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INTENSIFYING PRODUCTION AMONG SMALLHOLDER FARMERS: THE IMPACT OF IMPROVED CLIMBING BEANS IN RWANDA

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ABSTRACT

While bush beans (*Phaseolus vulgaris* L.) have long been the protein staple of Rwandan agriculture, improved climbing beans have been introduced within the last 10 years, enabling farmers to intensify, stabilize and better stagger production. Through a 1992-3 nation-wide survey of 1050 households, conducted in both major growing seasons, this study examines the adoption of improved climbing beans across regions and potential user groups. Use of improved climbing beans, by 500,000 households, cross-cuts farm size, economic class and gender boundaries, and is most intensive among the more disadvantaged. Initial concerns with staking material, how to obtain and manage it, have posed relatively few problems for farmers, and the surprising plasticity of improved climbers has encouraged research to more closely determine soil fertility demands. Increased incidence of root rot (*Fusarium oxysporum*) and fear of reduced genetic variability on-farm have resulted in the Institut des Sciences Agronomique du Rwanda (ISAR's) adopting targeted pathogen screening procedures and releasing many new cultivars simultaneously. The success of improved climbers, bringing Rwanda an additional US$ 8 to 15 million per year, has stimulated promising R &D efforts in Kivu, Zaire and southern Burundi, and several other Eastern African regions have been identified as prime for climbing bean introduction.

Key Words: **Central Africa, climbing beans, intensification, small farmer agriculture**

RÉSUMÉ

Bien que le haricot erigé (*Phaseslus vulgaris* L.) a longtemps été la source protéique de base pour l'agriculture Rwandaise, l'introduction dans les 10 derniéres années du haricot volubile amélioré a permis aux paysans d'intensifier, de stabiliser et de mieux étaler leur production. A travers l'enquête nationale réalisée sur 1050 ménages en 1992-93, cette étude examine l'adoption des haricots volubiles, région par région, et determine les groupes d'utilisateurs potentiels. Sur 500,000 ménages ayant des champs de différentes grandeurs, appartenant à des classes économiques différentes et de sèxes différents, l'usage des haricots volubiles est plus intense parmi les ménages les plus défavorisés. Le problème initial lié au matériel de tuteurage, à son obtention et sa géstion, n'a posé relativement que peu de difficulté aux paysans; en plus, la souplesse de volubiles améliorés a poussé les chercheurs à déterminer leurs besion en fertilité de sol. L'incidence accrue de pourritures racinaires due au *Fusarium oxysporium* et la crainte de faible variabilité génétique en champs a fait que l'ISAR (Institut des Sciences Agronomiques du Rwanda) a opté pour des procédures de criblage des pathogènes ciblés et pour la diffusion simultanée des plusieurs nouveaux cultivars. Le succès de volubiles améliorés entraînant pour le Rwanda des revenues de 8 à 15 millions de dollars par an, a stimulé les efforts prometteurs de la R-D dans le Kivu au Zaïre et le sud du Burundi ainsi

que dans plusieurs autres régions de l'Afrique de l'est où ils ont été identifiés comme des introductions élites.

Mots clés: Afrique Centrale, haricot volubiles, intensification, paysan

PROLOGUE

This impact study was completed just two seasons before the acute and extensive civil disturbances in Rwanda. As such, it represents an up-to-date picture of some of the production gains made in Rwanda agriculture just prior to its devastation. This success story might serve as an impetus in the revitalization of Rwandan Agriculture by farmers, the national and the international research community. It also provides a baseline against which future rehabiliation efforts can be measured.

INTRODUCTION

Beans (*Phaseolus vulgaris* L.) are a central crop in Rwandan agriculture. They are grown by 95% of farmers, in all major regions of the country (from 1000-2200 m a.s.l.) and provide 65% of the protein and 32% of the caloric intake (Ministere du Plan, 1988). Beans are the "meat" of the Rwandan countryside.

Until recently, the bush bean was by far the most prominent of bean types. *Phaseolus coccineus* has been grown in small isolated pockets of the mid-west (Zaire/Nile Divide), and local climbing beans were restricted to the northwestern part of the country (prefectures of Gisenyi and Ruhengeri). While in this northern region, local climbing varieties give about twice the yield of local bush cultivars (Brewster, 1988), elsewhere, farmers stressed what they perceived as the climbing bean disadvantages: they need to be staked, take about a month longer to mature, and demand for more fertile soils. Surveys in 1986 in southern and central Rwanda showed only 5% of farmers growing climbing beans, and then only in "tiny" plots (CIAT, 1987).

Research on improved climbing bean cultivars can be traced to the early 1970s at the Institut des Sciences Agronomiques du Rwanda (ISAR) (Nyabyenda, 1982, 1985; Rubaduka, 1987). Station trials examined varietal options, cultivar spacing, types of staking material and stake length. Research on improved climbing beans intensified with the formation of the Swiss Development Cooperation (SDC)-sponsored regional network on beans, a network of the national programmes of Rwanda, Burundi and Zaire and the International Centre for Tropical Agriculture's (CIAT) Bean programmes. Table 1 summarizes major themes addressed from 1984 to the present. While efforts were spearheaded by the regional network [in 1992 anointed "RESAPAC" or Réseau pour l'Amélioration du Haricot (Phaseolae) dans la Région de l'Afrique Centrale] and ISAR, many other partners were implicated in climbing beans R&D: seed services, development projects (e.g.

TABLE 1. Main themes in climbing bean research in Rwanda, since 1984

Dates	Activities	Select sources
1984 - 86	Diagnostic surveys of bean producing regions: Survey of farmer management of local climbing varieties.	CIAT, 1987; Graf *et al.*, 1991
1986 - 90	On-farm trials with several climbing cultivars.	ISAR, 1989; Voss and Graf, 1991
1986 - 90	Focused research on staking material options: particularly agroforestry species.	ISAR, 1990; Nyabyenda and Gasana, 1992
1986 - 90	Focused research on fertilization payoffs.	FAO, 1987
1990 -	Adoption and diffusion studies.	Graf, 1991; Sperling *et al.*, 1991

Sperling *et al.*, 1991), extension specialists as well as a large group of farmer experimenters.

The history and extent of climbing bean research has been well-described elsewhere (Graf *et al.*, 1991). This paper focuses on analysis of national trends in improved climbing bean use: its geographic extent, its spread among user groups, and the benefits and costs of climbers. While select studies have indicated pockets of high adoption (Graf, 1991; Sperling *et al.*, 1991), this report represents the first nation-wide analysis of improved climbing bean impact.

METHODS

The survey was conducted from February to June 1992 (season 1992B) and again from September 1992 to January 1993 (season 1993A). These A and B seasons represent the two major growing periods in the Rwandan agricultural calendar, with the "A" season considered more favourable for bean production due to its less intensive rains.

To achieve a randomized sample, and avoid the bias of bean researchers trying to promote their technologies, ISAR/CIAT scientists joined efforts with the Division des Statistiques Agricoles (DSA) located within Rwanda's Ministry of Agriculture. This department, created in 1981, is responsible for the permanent monitoring of the agricultural economy, i.e., 93% of Rwandan households. Division de Statistiques Agricoles regularly collects data on agricultural and livestock production, farm size, density of crops, demographic characteristics, and household income and expenditures (MINAGRID/DSA, 1991).

The sample selected for this study comprised that used by DSA for its standard monitoring: 1248 households, stratified along two criteria; agro-ecological zone and administrative unit (MINAGRID/DSA, 1991). During 1992B, data were collected from 1191 households of which 1043 (87.6%) grew beans during the season in question. Remaining households were not reached either because they were located in the intensive combat zone (41 cases) or because the interviewer fell ill (16 cases). During 1993A, data were collected from 1045 households of which 1004 (96.1%) grew beans. Ten households (5 in Cyangugu and 5 in Gisenyi) were not reached for various reasons. A significantly large number, however, were not interviewed due to escalation of the civil war. Surveys were neither carried out in the entire Prefecture of Byumba (N= 144), nor in three communes of Ruhengeri (N=49). Both are areas where adoption of improved climbing beans has been high. Hence improved climbing bean use may be slightly underestimated for season B but markedly underestimated for season A.

It is important to note that DSA switched its monitoring sample between the seasons 1992B and 1993 for the second time in its history. Thus,

TABLE 2. Farming households (%) sowing each type of bean, 1992B and 1993A, by prefecture

Prefecture	Season 1992B			Season 1993A		
	improved climbers	local climbers	bush beans	improved climbers	local climbers	bush beans
Ruhengeri	70	36	55	80	23	67
Gisenyi	54	36	17	45	76	44
Byumba	47	9	97	n/a*	n/a	n/a
Gitarama	21	16	92	25	8	92
Gikongoro	80	0	66	82	1	96
Kibuye	63	6	75	52	13	89
Butare	56	3	90	47	3	100
Kibungo	12	2	100	15	1	100
Cyangugu	26	8	87	28	6	92
Kigali	21	10	89	14	11	99
Rwanda	43	13	79	41	15	88

* Not available

the same farmers were not interviewed over two consecutive seasons, although each set is said to be representative of the national population as a whole. At present DSA has accompanying income data only for its older (i.e., 1992B) sample.

During both seasons, four types of data were collected; farmers were interviewed on bean practices; for example: number of fields, types and sources of cultivars, cultivar names; fields were measured (N=3432 for season B and 4348 for season A) and density of associations noted; production was assessed (green bean and green seed being expressed in dry seed equivalent); and improved varieties were identified using standard samples and by reference to seed source.

TABLE 3. Area sown to improved climbing varieties, by prefecture, 1992B and 1993A

Prefecture	Season 1992B		Season 1993A	
	% Total bean area	Hectares	%Total bean area	Hectares
Ruhengeri	39	5769	58	6370
Butare	13	876	4	687
Byumba	4	589	n/a*	n/a
Cyangugu	9	433	8	769
Gikongoro	48	356	21	1437
Gisenyi	82	3781	25	2497
Gitarama	8	767	8	1301
Kibungo	2	261	1	347
Kibuye	37	1669	21	1854
Kigali	6	1071	2	513
Rwanda	17	15572	10	15775

* Not available

FINDINGS

Overall use. Over forty percent of Rwandan bean farmers, 480,000 to 500,000 households each season, are now growing improved climbing beans (Table 2). As expected, a relatively high number of farmers are adopting in areas where climbing beans have traditionally been grown, that is, the prefectures of Ruhengeri and Gisenyi. Adoption has also been high in Gikongoro and Kibuye, areas of generally low soil fertility, which contradicts the usual assumptions about climbing bean demands. Butare hosts the national institute, ISAR, and both Butare and Gikongoro have benefitted from extensive climbing bean research as well as seed diffusion experiments and activities within their zone (CIAT, 1991; Graf, 1991; Sperling *et al.*, 1991).

While the average area a household devotes to improved climbing beans is small, 430 m^2 and 370 m^2 for B and A seasons, respectively, families are already managing several improved climber plots (1.92 on average, with the high range at 9 separate parcels). Nationwide, improved climbing beans now occupy between 10 and 20% of the total bean area, which, extrapolating from nationwide production area, amounts to more than 15,500 hectares each season (Table 3).

Key advantages of climbing beans. In addition to its generally higher yields, improved climbing beans have had a number of advantages for smallholder farmers, particularly in land scarce areas. On average soils, a typical climbing bean plot of about 400 m^2 gives some 75 kilogrammes or three baskets of beans, versus a single basket for the bush. Figure 1 more precisely compares this production versus land area ratio for climbing beans in one region north of Kigali (N=116 households in communes of Tare, Rushashi, and Musasa)(Sperling *et al.*, 1991), and shows how relatively small plots, e.g. 130 m^2 for season A are able to produce a good share of the bean harvest, enabling farmers to intensify production.

Another important advantage for small farmers is the production stability of an improved climbing bean. In the Kigali Nord area, project scientists estimated from five years on-farm trials that bush bean gives 600 kg ha^{-1} and 350 kg ha^{-1} for the A and B seasons, respectively, while comparable figures for Umbano, the improved variety in diffusion, were 1600 and 1350 kg ha^{-1} (G. Randrianmampita, pers. comm.). Thus, while during season of heavy rains bush beans yields are nearly cut in half, climbers lose less than a fifth of their prime season production. The more aerated canopy makes climbers more tolerant of foliar diseases and their longer cycle enables them to better recover from sharp and transient stresses. Finally, many farmers also appreciate the staggered development of climbing varieties: green leaves, an important source of vitamin A, can be consumed for up to 6 weeks (versus 2-3 for bush varieties) and risks (particularly theft) are partly diffused.

TABLE 4. Comparison of additional costs, yield and returns of improved climbing beans with local legumes in two geographic zones of Rwanda

	Gikongoro		Kigali Nord	
	Bush bean	Soy bean	Bush bean	Local Climbers
Additional yield (kg ha^{-1})	2125	1825	1000	580
Additional return (US$ ha^{-1})	930	752	438	254
Additional costs (US$ ha^{-1})	431	477	166	0
Additional net return (US$ ha^{-1})	499	275	272	254

** Adapted from Graf (1991)*
Labour is valued at 100 FRw (Rwandese Francs) per working day. The costs of stakes are 0.5 FRw/pcs for Pennisetum purpureum. They last 2-3 seasons, with a cost of 0.167 FRw per stake and season. Bean seed is valued at 50 FRw per kg, soybean seed at 40 FRw per kg. Bean harvest is valued at 35 FRw, soybeans at 40 FRw per kg. The conversion rate of FRw/ US$ valued at 80/1.

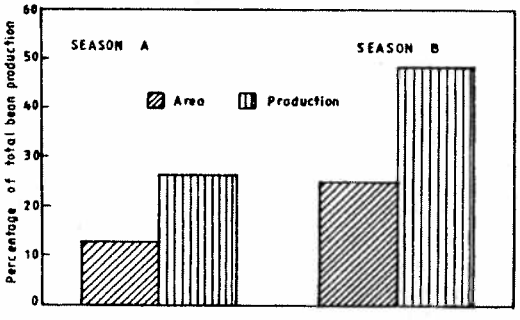
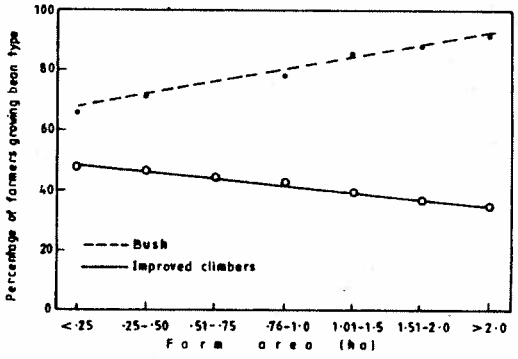


Figure 1. Relative contribution of improved climbers: Kigali Nord 1990

User groups. Poorer farmers are often portrayed as the least innovative: hence the decision by most development projects in Rwanda to work with the more "progressive" (i.e., wealthier farmers). In addition, climbing bean technology has been described as both labour demanding (Brewster, 1988) and capital demanding (Graf, 1991). Our findings cast some doubt on both these assumptions. Figure 2 indicates percentage of bean farmers adopting climbers according to farm size; even the largest category, farms over 2 ha, is very small when compared to most other farming areas in the world. Results show adoption to be relatively high among all categories (over 35%), with the highest rate, 48%, among those with total farm sizes of < 0.25 ha. Figure 3 charts adoption according to annual income, again with even the highest category, >12000 FRw/adult equivalent or US$ 92, being relatively low by world standards. Adoption proves to be significant across all categories of bean farmers, above 30%, with the highest rate, 50%, being among the very poorest-those with an annual income per adult equivalent of US$ 38 (or US$ 190 for the average family of 5). Finally, adoption was analyzed according to sex of head of household. Within the survey sample, 79.5% of households are nominally headed by men, with 20.5% by women. Among households adopting improved climbers, 79.3% were male-headed with 20.7% female-headed: hence, female-headed households were just as likely to adopt the new technology as those headed by men. Note that such female-headed households are among the most disadvantaged, both in terms of resource availability and access to extension



Figures 2. Relationship between use of bean type and farm size, Rwanda - wide survey, 1992B

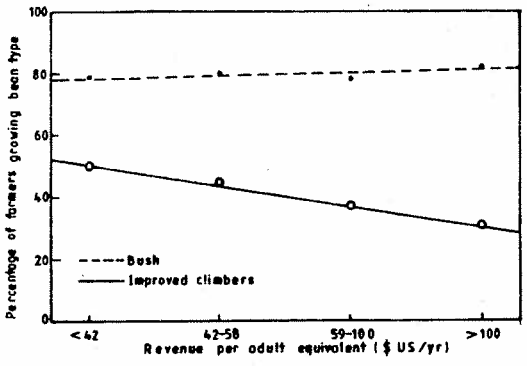


Figure 3. Relationship beetween use of bean type and farm revenue, Rwanda-wide survey, 1992B

services. In summary, the climbing bean technology appears to be scale-neutral, wealth-neutral, and gender-neutral.

Cost-benefits. The calculation of the costs-benefits of climbing bean technology is sensitive to certain key assumptions. To address possible variability, Table 4 suggests a number of realistic scenarios; climbing beans replacing bush beans where the latter are in significant stress, as in Gikongoro; climbing beans replacing bush beans where the latter are under less stress, as in Kigali Nord; and climbing beans replacing several crops: soybeans and local climbing beans (in Gikongoro and Kigali Nord, respectively). Yield data have been drawn from several sources (Graf, 1991; Sperling *et al.*, 1991), with labour, manure, and staking costs taken from Graf's (1991) synthesis. Our assumptions are conservative: for instance, we have valued labour at 100 FRw/day when there are indications that the opportunity cost, or market value, may be considerably lower in many areas. Similarly stakes and manure have been given relatively high market values. Taking the most common situation, climbers replacing bush beans, our analyses indicate that the new technology brings an additional 1000-2125 kilogrammes per hectare of beans with a net benefit of US$ 272 to US$ 499, depending on the site (Table 4). Given the survey finding of at least 15,500 hectares under climbing bean cultivation per season, the use of improved climbing beans annually brings 31 to 66 thousand additional tons of beans for Rwanda, equivalent to an extra 8 to 15 million US$ in income for Rwandan farmers.

TABLE 5. Households (%) using specific improved climbing bean cultivars among farmers growing improved climbing beans in Rwanda

Variety	Use 1992B	Use 1993A
	N= 448 households	N=409 households
Umubano (G2333)	57*	58
Vuninkingi (G685)	22	30
Cajamarca	11	10
Decelaya	4	3
Gisenyi 2-Bis	4	2
G2338	4	<1
Snap Beans V078	2	3
Ngwinurare	2	1
Puebla	2	-
RWV 78	2	-
Mwirasi	1	2
Urunyumba	1	<1
Flora	<1	2
AFR-13	<1	2
C-10	<1	<1
Gisenyi 6	<1	-
Muhondo 6 (G858)	<1	-
Zav-83052	-	1
AND-10	-	<1
G2331	-	<1

* The percentages surpass 100 as about a fifth of the farmers grow two or more improved climbing varieties.

SUSTAINABILITY CONCERNS

The extent of climber adoption, across regions and economic classes, has been unexpected. However, there remains a number of concerns, briefly addressed here, which will affect the stability of the technology as well as its prospects for further expansion.

Genetic variability. The majority of farmers using improved climbers are growing the variety

TABLE 6. Major woods used as staking material: Rwanda-wide survey,1991 (N=897 households)

Species	% Households
Eucalyptus sp.	29
Pennisetum purpureum	18
Ricinus communis	7
Acacia mearnsii	6
Vernonia amygdalina	5
Markhamia lutea	5
Grevillea robusta	4
Cupressus lusitanica	4
Arundinaria alpina (bamboo)	3
Cassia siamea	2
Euphorbia tirucalli	1
Senecio mannii	1
Pinus spp.	1
Ficus thonningii	1
Draceana afromontana	1
Morus alba	<1
Manihot spp.	<1
C. aurantium	<1
Erythrina abyssinica	<1
Olea africana	<1
Persea gratissima	<1
Acacia sieberiana	<1

Source: den Biggelaar (1994), Michigan State University, personal communication

Umubano, upwards of 55% for both seasons (Table 5). Moreover, in terms of climbers, about 80% are growing but a single variety. Such genetic narrowness can compromise production stability and, if yields of improved climbing cultivars are to remain high, research should put strong emphasis on releasing many and diverse cultivars. ISAR has actively responded to this challenge and now has a handful of highly appreciated climbing cultivars on-farm: Flora, Vuninkingi and Ngwinurare. This progressive release strategy should be continued. Fortunately, farmers continue to sow both bush bean mixtures and local climbing bean mixtures, with only 6% of bean growers planting improved climbers exclusively. Thus, considering all bean types, overall genetic variability on Rwandan farms remains high.

Staking options. It appears that Rwandan farmers have largely been able to alleviate what was originally perceived as a staking shortage. A 1991 nation-wide survey (den Biggelaar, 1994, Michigan State University, personal communication) indicates that 88% of farmers now obtain stakes from their own farms, having learned both to plant fast growing trees as well as recycle stakes more efficiently. Table 6 indicates primary woods used and suggests that the local species (e.g., *Acacia mearnsii* and *Grevillea robusta*) rather than the introduced agroforestry option remain preferred (Sesbania, Calliandra and Leucaena do not even appear on the list). Note that both farmers and researchers have been experimenting with other staking possibilities: use of live stakes (particularly maize or manioc) and weaving trellises of banana cord. The use of multiple options for staking should be promoted by extension, rather than focusing, as now, solely on wooden stakes and, particularly, on novel agroforestry material.

Root rots. In 1991, the popular variety, Umubano, showed severe wilting, resulting in yield losses of 50 to 100% on certain farms in the Prefectures of Butare and Gikongoro. The causal organism was identified to be *Fusarium oxysporum*, f.sp. *phaseoli*. New screening procedures confirmed that several of the varieties already being diffused, Flora, Vuninkingi and Puebla, showed resistant reactions to the pathogen (Centro Internacional de Agricultura Tropical (CIAT), 1992), and happily, farmers in affected areas are already shifting towards these cultivars (for example, see Table 7 for expanding Vuninkingi use). Researchers now routinely evaluate cultivars for their reaction to Fusarium wilt. The case of Umubano also shows how critically important it is to have multiple varieties in diffusion at any one time: farmers lost but a single season's climbing bean harvest as other cultivars were already known and available to them.

Soil fertility demands. Research in the past has asserted that climbing beans demand more fertile soils (Nyabyenda, 1987; Voss and Graf, 1991), and development projects have gone so far as to advise that climbers need both DAP and NPK. [This is a country where 2-3% of farmers use mineral fertilizer (MINAGRI, 1985)]. The more recent release of relatively plastic climbers, as well as the edge of many climbers in the face of root rots (appearing most often on poorer soils), suggest that the fertility exigencies of climbing

TABLE 7. Use of the four major climbing bean cultivars (% of households) among those growing improved climbing beans, Rwanda 1993A

Prefecture	N	Cajamarca	Deceleya	Umubano	Vuninkingi
Butare	67	1	-	45	48
Cyangugu	25	-	-	92	4
Gikongoro	75	7	-	81	23
Gisenyi	49	37	41	55	8
Gitarama	36	-	-	50	50
Kibungo	17	-	6	6	-
Kibuye	46	9	4	76	4
Kigali	19	5	-	74	26
Ruhengeri	75	17	11	40	56

varieties are not clearcut. Certainly, farmers seem to be growing improved climbing varieties on a range of soils. As of April 1994, targeted research on the relationship between climbing varieties and soil fertility was underway at sites in both Rwanda and Burundi (RESAPAC, 1993). Until results are synthesized, both research and extension should refrain from setting agronomic guidelines for the technology which many farmers simply can not fulfill.

FUTURE PROSPECTS

On the African continent, climbing beans are indigenous only to northern Rwanda, north Kivu, Zaire, a small sector in southern Burundi, and pockets in north and south Malawi. However, the potential for introducing improved climbers is widespread: south western Uganda, western Kenya, north and south Kivu, Zaire, northeastern Tanzania, central Madagascar, etc. The Zairean national programme in Mulungu (South Kivu) is already reporting rapid adoption (Musungayi *et al.*, 1992), and surveys in Burundi show improved climbers to be spreading in both traditional and non-traditional climbing bean areas (Walls *et al.*, 1993). Improved climbers have the best chances of finding wide acceptance when socioeconomic pressures for intensification are strongly felt; farmers in land scarce areas welcome a technology which brings evident production benefits in just a season's time. Our experience in Rwanda clearly shows that farmers are able to adopt such multicomponent technologies within relatively short periods, and that research can have significant impact with resource-poor farmers under low-input conditions.

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