Transmission of Southern Bean Mosaic Virus from Soil to Bean Seeds

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ABSTRACT

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After 12-hr exposure to virus-infested soil around the roots of bean plants infected with southern bean mosaic virus (SBMV), some Bountiful bean seeds acquired the virus and produced systemically infected plants. The incidence of infection was higher in bean seeds with cracked coats than in those with intact coats. Results were similar when bean seeds were soaked in SBMV preparations from leaves. Apparently SBMV infected the germinating seedlings mechanically, without the aid of a vector.

Southern bean mosaic virus (SBMV) (9) is seed, sap, and beetle transmissible and is released into the soil from the roots of systemically infected French bean, *Phaseolus vulgaris* 'Bountiful' (11). The soil-infesting virus can be conveniently assayed by rubbing soil leachate (drainage water from pots) over the leaves of *P. vulgaris* 'Pinto,' a local lesion host of SBMV (11). However, although Smith et al recovered moderate amounts of virus, no infection occurred when the SBMV-containing leachate was poured around the roots of healthy Bountiful bean seedlings (11). This result is consistent with the prevailing concept that, except for tobacco mosaic virus (1), virus released from roots rarely plays any part in plant infection, unless the virus is transmitted by a fungal or nematode vector (2,3).

Following the recent reports that cymbidium ringspot virus (5) and galinsoga mosaic virus (10) apparently are mechanically transmissible in soil, we did further tests with SBMV. We now report that Bountiful bean seeds acquire SBMV when exposed to virus-infested soil and that some of the resulting seedlings are systemically infected.

MATERIALS AND METHODS

Bountiful bean plants were raised in U.C. Mix II(c) autoclaved potting soil (6), and leaves at the primary leaf stage were inoculated with SBMV. One month later when the plants were systemically infected and releasing virus into the soil (79 lesions per Pinto bean leaf, by assay of soil leachate), Bountiful bean seeds were pushed into the soil. The seeds were retrieved 12 hr later, washed in running tap water, and sorted according to whether the seed coat was cracked or apparently intact. Seeds were then replanted at approximately 26 C, either between moist paper in the laboratory or in autoclaved potting soil in a glasshouse. Other Bountiful bean seeds were similarly treated, except that they were exposed to the soil around healthy instead of infected Bountiful bean plants.

After 1 wk of incubation, the seedlings germinating between paper were immersed in 10% (w/v) trisodium phosphate for 1 min, which destroyed exposed virus (*unpublished data*). The roots and hypocotyls of each seedling were triturated and the extract assayed by rubbing it over a corundum-dusted leaf of Pinto French beans. For seedlings germinating in soil, the roots were decontaminated in trisodium phosphate, and the roots, hypocotyl, and primary leaves of each seedling were assayed as a composite sample.

RESULTS AND DISCUSSION

Many bean seeds exposed for 12 hr to soil near SBMV-infected bean roots produced infected seedlings (Table 1). The percentage of infection was higher in seeds with a cracked coat (85%) than in seeds with an apparently intact coat (60%). This higher incidence of infection was positively correlated with faster imbibition during the 12-hr exposure to virus-infested soil, ie, 105% increase in weight vs. 67% increase for seeds with an apparently intact seed coat.

In two other experiments in which seeds were similarly exposed to SBMV-infested soil before planting in autoclaved soil, approximately 50% of plants were infected (nine of 18 plants grown from seeds with cracked seed coats and four of seven plants grown from seeds with intact seed coats). When the shoots and roots of infected bean seedlings were assayed separately, virus was usually present in both shoots and roots; occasionally, however, little or no virus was isolated from the roots or the shoot of an infected seedling.

In another test, eight Bountiful bean seeds were soaked for 11 or 22 hr in a 10^{-1} (w/v) extract of SBMV-infected leaves in tap water before planting in autoclaved soil and eight infected plants were produced, whereas no infection resulted from soaking similar bean seeds in tap water only. In a second similar test, 28 of 33 (85%) infected plants were produced from seeds with cracked coats, but only five of 38 (13%) infected plants were produced from seeds with intact seed coats.

When the cracked coats of Bountiful bean seeds that had been soaked in SBMV-infected leaf extract were removed, a considerable amount of green sap was seen surrounding the embryo. No such green sap was present when seeds with an intact coat were soaked and the coat removed. Apparently sap (or soil water) containing SBMV enters seed with a cracked coat readily, and the resultant

Table 1. Effect of planting Bountiful bean seed in soil near roots infected with southern bean mosaic virus (SBMV) on seedling infection

Seed exposed to soil	Seed coat	Growth medium[a]: Filter paper	Growth medium[a]: Soil
Infested with SBMV	Cracked	5/6	6/7
	Intact	5/10	7/10
Not infested	Cracked	0/10	0/10
	Intact	0/10	0/7

[a] Assays for SBMV were done after seed was exposed to infested soil for 12 hr and incubated for 1 wk in filter paper or freshly autoclaved soil. Results are given as number of infected seedlings/total seed germinated.

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high level of embryo contamination gives a high incidence of plant infection.

This is apparently the first report of seeds acquiring a virus from soil during germination. Infection of the germinating seedlings probably occurred mechanically through natural wounds, as apparently occurred when leaves of French bean plants were dipped in or sprayed with suspensions containing SBMV (7). The inability of some workers to obtain infection of French bean embryos by dipping them in a purified preparation of SBMV may be due to the relatively short exposure time of 15 min (12).

At least seven other viruses are released in appreciable amounts from living roots into soil (5,8,10,11,13). Although the possibility of seed acquisition of these viruses apparently has not been examined, five of them (tobacco mosaic, tobacco rattle, cymbidium ringspot, galinsoga mosaic, and tomato bushy stunt viruses) may infect plants growing in virus-infested soil in the absence of any recognized vector. We have also found (*unpublished data*) that SBMV and carnation mottle and sowbane mosaic viruses can cause infection of "bait" plants growing in soil containing virus-infested debris. These data support the concept that when stable viruses are released from living roots or debris in moderate to large amounts, they may cause plant infection, even without the aid of a specific fungal or nematode vector (4).

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