Dry bean seed quality in Honduras[1,2]

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ABSTRACT

Low germination and high levels of fungal infections were found in seed of June plantings of dry beans in Honduras. *Fusarium equiseti* (12-62% incidence) was the dominant internally seedborne fungus of that season. October plantings showed fewer (P=0.05) seed infections and less discoloration. *Fusarium semitectum* (7 to 21%) was the dominant seed microorganism. Stored seed (December to June) lost about 50% of its vigor and size without losing germination (89%). *Bacillus licheniformis*, with up to 37% incidence, was the dominant seed storage microorganism. Storage microorganisms included *Aspergillus* spp., other *Bacillus* spp., *Penicillium* spp., *Chaetomium* spp., *Mucor* spp., and *Flavobacterium* spp. *Fusarium* spp. varied in their recovery after storage. *Fusarium semitectum* was eliminated in storage, whereas *F. equiseti* increased. Levels of *Fusarium* spp., in recently harvested seed, and *Bacillus* and *Aspergillus* spp., in stored seed, were excellent indicators of seed quality losses in the field and storage in Honduras. Germination data alone was not a good indicator of seed quality because low vigor seed had excellent germination.

RESUMEN

Calidad de la semilla de frijol en honduras

Se encontraron altos niveles de infecciones por hongos que redujeron la germinación de semillas provenientes de siembras de junio en Honduras. *Fusarium equiseti,* con rango de incidencia de infecciones de 12 a 62%, fue el hongo predominante en esa época. Semillas de la siembra de octubre mostraron menos (P=0.05) infecciones por microorganismos y descoloración del grano. En esta época, *Fusarium semitectum* fue el hongo dominante con de 7 a 21% de incidencia. En las semillas almacenadas de diciembre hasta junio se notó la pérdida de casi 50% de su vigor, aunque las semillas germinaban a 89%. *Bacillus licheniformis* fue el microorganismo dominante en semillas almacenadas, infectando hasta el 34%. El almacenamiento aumentó las infecciones por *Aspergillus* spp., otras *Bacillus* spp., *Penicillium* spp., *Chaetomium* spp., *Mucor* spp. y *Flavobacterium* spp. Las especies de *Fusarium* variaban en sus reacciones al almacenamiento. *Fusarium semitectum* desapareció durante el almacenamiento mientras que *F. equiseti* aumentó su incidencia. Los niveles de *Fusarium* spp. en semillas recién cosechadas y *Bacillus* y *Aspergillus* spp. en semillas almacenadas fueron buenos indicadores de pérdidas en la calidad de la semilla de frijol en Honduras. Los valores de germinación no indicaban las pérdidas de vigor por almacenamiento.

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TABLE 2.—*Incidence of bean seed perforated by weevils in Honduran seed sources during 1985-86*

	Seed source[1] Percentage perforated seed[2]							
Assay month	1	2	3	4	5	6	7	8
October	14.5	3.0	1.0	6.0	0.0	0.0	0.5	0.0
December	1.0	5.0	3.0	1.0	0.0	0.0	0.0	0.0
June	1.5	4.5	1.5	0.0	0.5	0.0	13.0	2.0

[1]Seedlots 1 and 2 var. Cincuenteño from Olancho; 3 and 4 var. Zamorano and 5 and 6 var. Danli 46 from El Paraíso; and 7 and 8 var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resources of Honduras, respectively.
[2]Means based on 4 random seedlots of 100-seed each for each seed source tested.

The highest incidence of weevil (*Zabrotes subtacilatus*) damage was detected in "Cincuenteño" from Olancho (15%), and in "Zamorano" from the Panamerican Agricultural School (13%) (table 2). The June planting and the long storage period between plantings from one year to the next appear as the principle factors associated with increased weevil incidence.

Highest levels of shrivelled seed were detected from the seed crop which matured with residual moisture (table 3). The Panamerican Agricultural School, which used irrigation, had the fewest shrivelled seed. Olancho seedlots had the greatest number of shrivelled seed.

Sucking insect damage was greatest in the June planting (14%) (table 4). One Olancho seedlot had 47% of the seeds damaged by sucking insects. With the exception of one seedlot, sucking insect damage was found in less than 5% of the seed from the second planting.

TABLE 3.—*Percentage of shrivelled seed in 8 bean seed sources in Honduras during 1985-86*

	Seed source[1] Percentage of shrivelled seed[2]							
Assay month	1	2	3	4	5	6	7	8
October	0.5	16.5	0.5	1.5	1.0	3.5	0.0	0.0
December	14.5	7.5	3.0	3.5	9.0	10.0	0.0	0.0
June	25.0	1.0	2.5	8.0	1.0	1.5	0.0	7.5

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraiso; 7 and 8 are var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resourses of Honduras, respectively.
[2]Means based on 4 random seed lots of 100-seed each for each of the seed sources.

TABLE 4.—*Percentage of dry bean seed showing damage from sucking insects in 8 seed sources in Honduras in 1985-86*

	Seed source[1] Percentage seed damaged by sucking insects[2]							
Assay month	1	2	3	4	5	6	7	8
October	16.0	47.0	13.5	6.5	4.5	11.0	4.0	11.0
December	3.5	4.0	4.5	24.0	5.0	2.5	0.0	0.0
June	5.0	2.0	6.0	12.0	0.5	1.0	0.5	2.5

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraíso; and 7 and 8 are var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resources of Honduras, respectively.
[2]Means based on 4 random seedlots of 100-seed each for each seed source tested.

100-seed Weights.—The highest weights (31.5 g) were found in recently harvested second crop seed (table 5). Seedlots from the certified institutional seed were greater than those from farmers generally. Second crop seed showed marked losses of seed weight after storage (20.0 g in June).

Cellulose Pad Assay.—First crop seed from Olancho (67 and 75%) showed the lowest seed germination (table 6). Second crop seed before (90% germination) and after storage (88% germination) showed sizable vigor differences (table 7). Mean fresh weights of seedlings 10 days after planting were 34.9, 31.4, and 14.1 g for the October, December and June assays, respectively. Drastic reduction of vigor in the second crop stored seed was evident in all seed lots.

Agar Plate Assays.—Mean percentages of seed free from internal infection were 66, 81, and 51% for the October, December and June assays, respectively. Over 85% of seed from the institutional sources were free from infection compared to less than 80% for Olancho seedlots and all stored seed (table 8).

TABLE 5.—*Seed size in 8 Honduran bean seed sources during 1985-86*

	Seed source[1] Seed size (g/100 seed)[2]							
Assay month	1	2	3	4	5	6	7	8
October	16.3	14.7	17.7	25.3	23.6	17.4	30.4	26.5
December	27.9	36.5	28.2	29.7	29.7	28.6	38.7	32.9
June	15.3	20.3	18.2	19.3	16.6	23.6	22.7	24.1

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraíso; 7 and 8 are var. Zamorano from the Pan American Agricultural School and the Secretary of Natural Resources of Honduras, respectively.
[2]Means bases on 4 random seed lots of 100-seed each for each seed source tested.

TABLE 6.—*Cellulose pad germination of 8 Honduran seed sources during 1985-86*

Assay month	Seed source[1] Percentage seed germination[2]							
	1	2	3	4	5	6	7	8
October	75.0	67.0	91.0	89.5	76.0	84.5	94.5	93.5
December	97.5	92.0	98.0	97.0	61.5	87.5	93.5	89.0
June	86.5	84.5	91.0	96.5	83.0	90.5	86.5	85.5

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraíso; 7 and 8 are var. Zamorano from the Pan American Agricultural School and the Secretary of Natural Resources of Honduras, respectively.
[2]Means based on 4 random seed lots of 100-seed each for each seed source tested.

In recently harvested first crop seed 12 fungi were detected (table 9). *Fusarium equiseti* (Corda) Sacc. was the dominant fungus, reaching 62% incidence. *Fusarium semitectum* Berk. and Rav. was detected in the majority of lots with a maximum incidence of 11%. In less than 50% of

TABLE 7.—*Ten day seedling weights in 8 seed sources from Honduras during 1985-86*

Assay month	Seed source[1] Seedling fresh weight (g/10 plants)[2]							
	1	2	3	4	5	6	7	8
October	30.1	26.0	38.8	44.1	30.8	30.0	39.5	40.1
December	27.9	36.5	28.2	29.7	29.7	28.6	38.7	32.2
June	11.1	17.0	15.3	14.4	15.1	16.7	17.1	15.9

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 var. Danli 46 from El Paraíso; 7 and 8 are var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resources of Honduras, respectively.
[2]Means based on 4 random seedlots of 100-seed each for each seed sources tested.

TABLE 8.—*Percentage of seeds free from internally borne microorganisms in 8 bean seed sources in Honduras assayed on potato dextrose agar* in vitro *during 1985-86*

Assay month	Seed source[1] Percentage of seed free of infection[2]							
	1	2	3	4	5	6	7	8
October	31.0	6.5	90.0	61.5	81.0	67.0	94.5	96.5
December	69.0	70.0	94.0	93.5	55.5	89.5	94.0	86.0
June	49.0	47.5	59.5	79.5	49.0	30.0	48.5	45.5

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraíso; 7 and 8 are var. Zamorano from the Pan American Agricultural School and the Secretary of Natural Resources of Honduras, respectively.
[2]Means based on 4 random seedlots of 100-seed each for each of the seed sources tested.

TABLE 9.—*Incidence of internally seedborne microorganisms using agar plate assay of 8 Honduran seed sources in October 1985*

Microbial taxa	Seed source[1] Percentage seedborne infection[2]							
	1	2	3	4	5	6	7	8
Fusarium equiseti	18.5	61.5	1.0	2.0	3.0	14.5	1.0	1.0
F. semitectum	7.0	10.5	1.0	0.5	1.5	5.5	0.5	0.0
F. solani	0.0	2.0	0.0	1.5	1.0	1.5	0.0	0.0
Alternaria sp.	6.5	2.0	1.0	6.0	1.0	1.0	0.0	0.0
Rhizoctonia solani	0.0	0.5	0.0	1.0	7.5	2.5	2.0	0.0
Macrophomina phaseolina	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Phomopsis phaseolina	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Phoma sp.	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Cladosporium sphaerospermum	1.0	0.0	0.0	0.0	1.0	1.0	1.5	0.0
Aspergillus spp.	0.0	2.0	0.5	0.5	0.5	1.0	0.0	0.0
Penicillium sp.	0.0	0.5	0.0	0.0	1.0	0.0	0.0	0.0
Rhizopus sp.	8.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous Fungi	11.5	9.0	2.0	3.0	2.0	2.0	2.0	0.0
Bacteria	14.5	9.5	8.0	28.0	2.5	3.0	0.5	1.5

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraiso; 7 and 8 were var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resources of Honduras, respectively.

[2]Means based on 4 random seedlots of 50 seed each for each seed source.

the seed lots, *Fusarium solani* (Mart.) Appel and Wollenw. was found at less than 2% incidence. A number of bean field pathogens were isolated from Olancho seed including *Rhizoctonia solani* Kuhn (web blight and root rot), *Macrophomina phaseolina* (Tassi) Goid. (ashy stem blight), and *Phomopsis phaseolina* Weh. (pod and stem blight). The most common of these was *R. solani*, isolated from the majority of seed lots with a maximum incidence of 8%.

In recently harvested second crop seed, 11 fungi were detected (table 10). *F. semitectum* was the dominant fungus detected from all seed lots with a maximum incidence of 21%. From the majority of seed lots *F. equiseti* and *F. solani* were isolated with a maximum of 4 and 12%, respectively. In the second crop, *Macrophomina phaseolina*, *Phomopsis phaseolina*, and *Rhizopus* sp. were not detected. Although second crop had less overall infection of seed than the first crop, *Chaetomium* sp., *Curvularia lunata*, *Monilia* sp., and *Nigrospora* sp. were detected in second crop but not first crop seeds.

TABLE 10.—*Incidence of internally seed-borne fungi in 8 Honduran seed sources in December 1985*

Microbial taxa	Seed source[1] Percentage seedborne incidence[2]							
	1	2	3	4	5	6	7	8
Fusarium equiseti	4.0	1.5	0.0	0.5	1.0	0.0	0.0	0.0
F. semitectum	21.0	12.0	3.5	3.0	8.5	2.0	2.0	3.0
F. solani	0.0	1.5	0.5	0.0	11.5	0.5	1.5	0.0
Alternaria sp.	0.0	0.5	0.0	0.0	0.0	0.0	0.5	1.0
Rhizoctonia solani	0.0	9.5	0.5	0.0	6.5	0.0	0.0	0.0
Cladosporium sphaerospermum	0.0	1.0	0.0	0.5	2.5	0.0	0.5	0.0
Penicillium sp.	0.0	0.0	0.0	0.0	2.5	0.0	0.0	1.0
Chaetomium sp.	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Curvularia lunata	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Monilia sp.	0.5	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Nigrospora sp.	0.0	0.0	0.0	0.5	0.0	1.0	0.0	0.0
Miscellaneous Fungi	3.5	1.0	0.0	1.0	4.5	4.0	0.5	4.0
Bacteria	2.0	0.5	2.0	1.0	8.5	3.0	1.0	1.5

[1]Seedlots 1 and 2 are var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano and 5 and 6 are var. Danli 46 from El Paraíso; 7 and 8 were var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resources of Honduras, respectively.

[2]Means based on 4 random seed lots of 50 seed each for each seed source assayed after surface disinfection on sterile potato dextrose agar.

Twelve fungi were identified in the June assay of second crop seed (table 11). Detected in all seed lots with a maximum incidence of 37%, *Bacillus licheniformis* was the dominant internally seedborne microorganism. Among *Fusarium* spp., only *F. equiseti* was detected. Fungi which increased after the storage included *F. equiseti*, *Aspergillus* sp., *Penicillium* sp., and *Chaetomium* sp. In all lots *Aspergillus* spp. were detected with a maximum incidence of 10%. *Colletotrichum lindemuthianum* (Sacc. and Magn.) Scrib., the bean anthracnose pathogen, and species of *Gliocladium*, *Mucor*, and *Trichoderma* were detected only in the June assay.

DISCUSSION

Visual observations of seed can be helpful for determining the causes of poor seed quality. Seed pathology studies supplemented by visual assays, field data, and information on agronomic practices help better understand the interactions which lead to poor seed quality.

TABLE 11.—*Incidence of internally seedborne microorganisms in 8 Honduran bean seed sources during June 1986*

Microbial taxa	Seed source[1] Percentage seedborne incidence[2] 1	2	3	4	5	6	7	8
Fusarium equiseti	9.0	4.5	3.0	1.5	4.0	4.5	5.0	2.0
Rhizoctonia solani	0.0	0.0	0.0	0.0	0.0	0.0	2.5	3.0
Macrophomina phaseolina	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Aspergillus spp.	3.0	3.0	1.5	3.5	1.0	2.0	3.5	10.0
Penicillium sp.	0.0	0.5	2.0	1.5	0.5	0.0	2.5	0.0
Chaetomium sp.	0.5	0.0	0.0	1.0	5.5	0.5	0.5	1.5
Nigrospora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
Curvularia lunata	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0
Colletotrichum lindemuthianum	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trichoderma sp.	10.0	0.0	2.5	0.0	0.0	2.5	0.0	0.0
Gliocladium sp.	0.0	0.0	0.0	0.0	0.0	1.5	1.0	1.0
Mucor sp.	0.0	0.0	0.0	0.0	0.0	0.0	2.0	14.0
Miscellaneous fungi	3.0	4.5	3.0	4.0	1.0	2.0	3.0	1.5
Bacillus licheniformis	8.0	23.5	17.5	4.0	30.0	37.0	24.5	11.5
B. cereus	7.5	13.0	7.0	4.5	6.0	9.0	2.5	4.5
Bacillus sp.	8.5	0.0	4.0	0.0	4.0	0.5	1.5	0.5
B. subtilis	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Flavobacterium sp.	1.0	4.0	0.0	1.0	0.0	0.0	0.0	0.0

[1]Seedlots 1 and 2 were var. Cincuenteño from Olancho; 3 and 4 are var. Zamorano; 5 and 6 were var. Danli 46 from El Paraíso; 7 and 8 were var. Zamorano from the Panamerican Agricultural School and the Secretary of Natural Resources of Honduras, respectively.

[2]Means are based on 4 random seedlots of 50-seed each for each seed source assayed on sterile potato dextrose agar after surface disinfection.

In the United States, seed lots with less than 80% germination are usually considered undesirable and unreliable for commercial plantings. Bean seed in Colombia (3) and Costa Rica (13) are reported to germinate at 8 and 68%, respectively.

In the analyses of Honduran bean seed, farmer sources were often below 80% germination. Nevertheless, quality was not nearly as poor as that reported in Colombia and Costa Rica. Less humid growing conditions in Honduras may favor higher quality seed production than reported in the previous works.

TABLE 12.—*Seasonal variability in seedborne microorganisms from successively analyzing 8 bean seed sources in Honduras during 1985-86*

Microorganism	Percentage[1,2]					
	Inc.	Lot inf.	Inc.	Lot inf.	Inc.	Lot inf.
	October 1985		December 1985		June 1986	
Fusarium equiseti	11.6	100	0.9	50	4.2	100
F. semitectum	3.2	88	6.9	100	0.0	0
F. solani	0.8	50	1.9	63	0.0	0
Alternaria sp.	2.2	75	0.3	38	0.0	0
Rhizoctonia solani	1.7	63	2.1	38	0.8	25
Macrophomina phaseolina	0.4	25	0.0	0	0.3	13
Phomopsis phaseolina	0.2	13	0.0	0	0.0	0
Phoma sp.	0.3	13	0.4	13	0.0	0
Cladosporium sphaerospermum	0.6	50	0.6	50	0.0	0
Aspergillus spp.	0.6	63	0.0	0	3.4	100
Penicillium sp.	0.2	25	0.4	25	0.9	63
Rhizopus sp.	1.3	25	0.0	0	0.0	0
Miscellaneous fungi	3.9	88	2.3	88	2.8	100
Chaetomium sp.	0.0	0	0.1	13	7.2	75
Nigrospora sp.	0.0	0	0.2	25	0.4	13
Curvularia lunata	0.0	0	0.1	13	0.2	25
Monilia sp.	0.0	0	0.3	25	0.0	0
Colletotrichum lindemuthianum	0.0	0	0.0	0	0.1	13
Gliocladium sp.	0.0	0	0.0	0	0.4	38
Mucor sp.	0.0	0	0.0	0	2.1	75
Sclerotium sp.	0.0	0	0.0	0	0.1	13
Trichoderma sp.	0.0	0	0.0	0	2.0	25
Bacillus licheniformis	0.0	0	0.0	0	32.0	100
B. cereus	0.0	0	0.0	0	6.8	100
B. subtilis	0.0	0	0.0	0	0.1	13
Bacillus sp.	0.0	0	0.0	0	2.5	75
Flavobacterium sp.	0.0	0	0.0	0	2.8	38
Total Bacteria	8.4	100	2.4	100	42.1	100

[1]Inc. = percentage of seeds infected (incidence).
[2]Lot Inf. = percentage of the 8 seed sources in which infections were detected.

Few seed pathology studies have related seed quality to seasonal or regional differences in production environment or methods. In Honduras, first crop beans had elevated infection by fungal pathogens because of generally higher temperature and rainfall found during that planting season. Seed shrivelled from the second crop, which developed under residual moisture. In Illinois (16) in soybeans best seed quality is produced in the cooler and drier northern tier; whereas, lower quality is particuliarly associated with counties bordering major waterways in the South.

Besides the direct association of seed infection with reduced seed germination and quality, major pathogens of bean are seedborne and can be transmitted by planting infected seed. Over 50% of the field pathogens of bean are believed seedborne (2). In this study about one half of the seedlots carried internal infections of *F. solani*. *Fusarium solani* causes dry root rot, a major disease on beans (1).

Bolkan (1) and others have suggested that *F. solani* is immobile except for its movement as chlamydospores in soil. Nash and Snyder (12) demonstrated spread of *F. solani* in soil accompanying seed lots. In Honduras, *F. solani* infects dry bean seed internally. Seed infection could be an important means of long range dispersal of this pathogen. In soybean in Puerto Rico, internally seedborne infections by *F. solani* are also reported (6). The traditional view of *F. solani* having only soil-borne movement may need modification. Studies on seed transmission of *F. solani* and its importance are needed.

Fusarium spp. are not often considered dominant seed-borne pathogens on grain legumes. *Fusarium equiseti* and *F. semitectum* were the dominant fungi on first and second crop seed at harvest in Honduras. Both were associated with low seed germination and low quality seed lots. *Fusarium equiseti* was associated with low bean seed quality in Colombia (3). In Puerto Rico, *F. semitectum* has been found a major seed pathogen in a variety of legumes (6,8). The importance of *Fusarium* spp. may have been underestimated in earlier reports.

Rhizoctonia solani was detected in about half of the Honduras seed lots. Like *F. solani*, *R. solani* is usually considered an obligate soil-borne disease. In Idaho and California (9) 22% of bean seed lots had seed with *R. solani* infections. *Rhizoctonia* web blight is an important disease of beans in Central America (5). In web blighted soybeans in Puerto Rico, about 5% seed infection was found (7). Seed isolates of *R. solani* in Honduras may be a mixture of web blight and root rot isolates of *R. solani* requiring future studies employing anastomosis testing to distinguish them.

Although second crop seed had the best harvest seed quality, after storage from December to June a diverse storage microflora developed associated with significant losses in seed vigor and weight. After storage *Aspergillus* was the fungal genus most isolated. López and Christensen (10) reported the association of *Aspergillus* with deterioration of dry beans in storage.

In stored seed *Bacillus licheniformis* was the dominant microorganism. In soybean, *Bacillus subtilis* was pathogenic to seed at temperatures of 30° C or more (4,14,17). In bean seeds from the western United States *Bacillus* spp. predominated but no pathogenicity was found when clean seed were inoculated and incubated at 20° C (15). In our pathogenicity testing, which will be reported in a future work, inoculating clean seed with *B. licheniformis* at 28° C reduced seed germination by 20% and lowered seedling weights. The little emphasis given *Bacillus* spp. as a grain legume pathogen can be attributed to use of unfavorable environments for pathogenicity testing and the mycological bias of most seed pathologists.

Stored bean seed showed more diverse microflora than recently harvested seed. There was evidence for the succession of field to storage fungi as was described by Hepperly and Rodríguez in pigeon pea seed (8). Moreover, *Gliocladium* and *Trichoderma* species, which are well known hyperparasitic genera, were detected in stored seed but not encountered in recently harvested seed lots. It is possible that the hyperparasites are a tertiary wave of mycological succession, i.e. field, storage, and then hyperparasites. Seeds are convenient living laboratories useful in demonstrating ecological concepts such as succession and easy sources of biological control agents.

Considering the sizable loss of bean seed quality in normal storage in Honduras, two alternatives are suggested: producing seed beans in the dry season from December to March under furrow irrigation to optimize seed quality and minimize the period of seed storage; and developing improved storage facilities to better control the storage environment. The development of acceptable bean varieties with improved tolerance to weathering and storage deterioration should be explored to help over the long run. López and Crispin (11) have described considerable differences among dry beans as to storage tolerance.

LITERATURE CITED

1. Bolkan, H. A., 1980. Root rots. pages 65-99. *In*: Dry Bean Production Problems, H. Schartz & G. Gálvez (Eds), CIAT, Cali, Colombia.
2. Ellis, M. A., 1980. Seed pathology. pages 303-14. *In*: Dry Bean Production Problems, H. Schwartz & G. Gálvez (Eds), CIAT, Cali, Colombia.
3. ——, G. E. Gálvez and J. B. Sinclair, 1976. Internally seedborne infection by fungi and seed quality of dry bean seed in 4 Colombian states. *Colomb. Not. Fitopat.* 5: 79-82.
4. ——, F. D. Tenne and J. B. Sinclair, 1977. Effect of antibiotics and high temperature storage on decay of soybean seeds by *Bacillus subtilis*. *Seed Sci. Technol.* 5: 753-61.
5. Gálvez, G. E., P. Guzmán and M. Castaño, Web Blight. pages 103-08. *In*: Dry Bean Production Problems, H. Schwartz and G. Gálvez (Eds), CIAT, Cali, Colombia.
6. Hepperly, P. R., 1985. *Fusarium* species and their association with soybean seed under humid tropical conditions in Puerto Rico. *J. Agric. Univ. P. R.* 69 (1): 25-33.
7. ——, J. S. Mignucci, J. B. Sinclair, R. S. Smith and W. H. Judy, 1982. *Rhizoctonia* web blight of soybeans in Puerto Rico. *Plant Dis.* 66 (3): 256-57.
8. —— and R. Rodríguez, 1984. Mycofloral succession and viability losses in pigeon pea seed in Puerto Rico. *J. Agric. Univ. P. R.* 68 (1): 19-31.
9. Leach, C. M. and M. Pierpoint, 1956. Seed transmission of *Rhizoctonia solani* and *Phaseolus vulgaris* and *P. lunatus*. *Plant Dis. Rep.* 40: 907.
10. López, L. C. and C. M. Christensen, 1962. Effects of storage fungi on dry beans. *Agric. Tec. Mex.* 2: 33-7.
11. —— and A. Crispin, 1971. Varietal resistance to storage fungi in dry bean. *Agric. Tec. Mex.* 3: 67-9.
12. Nash, S. M. and W. C. Snyder, 1964. Dissemination of the root rot *Fusarium* with bean seed. *Phytopathology* 54: 880.

13. Sánchez, F. R. and A. M. Pinchinat, 1974. Bean seed quality in Costa Rica. *Turrialba* 24: 72-5.
14. Schiller, C. T., M. A. Ellis, F. D. Tenne and J. B. Sinclair, 1977. Effect of *Bacillus subtilis* on soybean seed decay, germination, and stand inhibition. *Plant Dis. Rep.* 61: 213-17.
15. Schnathorst, W. C., 1954. Bacteria and fungi in seeds and plants of certified bean varieties. *Phytopathology* 44: 588-92.
16. Short, B. J., A. P. Grybauskas, F. D. Tenne and J. B. Sinclair, 1981. Epidemiology of *Phomopsis* seed decay of soybean in Illinois. *Plant Dis.* 65: 62-4.
17. Tenne, F. D., S. R. Foor and J. B. Sinclair, 1977. Association of *Bacillus* with soybean seeds. *Seed Sci. Technol.* 5: 763-69.