Chapter 2

COMMON BEANS IN AFRICA AND THEIR CONSTRAINTS

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Introduction

The common bean (*Phaseolus vulgaris* L.) is an ancient New World domesticate. Beans spread widely in post-Columbian times and reached Africa from Brazil with the slave trade. They had reached Europe by the sixteenth century and probably spread to coastal parts of Africa not long afterward through the Portuguese. *Phaseolus vulgaris* became established as a food crop in Africa before the colonial era. The wealth of local names given to distinctive cultivars is evidence of the long establishment of beans as a food crop in East Africa (Greenway, 1945; Leakey, 1970a).

The total annual production of common beans in Africa is estimated at two million tons of dry seed. This is about 25% of world production (Table 1).

The Production Environment

The common bean is adapted to temperate and cool tropical climates. In Africa, production is concentrated in the cool highlands of central and tropical eastern Africa where beans are the most important pulse crop. However, beans are also grown as a winter irrigated crop in North Africa and parts of southern Africa. Within the highland areas, the production environment is diverse; the altitude ranges from 800 to 2300 m above sea level, although the higher elevation zones (1900-2300 m) are largely confined to the

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Table 1. Estimated annual production (t in thousands) of common beans in Africa, according to region.

Region	Proportion of total production	
	(t in thousands)	(%)
Great Lakes Region		
Rwanda	282	12.8
Burundi	193	8.8
Zaire	96	4.4
Eastern Africa		
Ethiopia	33	1.5
Kenya	567	25.8
Uganda	259	11.8
Somalia	1	>0.1
Southern Africa		
Tanzania	350	15.9
Zambia	35	1.6
Malawi	67	3.0
Mozambique	15	0.7
Zimbabwe	46	2.1
Angola	40	1.8
Lesotho	10	0.5
Swaziland	1	>0.1
Other regions	205	9.3
Total Africa	2200	100.0

SOURCES: CIAT, 1985 and 1986; FAO, 1986.

volcanic slopes of the Virunga region of central Africa. In contrast to Latin America, production of *P. vulgaris* in Africa gives way to *P. coccineus* L. above 2300 m. Most production is found on plateaus between 1200 and 1700 m.

Soil type also varies considerably between regions of production. Beans in the Ruhengeri district of northern Rwanda and to the west of Arusha in northern Tanzania, enjoy excellent fertile volcanic soils. Elsewhere, production can be seriously constrained by soil infertility, including acidity. Highly acid soils, with a pH as low as 4.2, are found in the bean-producing areas of Mbala district of northern Zambia, in the Usambara Mountains near Lushoto in Tanzania, and on the Nile Zaire Crest of Rwanda.

Mean temperature in the principal areas of bean production ranges from 16 to 24 °C. Annual precipitation is in the range of 500-2000 mm, with a bimodal distribution in eastern Africa (usually between latitudes 6° N and S) as a result of movements of the intertropical convergence zone. Average annual rainfall varies substantially with location and, in some places, particularly in the drier regions at the unstable frontiers of rainfall systems, rainfall is markedly variable from year to year (Bunting, 1961). A valuable method is available for calculating the confidence limits for seasonal variation in rainfall in East Africa (Manning, 1956). However, in bean-producing areas, mean precipitation during a single season varies relatively little: 400 mm (about the minimum rainfall required for a bean crop) to 800 mm. Seasonal length, from sowing to harvest, varies from about 70 days in drier lowlands to about 150 days in humid highlands, although obviously seasonal length depends also on latitude of the site and growth habit of the predominant bean cultivar.

The wide variability of production environments results in a wealth of diversity in cropping systems as well as in agronomic constraints to bean production.

Crop Production Systems

Beans are produced in a wide range of production systems in Africa. Large-scale monoculture production of navy beans for canning and export still occurs in some areas, although this industry has collapsed in northern Tanzania, Uganda, and Ethiopia where canning-bean production was once substantial. For example, in Tanzania, the production of navy beans for export started in 1937 and expanded to more than 2500 tons in 1952. Rising interest in the crop attracted inexperienced producers; quality therefore declined rapidly just when canners became increasingly demanding. In an effort to keep the industry alive, the cultivar Michigan Pea Bean was introduced into East Africa without careful testing for adaptation. Unlike the cultivar Comptesse de Chambord which was the principal cultivar grown in the early years, Michigan Pea Bean was especially susceptible to rust and, as a result, was almost totally destroyed.

Subsequent work focused on screening a collection of white-seeded types for suitability for local production for canning. The cultivar Mexico 142 was among those selected and is now one of the most widely grown navy beans in eastern Africa (Leakey, 1970a; Macartney, 1966; Robertson, 1955). In the Arusha region of Tanzania, about 25,000 ha of beans are grown on a large scale on contract to European seed firms. The cultivars grown are bush types selected for their acceptability in Europe as snap beans and are produced in monoculture. They receive more inputs, including aerial application of insecticide, than do food bean crops.

In the Great Lakes Region of central Africa, beans are grown primarily for home consumption and usually in association with other crops. In Burundi, although as much as 20% of the crop may finally be marketed, farmers almost never initially intend to market them (Bergen, 1986). The same situation arises in Rwanda where available data (SESA, 1984; J. Voss, unpublished data) reveal a home consumption rate of more than 80%. The north Kivu region of Zaire has a much higher degree of marketing with sales to Kinshasa and, in times of shortage, to Rwanda and Burundi. Although reliable statistics are not available, estimates suggest that market-oriented production may be as high as 70%.

The cultivation of staked climbing beans predominates in those parts of the Great Lakes Region which have high rainfall, high population density, and fertile soils. This includes the Ruhengeri and Gisenyi regions of Rwanda, most of north Kivu in Zaire, and parts of the west flank of the Nile Zaire Crest in Burundi. The main reasons for growing climbing beans in these areas are their greater resistance to pathogens (because of their physiological escape mechanism) and the need to intensify production (because of high population density).

Climbing beans are grown in a number of systems. At high altitudes, between 2000 and 2300 m, monoculture predominates, but relay cropping and associated cropping with maize are also practiced. At lower altitudes, 1200-2000 m, complex associations become more common. In Rwanda and Burundi the most common associations are with bananas (Figure 1)[1], maize (most commonly

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[1] This and all other numbered figures are collected together as a separate booklet at the end of the book. Lettered figures are found within the text.

staked between maize plants), and sweet potatoes. In north Kivu, staked climbing beans are most often grown in monoculture, perhaps because of the more market-oriented production. However, associations with maize, bananas, and coffee are also practiced.

Landraces of mixed seed type are common in Uganda (Leakey, 1970a), Malawi (Martin and Adams, 1985), southern Tanzania, and, especially, in the Great Lakes Region. Here, varietal mixtures (Figure 2) provide small farmers with a more reliable seed yield under low-input conditions, apparently by buffering against environmental stress, including disease. Work carried out by the International Service for National Agricultural Research (ISNAR) has demonstrated that most exotic varieties were less well adapted and more affected by diseases than the mixtures of local varieties used by farmers (ISNAR, 1983). The shift to cultivation of pure varieties is associated with market production. Consumer preferences for certain grain types apparently govern traders' demand for greater grain uniformity and price premiums, so accounting for this shift. Pure lines receive a market price premium over mixtures at about 20% in Burundi, as much as 100% in Zaire, and at over 900% in Uganda where uniformity and the need to meet consumer preferences are of paramount importance.

Food beans for subsistence are typically produced on a small scale, usually in association with other crops. In Uganda, an estimated 75% of all beans are grown in association on small farms. Similarly complex cropping systems are found in Kenya, the southern highlands of Tanzania, northern Zambia, and Malawi (Edje et al., 1981; Leakey, 1970a; Spurling, 1973). The crop most commonly associated with beans is maize, although the bean-banana-coffee association predominates in some areas. Other companion crops include sweet potatoes, peas, cassava, yams, cocoyams, potatoes, and peanuts (groundnuts).

In Malawi, more than 94% of cultivated land is under associated cropping (Edje et al., 1981) as in other densely populated areas, including the Kagera Region of Tanzania (Tibaijuka, 1984) and the Great Lakes Region. Associated cropping is more common in areas where land is scarcer (because of denser human population) and less common in areas where production is more market oriented (as in

Kenya). However, monoculture seldom accounts for more than 40%. Associated cropping offers several advantages to the small farmer: it enables greater productivity where land is restricted (Neumann et al., 1986), it decreases the risk of complete crop failure, and it often decreases disease severity (Msuku and Edje, 1982; van Rheenen et al., 1981). The banana-bean association is common in Rwanda, Burundi, Uganda, and the Kagera Region of Tanzania. In Rwanda, 60% of bean production is estimated as being in association with banana (Nyabyenda et al., 1981). The situation is similar in Burundi. The banana association plays an important role in reducing drought stress for the associated bean crop and thus improves the stability of the system. However, the water and nutrient relations of the banana-bean association have not received sufficient attention (Osiru and Mukiibi, 1984). In the coffee-growing areas of north Kivu, Zaire, coffee is always associated with beans.

Crop Production Constraints

The main production constraints reported in the literature are poor agronomic practices, soil infertility, lack of improved cultivars, moisture stress, weed competition, and damage caused by pests and diseases. However, in systems involving complex associations, the claim often made by researchers that farmers' practices are sub-optimal is difficult to evaluate objectively because research designs become almost impossibly complex. Too often, assumed priorities reflect prejudices on part of the scientist rather than the true constraints to crop productivity. Indeed, some systems of subsistence agriculture are balanced, self-supporting, tropical agroecosystems (Igbozurike, 1971; Janzen, 1973) in which coevolved crops have achieved an equilibrium, not only with one another and with their environment (Bunting, 1975), but also with their parasites. Consequently, the farmer always has a stable source of food for himself and his family, rather than risk hunger for the sake of high productivity. The poorer the farmer and the less fertile the soil, the more important yield stability becomes. His decision to grow beans in complex associations and often in varietal mixtures therefore stems from the need to maximize stability of performance rather than productivity per se. The determination, then, of the relative importance of production constraints can and must be performed with diagnostic exploratory trials onfarm. This will set realistic priorities for future research in each agroecological zone in which beans are produced. For example, in those parts of Rwanda where beans have been cultivated for several centuries, onfarm trials have yet to show significant yield advantages of new varieties over traditional ones. Conversely, in areas of recent immigration, new varieties have shown yield advantages of as much as 35% superior to farmer mixtures (Graf and Trutmann, 1987).

The Centro Internacional de Agricultura Tropical (CIAT) team in the Great Lakes Region has been using a multitiered approach to identify the main production constraints. This consists of a combination of farmer surveys, informal interviews, trials to determine limiting factors, and onfarm varietal trial evaluations. Farmer surveys in Ruhengeri, Rwanda, show that insect attack, drought, excess rain and associated diseases, low soil fertility and insufficient compost and manure, and lack of land were all considered by farmers as significant production constraints (Table 2).

Table 2. The importance of varietal characteristics, according to 120 farmers interviewed in Ruhengeri, Rwanda, 1985-86.

Importance	Characteristic	Score[a]
High importance	Yield	92
	Rain tolerance	85
	Earliness	78
	Drought tolerance	76
Medium importance	Taste	60
	Upright architecture	48
Low importance	Storability	36
	Fast cooking	31
	Green bean quality	29
	Leaf quality	20
	Color	6

a. Scoring is based on a scale of 0 to 100 where 100 signifies that all farmers identify the characteristic as very important.

SOURCE: J. Voss and K. Dessert, unpublished data.

Trials in the Great Lakes Region to determine limiting factors have shown soil fertility and diseases to be the two most limiting factors under most production conditions. A clear negative interaction between soil fertility and disease is often found. Gains made through increasing soil fertility are offset by losses from increasing disease pressure if diseases are not controlled. If a farmer is forced by economic or labor considerations to choose between increasing soil fertility or controlling diseases, the latter is more likely to bring about significant yield increases (Graf and Trutmann, 1987; Trutmann and Graf, 1987).

At lower altitudes in the Great Lakes Region, and elsewhere in eastern and southern Africa, insect pests are also significant limiting factors. Bean fly (*Ophiomyia* spp.) can cause substantial damage, especially on less fertile land. Recent work in northern Zambia suggests that application of fertilizer onfarm may effectively suppress the damage resulting from bean-fly infestation.

Disease as a Production Constraint

The common bean was introduced to the highlands of eastern Africa about 400 years ago and the highlands are now a secondary center of genetic diversity. It appears that accompanying the crop were many of the seed-borne pathogens that plague the crop in its primary center of origin in the New World. The principal diseases of beans are, therefore, essentially the same in the two centers. Nevertheless, there are a few important dissimilarities in the pathogen spectra of the two continents.

Literature on bean diseases in Africa is fragmentary. Most major reviews have not dealt extensively with African literature, although Allen (1983) has attempted to redress the imbalance. Notable gaps in knowledge of the importance of bean pathogens include Angola, Cameroun, Chad, and Togo, each of which is a significant producer of the crop.

In comparison to fungi and bacteria, whose distributions are relatively well cataloged in territorial checklists of pathogens (CMI, 1970, 1971, and 1979), virus distribution is poorly known. Because viruses are difficult to identify, maps of their distribution in Africa are prone to inaccuracy, especially when identification has been based on symptomatology alone.

The most important virus pathogen of beans in Africa is the bean common mosaic virus (BCMV). It is reliably identified from central and eastern Africa where necrotic strains are common and damaging (CIAT 1987; Kulkarni, 1973; Mink, 1985; Omunyin, 1979; Silbernagel et al., 1986). Peanut stunt virus has been identified recently in beans in the Sudan (Ahmed and Mills, 1985) but cucumoviruses are not known from beans in East Africa (Bock et al., 1975). Similarly, southern bean mosaic virus (SBMV) has not yet been detected in beans in eastern Africa, although it is known in legumes in western Africa (Givord, 1981; Lamptey and Hamilton, 1974). Bean golden mosaic virus (BGMV) has not been found, although a closely related virus occurs in lima beans (*Phaseolus lunatus* L.) in Nigeria (Vetten and Allen, 1983; Williams, 1976). Cowpea mild mottle virus, known in various legumes in West Africa, has recently been found in natural infections of bean in Tanzania (Mink, 1985). Alfalfa mosaic virus is recorded in beans in South Africa (Neveling, 1956). Both tobacco mosaic virus (Hollings et al., 1981) and bean yellow mosaic virus (BYMV) have been recorded in beans in Kenya, although BYMV is now thought as eradicated. Peanut mottle virus is also known from *Phaseolus* spp. in East Africa (Bock, 1973).

Among the bacterial diseases, the only one of uncertain status is bacterial wilt caused by *Curtobacterium flaccumfaciens* (syn. *Corynebacterium*) which is thought to occur in Kenya (Hubbeling, 1973). Bacterial brown spot, incited by *Pseudomonas syringae* van Hall pv. *syringae*, is also known from beans in Kenya and Burundi (Duveillier and D. Perreaux, personal communication, 1986; Kaiser and Ramos, 1980). Both common bacterial blight and halo blight are widespread and important.

The major fungal diseases of beans in Africa, as in Latin America, are angular leaf spot, anthracnose, and rust. Ascochyta blight is very damaging in the highlands of the Great Lakes Region, and floury leaf spot, caused by *Mycovellosiella phaseoli* (Drummond) Deighton, is locally important. Web blight is probably of little importance (unlike in Central America where it is severe). Certain fungal pathogens have not been reported from Africa, including white leaf spot caused by *Pseudocercosporella albida* (Matta *et* Belliard) Yoshii *et* Aamodt, gray leaf spots (*Cercospora vanderysti* P. Henn. and *C. castellanii* Matta *et* Belliard), and the round leaf spot, *Chaetoseptoria wellmanii* Stevenson. Conversely, scab (Figure 3), caused by *Elsinoë phaseoli* Jenkins is known from beans only in Africa, although it is a pathogen of lima bean and cowpea in the New World (Allen, 1983; Jenkins, 1931).

There is evidence, in some cases, of substantial diversity among pathogens in Africa. Studies of anthracnose (Ayonoadu, 1974; Leakey and Simbwa-Bunnya, 1972), rust (Allen, 1975a; Howland and Macartney, 1966; Mmbaga and Stavely, 1986), and angular leaf spot (Hocking, 1967) have each revealed new variants that do not correspond exactly with races described in the New World. Preliminary evidence from studies on ascochyta blight in Africa suggest that the most important causal agent is *Phoma exigua* var. *diversispora* (Bub.) Boerema and not *P. exigua* var. *exigua* Desmazieres, the latter being a synonym of *Ascochyta phaseolorum* Saccardo (Boerema, 1972; Boerema et al., 1981; M. Gerlagh and G. H. Boerema, personal communication, 1986).

Recent collaborative studies on halo blight by J. D. Taylor from the National Vegetable Research Station in England and scientists at CIAT have identified new races of *Pseudomonas syringae* pv. *phaseolicola* not known to occur outside Africa. Similarly, the predominance of necrotic strains of BCMV in eastern Africa contrasts with known strain spectra elsewhere. This raises the question of the origin of some of these variants. It is no longer certain that they all have necessarily coevolved with *P. vulgaris* and have been transported with its seed.

Estimates of the relative importance of bean diseases in Africa (Table 3) have been obtained chiefly from studies conducted on research stations where artificial inoculation can be relied upon. While such estimates can give some indication of potential loss, they do not always accurately reflect the relative importance of a particular disease among other agronomic constraints experienced on the farm.

Table 3. Estimates of crop losses induced by pathogens in beans in Africa.

Disease	Cultivar	Crop loss (%)	Source
Anthracnose	–	92	Peregrine, 1971
	T 8	86	Shao and Teri, 1985
	Mexico 142	27	Shao and Teri, 1985
	T 3	4	Shao and Teri, 1985
Angular leaf spot	Selian Wonder	25	Swai and Keswani, 1984
	Kabanima	8	Swai and Keswani, 1984
Rust	White-seeded types	100	Howland and Macartney, 1966
	Selian Wonder	11	Mbowe and Keswani, 1984
	Canadian Wonder	14	Mbowe and Keswani, 1984
Scab	–	43-76	Mutitu, 1979
Bean common mosaic virus	Kabanima	14-18	Meketo and Keswani, 1984

Recent results from diagnostic onfarm trials in Rwanda have recorded grain yield increases of 400-1000 kg/ha in beans from the chemical control of fungal and bacterial pathogens. In the highlands, above 1900 m, there are demonstrable advantages in using combined resistance to anthracnose, angular leaf spot, and ascochyta blight, as well as controlling root diseases. At intermediate altitudes, anthracnose and angular leaf spot resistance is required, and BCMV resistance is necessary for climbing cultivars (Trutmann and Graf, 1987).

In Zambia, Greenberg et al. (1987) have used multiple regression analysis of disease scores against seed yield of beans to estimate yield loss caused by pathogens and to set priorities among diseases at any given location. Ohlander (1980) took a similar approach to bean diseases in Ethiopia, demonstrating that similar studies are required elsewhere, because priorities change from location to location.

More work is also needed on the possible interactions between pathogens and the diseases they cause (Allen and Russell, 1987). Casual observations in the field suggest that interactions may sometimes lead to misidentification of diseases and perhaps also to alteration of host responses in resistance screening.

Disease Management

Current practices

Surveys in Rwanda demonstrate that farmers' conceptual knowledge of "disease" is very scanty: "disease" is almost always equated with "too much sun" or "too much rain" (CIAT, 1985). Chemical control of disease in beans is almost nonexistent because of the scarcity of agrochemicals, limited access to equipment with which to apply pesticides, and the meager capital available to smallholders for buying them. Nevertheless, there is evidence that current cultural practices adopted by many bean farmers do limit disease severity and spread. Traditional practices such as shifting cultivation, with its intervening periods of bush fallow; the burial of crop debris in mounds[2] in the chitemene farming system of northern Zambia (Richards, 1939); and the cultivation of crop mixtures, provide some measure of disease management. Recent studies (CIAT, 1986 and 1987) show that roguing of diseased seedlings and removal of diseased basal leaves at weeding can decrease disease incidence. The chosen time of sowing and plant population may also, in some instances, aid escape from disease. Studies in the southern highlands of Tanzania suggest that the selection of unblemished seed by farmers is also likely to lessen disease severity in a subsequent crop (F. M. Shao, unpublished data, 1983).

Various studies on the effect of crop association on disease severity have shown that diseases of beans are usually, but not invariably, less severe in a maize intercrop (Msuku and Edje, 1982; van Rheenen et al., 1981). Various factors have been suggested such as impeded spore dispersal, altered microclimate, and various biotic effects (Allen, 1975b; Allen and Skipp, 1982; Moreno, 1977).

Similarly, varietal mixtures of beans are more stable and better buffered against disease than are pure lines (Ishabairu and Teri,

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[2] The mounds are made when clearing the cropping land. Crop debris and residues, grasses, and weeds are piled up and covered with earth. The mounds are then left until they convert to compost when they are used as fertilizer for the cropping land.

1983; A. Panse and J. H. C. Davis, unpublished data, 1986). This is in keeping with similar studies done on mixtures of cereals (Jeger et al., 1981; Wolfe et al., 1981).

Prospects for improved systems of integrated disease management

Existing systems of crop production in Africa tend to be stable, being adapted to the environment and current needs and resources of the small-farming family. However, they may not be sufficiently productive to meet the needs of the future. In order to increase their productivity, we must understand how existing cropping systems work. The next step is to devise means of changing those systems, albeit without recourse to heavy input. Bunting (1983) has suggested that the first gift agricultural science has to offer to a crop producer is a range of improved varieties that are adapted to the local environment and that have some built-in resistance to as many as possible of the pests and diseases which are locally important. Indeed, among the control strategies available, host-plant resistance has become widely recognized as the pivot of integrated disease management, to which both chemical and cultural control measures may contribute. Resistant cultivars cost the farmer nothing, nor does their adoption necessarily disrupt his farming system.

Very little attention was given to the genetic improvement of beans for local consumption in Africa before independence. In eastern Africa, for example, breeding efforts were directed at the selection of navy bean cultivars for canning and export (Macartney, 1966; Robertson, 1955). Work on beans as a subsistence crop has been confined, in effect, to the last 25 years. A breeding program, begun by S. K. Mukasa and continued by C. L. A. Leakey in Uganda, was the first and, perhaps, most successful (Leakey, 1970a). Subsequent programs have been established in many other countries, notably Malawi (Edje et al., 1981; Mughogho et al., 1972), Kenya (Njugunah et al., 1981; van Rheenen, 1979), Tanzania (Karel et al., 1981), Rwanda (Nyabyenda et al., 1981), Ethiopia (Assefa, 1985; Ohlander, 1980), and Zambia (Grain Legume Research..., 1986?; Sarmezey, 1977).

Improved cultivars have been released by many of these national programs. In Uganda, during the mid 1960s, selections made for resistance to anthracnose among local cultivars led to the naming of Banja 2 which was subsequently used as a parent in hybridization. Banja 2, in turn, led to the K series of lines, notably K 20, many of which outyielded Banja 2. Some also possessed resistance to angular leaf spot in addition to anthracnose. Crosses made during the sixties in Uganda formed the nucleus for further improvement. Lines such as K 20 and Kabanima, are now found in many African countries (Leakey, 1970a). K 20 was later released as GLP 2 in Kenya in the early 1980s and Kabanima was released in Tanzania in 1978 (Karel et al., 1981). Releases made recently in Tanzania include P 304 (a climbing type with large cream-colored seed of Colombian origin, renamed Uyole 84) and T 23 (like Kabanima, a large-seeded sugar bean, renamed Lyamungu 85).

The contribution of breeding and selection to improvement in productivity is most spectacular in Zambia, where Carioca was released as a new bean variety in 1985. Under experimental conditions, Carioca has shown an average improvement in seed yield of 450% over the previously recommended variety, Misamfu Speckled Sugar. In onfarm trials it has given almost double the yield of local cultivars without added inputs. The superiority of Carioca appears to depend on its combined resistance to scab (in Zambia), angular leaf spot, and anthracnose, as well as tolerance to soil acidity (Grain Legume Research..., 1986?).

Similar improvements are expected to occur elsewhere, as further advances in disease-resistance breeding are made. The bases for further improvements are more effective use of the very extensive germplasm collection of *Phaseolus* held at CIAT, more reliable methods of field screening against disease, more precise definition of agroecological zones to more accurately deploy in the environment combined resistance and the cultivars that possess it, and further development of regional networks for the effective exchange of superior genotypes, information, and ideas (Allen and Ndunguru, 1984). Since 1983, three regional programs have been based in Rwanda, Ethiopia, and Tanzania to serve the Great Lakes Region of central Africa, eastern Africa, and southern Africa, respectively.

It has long been appreciated that there is no premium on genetic uniformity in tropical subsistence farming and there is no need to develop pure lines of beans in Africa (Leakey, 1970b). In fact, it is important to retain enough genetic diversity for cultivar improvement, particularly as future systems of bean production are likely to be more intensive in terms of time and space, especially in areas already densely populated. Such intensity in turn will lead to concomitant changes in disease pressure. Host-plant resistance has to be supported by higher standards of seed health (through selection and safer seed dressings) and by diversified systems of farming that provide some measure of protection from disease. It may be possible to alter the components of varietal mixtures without impairing their intrinsic balance.

In systems where varietal mixtures predominate, methods of disease control other than host-plant resistance remain an important component of disease management strategy. Time must be allocated to investigate farmers' current practices to identify areas where simple improvements to the system can be made. Cultural practices are important because of their intrinsic bias toward small farming where the land to labor ratio is low. Better cultural practices can improve the quality of farmers' seed (CIAT, 1987; Trutmann and Kaytare, 1986). The use of specific crop associations, rotations, or composts may reduce foliar and soil-borne diseases.

Although available technologies have been recently reviewed by Palti (1981) and Hoitink and Fahy (1986), little is known about technologies currently used by African farmers. Certain chemical seed treatments may find a place where specific problems such as root rots and seed-borne pathogens, are severe (Trutmann, 1987). Similarly, cheap phytosanitary products have an important role in the production of high quality seed of improved varieties.

The challenge that now confronts Africa is to devise means of bringing about significant improvements in productivity without placing heavy reliance on added inputs and without adversely disrupting existing systems of cropping. Development of sustainable cropping systems with beans is likely to rest substantially upon effective disease management. New materials and methods are now being developed through cooperation between CIAT, other international agencies, and the national bean programs. If they are used effectively in the environments to which they are adapted, then a significant impact can be made on bean production in Africa.

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