IMPACT OF THE EASTERN AFRICA BEAN RESEARCH NETWORK ON RESEARCH PRIORITIES, NATIONAL RESEARCH AND FARMERS [1]

R.A. Kirkby [2] , C. S. Wortmann and H.E. Gridley [3]

The Bean Production Environment

Common bean *(Phaseolus vulgaris)* is grown on more than 3 million hectares in eastern and southern Africa. Seven countries each produce more than 150,000 tons: Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda and Zaire. The crop is nationally or locally important in another ten countries.

Almost all beans are produced by small farmers, and especially by women, traditionally for subsistence consumption. Poverty in Africa is still largely a rural phenomenon (von Braun and Paulino, 1990) and, in the highlands where land is in shortest supply, beans are a particularly important part of production. Average farm size in parts of Rwanda, Zaire and Kenya is now less than 0.5 hectare; in Rwanda as a whole, beans contribute more than 50 percent of dietary protein. As outmigration from the highlands continues, bean production is becoming increasingly important also in semi-arid areas: for example, Eastern Province has become the largest bean producing area of Kenya, Africa's largest producer. Most beans are produced under low external input conditions, and in several countries more than 80% is intercropped, most commonly in maize or banana.

Demand from urban areas is also increasing considerably - the annual growth rate of the urban population of most principal bean producing countries exceeds 8% (World Bank, 1989) - and even the middle classes are now consuming beans rather than meat. A recent study in Uganda showed bean consumption there to be relatively insensitive to price (Vanegas 1992). Beans have become important cash crops for many farmers; cross-border trade into bean-deficit countries such as Kenya and Rwanda is difficult to quantify, but one of Kenya's largest bean markets is in a non- producing area close to the Tanzania border (Grisley and Munene, pers.comm.).

---

[1] Paper presented at the Symposium on the Impact of Technology on Agricultural Transformation in Africa, Washington D.C., 14-16 October, 1992.

[2] Pan Africa Coordinator, CIAT, P.O. Box 23294, Dar es Salaam, Tanzania.

[3] Regional Agronomist and Breeder, CIAT, Kawanda Research Station, P.O. Box 6247 Kampala, Uganda.

Production for export from Africa includes Ethiopia's traditional dry bean markets in Europe and the Middle East, which earned US$18 million in 1990 (Haile, 1990), and Kenya's more recently developed snapbean trade to Europe, earning US$28 million in the same year.

Constraints, Research Opportunities and Priorities

Average bean yields in Africa are low, generally less than one ton per hectare, and increases in production achieved primarily through area expansion have slowed since the 1970s. The principal technical constraints to raising productivity at the farm level are low soil fertility and drought, diseases and insect pests, and the use of local varieties having low yield potential; an important opportunity exists also to intensify cropping systems in which beans are produced. Socioeconomic constraints include the low level of purchased inputs, and lack of access to improved seed. Policy constraints have not been as widespread in bean production as, until recently, has been the case with cereals.

While the relative importance of these constraints varies by country and zone, the primary challenge is to narrow the large gap often found between on-station and farmers' productivity in ways that are feasible and economically attractive to producers. It appears unlikely in the near future, in most of the region, that farmers will accept appreciably higher levels of purchased inputs for bean production. Many past attempts to transfer high-yielding bean technology from stations to farmers failed, and the exceptions have involved simple, inexpensive innovations - notably the bean variety K20, bred in Uganda, released there in 1969 and subsequently also in Kenya and Tanzania, and now commanding up to 40% of production in those countries.

Low soil fertility and drought

Specific problems of soil fertility vary considerably by soil type and cropping history. Phosphorus and nitrogen deficiencies are widespread; highly acid soils are found in bean-producing areas of northern Zambia and on the Nile-Zaire Crest in Rwanda; and potassium deficiency has recently been found to be important in several areas, including Tanzania's Usambara Mountains. This research theme has only started to receive high priority since intensive on farm research with bean producers began in the mid 1980s; diagnostic trials (e.g. Graf and Trutmann, 1987) showed that disease symptoms tended to mask the serious losses due to poor soils, and that the selection of appropriate treatment designs is important to ensure correct ranking of yield-limiting constraints.

Inorganic fertilizer trials have been carried out by several countries, although not always under representative conditions on farm, including intercropping. Only in Kenya do farmers commonly apply these fertilizers to beans. The practice would be more attractive economically if recommendations were made more specific to local conditions. This is one objective of recent network research on leaf tissue diagnosis (Wortmann, Kisakye and Edje, 1992), which is now ready for pilot-scale extension testing, and of studies of plant nutrient fluxes to characterize nutrient losses in representative cropping systems. Improved management of farmyard manure has also been identified as a research priority.

A low-input approach to green manuring by intercropping beans with *Crotalaria orchraleuca* shows promise for raising yields of subsequent crops (Wortmann and Musa, in press). Agroforestry associations with deep-rooted legumes such as *Sesbania spp.* warrant continued work, particularly on farmer acceptability and on management for different conditions. Agroforestry research is being conducted in collaboration with AFRENA/ICRAF and with NGOs; the latter are particularly interested in using improved bean technology (e.g. introduction of climbing types requiring stakes) that provides farmers with an immediate incentive for using agroforestry in soil fertility maintenance.

Biological nitrogen fixation of bean varieties is being improved at CIAT headquarters partly by crossing selected African landrances which nodulate early with other materials that fix nitrogen for a longer period. A network of complementary sites across Africa is in use for collaboratively screening large sets of bean germplasm, not only for low nitrogen conditions (Ethiopia) but also for tolerance to low phosphorus (Tanzania) and to high soil manganese (Zaire) and aluminum (Zaire). Genetic tolerance to drought, principally through deep rooting, is also showing promise for stabilizing yields and warrants continued effort within the network.

Losses to foliar diseases and root rots

The control of bean diseases and pests has been considered historically to be the highest priority for bean research in Africa generally.

The principal diseases of beans were apparently introduced 400 years ago along with the crop, and therefore are essentially the same as are found in Latin America (Allen et al, 1989). Sources of resistance to the main foliar diseases (anthracnose, bacterial blight, angular leafspot, rust and bean common mosaic virus) have now been identified in locally well-adapted introduced germplasm and need to be combined in multiply resistant varieties. Progress is expected to be rapid in most cases. However, necrotic strains of the principal virus occur only in Africa and have required the development of a different breeding strategy from that used in Latin America; breeding support to the network in this field is provided from Kawanda, Uganda. As surveys suggest that Ethiopia is free of these particular strains (Spence and Walkey, 1992), continued participation of that country in regional variety trials requires urgent development of a virus indexing capability there.

Root rots, caused by a complex of organisms, are becoming serious in intensively cultivated, low fertility soils; this accounts for a recent production decline in Rwanda. Their control presents a more difficult problem, not least because of interactions with soil fertility and with bean stem maggot infestation, which appears to facilitate the entry of rots. Research is focused in Rwanda, but should benefit Kenya and other countries that are expected to face the same problem as land shortage forces continuous cropping. A resistant, Rwanda-bred variety (Rwandarugali) has already been adopted by 4500 farmers in that country (R. Buruchara, pers. comm.), and research on integrated management is giving attention to combining moderate levels of genetic tolerance with mulching and/or improved drainage.

Losses to insect pests

Three pests stand out as being of pan-African importance, and are the focus of network research: bean stem maggot *(Ophiomyia* spp.), bruchids in storage and, to a lesser degree, aphids as vectors of viral diseases (Ampofo, 1989).

The bean stem maggot complex does not occur in Latin America. Africa must rely solely on its own research. A consistent effort started in the 1980s from a very low base of knowledge on this problem. The only control measure recommended in many countries is chemical seed dressing, but the most effective insecticide is endosulfan, now widely banned. Thesis research and taxonomic studies have increased understanding of species, their ecology and distribution. Five years ago Ethiopia and Burundi identified the first varieties with good tolerance, but most were black-seeded. Intercrossing these and other lines is showing promise that resistant varieties acceptable to farmers will be produced eventually, a process assisted now by the identification of species-specific "hot spots" for use in selection. Integrated management of this pest is a more distant goal, since several of the cropping practices that contribute to lower infestation levels are unlikely to be compatible with farmers' other objectives (Abate, 1989).

The main control measures currently available against bruchid damage in storage are insecticides and early (often uneconomic) sale after harvest. Treatment with vegetable oils or sand is effective, but side-effects have prevented widespread adoption. Several simple mechanical methods have been effective under laboratory conditions and now warrant participatory development with farmers (see Table 2). Genetic resistance, wholly effective against *Zabrotes,* one of the two species that attack beans, has been identified and transferred at CIAT from wild beans to commercial seed types; this simply inherited trait has been proven in Africa and could be incorporated routinely into new varieties if sufficient resources were available.

Yield potential of bean varieties

Local varieties are not only susceptible to many of the above constraints, but also have a low potential yield. Although new genotypes have evolved in Africa, original introductions from Latin America represented only a fraction of the available diversity, and a vigorous program to broaden the genetic base for selection in national research systems has been undertaken. While this continues to be a productive approach (see Table 1) especially for the smaller countries (and as work in the Americas focuses increasingly on raising the crop's physiological and genetic barriers to yield), the need now in the larger countries of Africa is to develop more active crossing programs to meet local needs.

Good opportunity also exists to extend the success already achieved in Rwanda by introducing climbing beans, which yield up to twice as much as bush types, into areas where these types are not traditionally grown. This technology is spreading rapidly in Rwanda (Sperling and Grisley, in preparation) and in Uganda (Grisley and Mwesiga, 1992), and research is in progress in other countries. Selection of climbers for earlier maturity, for which variability already exists, would extend their potential area of adoption.

Intensification of cropping systems

Beans, being quick to mature and shade tolerant, are most commonly grown in intercropping systems. While farmers can be expected to continue experimenting with modifications to these systems, rapidly increasing demands on land warrant continued participatory research to speed up these developments and to maintain soil fertility. Specific opportunities exist to increase productivity: for example, in the banana/bean system through use of climbing cultivars in Rwanda, for double cropping with rice in the dry season in Madagascar, for extending sugarcane/bean intercropping expertise from Mauritius to other countries, and for using beans to intensify maize monocropping in Ethiopia.

Improved methods for tillage and weed control are required, particularly to raise the productivity of labor in extensive systems; one effect of the AIDS epidemic is likely to be a shift in some cropping systems towards less labor input. Better suppression of weeds through varietal selection for appropriate characteristics can contribute to a solution (Wortmann, in press). On-farm testing of a minimum tillage system is in progress in Kenya; and an inexpensive ox-drawn tie ridger and seeder in Ethiopia, also now entering on-farm tests, would permit mechanical control of weeds, currently the most important factor limiting bean yields there.

Accelerate technology transfer through improved seed systems

Formal seed systems in all member countries are proving (now that new varieties are flowing from research) to be slow, expensive or simply unable to supply bean seed to farmers. The problems are particularly acute in the case of beans, because scale and profit margins are reduced by the crop's true-breeding nature, by the subsistence nature of some of the production, by inherently low multiplication rates and by farmers' preferences for a range of grain types often grown in mixtures.

The remedy for the bean crop does not lie in further investment in large scale seed schemes or even with privatized companies. The greatest benefits reside in improving access to new genotypes, not in supplying very clean seed at high prices. Work in Rwanda and Uganda is confirming Latin American experience that new bean varieties can be disseminated at very low cost through non-formal channels. Good performance in farmer-managed trials can lead to direct adoption and farmer-to-farmer transfer, including transfer to new villages (Grisley and Mwesiga, 1992). Sustainably low-cost dissemination of a released variety can be achieved by feeding into existing non-formal channels such as farmer seed specialists and market seed vendors, provided local channels are well understood (Sperling and Loevinsohn, 1991). Further anthropological research is therefore required, particularly in anglophone countries, followed by appropriate modifications in implementing the general approach. In some countries pilot demonstrations will be needed to effect changes in seed policies.

Increase farmers' returns from beans

Experience with beans in Latin America suggests that production-increasing technology ultimately will most benefit poor consumers, rural and urban alike, through availability of cheaper protein. However, there are specific opportunities for developing technology that will have relatively greater impact on producer incomes. A Kenyan food scientist has demonstrated that consumers are prepared to pay well for vegetarian bean-based samozas (a local fast-food), which suggests a higher price outlet for high-yielding varieties, and incidentally reducing the need for breeders to pay close attention to preferred grain type. She is also disseminating this approach to other network members.

The unusual case of low preference for beans by many Ethiopian urban dwellers more used to other pulse foods may be addressed partly by price differentials with higher-yielding beans. Also, selection of bean varieties (eg. Carioca from Brazil) which may match better their taste preferences would facilitate this trend.

Network Impact on National Research

An African network operates through interaction among three regional groupings: the Great Lakes countries, Eastern Africa and the SADCC countries of southern Africa. An explicit part of CIAT's strategy, since its first staff member in Africa was outposted to Rwanda in 1983/84, has been to catalyze regional cooperation among bean researchers. Regional priorities and annual budgetted workplans are set collaboratively by a steering committee for each region. CIAT's staff base locations, and their activities, are to a considerable extent integrated within individual national research programs. Consequently, it is important to recognize that it is often not possible to attribute specific changes within national programs to association with this network. What is clear, however, is that in many countries bean research is more relevant, cost-effective and productive than it was in the early 1980s.

Research planning

Each national agricultural research organization confronts such a large number of significant production-limiting constraints that resources are inadequate to effectively research all those problems. Since many of these constraints are common across countries in the region, there is much to be gained by combining efforts in an agreed division of research responsibility.

Ten years ago the principal difficulty to be faced in planning bean research was the lack of depth to understanding of the system within which beans were produced, marketed and utilized (CIAT, 1981). Since then at least twenty studies have been carried out with seven national bean and/or farming system research programs, and were followed up with other on-farm research activities. National strategic planning workshops on bean research were held in Ethiopia, Kenya, Tanzania and Uganda; these sessions have helped to cement inter-institutional cooperation to form national networks, and their published output provides a reference point for annual trials planning meetings.

An example of feedback from on-farm research to planning was the addition of weed-suppressing growth characteristics in bean varietal selection in Ethiopia, following a study of farmers' weed management (Mulatu et al, in press). Another example is the practice in Rwanda (Table 1 and P. Nyabyenda, pers. comm.) of releasing a large number of varieties having different characteristics. Whereas plant breeders tend to be rewarded for a more conservative approach to variety release and, in effect, for reducing genetic diversity on farms, anthropological studies there had shown that farmers reselect components and manage complex mixtures of bean varieties adapted to different soil types, season and end use (Voss, 1991). Some problems formerly held to be important have also been dropped from national priorities for research, such as ascochyta blight in Uganda (Grisley, 1991), or for extension, as with row planting in Ethiopia (IAR, 1991).

Regional research priorities are identified as a function of the wide occurrence of certain agroecosystems in which beans are grown, and of some specific problems of pests, diseases and soil. Disciplinary working groups of local specialists are convened at the pan-African level (six groups each meet at three-year intervals) to advise regional steering committees on bean research priorities in their field. The steering committee harmonises these sources of advice into a regional workplan in accordance with available funds, and approve and monitor a set of regional research subprojects.

This portfolio of collaborative subprojects aims to minimize duplication of effort across countries by encouraging specialization on priority topics wherever experienced scientists and suitable ecological conditions coincide. An increased number of crop and soil fertility management subprojects reflects the direction set by the committee, while the range of new topics (e.g. acid soil management and water harvesting) represents "responsive funding" which encourages and builds on the creativity of researchers and national systems.

Improved techniques

The use of relevant methods has long been a concern of CIAT's, exemplified by its consistent advocacy of conducting bean varietal selection under representative, non-fertilized conditions (Nickel, 1984). Training of scientists and technicians in appropriate techniques has been a principal occupation of regional staff - more than 500 national program participants have been involved in network courses. One example of the many effects to be seen is the now routine use of consumer preferences and cooking time evaluations in national varietal testing.

The quantum leaps in productivity of the first releases over existing varieties, stemming from selection in the broadened germplasm base, cannot be expected to continue without the development of some strong national crossing programs. Several network activities currently aim to encourage this aspect.

Possibly the most striking difference in bean programs from 1985 to today is the emphasis on on-farm research. Participatory research methods are widely used in some (but not yet in all) countries, and have enabled farmers to be brought into the formal research process at an earlier stage. The potential cost savings to NARS, as compared with "conventional" on-farm research, have been emphasized, as in the case of farmer selections made at the research station (Sperling, 1989). A parallel reduction in costs for on-station research has been made possible by the finding that bush bean varietal selection for the banana association does not require that initial observations be made under intercropping conditions (Wortmann and Sengooba, 1992).

Measures of research output

Bean breeders in larger national programs are handling at least 1,000 distinct types and several hectares of nurseries annually, whereas formerly many evaluated only a few dozen lines. Since 1986, nine countries have released and disseminated to farmers more than twenty-five new varieties. In several cases these are the country's first release of a new bean variety; in some others (e.g. Ethiopia, Uganda), their first release for fifteen years. More significantly, the development of broad germplasm bases for selection within national programs is permitting a continued flow of improved varieties (Table 1). All these varieties were released on the minimum criteria of heavier yield and acceptability to a sample of producers, and many also have specific characteristics that enhance stability of yield or confer culinary and market advantages.

The last two or three years have seen a considerable increase in development of crop and soil management technologies for bean production. Table 2 shows cases in which effects of the network appear most clearly. The longer average lag period before making farmer evaluations, in comparison with varietal examples, is unsurprising: technology design generally requires more thorough diagnoses of production systems.

An unfortunate but widely held view in scientific circles has been that a plant breeder's output is measured by released varieties and that of an agronomist by published papers (Hudson, 1979). Although further changes are still needed in incentive systems for professionals in the region, attitudes have become more oriented towards achieving research impact at the farm level. For example, measures have been taken in several countries to ensure that seed of new varieties reaches farmers, often through non-formal channels. In Rwanda more than 70,000 farmers are already growing the new variety Umubano, and several other varieties are also being adopted, at least in part due to using farmer-to-farmer dissemination systems. In Uganda, 64 percent of collaborators in on-farm trials passed on seed of new varieties to others, and several NGOs and development projects have now accepted the role of multiplying and disseminating varieties proven with farmers. Similar examples are to be found in Tanzania and Zambia.

Communication of results

Each subregional grouping of countries holds regular multi-disciplinary workshops, in addition to participating in the pan-African specialized meetings mentioned above. Nineteen workshop proceedings have been published by the African network, providing a professional incentive and opportunity for researchers to analyze and present their findings for peer review. Annual reports of national bean programs are also exchanged, and visits to other countries sharing similar problems are now common. This has led to direct transfer of technology between countries, and in some cases to the decision to proceed directly to farmer evaluations without prior testing on a research station (Table 2).

Impact with Farmers

The principal impact so far is from the introduction of climbing beans. A current impact study for the variety Umubano in southern Rwanda indicates that at least 70,000 farmers have adopted this variety (and significant numbers are growing other high-yielding climbers) on an estimated area of 10,800 hectares. Farmers' mean yields for Umubano, at 1.8 ton per hectare, are 523kg per hectare higher than for bush types (Grisley and Sperling, in preparation). This is an appreciable benefit for farmers in the most densely populated country in Africa, a country which imports 25% of the beans consumed and where poorer farmers tend to be net purchasers of beans (Loveridge, 1988).

At standard world bean prices this yield increment is worth US$261 per hectare, or $2.82 million for this technology in 1991. This amount exceeds total donor expenditures on all bean research networks in Africa in 1991. Umubano is still spreading in Rwanda, as well as in Burundi and Zaire; it is thought to have considerable potential in highland areas of Kenya and Uganda also. On present evidence the following targets could be met by the year 2000: adoption on 15% of the bean area of Rwanda, on 10% of Kivu province of Zaire, and on 5% of the bean areas of Burundi, Kenya and Uganda. This would yield US$29.9 million in the year 2000 ($18.4 million if Kenya and Uganda were excluded). Counting the costs of all donor (CIDA, SDC and USAID) support to bean research networks in Eastern Africa and the Great Lakes since their inception in 1983, the internal rate of return for this investment by 2000 would be 30.3% (D. Pachico, pers. comm.).

Smaller numbers of farmers have adopted new varieties in Burundi, Ethiopia, Tanzania, Uganda, Zaire and Zambia; most of these cases are from recent releases, and several adoption studies are in progress.

The large array of new technology now in on-farm testing, much of it in the area of crop and soil fertility management, augers well for future impact with farm families and consumers. The consistent encouragement of participatory research methods, in advance of having a technology ready for "on-farm testing", leads us to believe that many of these new varieties and practices will be adopted.

Acknowledgements

The authors wish to acknowledge that the results reported here represent research contributions by many colleagues, both in national programs and in CIAT.

Financial support for regional bean activities in Africa is provided primarily by the United States Agency for International Development, the Canadian International Development Agency, the Swiss Development Cooperation and by national institutes for agricultural research.

References

Abate, T. 1990. Studies on genetic, cultural and insecticidal controls against the bean fly, Ophiomyia phaseoli (Tryon)(Diptra: gromyzidae) in Ethiopia. PhD thesis, Dept. of Biol. Sci., Simon Fraser University, Vancouver, Canada. 177p.

Allen, D.J.; Dessert, M.; Trutmann, P. and Voss, J. 1989. Common beans in Africa and their constraints. Ch.2 in: Schwartz, H.F. and Pastor-Corrales, M.A. (eds). Bean Production Problems in the Tropics. Centro Internacional de Agricultura Tropical, Cali, Colombia. 2nd Edition.

Ampofo, J.K.O. (ed.) 1989. Proceedings of the first meeting of the Pan-African Working Group on Bean Entomology, Nairobi, Kenya, 6-9 August 1989. CIAT African Workshop Series, No.11. 48p.

CIAT, 1981. Regional Workshop on Potential for Field Beans in Eastern Africa Lilongwe, Malawi, 9-14 March 1990. Internaciona de Agricultura Tropical, Cali, Colombia. 226p.

Graf, W. and Trutmann, P. Methodology and results of diagnostic trials on common beans in Rwanda: a critical; appraisal. Pp 71-79 in: Kirkby, R.A. (ed.), Proceedings of a Workshop on Bean Research in Eastern Africa, Mukono, Uganda, 22-25 June 1987. CIAT African Workshop Series, No. 2.

Graf, W., Voss, J. and Nyabyenda, P. 1991. Climbing beans introduction in southern Rwanda. Ch. 3 in: Tripp, R. (ed), Planned Change in Farming Systems: Progress in On-Farm Research. J. Wiley & Sons, Chichester, U.K. 348p.

Grisley, W. 1991. Proceedings of a workshop on national research planning for bean production in Uganda, Makerere University, Uganda, 28 January - 1 February 1991. CIAT African Workshop Series No. 10. 109p.

Grisley, W. and Mwesiga, D. 1992. Adoption and diffusion of climbing beans following an introduction of new cultivars from on-farm trials in the Kabale District of Uganda. Paper presented at a Workshop on Impacts of On-Farm Research, CIMMYT, Harare, 23-26 June 1992.

Grisley, W. and Sperling, L. In preparation. An analysis of the adoption and diffusions of released bean cultivars in Rwanda over the period 1985 to 1991.

Haile, H. 1990. Importance of haricot bean exports to the Ethiopian economy. Pp 31-33 in: Research on Haricot Bean in Ethiopia: an Assessment of Status, Progress, Priorities and Strategies. Institute of Agricultural Research, Addis Ababa.

Hudson, J.P. 1979. Note on editorial policy. Expl. Agric. 15:305-306.

IAR. 1990. Research on haricot beans in Ethiopia: an assessment of status, progress, priorities and strategies. Institute of Agricultural Research, Addis Ababa, Ethiopia. 114p.

Loveridge, S. 1988. Uses of farm and market nursery data to inform food security policy in Rwanda. D. Phil. dissertation, Dept. of Agric. Econ., Michigan State University, E. Lansing. 336p.

Mulatu, T., Regassa, T. and Kirkby, R.A. In press. Developing technologies for smallholders: on-farm research in the Nazreth area. Ch.10 in: Franzel, S. and van Houten, H. (eds), Research with Farmers: Experiences developing Technologies and Policies in Ethiopia. Commonwealth Agricultural Bureaux International, U.K.

Nickel, J.L. 1984. Low-input, environmentally sensitive technologies for agriculture. Grant F. Walton International Lecture presented at Rutgers, The State University of New Jersey. 16 October 1984. Centro Internacional de Agricultura Tropical, Cali, Colombia. 22p.

Spence, N.J. and Walkey, D.G.A. 1992. Interim progress report of the distribution and identity of strains of bean common mosaic virus in Africa. Natural Resources Institute, Chatam, UK. 17p.

Sperling, L. 1989. Breeding to meet farmers' needs. Pp90-105 in: Smithson, J.B. (ed) Proceeding of a Workshop on Bean Varietal Improvement in Africa. Maseru, Lesotho, 30 January - 2 February 1989. CIAT African Workshop Series No.4.

Sperling, L. and Loevinsohn, M. 1991. The dynamics of improved bean seed varieties among small farmers in Rwanda. Paper presented at Farming Systems Research and Extension Conference, East Lansing, Michigan, October 1991.

Vanegas, M. 1992. An econometric analysis of the dynamics of the Uganda beans economy. Dept. of Agric. Econ. Working Paper No. 92-1, Makerere University, Kampala, Uganda. 83p.

von Braun, J. and Paulino, L. 1990. Food in sub-Saharan Africa:trends and policy challenges for the 1990s. Food Policy (December 1990):505-517.

Voss, J. 1991. Farmer management of varietal bean mixtures in central Africa: implications for a technology development strategy. In: Farmers and Food Systems. Cornell University Press, Ithaca, N.Y.

World Bank. 1989. World Development Report 1989. New York: Oxford University Press/World Bank.

Wortmann, C.S. In press. Contribution of bean morphological characteristics to weed suppression. Agronomy J.

Wortmann, C.S., Kisakye, J. and Edje, O.T. 1992. The diagnosis and recommendation integrated system for beans *(Phaseolus vulgaris* L.) - determination and validation of norms. J. Plant Nutrition (in press).

Wortmann, C.S. and Musa, S. In press. Evaluation of *Crotalaria ochraleuca* as a green manure. Bean Program Annual Report, 1991. CIAT, Cali, Colombia

Table 1. Some new bean varieties developed through the network

Technology	Country	Origin	Primary Advantage	Chronology of Release and Adoption	
Roba	Ethiopia	Bred at CIAT as A176. Introduced in CIAT nursey	Higher yield than farmers' food bean types by 52% over 19 environments; good taste; quicker cooking.	1989 1991 1992	Release nationally by Ethiopia Grown by farmers in Rift Valley Grown by farmers in Southern zone
Awash	Ethiopia	Developed in Colombia as Ex-Rico 23. Introduced in CIAT nursery	Higher yield than standard commerical variety by 17% over 38 environments. Canning quality excellent.		As for cv. Roba above
A410	Ethiopia	Bred at CIAT	56% yield advantage over farmers' large-seeded variety in 28 environments.	1989 1992	Released by Burundi On-farm testing
A 262	Ethiopia	Bred at CIAT	44% yield advantage over farmers' predominant large-seeded variety in 28 environments; much less susceptible to bacterial blight	1992	On-farming testing
Rubona 5	Uganda	Bred by Colombia national program. Release by Rwanda in 1986. Introduced to Uganda in 1987 as Rwanda entry in regional trial	Higher yield than farmers' predominant variety.	1989	Released by Uganda
G13671	Uganda	Introduction from CIAT's germplasm bank	Higher yield; semi-climber.	1989	Released. Adoption in Kabale area from on-farm trials.
White Haricot	Uganda	Local variety	Preferred for storability after cooking	1989	Released. Widely adopted in Kabale area from on-farm trials.
CAL 96	Uganda	Bred at CIAT	Mean 30% higher yield than predominant variety of farmers (K20); disease reactions similar.	1990 1991 1992	Pre-release multiplication by Uganda. On-farm tests show particular promise and acceptability in Kabale area. Extensive demonstrations and seed production by NGOs and projects.
RWR 136	Uganda	Bred at CIAT for Africa	Mean 27% higher yield than predominent variety of farmers; disease reaction similar.		As for CAL96 above
MCM 5001	Uganda	Bred at CIAT for Africa	Mean 80% higher yield than predominant variety of farmers; resistant to blackroot.		As for CAL96 above with wider acceptance in other areas of Uganda

Table 1 (con't)

Technology	Country	Origin	Primary Advantage	Chronology of Release and Adoption	
RAZ-lines	Uganda	CIAT Backcrosses of commercial grain types with resistance from wild beans	Complete resistance to Zabrotes bean bruchid.	1990 1992	Resistance confirmed in Ethiopia and Uganda. Field evaluation for yield and acceptability to farmers.
8 more promising materials	Uganda	Various, mostly CIAT introductions		1992	On-farm tests at 120 locations
Umubano	Rwanda	Introduced from CIAT germplasm bank	Climber. 100% yield advantage on good soils. Leaves preferred also.	1987 1991	Released by ISAR. Seed distributed by ISAR, seed service and extension. Estimated now grown by 70,000 farmers.
Rwandarugali	Rwanda	Bred in Rwanda in 1980 to improve Rubona-5 for anthracnose.	Semi-Climber, tolerant to poor soils and root rots.	1987 1991 1992	Release by ISAR as RWR 221. Name changed by adopting farmers. Increased seed distribution. Grown by 4500 farmers.
17 other varieties	Rwanda	Rwanda, Burundi, Latin America & CIAT	Various - principally for disease resistance & yield.	1985-90	Released by ISAR. 230 tons seed distributed.

Table 2. Some crop and soil management practices developed through the network

Technology	Country	Origin	Primary Advantage	Chronology of Release and Adoption	
Staked climbing beans	Rwanda	Transfer of staking system from N. Rwanda/N.E. Zaire, using varieties from Latin America.	Average 60% or better yield advantage over traditional bush bean culture.	1985 1987 1991	On-farm evaluations Promoted through development projects 70,000 adopters of system using cv Umubano.
Climbing beans a) staked	Uganda	Transfer of system and five best varieties from Rwanda program.	Adopting farmers recording 50%-100% yield advantage over non-climbing beans.	1988 1991	Started with on-farm tests CARE and others promoting and multiplying seed. Results most promising in Kabale area: two years after on-farm tests, 66% of collaborating farmers were still growing one or more of the climbing types.
b) staked/ agro-forestry		AFRENA/ICRAF collaboration.			
c) relay intercropped with maize		System development on station in Uganda, bean varieties from Rwanda			
Crotalaria ochraleuca as a green manure intercrop	Uganda	Modification of work in Tanzania	Little or no yield reduction from intercropping, which gives 60-80% yield increase in the following season's maize crop	1992	On-farm tests with five farmers in each of six districts.
Hedgerow intercropping with bush beans	Ethiopia Tanzania Uganda	Developed on station by IAR scientists In collaboration with SECAP. In collaboration with AFRENA/ICRAF.	Soil fertility maintenance, erosion control and/or fodder production with minimal loss of crop yield.	1992	On-farm tests in all three countries.
Weed control through broadcast seeding at high rate & competitive variety selection	Ethiopia	Farmers' practice in Rift Valley	Increased productivity of labor: little or no bean yield loss without diverting labor from tef production	1987 1989	Discussion with farmers and observations on demonstrations of hand-weeding. Row-planting recommendation changed and breeders' selection criteria modified.
Minimum tillage for beans	Kenya	On-station modification of practice of some farmers (for maize)	Increased productivity of labor and/or better yields through earlier planting.	1991	On-farm tests in Central Province
Maize/bean intercropping patterns	Kenya	Between-row intercropping recommendation in early 1980's.	Improved feasibility of an old recommendation that was not adopted		
Broadcast seeding bean into maize during weeding	Ethiopia	On-farm modification to a station-designed pattern as a result of IAR diagnostic research.	Intensification of sole maize cropping without reducing maize yield and with minimal labor increment.	1987-89	On-farm tests. Practice now recommended in western Ethiopia.

Table 2 (con't)

Technology	Country	Origin	Primary Advantage	Chronology of Release and Adoption	
Beans inter-cropping in young sugarcane	Kenya Malawi Tanzania	Developed in Mauritius (also Colombia).	Intensification and food self-sufficiency	1988 1991	On-farm trials led to recommendation in Mauritius. Mauritius developing strategy with other EABRN countries for transfer/modification to their conditions.
New bean varieties tolerant to low P, low N and/ or high Mn.	Ethiopia Kenya Tanzania Uganda Zambia	Screening on selected problem soils across network	Low input approach to soil fertility	1992	Multi-season screening has identified best 35 lines, for evaluation by farmers.
Seed dressing against bean stem maggot	Burundi Rwanda Ethiopia	First developed by Zambia. Information transfer through network.	Inexpensive control	1987 1988	Direct transfer to on-farm testing in Rwanda. Extension bulletin to guide safer use developed. Widespread use by Rwanda Ministry of Agric.
Sieving and/ or tumbling of stored seed	Uganda Tanzania	Uganda and CRSP-sponsored PhD thesis by Tanzania	Inexpensive control without pesticide or cash outlay	1992	On-farm testing in Uganda.
Intergrated management of root rots	Rwanda	Developed in Rwanda	Combines moderate genetic tolerance with soil management	1990-	On-farm research continuing