All intake orifices were at the same height. With each of these samplers, a 5 mm-diameter stationary glass rod with a strip of double-coated cellophane tape was placed at the same height and about 10 cm from the intake orifices. A Rotorod sampler was

TABLE 1. Total number of urediospores of *Puccinia graminis* collected by the Hirst trap, Kramer-Collins (K-C), and 7-Day Drum samplers during a 2-minute sampling period operating at a flow rate of 28.3 liters per minute in a wind tunnel with a wind speed of 18 kph

Test	Hirst Trap	K-C Sampler	7-Day Drum Sampler
1	962	874	947
2	1418	1265	1363
3	1134	851	1038
4	1058	911	962
5	1031	993	925
6	909	890	860
7	998	881	934
8	974	892	915
9	834	878	793
10	926	962	1178
11	1063	904	911
12	1120	1184	1088
13	1136	1170	1318
Means	1043	973	1018

Analysis of variance:

Source of variation	Sum of squares	df	Mean square	F-test
Sampler	32,486	2	16,243	0.69
Error	847,718	36	23,548	
Total	880,204	38		

placed on the opposite side from the stationary rods of each of the three samplers, so that the trapping surfaces were at the same height as the intake orifices and about 10 cm away. The stationary rods and the Rotorod samplers were used to monitor the uniformity of the spore cloud passing through the tunnel.

Five different series of tests were run with samplers in the tunnel rearranged between tests. In some tests, the Rotorod samplers were not used. In some, rotary intake tubes of different heights were used. Some tests also were made at different wind speeds. In all tests, results were similar to those reported here.

In each test, approximately 50 mg of *Puccinia graminis* urediospores were released into the air stream on the opposite side of the fan from the samplers so that spores were carried through the fan blades for more even distribution.

All samplers were connected to a single extension cord with multiple outlets. All were started just before the spore release and turned off simultaneously 2 minutes after spore release. All three suction traps were equipped with the same type air-flow meters and vacuum pumps and were set to run at an air-flow rate of 28.3 liters per minute. The flow meter of the Hirst trap was disconnected so air flow was directly from the sampling chamber of the sampler to the air-flow meter of the vacuum pump assembly.

RESULTS.—Results of one series of tests with samplers arranged as just detailed are presented in Tables 1 and 2.

Differences between the number of spores impacted in the three collections on the stationary rod samplers and the three Rotorod samplers were nonsignificant indicating homogeneous dispersion of spores in the wind tunnel during each test (Table 2).

All three suction traps were set at the same air-flow rate (28.3 liters per minute), which differed from the rates of air sampled by the stationary rod and Rotorod samplers. Each volumetric trap sampled the same volume of air during each test. Efficiencies of the three suction type samplers did not differ statistically in collecting particles the size of urediospores, approximately 20-30 μm (Table 1).

DISCUSSION.—It is highly important to select a sampling device or method appropriate for a particular study. Sampling methods and techniques are discussed in books by Gregory (2) and Ogden et al. (11), but automatic volumetric suction-type samplers are probably best suited for those interested in the epidemiology of plant disease fungi. The standard 24-hour Hirst trap, the 7-day Burkard trap (a modification of the Hirst trap), and the Kramer-Collins spore sampler have been used most

TABLE 2. Figures recorded for the stationary rods and Rotorod samplers represent the number of spores collected on a portion of the trapping surface; these figures have not been converted to a standard and therefore are not comparable to those of the suction traps, but serve only to demonstrate the uniformity of distribution of spores in the wind tunnel during the sampling periods. Stationary rods and Rotorod sampler counts are grouped with the suction trap that they were located next to during each of the tests

	Hirst Trap		K-C Sampler		7-Day Drum Sampler	
Test	Stat. Rod	Roto-rod	Stat. Rod	Roto-rod	Stat. Rod	Roto-rod
1	285	227	383	285	276	218
2	322	354	282	366	377	358
3	254	249	280	267	243	277
4	194	269	250	273	276	243
5	234	239	323	294	274	274
6	263	225	207	244	200	275
7	256	248	225	240	248	277
8	247	230	283	236	241	266
9	218	233	266	241	236	232
10	312	291	366	302	296	305
11	209	238	285	258	286	232
12	370	283	376	326	355	328
13	340	240	337	277	339	290
Means	270	258	297	278	281	275

frequently in such studies. The apparent lack of understanding of the relative merits and varied application of those samplers prompted this report.

Sampler bodies on each of the Hirst trap, 7-Day Burkhard, and the new 7-Day Drum sampler units turn to keep the intake orifice facing into the wind at all times. The body of the K-C sampler does not rotate; however, a rotary-vane intake adaptor is available (G. R. Manufacturing Co., Manhattan, KS.) to keep the intake orifice facing into the wind. The adaptor has an intake tube with a 90-degree bend to carry the air flow downward, through a slit into the chamber of the sampler. The adhesive-coated slide rests on a platform just below the slit. Although that appears to be a disadvantage, our wind tunnel tests indicate that movement of air through the adaptor does not reduce collecting efficiency.

As stated earlier, the K-C sampler was originally designed for field use to study patterns of spore release by specific fungi. In such studies, various types of adaptors are used to position the intake orifice near the organism being studied. It is important only that the intake orifice remain at the same position and that the air-flow rate remain constant throughout the study. That way, direct comparisons can be made from hour to hour and then correlated with time of day and environmental conditions. Numbers per volume of air in such studies are meaningless because they may vary with distance of the sampler from the specimen, size of the specimen, etc.

Its small size, battery operation, and range of sampling with interchangeable cams, uniquely qualify the K-C sampler for studies of spore discharge and release, while the Hirst, Burkard, and 7-Day Drum samplers are not well suited for such studies because of their size and the design of their intake orifices. All three were designed for general sampling of the air spora at a given location; the K-C sampler also can be and has been used for such studies. However, a rotary-vane intake adaptor must be used with the K-C sampler. Harrington and Calvert (4) have shown that efficiency of the K-C sampler averages less than 20% when its orifice is oriented at right angles to the air flow and less than 3% when oriented downwind. When its orifice was oriented into the wind by the rotary intake adaptor, its efficiency approached 100%. The results of our wind-tunnel studies also show that sampling efficiencies of the Hirst, K-C, and 7-Day Drum sampler do not differ significantly when a rotary intake adaptor is used with the K-C sampler.

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