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Network on Bean Research in Africa
Reseau de Recherche sur le Haricot en Afrique

ENHANCING SMALL FARM SEED SYSTEMS
PRINCIPLES DERIVED FROM BEAN RESEARCH
IN THE GREAT LAKES REGION

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PREFACE

The Network on Bean Research in Africa serves to stimulate focus coordinate and inform research efforts on common bean The network is organized by the Centro Internacional de Agricultura Tropical (CIAT) through three interdependent sub regional networks for the Great Lakes region of Central Africa for Eastern Africa and in conjunction with SADC for the Southern Africa region

The common bean *Phaseolus vulgaris* L is grown by small farmers on nearly 4 million hectares in Africa In much of this area concerted efforts to improve productivity in this crop started only within the last 10 years although a few countries including Rwanda had developed active research programs much earlier More bean varieties are now available from research but reports from many countries suggest that conventional approaches to their dissemination have been disappointingly slow in achieving impact for farmers and consumers

This volume is the fifteenth in a working document series that serves research on common bean in Africa It draws on five years of interdisciplinary research on seed systems carried out in the Great Lakes region of Burundi Rwanda and eastern Zaire with financial support from the Swiss Development Cooperation (SDC)

Two other papers in the series analyzed bean seed channels in this region (No 13) and documented the impact of improved climbing beans in Rwanda in which these principles played a vital part (No 12) Taking a strategic approach to seed systems starting with variety development rather than after a variety has been identified is also likely to be applicable to many other crops and in other regions

Two associated series of publications Workshop Proceedings and Reprints are also available Further information on regional research activities on beans in Africa can be obtained from

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ENHANCING SMALL FARMER SEED SYSTEMS
PRINCIPLES DERIVED FROM BEAN RESEARCH IN THE GREAT LAKES REGION

by Louise Sperling Urs Scheidegger and Robin Buruchara[1]

INTRODUCTION

New bean varieties can help boost small farmer agriculture Low initial input and low maintenance they are easily integrable in existing even complex cultural systems Yet new cultivars realize their worth only when they can be accessed and sustained by smallholders While African national programs devote the lion s share of their budgets to varietal improvement the research component often stops once the genetic material is identified Multiplication and diffusion of seed are regarded as functional tasks-- with the result that formal systems are relatively standardized and centralized Seed multiplication and distribution are seen to present challenges in the sense that any mass reproduction presents challenges techniques are known they are sometimes hard to execute effectively

Work underway in the Great Lakes suggests a divergent view concerning seed sectors Far from functioning well under standardized models seed systems need to be tailored towards the clientele as well as towards the agro-ecological environments they serve--much in the same way varietal material needs to be tailored Findings from the Great Lakes will probably be most relevant to other regions which typify intensive small farmer agriculture on the margins The agro-ecological systems are highly heterogeneous with stressed niches still farmed e g those with poor soil fertility Beans are primarily produced for home consumption and while they are often well manured they rarely benefit from purchased inputs

This paper synthesizes five years of research on bean seed distribution and multiplication in the Central African region and suggests basic principles for enhancing the development of sustainable seed systems While our prime focus has been on new cultivars many of the lessons also apply to seed interventions involving farmer varieties

PROBLEMS FROM ABOVE AND BELOW

Concerns with bean seed multiplication and diffusion of new varieties emerged from studies in both the supply-side and demand arenas

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The formal sector

A Great Lakes (Rwanda Burundı and Zaıre) bean seed conference ın 1989 hıghlıghted consıderable dıscontent by all partners of the formal seed chaın (Sperlıng ed 1992) Even the term seed ıtself emerged as hıghly controversıal and partıcıpants referred to ıt emphasızıng dıfferent crıterıa and standards ıncludıng

Genetıcs [performance of varıety and crıterıa of Dıstınctıveness Homogeneıty Stabılıty (DHS)]

Phytosanıtary qualıty (seed born fungal bacterıal and vıral dıseases)

Physıcal qualıty (purıty humıdıty ıncıdence of mechanıcal damage rate of germınatıon)

Quantıty/avaılabılıty (where when at what prıce)

Many partıcıpants dıd not dıstınguısh among these wıth the term ımproved seed beıng used by each to refer to the one or two aspects whıch he/she found most relevant Thus seed producers reproached breeders for not havıng really better varıetıes Breeders reproached the seed servıce for not producıng and dıstrıbutıng theır varıetıes suffıcıently Seed control representatıves crıtıcızed hıgh ınfectıon rates of seed wıth bacterıa and vıruses whıle producers poınted to the hıgh costs of pestıcıdes (needed to control fungal dıseases) Controversy also arose as to the relevance of DHS crıterıa ın a regıon where most beans are cultıvated ın mıxtures Typıcally no results were presented as to how ımproved seed or clean seed mıght be superıor to farmer s seed save for the genetıc component

The economıc analyses or lack of them suggested a damnıng assessment of the seed system most were tryıng to perpetuate No demand estımates were presented for any of the three countrıes and productıon costs for ımproved seed varıed from two to sıx tımes the market prıces for bean graıns Hıdden subsıdıes were tolerated ın most seed multıplıcatıon operatıons wıth ımportant shares of productıon sold to development projects or ıntermedıary organızatıons whıch ın turn subsıdızed sale to farmers at reasonable prıces Many of the ınstıtutıons sımply refused to calculate the productıon costs for seed as ıt would be unreasonably hıgh Hence the fact that most of the seed produced could be sold was by no means a proof of true demand for formal sector seed

Evıdent from the conference was how lıttle the formal seed sector knew of ıts own ınternal performance or of ıts effect on ıts clıent populatıon of farmers Subsequent research helped to better delımıt some of the concerns One study ın Rwanda (Grısley and Sperlıng ms) traced the dıffusıon of seed from the Government Seed Servıce to development projects who act as ıntermedıate multıplıers and dıffusers The relatıonshıp between seed receıved from the servıce and that dıstrıbuted to farmers showed a pattern of shrınkage or what mıght be termed a negatıve multıplıcatıon (Table 1) The selectıon of varıetıes on offer also showed bıas the varıetıes multıplıed in high volumes were mostly of large grains suitable for fertile soils Significantly the cultivar RWR 221 was not offered by the seed service although farmers placed it among the more desired cultivars the service declined to diffuse it due to its susceptibility to rust in their low lying centralized multiplication plots (This problem proves of minimal importance in farmer s fields) In its present form the seed service in Rwanda reached 1 in 600 bean farmers (Scheidegger 1992)

Table 1 Seed multiplication rates from Rwandan Seed Service to development projects (1985-1991)

Variety	Seed distributed by Seed Service (kgs)	Grain size	Seed distributed to farmers / Seed received from Service
Bush			
Rubona 5	51 887	L	0 58
Ikinimba	3 481	S	2 27
Bataaf	4 878	M	0 55
Kilyumukwe	18 159	L	0 53
Ikinyange	9 316	M	0 74
Urugezi	150	M	1 0
Kirundo	560	M	42
Climbers			
Gisenyi 2 bis	17 345	L	1 03
Urunyumba	15 570	L	0 43
Umubano	14 225	M	1 54
Puebla	5 507	L	1 48
Vuninkingi	1 999	M	0 45
Muhondo 6	4143	M	0 43
Cajamarca	1342	L	0 11

Source calculated from Grisley and Sperling ms
Grain sizes are characterized as small (S) medium (M) and large (L)

Farmer to-farmer diffusion

Analysis at the farm level highlighted still other seed issues Beans being a self pollinating crop researchers had tacitly assumed that on farm trials a spate of them might help to move genetic material fast and widely As common wisdom on farmer to farmer diffusion dictates varieties move themselves Yet studies of the trajectory from on farm trials of three of the L Institut des Recherche Agronomique du Rwanda s (ISAR s) more popular bush cultivars showed different trends Given the small size of farmer plots the initial distribution of seed to another farmer was generally delayed 2 3 seasons with many farmers not distributing over significantly longer periods The circle of diffusion proved socially narrow best friends close family and important neighbors received seed but certainly not all who asked Further the speed of diffusion differed significantly among varieties those highly productive that is high multiplication rates and grown in fertile and more stable environments moved quickly Those targeted for stress environments had lower multiplication rates and more erratic production climates (e g drought prone less fertile soils) and moved much more slowly Surprisingly varieties highly appreciated by farmers sometimes disappeared from their plots altogether Seeds of the new variety could be lost due to agro environmental vagaries suffered by all varieties the local as well as the exotic Socio-economic factors might also force the farmer to stop sowing she could fall ill and abandon the new crop or more often among the poor might be obliged to eat the seeds While local varieties could be reacquired from neighbors or local markets access to new cultivars proved more restricted (Sperling and Loevinsohn 1993)

In sum neither system the formal nor the farmer to-farmer diffusion process (here from on farm trials) was performing as envisioned in terms of moving new cultivars

DIAGNOSIS OF INFORMAL SEED SECTOR DISTRIBUTION ISSUES

Initial studies had ignored how most of the farmers get most of their seed Focusing on the formal seed system researchers has long left basic questions unanswered Did farmers in the Great Lakes obtain seed off farm? If so how large were their needs? What channels did they use and why? Were certain seed characteristics more valued than others? And the ultimate question could seed provision strategies for new varieties benefit from building on informal mechanisms?

Seed system diagnostics of the informal sector were subsequently carried out in all three Great Lakes countries in the South Kivu Region in Southern Rwanda and in three major bean growing regions of Burundi [2] Farmers were chosen randomly with all wealth classes represented and

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[2] For detailed results see
Sperling L (summary)
1992 Analysis of bean seed channels in the Great Lakes Region South Kivu Zaire Southern Rwanda and select bean-growing zones of Burundi Seventh Regional Seminar on Bean Improvement in the Great Lakes Region of Africa Goma 2-6 November 1992

interviews were held by preference with adult women those most experienced and knowledgeable of bean seed Perhaps only the Burundian findings can be extrapolated to represent countrywide variation The Southern Rwanda and South Kivu studies random within bounds represent interests primarily of smallholder non-commercially oriented farmers indeed the majority of the population

Several of the findings sketched below directly affected the design of subsequent interventions

Quantity and original sources of seed planted

Overall the quantity of bean seed planted by farmers in all three countries is relatively low Annually farmers in the middle income range plant 24 34 and 81 kgs for Rwanda Burundi and Zaire respectively with seed use per major season varying between 10 and 45 kgs--the latter being but half a bag (Sperling summary 1992) Most farmers in South Kivu Southern Rwanda and Burundi (upwards of 70%) obtained their original seed from relatives usually the man s parents The couple often resides near these relatives and such seed is preferred as it is said to be well adapted locally With time however many had also made partial modifications in the composition of their seed stocks (40% for the Zairian sample 60% for the Rwandan and 22% for the Burundian) with a good number changing their seed stock completely (14 % 18 % and 61 % respectively) Seed acquisition including varietal composition is very dynamic

Sources of bean seed

Many channels exist for acquiring bean seed (Table 2 lists 11)) with different types of farmers giving preference to specific outlets In all Great Lakes countries about three fifths of the farmers obtain at least some of their seed from their own production (own stock) (Table 2) various markets being the other very significant source When farmers speak of market sources in South Kivu they are generally referring to the many decentralized markets at which farmers themselves may sell their own bean seed hence the categories market general category and market farmer merchant are not well differentiated for the Zairian data In Rwanda and Burundi in contrast farmers clearly distinguish among the large town markets (market general category) the town wholesalers who own their own shops (large merchants) the decentralized country or boutique vendors (local merchants) and the farmers who sell their own harvest in town or rural market

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(con t)	<u>Case studies</u>	
	Rwanda	L Sperling U Scheidegger and B Ntabomvura
	Zaire	T Musungayi J Murhandikire and L Sperling
	Burundi	S Walls B Smith L Sperling and L Niyobampampa

Only the last Burundian case study was also published separately See Walls et al 1992 places (market farmer merchant) Seed quality differs among these merchants as does the possibility of obtaining credit against future harvest Farmer merchants are relatively rare in Rwanda as farmers who sell (or exchange) their own production usually do so in the countryside as one neighbor to another' (hence the category neighbor') This category of neighbor" for seed is little found in the South Kivu region In terms of the market overall the Burundian analyses give an idea of its surprising importance among this population of primarily subsistence farmers on average <u>each</u> Burundian farmer purchases 5 4 kgs from the market season A (September to January) and 15 kgs for season B (February to June)

Table 2 Percent of farmers who relied on a particular bean seed source during the principal growing season 1991-2*

Source	Zaire (N=194)	Rwanda (N=144)	Burundi (N=248)
Own stock	59	63	66
Relatives			1
Market General category	58	9	24
Market farmer seller	1	11	12
Market Small local merchant		3	11
Market Large merchants		9	3
Neighbors	1	10	4
Development Project			3
Church		3	<1
Cooperative		1	<1
National Program			
Government outlet		1	

Figures exceed 100% as farmers may use multiple sources

Use of the two major categories of seed channels-- own stock and market (the latter being a composite category of all market types)-- varies considerably by wealth In all three regions only about half of the poorer farmers can draw on their own stock for <u>any</u> quantity of seed in contrast to the wealthy all of whom use their own harvested seed for at least one season of the year (Table 3) The richer farmers seem to use markets to find select genetic material rather than to top off or fill in for inadequate seed stocks The reliance of the poor on the market is quantitatively and qualitatively different In the Rwandan sample 33% of the poor purchase 100% of their seed at least one season in Burundi 70% purchase all of their seed for at least one season and in Zaire 52% rely totally on the market for one season (These tallies exclude those who depend on the church or the state for free seed) (Sperling summary 1992) Farmers lament they may even consume their entire crop green either the pods or the fresh seeds Most are seeking something to put in the ground that will sprout the concern is for seed quantity not for refining choice of varieties

Table 3 Percent of farmers using the two major seed channels by social class and season 1990-1992

	Zaire		Rwanda		Burundi	
	A	B	A	B	A	B
Own stock						
Poor	51	49	44	62	55	34
Medium	65	64	63	85	81	73
Rich	80	100	91	100	100	85
Market						
Poor	66	60	46	26	51	80
Medium	40	53	36	5	22	52
Rich	13	17	6	0	4	32

Farmer assessment of good seed and seed channels

Within these economic constraints however farmers try to maximize their access to what they consider as good seed In describing desired characteristics Rwandans (N=89) focused on varietal aspects in 76% of the responses (emphasizing adaptedness to local conditions and earliness as desired traits) with physical or phytopathological traits representing the rest of the criteria cited (good physical appearance good germination and seed treated with pesticides) Burundian responses were similar (Table 4) varietal aspects were particularly cited (65% of the responses) with a preference for small grained seed (does well on our poorer soils and is economic to sow) A key finding was that formal seed service concerns such as good conditioning or healthy seed were given little prominence as farmers feel they can readily control these aspects themselves The health of farmer produced seed is explored in-depth below

Given the varietal emphasis farmers generally prefer to use mixtures long tested on their own farms as through a process of selection such seed is regarded as well adapted to the farmers specific agronomic conditions In Rwanda and Burundi in terms of both genetic and physical quality second best seed is said to come from neighbors whose planting conditions might be similar and who have an ethic to deliver well-sorted beans (e g not broken immature discolored or damaged in storage) (see also Sperling in CIAT 1988) In Zaire such neighbors seed may be found at the market where buyers search for faces and/or varieties with which they are very familiar Similarly Rwandans and Burundians search hard among market stalls to find a) varieties they believe will do well and b) seed which is free of evident physical defect The problem with such better-quality seed is both its relatively high cost as well as availability It goes quickly and may cost 10 15% more than beans for consumption Not surprisingly the wealthier may have greater access than the poor to evident sources of better quality seed For example in Rwanda 50 % of the sources they used in season A outside their own stocks fell into the categories of neighbors (better quality local seed) or development projects and government offices (better quality exotic seed) Such locales represented 18% of the sources used by poorer farmers for acquisition of seed off farm Ultimately farmers may be obliged to buy from commercial channels just because seed is available upon request

Table 4 Burundian farmers definition of good seed (N=295)

Criteria**	# Responses	% Responses	/ Farmers
Varietal factors	422	65	90 2
Small grained			
Good yield			
Known variety			
Seed sorting	144	22	41 7
Rotten immature broken grains eliminated			
Bruchid damaged grains eliminated			
Economic factors	35	5	9 8
Grains economic to sow (small)			
Conditioning	25	4	7 8
Good germination			
Appropriate moisture content			
Seed health	18	3	5 8
Other	2	<1	0 7

Farmers permitted to cite up to three criteria

** Each of the categories represents a cluster of responses Thus varietal factors includes such criteria as desire for small-seeded varieties early maturing varieties varieties that resist drought and so on The major criteria have been listed under each aggregate entry

Discussion bean seed and the informal sector

The studies of the farmer seed systems show that relatively large numbers of farmers regularly procure a high proportion of seed from outside their own farms[3] While neighbors seed (equated with locally adapted) is preferred (whether purchased on farm or at market stalls) many farmers are obliged to purchase what they consider second quality seed through commercial channels which offer regular supplies of a range of varieties Poorer farmers in particular are constant market clients unable to save seed harvested or at times forced to eat entire harvests as green beans or green seed Up to now development projects and national seed programs have provided proportionally little of the bean seed in use although some genetically improved varieties are reaching farmers through the informal channels (Scheidegger in CIAT 1993) For farmers the present seed procurement channels often represent a trade-off between quality seed (genetically and physically) and cost and availability

SYNTHESIS PRINCIPLES GUIDING SEED DISTRIBUTION OF NEW VARIETIES

The above studies helped to identify Key Principles for guiding the distribution of new varieties to meet small farmer needs these are sketched below

Farmers clearly use informal channels regularly Building on these channels rather than creating new ones can help keep down costs as well as assure timely delivery of seed (a fault for which development projects were regularly critiqued) Different clients use different channels some preferring the open markets for the variability on offer others relying on neighborhood country stores for their convenience and credit possibilities Building on a diversity of channels facilitates new varieties reaching different clientele and speeds up diffusion Having many points of distribution on a recurrent basis can help farmers restock novel varieties particularly those who regularly eat their full harvest Finally while many farmers buy seed overall they plant relatively small quantities and new options should be available in test sizes Small quantities allow farmers to explore a new product with limited risk and expense but also help seed services with limited volume capacity stretch access to their products These principles are summarized in pragmatic form in Figure 1

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3 This data contrasts with recent reviews which suggest that in developing countries 80 % of the total requirements are met by farmer saved seed (Cooper 1993 citing Groosman et al 1991)

The Great Lakes work also turns upside down some of the normal stereotypes about market-orientation The poorer the Rwandan Burundian or Zairian farmer the larger is the proportion of his/her seed bought

Figure 1

PRINCIPLES GUIDING SEED DISTRIBUTION OF NEW VARIETIES	OBJECTIVE
Build on existing channels	Sustain low cost
	Assure timely delivery
Use different channels	Reach different clients
Promote many distribution points	Allow farmers to restock
Diffuse small quantities to many farmers	Assure efficiency

ACTION RESEARCH SEED DIFFUSION EXPERIMENTS

The potential effectiveness of such principles was tested through a series of action-oriented experiments These trials pushed NARS CIAT and development projects partners onto the borders on research proper but proved vital for sharpening recommendations They also served to breakdown long held stereotypes e g farmers won t buy new varieties in a cost effective manner

Design of seed delivery package

A prelude to the diffusion experiments was the design of a simple product delivery package-- of interest to seed purveyors i e merchants and seed users i e farmers Small quantities (options of 50 100 and 250g) of highly productive varieties (both bush and climbing beans) were packed in heat sealed plastic bags along with an identifying leaflet (This format parallels that used by street vendors for selling peanuts) From the merchants point of view the self-contained premeasured bags made distribution a clean and generally quick process Farmers saw such test sizes as a low risk investment and the finished packets suggested a reliable product (that is of standard quantities and of research proven varieties) The leaflet describing basic varietal characteristics (printed in Kinyarwanda the local language) made the new technology understandable to all direct collaboration with an extension agent or development agency became unnecessary (Sperling in CIAT 1990)

Distribution experiments (CIAT) through local seed outlets

CIAT itself experimented with two local channels as test distribution outlets local country stores and centralized open markets Four types of packages were made available (Scheidegger in CIAT 1991)

1) 250 g of a single bush variety
2) 250 g of a single climber
3) set of 4 bush varieties (50g each)
4) set of 3 climbers and a sample of Sesbania macranta (50g each)

In terms of production costs bags labor for packing and labels represented US$0 02 per unit (single variety) and $0 05 per unit (set) seed (at market price) $0 10 and 0 08 respectively Packages were sold to vendors at $0 12 per unit

In September 1991 (just before sowing time) ten country store owners (all those contacted) readily took about one hundred of these packages on commission These shops typically serve a range of 1000 to 3000 farms and commercialize 1 3 tons of seed of local mixtures per season Merchants sold the packages to farmers at US$0 16 $0 24 (average 0 20) per unit Farmers thus paid on average $US 0 80/kg (single variety) and $US 1 00/kg (sets) of bean seed of new varieties the going rate for local cultivars hovered around $0 40 per kg Demand appeared greatest for packages of single varieties with bush beans sought before climbers Merchants sold the most preferred packets within 2 3 days and showed great interest to continue the experiment

Sales at the village market were logistically more difficult as the handy plastic packages were easily stolen (as opposed to local mixtures normally sold in bulk) As more farmers can be reached through open markets the traditional sprawling merchandise display may need to be modified if vendors continue with the sales The single market merchant contacted disposed of 140 packages in two hours

This set of distribution experiments confirmed that farmers are readily paying for new varieties at two to three times the open market price of local seed Merchants in turn find profit in handling the sales and the country store seems to be an effective channels for reaching large numbers of farmers

Distribution experiments (development projects) through local seed outlets

The above model was repeated and expanded by a series of development projects with trends further confirmed The experience of the Agricultural Project of Karama is a case in point

The Project carried out three sets of diffusion experiments In September 1990 the first test packets of a single climbing variety Umubano were diffused in their zone the climbing variety being largely unknown to farmers Packets were sold via the government agricultural stores and with 225 kg of stock the Project was able to reach 900 farmers The next year Karama became the leading producer of climbing beans in the county

By September 1991 farmer multipliers had produced some 1716 kg of Umubano seed all of which was sold and diffused (sometimes in larger quantity) In this and the following season (Sept 1991 and February 1992) the Project also introduced another variety via small packet sales Vuninkingi because Umubano started to have problems with root rots Through the new seed diffusion mechanism the varietal replacement moved swiftly onto farmers fields

In September the Project already with formidable seed accomplishments asked if it could improve its performance could a greater range of varieties be diffused? in less time to more farmers? It was then that managers decided to sell in the open markets those normally frequented by farmers to buy household goods fresh fruits and vegetables livestock The conscious decision to sell only small size packets 125 gr was tenaciously held Small quantities allowed farmers to buy samples with their pocket money and stretched a limited seed stock a long way

The Project sold four climbing varieties (Puebla Ngwinurare Flora and Vuninkingi) without and without fertilizer accompaniment Rotating among 6 markets several hours each day all seed 1590 packets were sold within the week with many potential customers still clamoring for more As about 60 % of the buyers came within their zone the Project calculates that it reached 9 3% of its total population of 6288 families with this little exercise alone Table 5 details costs To keep price down varietal packets were subsidized for 4% of their cost The manager believes they can raise the price of the goods (completely covering costs)--and still have greater demand than supply (Projet Agricole de Karama 1992)

Table 5 Production costs (FRw) of seed packets Agricultural Project of Karama September 1992*

Packet	Seeds alone (125 gr)	Seeds + DAP (125gr + 200gr)
Seeds (60 FRw/kg)	7 5	7 5
Fertiliser DAP (45 FRw/kg)	–	9 0
Plastic packaging	1 0	2 0
Information sheet seeds	0 4	0 6
Labor for packaging	1 5	3 0
TOTAL COST	10 4	22 1
SALE PRICE	10 0	20 0
Information sheet fertiliser	--	8 0
SUBSIDY	0 4	10 1

Source Projet Agricole de Karama 1992
FRw/$US= 130/1

Discussion seed diffusion experiments

Such seed sale/diffusion proves to be an easy activity for development projects/ NGOs to pick up With limited effort results are impressive reaching small farmers quickly Using market channels similar experiments have been conducted in Zaire Uganda Tanzania and Ethiopia (T Musungayi C Wortmann O T Edje personal communication) Diffusion of new varieties has also been tested through non seed outlets nutritional centers charitable organizations and agricultural training schools Particularly with nutritional centers a new range of clientele generally unreached by extension efforts showed unusual enthusiasm for the new varieties (Sperling et al 1992)

The beauty of the small seed packet technique is at once its simplicity and impressive potential for impact In Rwanda calculations show that with a mere 5 tons of seed 100 000 farmers can be reached or just under 10 / of the population Getting the same seed out but more quickly and widely translates into discounted social benefits jumping from 5 to 8 million for each variety (Scheidegger 1992) Such a diffusion paradigm looks for impact rather profits <u>per se</u> and in the process shifts considerable gains over to small farmers themselves

DIAGNOSIS OF INFORMAL SEED SECTOR GENETIC MANAGEMENT

The amount of bean genetic diversity existing in Great Lakes fields is the most impressive in the world In Rwanda alone recent studies show at least 550 local varieties in active use on farmers fields (Scheidegger in CIAT 1993)

Great Lakes farmers manage this diversity in the form of mixtures blends of on average 11 components but at times encompassing 30 different varieties (Lamb and Hardman 1985 Voss 1992) The advantages of such mixtures are well known to farmers and the international scientific community They help stabilize and stagger production both trends leading to enhanced food security Varietal blends can reduce disease incidence by creating physical barriers to its spread leading to direct yield enhancement (Pyndji and Trutmann 1992) Mixtures can also allow farmers to meet diverse production needs (consumption marketing) on single plots rendering land and labor more efficient (Ferguson and Sprecher 1989 Voss 1992)

Great Lakes farmers constantly adjust mixtures both to mitigate against fluctuating conditions as well as to target blends to perform maximally in various micro niches Thus different mixtures are adjusted and sorted for different seasons (Sperling 1992) and for varying agro-ecological conditions such as for more or less fertile soils or for association within banana stands (Voss 1992) Mixtures are also remarkably dynamic farmers regularly add (and subtract) varieties to meet specific production ends New cultivars are particularly added if they share compatible characteristics with other components (e g complementary cooking time) if they continue to perform well when combined and if their addition does not threaten the vitality of the local components (Sperling in CIAT 1991)

Given such a fluctuating profile for mixtures according to season micro-zones individual production goals it is perhaps not surprising that mixtures on one farm may contrast with mixtures found on the circle of adjacent farms To-date the most detailed regional analysis of mixtures (Cishayayo et al ms) shows that only 20% of the mixture components (varieties) were found to be shared among pairs of farmers living within 3 km

Many of the aims of mixture management production stability targeting for diverse or fluctuating conditions can be met even if diverse genotypes are managed separately (e g on distinct plots) Indeed most households in Africa do not sow mixtures and many gear part of their production towards an urban market which may demand a rather uniform product (e g the case of small white beans in North Kivu) Even within such constraints however diversity can be encouraged through innovative breeding and seed multiplication programs for example many white cultivars can be released or different varieties can be promoted for market sale vs home consumption Below is an example of an experimental selection program from the Great Lakes which also has applicability for contexts with less existing diversity The key concepts are targeting decentralization and options

ACTION RESEARCH USER INVOLVEMENT IN THE SELECTION OF NEW VARIETIES

National breeding programs normally screen for varieties with good yield potential (on station) and select disease resistance Out of a large range of varieties initially on offer perhaps 200 in the early yield trials 2 5 may make their way on farm with 1 or 2 eventually finding wider adoption Breeders search for a few widely adapted cultivars to accommodate large scale centralized seed production (Davis 1990)

Such a narrowing of genetic variability on farm may compromise production stability for farmers In heterogeneous environments however (agro-ecological and social) such narrowing may also represent missed opportunities for breeders that is many of her/his varieties never tested on farm potentially could find a productive place in farmer micro niches The challenge is identify acceptable (potentially locally adapted) variability early in the selection process

As documented above farmers in the Great Lakes have considerable experience in managing bean diversity From 1988 1993 an experimental program at ISAR sought to build on such expertise in order to identify a greater range of farmer acceptable varieties The ISAR/CIAT team could have pursued a standard approach interviewing farmers on their desired criteria and feeding back the information to scientists Thus for example results might have shown that farmers have a range of criteria not always prioritized by breeders for instance short cooking time However the limits of such unilinear feedback approaches are obvious in complex environments Farmers may have many desired criteria not all are equally important to all farmers and the balance among criteria is often difficult to judge for different client groups Further such static descriptions fail to take account of complex gene by environment (GxE) interactions Because only farmers can be expected to know the demands of their own micro-niches the experiment decided to directly bring farmers onto station to select their own germplasm

During Phase I of the Participatory Selection Program farmer varietal experts in Rwanda talented women evaluated some 15 varieties in on station trials conducted 2-4 seasons before normal on farm testing Such evaluations took place at three stations at high (2200 m) mid (1650 m) and low altitude (1400 m) From station trials women selected several varieties for home experiments in order to compare their station evaluations with actual farm field production On station evaluations showed that farmers select along two sets of criteria according to preference and performance variables While preferences such as cycle length can be easily anticipated by breeders performance variables seem to represent a combination of traits which allow varieties to say perform well under banana stands Such performance variables are not easily integrated in a formal breeding framework

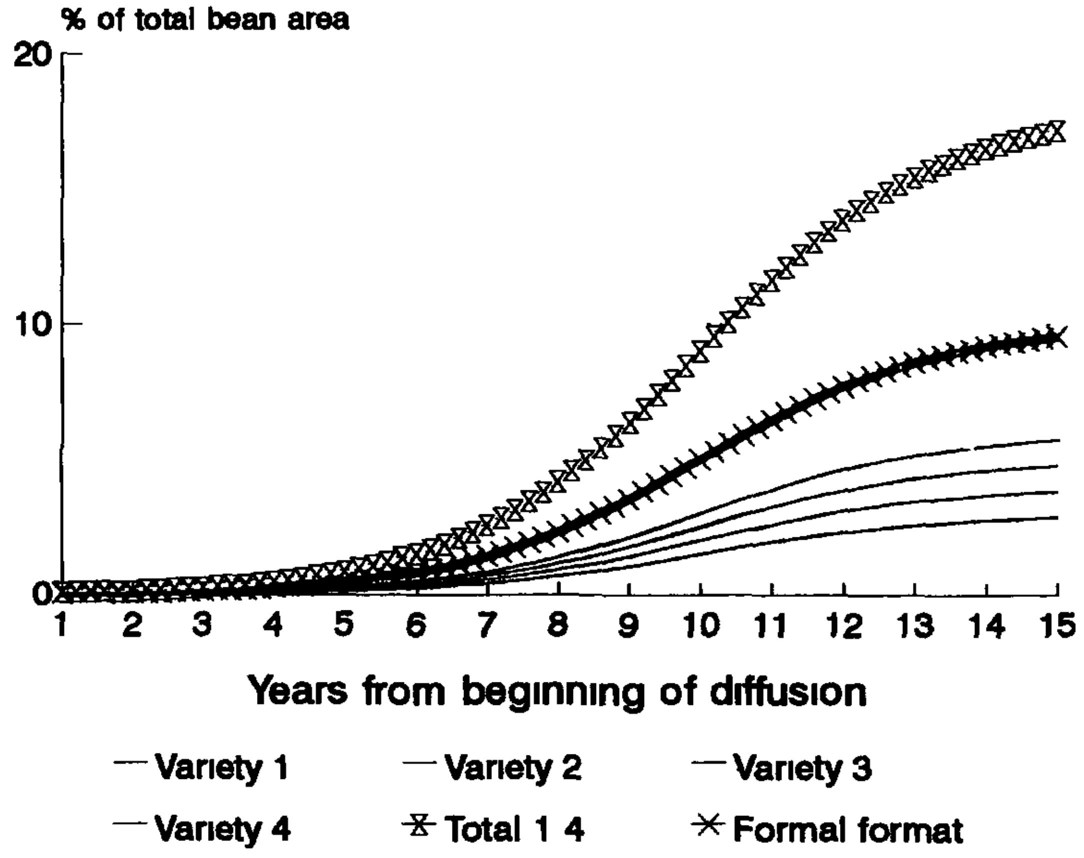
On farm results demonstrated farmers considerable ability to target cultivars from station fields to their own home plots during one season they attained average production increases of up to 38 % The diversity of cultivars desired by farmers was also considerably greater than that normally on offer the number adopted over the two year experimental period 21 matched the total number of varieties released by the national program in the previous 25 years (Sperling et al 1993) Follow up surveys showed farmers longer term appreciation for the varieties they selected

In Phase II of the experimental program women experts coming to station represented the interests of specific cooperating groups They also screened a broader range of cultivars earlier in the selection process 80 100 entries in on station trials 5 7 seasons before conventional on farm testing Farmer selected cultivars were then managed in decentralized community plots serving an area of some 6 000 households (Scheidegger et al 1991) During the first two community trials alone participants selected 26 different varieties for home testing

The experience honed ISAR/CIAT methods for integrating users into the selection process While the users in Rwanda were farmers elsewhere large scale merchants might prove appropriate selectors The experiment also however sharpened team thinking on how to design breeding programs geared towards both impact and promotion of genetic diversity Rather than release one variety to cover 10% of the land (for the team a dangerous upper limit) why not diffuse four six eight varieties each meeting needs of say 3 5% of production areas The production gains will be greater--and more stable It is important to note that the varieties screened by farmers included both new cultivars and farmer varieties In fact two of ISAR s greatest successes within the formal breeding program have been with the local varieties Kilyumukwe and Ikinimba (Scheidegger in CIAT 1993)

Figure 2 illustrates the concept of multiple varietal release which targets micro niches A commitment to such an approach implies a breeding program which is ready to offer a range of varieties at one point in time and also prepared to dynamically release a good number of varieties through tıme Seed systems would have to have the capacıty to respond to such local needs and to meet fluctuatıng productıon demands

Fıgure 2 Adoptıon potentıal partıcıpatory v formal format



SYNTHESIS PRINCIPLES GUIDING GENETIC MANAGEMENT OF SEED OF NEW VARIETIES

The above studıes of farmers own varıetal management and expertıse shaped how researchers conceıved of new varıetıes role ın an overall program to ımprove the seed sector for small farmers In brıef dıversıty wıthın farms and across farms suggested that *farmers need for range of varıetıes* ıs great and conversely that the demand potentıal for varyıng varıetal optıons ıs wıde Key prıncıples guıdıng the genetıc profile of new seed aımed to encourage dıversıty by regıonalızıng varıetıes on offer by assurıng a spectrum of choıce at one poınt ın tıme vıa multıple seed entrıes by allowıng both local and new cultıvars to be screened and by encouragıng a process of dynamıc varıetal ıntroductıon Possıbılıtıes for local adaptatıon could be reınforced ıf farmers themselves had more feedback in the selection process through early consultation or even active involvement in selection While the Great Lakes may be an extreme case in terms of existing diversity the general principles for coupling diversity with production gains apply more widely The principles summarized in pragmatic form in Figure 3 could also be used to broaden diversity in areas where it is now dangerously restricted

Figure 3

PRINCIPLES GUIDING GENETIC MANAGEMENT OF SEED OF NEW VARIETIES	OBJECTIVE
Regionalize varieties on offer	Target agro-economic socio-economic needs
Diffuse several varieties at each outlet Promote dynamic process of introduction	Meet farmer s diverse needs Encourage genetic diversity
Integrate early user evaluation	Assure farmer acceptability
Promote the screening of both local farmer varieties and new cultivars	Encourage genetic diversity Help sustain local varieties
Tolerate (promote?) genetic heterogeneity of single cultivars	Enhance stability of single cultivars

DIAGNOSIS OF INFORMAL SEED SECTOR PRODUCTION ISSUES

In 1989 CIAT Great Lakes encouraged a development project (Projet Kigali Nord) to buy back from its farmer collaborators seed of a new variety they had received seasons before in the context of on farm testing Although the Project was initially reluctant to do so it later made this its major strategy to obtain large amounts of seed of new cultivars for further distribution (in the 1991 A season as much as 8 tons were collected from farmers and mostly moved to other regions (PKN 1991) Other projects followed the example

The advantages of this approach are evident Seed of new cultivars is obtained at relatively low cost (15 30% above market prices of consumer beans) the work of seed selection can be shifted to farmers who do it more efficiently than employed labor and early adopters among farmers get the chance to realize some extra revenue

Most of the Great Lakes research on seed issues has focused on distribution and varietal issues rather than seed production per se The diffusion format described above can be appended onto a routine formal seed production program So can the activities revolving around early user involvement and promotion of varietal diversity There seemed to be little need to target efforts on production for the sake of production Bean seed overall is relatively plentiful in the Great Lakes over 90 % of farmers grow beans and most do so for two season per year Regional shortages occurring perhaps because of acute climatic conditions can be filled through transport of seed over relatively short distances Production issues for the sake of assuring large quantities of seed might certainly have to be addressed in other contexts for example where wide regions are unable to sufficient seed supplies and/or where extensive distances inhibit easy seed transfer

Our own focus has been on the seed of new varieties whether researcher or farmer bred In such a situation what seed production issues need to be brought to the fore? Seed quality is often cited as the key concern

Seed Quality overview

Discussions of seed quality usually lump together a number of standard criteria

1 physical purity
2 physical/physiological parameters
3 genetic purity (within equal grain phenotypes)
4 disease infection

While all are deemed essential by formal seed production specialists farmers needs/wants may prove to be more selective

Physical purity is not an issue for most bean farmers in the Great Lakes Sowing is done by hand and stones or other inert material can be easily sorted out Concerns with germination likewise prove somewhat secondary Studies of farmers seed germination show overall germination rates to be high (Scheidegger in CIAT 1991) and where farmers do expect low germination they simply increase seeding rates (example farmers regularly seed at higher rates on poorer soils) Such a strategy results in slightly increased seed use per ha but costs can usually be absorbed as only small areas are sown

Another physiological parameter initial seedling vigor seems to vary little across Great Lakes farms Controlled studies examined the effect of production harvesting and storage conditions on seedling vigor Researchers were particularly concerned with the effects of premature harvest on seedling vigor as socio-economic pressures urgent need for food widespread theft-- are forcing farmers to routinely harvest before beans reach complete maturity While researchers (as well as farmers) observed more off color grains with these early harvests no effects were evident in terms of germination rate seedling vigor or yield (Scheidegger in CIAT 1992) Similarly seed produced in acid low phosphorus soils did not perform differently from seed produced in fertile soils (Ibid) The duration of storage affected seedling vigor slightly but this effect was not translated into yield differences

Genetic purity within grain types a criterion for seed quality highly emphasized in textbooks can prove to be somewhat of a liability in the farmers fields with rigid uniformity stability of the genotype is threatened It is our belief that purity is predominantly important when harvests are mechanized or when markets demand an unusual homogeneity of product neither condition holding true for Great Lakes bean production Tolerance for heterogeneity within single cultivars has been added to the list of principles guiding genetic profiles of new varieties (Figure 3)

Having eliminated most of the above seed quality concerns as controllable or irrelevant the issue of disease infection remained important for conceptualizing future seed production strategies

Disease infection targeted assessments

Farmers themselves rarely renew seed for health reasons <u>per se</u> (for example in Burundi less than 1% of farmers) (Sperling field notes 1992) The value of highly-controlled disease free seed also has to be questioned in tropical areas where seed is only one of several sources of disease inoculum No winter season means that pathogen survival in the field is higher Staggered planting typical for the tropics means that early plantings can act as sources of inoculum for later ones And a close succession of beans in a rotation allows for an effective carry over of inoculum from one bean crop to the next (Scheidegger 1992) Still one should not assume or accept the poor quality of farmers bean seed if indeed it is poor' Two experiments were conducted to examine seed quality one comparing different seed sources of a genetically improved variety the other comparing different sources of local varieties

<u>Disease infection and new varieties</u> In the first experiment Umubano an exotic climbing variety was chosen as test variety because it had been distributed to farmers for several seasons is widely grown and easily identified Its shortcoming for the experiment was Umubano s resistance to anthracnose ruling out this disease as a parameter for seed quality evaluation

Samples were purchased from the Rwandan Central Seed Service (=basic seed) the local prison which had produced in collaboration with the extension service two farmers producing seed with the guidance of a development project (= artisanal seed) and seven farmers---the last three sources being in the same locality The national program s breeder s seed was used as a check All samples were sown under the same conditions on station and were closely monitored

Table 6 shows statistical parameters of the trial No differences were detected among samples for emergence vigor and yield Phytopathological parameters were significant only for ascochyta For CBB incidence was generally low and thus data are rather erratic The high mean incidence of Angular Leaf Spot probably reflects more air borne than seed borne infections No consistent differences between seeds produced under more formal settings and seeds obtained from farmers were observed (Figure 4) The National Program s seed had a lower initial vigor than most other seeds with phytopathological parameters being slightly better than average This seed was freshly harvested a fact which may have influenced physiological performance (Scheidegger and Buruchara in CIAT 1991)

Laboratory tests (seed germination on wet filter paper in Petri dishes and subsequent counts of infected seed under the stereo binocular microscope) carried out on 126 grains per sample confirmed the low general infection of all samples and again gave no distinction between farmers seed and seed produced in formal settings The values were too low for statistical analysis (Buruchara in CIAT 1991)

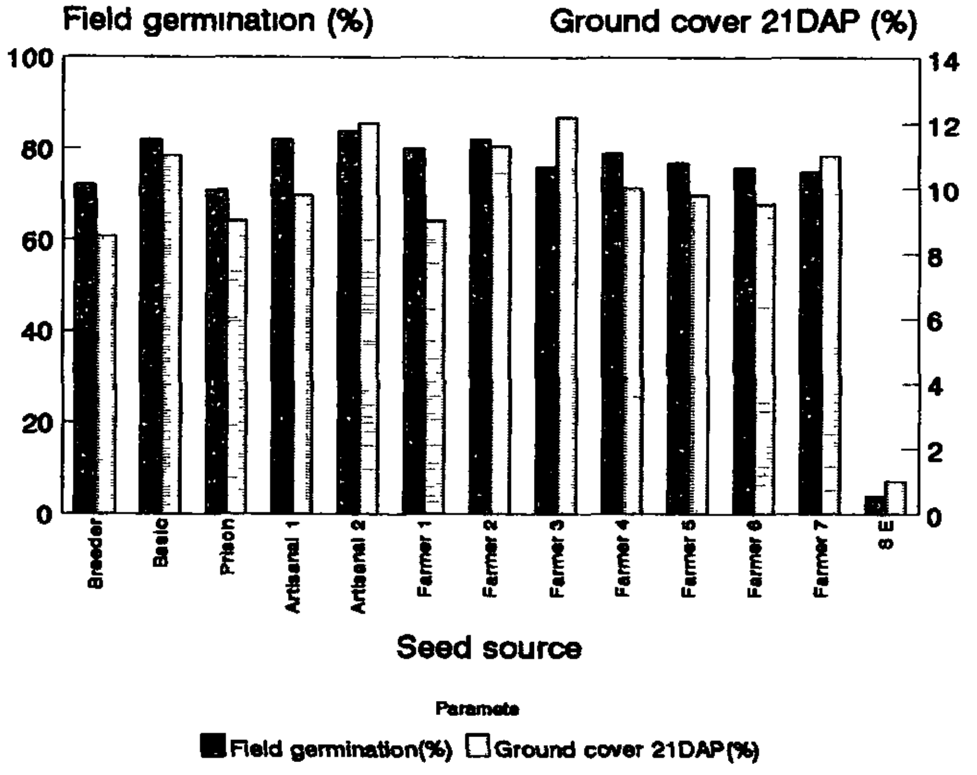
Table 6 Performance of 12 seed samples of G 2333 in a field trial Rubona 1991A

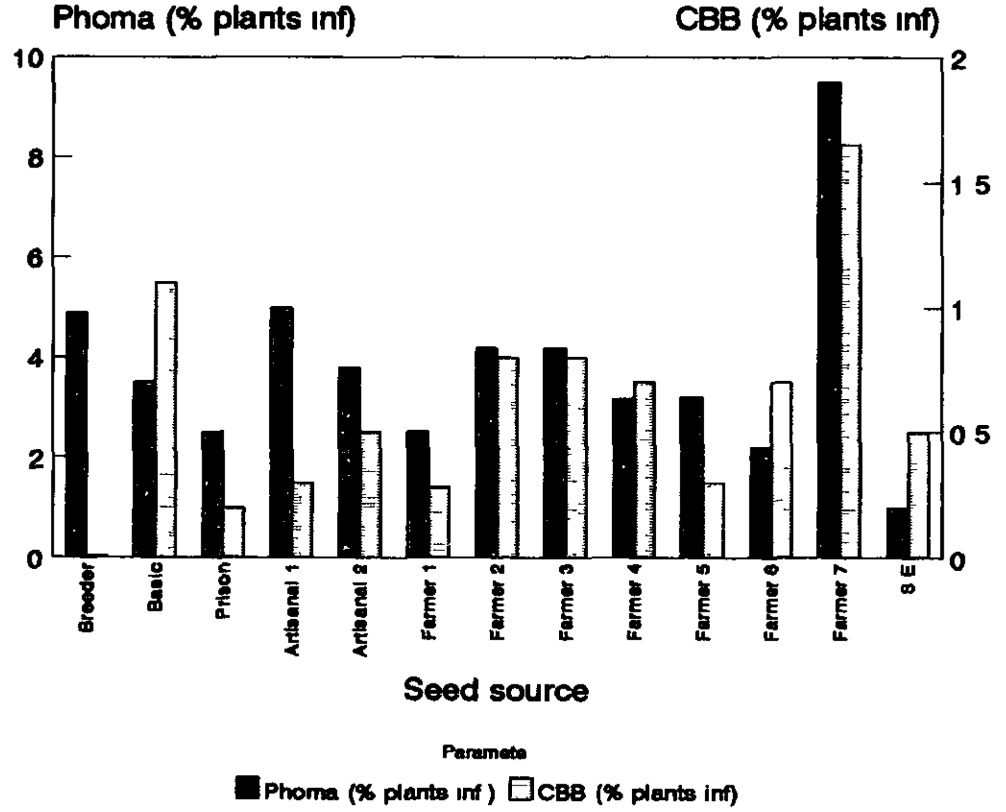
Seed quality parameter (transformation)	F Test (P) transformed	C V (%) transformed	Overall mean *untransformed*
Field emergence 19 DAP (arcsin)	0 33	15	78%
Ground cover 21 DAP	0 20	20	10 /o
Ground cover 27 DAP		22	29%
CBB incidence R5 (arcsin)		166	0 6 /o
Ascochyta incidence R5 (arcsin)	0 02	56	4%
Angular Leaf Sp inc R5 (arcsin)	0 20	13	55 /o
Yield (grains)	0 30	16	2123 kg/ha

Disease infection and local varieties The quality issue was pursued further in an experiment which compared the quality of seed of local varieties produced by farmer experts with that multiplied by the general farming population Farmer seed experts are recognized by their communities as in dividuals who produce and sell high quality seed When describing their techniques of seed production the four women interviewed cited good agronomic practices as the key manuring sowing on time weeding and particularly harvesting only when the grains were fully mature None of the seed experts felt that her seed renown was due to superior varietal material

The quality of expert seed was compared with that produced by neighbors and that sold in nearby country stores Comparison was made on seed obtained from 4 areas (Cyargwa Karama Kigembe and Muganza) on the basis of phytopathological (both laboratory and field) and agronomic characteristics For phytopathological comparisons seed samples were separated into principal common components (common only within these sites) incubated and examined for types and levels of seed infection under laboratory conditions A similar comparison but using all components of the samples was made under field conditions at Rubona

Figure 4 Comparison of seed samples of G-2333 Rubona station trial 1991B





The seedborne pathogens found to be associated with some of the seed were *Fusarium oxysporum* f sp *phaseoli Colletotrichum lindemuthianum Phoma exigua* var *diversispora* the causal agents of fusarium wilt anthracnose and phoma blight diseases respectively However the level of infection per seed sample tested was very low ranging from 0-6% Frequency of fusarium pathogen was higher in Cyargwa (18 4 % out of all seed tested) than in any other region mainly on the beige colored grain type in comparison to 4 1% in the red colored type within the same sample Similarly the frequency of anthracnose was high in seed from Kigembe (5 9%) and Muganza (4 9%) in the red and black seed types respectively implying influence of region and components of the farmers seed on the types and levels of pathogens observed All samples from different sources from Karama for example were not infected by any pathogen In general differences between expert seed and seed from other farmers were not significant due to no or low infection levels observed Apart from Cyargwa where expert seed (beige color component) had a relatively higher infection (6 %) of fusarium pathogen than seed from other farmers (2 3%) expert seed from all other areas was free of fusarium phoma and anthracnose pathogens Seed from neighbors had some although slight infection of anthracnose (0 8 3 3%) fusarium wilt (0 1 2%) and phoma (0 1 2%) pathogens (Buruchara in CIAT 1992)

Parameters evaluated in the field were germination incidence of seedborne pathogens and disease severity Results obtained showed no significant differences in germination incidence of anthracnose angular leaf spot phoma blight and BCMV between expert seed and seed from neighbors However at R6 there were differences in severity of anthracnose between regions with Muganza showing higher disease scores This agreed with the laboratory observations where principal seed components from Muganza showed relatively higher seed infection by anthracnose and which suggest their susceptibility (Buruchara in CIAT 1992)

These results show that phytopathological quality differences between expert seed and other sources compared here did not occur due to very low infection levels overall particularly for pathogens like anthracnose and phoma that visibly affect the seed Both experts and farmers selecting out of blemished seed greatly reduces infection with seed experts being slightly more skilled at the task The latter s seed were all free of the two pathogens whereas seed from all other sources had some infection On the other hand Fusarium infection of seed may not be visibly recognizable thus the difficulty of distinguishing between infected and non infected seed

ACTION RESEARCH SHOULD FARMERS IMPROVE THE QUALITY OF THEIR SEED?

The results above suggest that the health of farmers seed is not as bad as the stereotypes hold and that farmers actively try to control its quality Could farmers management practices aimed at improving seed health (mostly by selecting for sowing only grains without blemishes around the hilum (Trutmann Voss and Fairhead 1993) be improved still further? In an early experiment seed of varietal mixtures was produced on station with intensive fungicide protection and without In the subsequent season the crop grown from the pathogen free seed yielded 21 % more than the crop grown from seed from the check plot (Trutmann and Kayitare 1991) indicating that there was scope for improving productivity through seed health

Later on farm experiments concentrated at improving seed health through measures accessible to Rwandan farmers and applicable on farm Seed plots were established and managed along the following

1 Stricter elimination of seeds with blemishes (including blemishes away from hilum area)
2 Seed treatment with benomyl thiram and endosulfan
3 Elimination of diseased plants (bacteria and viruses) from the field
4 Removal of diseased leaves (including removal from the field)
5 Early harvest
6 Positive selection at harvest at the level of pods and plants

While seed produced this way had a lower percentage of blemished grains than the check (0 3 instead of 1 2%) it did not produce significantly higher yields Seed stocks multiplied in this way during three consecutive seasons showed appreciably less disease symptoms in the foliage yet the yield advantage of 14% (different at $P<0\ 1$) was still not very convincing

Thus although simple measures for further improving seed health on farm could be identified they are not likely to be widely adopted as production benefits are too small to compensate for the laborious and long term efforts needed to improve seed stocks Trutmann and Kayitare (1991) note further obstacles to a sustained impact of the on farm seed improvement strategy they tested First education of farmers on distinguishing diseases would be necessary Second in unfavorable seasons the multiplication plots would not yield enough for the next season s planting and the shortage would have to be recouped either by less rigorous seed selection or by using grains from the normal production thereby interrupting the process of gradually improving seed stocks

While in the Great Lakes seed health has proven to be an opportunity for productivity increases in but a few cases studied the importance of seed health depends on many factors notably cropping system prevalent diseases variety or varietal mix climate and its effects on disease epidemiology As a research strategy improving seed health should be newly assessed for each set of circumstances generalization would be inappropriate

SYNTHESIS PRINCIPLES GUIDING PRODUCTION OF SEED OF NEW VARIETIES

Great Lakes research teams have focused relatively little on the production of seed per se as we believe a little amount of seed can go a long way Our initial research on seed health suggests that it is less of a problem in the informal sector than we had originally thought Local institutions should probably look into this aspect on a case by case basis

In starting to think about principles guiding seed production we would emphasize decentralizing it if only to assure the delivery of more regionally specific or locally adapted cultivars Policy makers might need more data on the advantages of certified seed (does it give yield gains over what period and at what cost) They should also explore possibilities for producing seed of various quality levels so as to deliver a good (not great) quality product at an affordable price Such intermediate quality would of interest for farmers who search first *superior genetic quality in a* production geared primarily towards home consumption As a general rule we suggest that seed produced under any scheme of external intervention (formal or informal) never have higher levels of disease infection than the seed farmers presently use The best way to ensure this is to have it *produced by farmers themselves* in a way as close to possible to their normal methods and in locations (environments) as close to those routinely used

Seed experts present but one avenue for building on existing seed systems which already link production to distribution and which offer a good opportunity to keep down costs Seed experts identified within the Southern Rwandan zone regularly produce and sell 300 600 kg each of seed during the major growing season (Sperling in CIAT 1992) This mean figure of 450 kg per expert compares favorably with the 1600 kg per variety per year (or total 20 25 T) produced by the central seed service Seed experts with no subsidies aim to serve a highly localized group of 100 300 clients In contrast the *central seed service aims to serve country wide demand* (upwards of 1 million bean-growing households) Other local level seed production channels could also prove viable e g cooperatives private entrepreneurs

Figure 5

PRINCIPLES GUIDING PRODUC TION OF SEED OF NEW VARIETIES	OBJECTIVE
Build on existing farmer production systems	Profit from existing production to distribution links Keep down costs
Explore different seed quality products	Offer affordable seed for varying clients those needing certified seed for export those looking for superior genetic material in production geared towards home con sumption

To date a single NGO project has tried to combine the above sets of strategies user identification of varieties local level seed multiplication and diffusion in small packets through local markets and country vendors The results at the Projet Agricole de Muganza in Rwanda have been encouraging In 1992 alone the women s *group identified some* 11 *promising* climbing and bush beans multiplied over a ton of seed of five previously selected varieties and diffused them through three informal channels with all phases being locally controlled (PAMU 1993)

CONCLUSIONS

The Great Lakes bean seed research has been influential not only at the farm level (having significant impact) but in the policy arena Drawing on such results both Burundi and Rwanda are in the initial stage of exploring more decentralized seed systems (Walls et al 1992 Conceptra 1993) consultancy report) Recommendations obviously differ according to crop but beans self pollinating and largely produced to home consumption represent the prime candidate for alternative production and distribution formats

In reviewing our five years of research one major tenet guided our strategy Define your seed problem well and build on what are promising opportunities Lack of good seed so commonly heard is too vague a problem to be of operational use

Figure 6 sketches a reflective framework for identifying such opportunities and indicates choices made in the Great Lakes Bean Research Network Choices elsewhere will vary according to such factors as agro-ecological climate type of crop and above all user needs We end this paper where we started seed systems need to be tailored

Figure 6 Possible points of intervention to strengthen seed systems for small farmers including specific strategies adopted within Great Lakes Bean Research

Opportunities to improve overall availability of seed	Applicability to *Great Lakes*
When beans move into a new area	no
In regions where good seed cannot be produced	no
In areas or for strata of farmers who are notoriously short of seed	yes *but difficult*
In areas with storage problems (only one crop per year)	no
To satisfy high demand of seed because of unfavorable climatic conditions	yes but difficult

Opportunities for improving seed quality might existing through research on	Applicability to Great Lakes
Physical purity	no
Physical/physiological parameters	no
Genetic purity (within equal grain phenotypes)	not appropriate
Decreasing disease infection	perhaps in special cases

Opportunities for improving genetic acceptability/stability of seed through	Applicability to Great Lakes
Better agro-ecological targeting	yes
Better differentiation of user needs	yes
Promoting range of cultivars on farm	yes
Systematic screening and promotion of farmer varieties (landraces) along with new cultivars	yes

Figure 6 (cont) Possible points of intervention to strengthen seed systems for small farmers including specific strategies adopted within Great Lakes Bean Research

Opportunities for improving direct access to seed through	Applicability to Great Lakes
Use of different channels	yes
Making product more affordable	
e g offering in different sizes	yes
building on farmer production and distribution channels	yes

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