Chapter 1

Bean Production and Pest Constraints in Latin America

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Introduction

Dry beans *(Phaseolus vulgaris* L.) are exposed to a large array of yield constraints during their growth cycle in Latin America and other regions of the world. This chapter will concentrate primarily on disease and insect constraints which influence bean production in Latin America. A brief review is given on Latin American bean production, followed by a discussion on economical and pathological aspects of control strategies.

More than one-third of the dry bean production in the world occurs in Latin America. Average bean yields in Latin America are less than 600 kg/ha, compared to monoculture yields of nearly 1400 kg/ha in the United States (Table 1) and three to five tons under experimental conditions in Latin America (3). During the last decade the production growth rate of beans in Latin America was substantially less (0.27%) than the population growth rate (2.80%), and caused per capita consumption to decrease while bean imports and legume prices increased. These trends have aggravated nutritional and balance-of-payment problems in many Latin American countries (24).

Total bean production has changed relatively little in Latin America during the last decade due to a net balance realized between expanded production area and reduced crop productivity (Table 2). Not only have dry bean yields declined during the last decade, but they also have showed extreme fluctuation between years. Variable weather conditions, poor soil fertility, bean diseases and insect pests appear to be the most important factors contributing to declining and erratic yields (3, 13, 23, 25, 26, 27). The recent decline in Brazilian yields greatly influenced total productivity, since Brazil is responsible for 54% of Latin American bean production.

Recent severe disease epidemics of bean golden mosaic virus and chronic problems with anthracnose and common bacterial blight appear to have been most responsible for this decline (24).

Brazilian yield declines also have been influenced by the displacement of beans to more marginal production areas due to the influx of more profitable crops such as soybeans. This displacement also has occurred frequently throughout other regions of Latin America because of the inherent risks involved in bean production, low absolute yields and profitability, and the lack of a stable price after harvesting. These factors, plus difficulties in mechanizing the dry bean harvest, have concentrated bean production on small farms in most of Latin America (13, 16). Production on small farms usually implies low levels of purchased inputs, associated cropping, and production area shifts as soil nutrients become depleted or eroded (Table 3).

Determining Priorities Among Bean Pathogens and Pests

The importance of a plant pathogen or pest is determined by the economic loss it causes. The magnitude of this loss depends on how frequently it occurs and how severe the damage is during each crop cycle. Most estimates of yield losses in Latin America are based on experimental data and should, therefore, be regarded as estimates of yield losses under conditions of good soils, high level management, often high use of inputs and usually high disease or insect incidence. Table 4 lists estimated yield losses obtained for important bean pathogens and insect pests, primarily under these conditions. However, it is difficult to extrapolate these experiment station or glasshouse disease loss estimates to those of commercial operations.

One study of farm level pest and pathogen incidence was conducted in the major Colombian zones of bean production in 1974-1975. Based on data taken during repeated visits to 177 farms, the relative importance of various pests and pathogens was estimated by multiple regression analysis (22, 23). Table 5 summarizes the magnitude of production losses obtained during this growth cycle in various Colombian regions. For example, leafhoppers caused 1.3 million dollars damage in three regions during one semester's production. Pest and pathogen incidence is expected to vary not only by region but also between seasons and cultivars. Hence, much information is necessary for the definitive priority ranking in specific production regions in Latin America.

Bean Disease Control Strategies

Many measures are available in Latin America to control bean diseases, including cultural practices, crop rotation, sanitation and disease avoidance, production of pathogen-free or clean seed, chemical control and resistance breeding. Associated cropping with maize may reduce certain insect problems and create a physical barrier to the spread of a pathogen such as the common bacterial blight bacterium (1, 10, 11). However, it can enhance infection by other pathogens such as the angular leaf spot fungus (20).

Dry bean pathogens causing diseases such as bean common mosaic virus, common bacterial blight, angular leaf spot, and anthracnose are able to infect seed and be transmitted within seed. When compared with highly infected farmers' seed, impressive results have been obtained by planting clean seed (3, 7). In Guatemala, clean seed combined with other inputs raised yields to 1.5 tons/ha on 84 ha in two valleys compared with the national average of 515 kg/ha. Results in Colombia for certified and protected seed (produced with heavy chemical application in a high rainfall region) were not impressive. In fact, certified seed gave lower yields than farmers' seed and the protected seed was only marginally superior with a 106 kg/ha difference (3). In bean production regions with a high incidence of pathogens, pathogen-free seed may have to be combined with other control strategies to reduce disease incidence. Substantially higher yield differences will be necessary to offset the costs of implementing and maintaining clean seed production programs.

Clean seed production in semi-arid regions of the western United States undoubtedly has contributed substantially to the reduced importance of anthracnose and bacterial blights in the United States. However, clean seed programs are expensive since they require:

- specific regions unfavorable to pathogen development and survival, but favorable to plant development
- increased production costs for irrigation, inspection, chemical protection and transportation back to production regions
- distribution to farmers.

A successful clean seed production program often requires financial support by the government or a producers' cooperative to reduce seed costs and insure farmer acceptance. However, when combined with other control measures, clean seed may be a low cost and effective control measure for certain pathogens (3).

In Latin American bean production, chemical control involves multiple spraying and substantially increased production costs. However, it often results in only limited success. For example, growers in the Cauca Valley of Colombia spent large amounts for agricultural pesticides and still suffered substantial damage from rust and leafhoppers (23). Chemical control also is often associated with large farm size, since these farmers generally use more inputs and receive more technical assistance than those with smaller farms (Table 3). However, most bean production in Latin America occurs on small farms. When chemicals are used, they may be inappropriate to control specific plant pathogens or insects, since farmers often apply only those chemicals which are known to be most effective on their more profitable cash crops such as coffee or potatoes (Sanders, unpublished data). Moreover, indiscriminant application of broad spectrum chemicals can eliminate beneficial insect predators of bean pests and reduce the potential effectiveness of biological control agents. Chemical control of bean diseases and insects in Latin America, therefore, should be considered a large farmer solution, a short- term measure while resistances are being incorporated into commercially acceptable bean cultivars, and a component of integrated control.

Breeding for disease and insect resistance is an essential component if the control strategy for Latin America is to be directed toward all producers, irrespective of their economic resources. The gain from breeding for resistance to specific pathogens and insects will depend on expected yield losses from the pathogen, the probability of success in breeding resistance into a high yielding and marketable cultivar, and the period during which the resistance mechanism maintains its effectiveness. Thus, not only must sources of resistance exist and be incorporated easily into commercially acceptable cultivars, but they also must endure long enough to ensure that overall benefits are greater than the costs incurred in breeding and diffusion efforts.

When multiple races or strains of a pathogen exist, probability of the loss of effective resistance becomes an important consideration, especially in the tropics where environmental conditions in many regions favor nearly continuous disease pressure. Alternative breeding strategies for more stable resistance, for example non-race-specific resistance, also must specify the time period and cost required to develop this protection. It is not sufficient to point out only that race-specific resistance breaks down. It also is necessary to identify a higher payoff with an alternative control measure and to compare net returns during the different time periods. Race-specific resistance to rust would have been worth 1.2 million dollars, even if effective only for one season and the cultivar were distributed only throughout the Cauca Valley (Table 5). Nevertheless, a more stable and longer-term form of resistance is preferred if it has a higher economic return than alternative controls or is the only practical control available to producers with limited economic resources.

Another problem is the increased probability of a general epidemic occurring after widescale diffusion of a new cultivar with race-specific resistance or different cultivars derived from relatively similar and uniform germplasm sources. Such an epidemic occurred during 1970 in the United States when 75-90% of the commercial maize hybrids planted were derived from a single source of cytoplasm. These hybrids were susceptible to various pathogens such as *Phyllosticta maydis* and *Helminthosporium maydis* race "T". The latter reduced U.S. yields by 15% in 1970 (4). Geographical diversity of production areas and farming systems, differences in consumer preferences for bean type, and the expected slow diffusion of new materials to the many small farmers producing beans in Latin America all reduce the danger of a widescale epidemic inherent in an agricultural system which relies on widely diffused and genetically uniform cultivars. Nevertheless, the stability of plant resistance mechanisms must be monitored continuously by research and extension personnel throughout Latin America and other dry bean production regions in the world.

Summary

Beans are attacked by a large number of plant pathogens and insect pests, many of which can reduce yields drastically. Farmers with small land holdings usually have limited resources but produce most of the beans in Latin America. Control strategies feasible for these growers may be restricted to those strategies which do not require large cash inputs, hence breeding for resistance may be the most desirable alternative available. National and international bean production programs must accurately identify yield constraints prevalent in specific production regions to provide more efficient use of the large manpower, research expenditure and time requirements necessary to implement resistance breeding.

Stability of resistant materials can be improved with an integrated control strategy consisting of resistance, cultural practices, chemicals and clean seed production for those diseases in which resistance does not confer immunity to infection. This integrated control strategy will need to be adapted to specific regional problems. As in the case of disease and insect priority identification, a more systematic collection of information is necessary to evaluate the costs and probability of success for control strategies so that the research by pathology, entomology and breeding on the experiment station is more applicable and quickly available to farmers.

Table 1. Dry bean production in the world during 1975-77 (9).

Country	Production Area ('000 ha)	Total Production ('000 ton)	Average Yields (kg/ha)
Brazil[a]	3788	1973	521
Mexico	1525	837	547
Argentina	167	187	1085
Chile	82	85	1032
Colombia	112	78	693
Guatemala	119	70	599
Paraguay	70	54	771
Nicaragua	69	51	746
Peru	64	49	772
Venezuela	95	48	493
Honduras	87	47	540
El Salvador	54	38	703
Dominican Republic	45	33	731
Ecuador	66	30	451
Cuba	35	24	686
Costa Rica	36	15	417
Panama	17	4	235
Latin America[b]	6486	3677	567
China	2605	2229	856
United States	570	779	1370
Japan	113	148	1310
Canada	68	97	1435
Far East	9472	3179	336
Africa	1961	1106	564
Western Europe	941	483	513
Near East	230	302	1313
South Africa	69	64	927
World[c]	23722	12392	522

a/ Cowpeas were deleted from the Brazilian bean data.

b/ Several Latin American countries were excluded because of inconsistent data. However, their share of production was very small.

c/ These totals include production data from the above countries plus others not listed.

Table 2. Rates of increase for production, area and yield of beans in Latin America during 1965-1976 (24).*

	Rate of Increase		
Country	Production	Area	Yield
Brazil	-0.89	1.92	-2.81
Mexico	0.99	-2.07	3.05
Argentina	16.17	14.89	1.28
Guatemala	4.21	2.24	1.97
Colombia	6.77	3.26	3.50
Chile	-0.69	2.75	-3.45
Honduras	-0.54	0.88	-1.43
Nicaragua	1.93	0.77	1.16
Haiti	1.01	0.33	0.68
El Salvador	8.79	6.27	2.52
Peru	-3.80	-2.04	-1.76
Paraguay	2.04	6.65	-4.61
Venezuela	-3.76	-1.76	-2.00
Dominican Republic	3.41	1.05	2.36
Ecuador	-1.16	-0.48	-0.67
Cuba	0.35	-0.59	0.94
Costa Rica	-2.21	-4.25	2.04
Panama	-5.83	-4.01	-1.82
Uruguay	-2.66	-0.65	-2.01
Latin America	0.27	0.79	-0.52

* Estimated with the semi-log model: $LY = A + bX$, where LY is the log to the base e of production or area. A and b are the parameters of the regression, and X represents years. Differentiating LY with respect to year gives $\partial LY / \partial X = b$, thus the annual rate of change is b. When b is multiplied by 100, the geometric growth rate is obtained.

Table 3. Characteristics of bean production in the four principal production regions of Colombia (23).

	Production Region			
Characteristic	Valle	Huila	Nariño	Antioquia
Average elevation (meters above sea level)[a]	1120	1323	1309	2270
Average farm size (ha)	48.0	29.5	9.2	4.4
Area in beans (ha)	22.6	4.1	1.8	1.5
Percentage of farms using:				
Irrigation	45	2	0	0
Certified seed	52	7	5	0
Fertilizers	84	20	0	100
Herbicides	32	0	0	0
Insecticides	87	20	5	33
Fungicides	100	14	0	42
Credit	87	53	58	50
Technical assistance	70	18	5	8
Mixed cropping	0	74	95	100
Machinery	100	44	0	0
Bean yield (kg/ha)	906	680	467	533
Bean equivalent yield (kg/ha)[b]	906	825	732	723

a The range was substantital in two of the regions:

Valle	1030 - 1310m,	Nariño	865 - 1560 m.
Antioquia	2200 - 2410m,	Huila	950 - 1560 m.

b The bean equivalent yield is: $Y_B + \frac{PcYc}{P_B} = Y_{B.E}$

Where Y_B is the bean yield, Yc is the corn yield or other crop yield, $Y_{B.E}$ is the bean equivalent yield and $\frac{Pc}{P_B}$ is the corn (or other crop price) relative to the bean price (P_B)

Table 4. Estimated bean yield losses attributed to plant pathogens and insects.

Plant Disease or Insect Pest	Estimated Yield Loss	Literature Cited
Bean Common Mosaic Virus	53-68% (U.S.A.)	15
	16-95% (Latin America)	3
Bean Golden Mosaic Virus	48-85% (Brazil)	5
Common Bacterial Blight	10-38% (U.S.A.)	28
	18-45% (Colombia)	22
Rust	38-50% (Brazil)	21
	18% (Colombia)	29
	40-80% (U.S.A.)	28
Anthracnose	38-99% (Colombia)	3
	100% (U.S.A.)	28
Angular Leaf Spot	50% (U.S.A.)	14
	40-60% (Colombia)	2
	80% (Mexico)	6
Root Rots	60% (Brazil)	12
	15-86% (U.S.A.)	17
Leafhoppers	14-23% (Wet season, Colombia)	25
	73-95% (Dry season, Colombia)	25
Bean Pod Weevil	94% (El Salvador)	18
	90% (Mexico)	8
Storage Insects (Bruchids)[a]	35% (Mexico, Central America, and Panama)	19
	7.4% (Colombia)	26

a The insect damage losses were not separated from other storage losses.

Table 5. Bean production losses caused by plant diseases and insect pests in three Colombian bean zones during 1974-1975 (23).

	Estimated Value of Production Loss During One Crop Cycle	
Production Problem	Cauca Valley [a]	Huila and Nariño [a]
Plant Diseases		
Rust	U.S.$ 1,171,000	-
Common Bacterial Blight	933,000	-
Angular Leaf Spot	552,000	-
Viruses [b]	-	400,000
Anthracnose	-	282,000
Powdery Mildew	-	250,000
Root Rot [c]	-	207,000
Insects		
Leafhoppers	749,000	537,000
Thrips	-	510,000

a The average elevation above sea level was 1120 m in the Cauca Valley and 1320 m in Huila and Nariño.

b The interviewing agronomists were unable to always differentiate between virus symptoms caused by bean common mosaic virus, bean rugose mosaic virus or other viruses.

c No attempt was made to identify the specific root rot pathogen responsible.

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