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Participatory Bean Breeding with Women and Small Holder Farmers in Eastern Ethiopia

[1]Teshale Assefa, [1]Girma Abebe, [2]Chemeda Fininsa, [2]Bulti Tesso and [3]Abdel-Rahman M. Al-Tawaha
[1]Melkassa Agricultural Research Center, P.O. Box 436, Nazreth, Ethiopia
[2]Alemaya University, Dire Dawa, Ethiopia
[3]Department of Plant Science, McGill University Macdonald Campus,
21,111 Lakeshore Road, Ste. Anne de Bellevue, QC H9X 3V9, Montreal, Canada

Abstract: The Ethiopian national bean program traditionally followed conventional approaches in bean improvement for smallholder farmers. The relative effectiveness and efficiency of Participatory Plant Breeding (PPB) compared to conventional approaches is not fully understood. The study was initiated to evaluate participatory plant breeding in bean improvement to disseminate more acceptable and productive bean varieties for poor farmers. The study was conducted in eastern Ethiopia. Breeders and farmer selectors evaluated and then selected lines on-station from a diverse germplasm pool. The breeders followed a conventional approach, while farmers evaluated their selected lines on their farm. The germplasms included bush and climbing beans in its selections. The selection demonstrated that farmers were capable of making significant contributions in identification of superior cultivars within a relatively short period. They effectively evaluated and selected from large numbers of fixed lines. They applied up to 40 distinct selection criteria indicating the complexity of the user needs and production conditions. However, yield tolerance to biotic and abiotic stresses, drought, earliness, marketability, cooking characteristics, seed colour and size and growth habit were considered key criteria. Involving farmers in the selection process had several impacts, not only on farmer perceptions and skill building but also on the formal breeding process, farmer acceptance**,** farmer production and income, farmer-held diversity, farmer breeding and seed processes, farmer empowerment and costs. A new formal-led breeding scheme incorporating farmer participation is also developed. Lack of an effective seed delivery system and supporting policy is likely to constrain release and rapid dissemination of PPB varieties.

Key words: Fixed lines · germplasms pool · Participatory Plant Breeding (PPB)

INTRODUCTION

Conventional breeding programs are seldom designed to meet the specific requirements of different types of farmers and ecologies who due to many reasons may have contrasting preferences, which might require different breeding approaches. In the past, researchers have shown appreciation for farmers' practices and knowledge. The history of formal breeding and genetics has roots in farmers' practices [1]. Farmers' innovations have made significant contributions in their own right, either in experimenting and disseminating introduced crop types [2] or in the identification and isolation of valuable lines [3]. Recently, however, there is a sustained level of international interest in farmer participatory research [4-6].

In crop breeding, PPB is thought to have the potential to develop crop varieties better adapted to farmers' local environmental conditions [7,8] or quality requirements or enhancing bio-diversity [9] through farmer involvement.

Beans are important pulse crop in the central, southern, eastern, western, northwestern and northern part of the country. They predominantly grown for cash in the central rift valley, but in other parts they are a major stable food supplementing the protein source for the poor farmers who can not afford to buy an expensive meat. Bean genetic diversity on farm is much lower in Ethiopia and until the 1990s few new varieties had been released to farmers [10,11]. Typically, the Ethiopian bean-breeding program takes about 8-10 years to release an improved variety (Fig. 1). Of these, about 70 percent of the time is spent on breeding activities, nurseries to yield trials. Even then, the result may be disappointing in that the rate and extent of adoption of those released varieties are often quite low.

Corresponding Author: Abdel-Rahman M. Al-Tawaha, Department of Plant Science, McGill University Macdonald Campus, 21,111 Lakeshore Road, Ste. Anne de Bellevue, QC H9X 3V9, Montreal, Canada

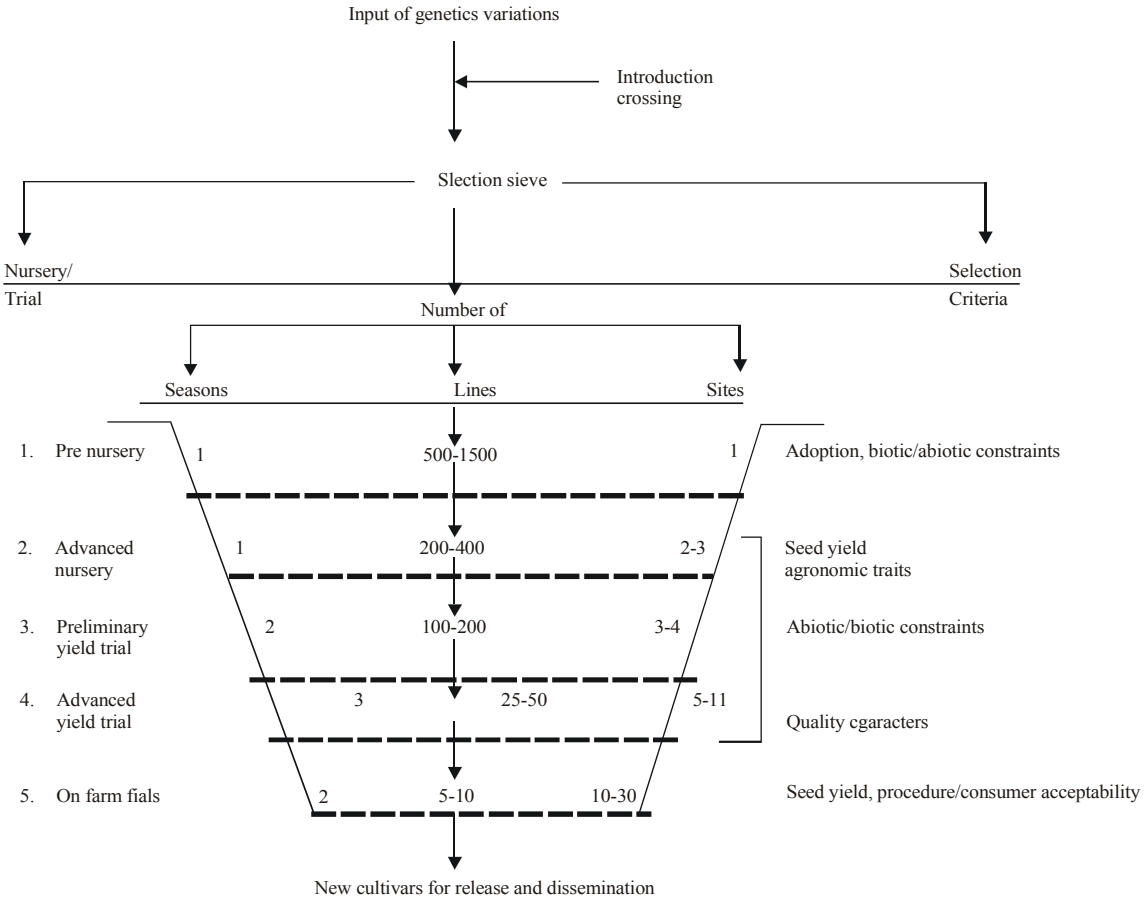

Fig. 1: Diagrammatic representation of a yield evaluation and testing

Participatory research can help to reduce the time involved, reduce the number of unacceptable varieties and increase the number of options available to farmers. More decentralized breeding approaches are also needed that exploit genotype by environment interaction, making use of specific adaptation and the active participation of farmers. Advantages and disadvantages of involving farmers in the early stages of bean breeding strategy were not critically assessed. The Ethiopian National bean Improvement Program has in 1998-commissioned research that is the first attempt at comparing PPB approaches to the conventional breeding scheme used in the country. PPB project was initiated in 1998 to develop more client-oriented products in a participatory approach. The project was carried out in three communities to compare PPB and the conventional breeding approach.

MATERIALS AND METHODS

Site and farmer selection: In April 1998 breeders, agricultural economists and in collaboration with minister of Agri. experts from district office Alemaya conducted a survey to identify potential sites, which can host the PPB project. The criteria considered during site selection were relative land area allocated for bean growing, number of bean growers, accessibility and engagement in other research projects. Based on the above criteria three communities from Alemaya (eastern Ethiopia) were selected on key types of bean production systems. These were Tinke Peasant Association (PA), Ararso PA and Efabate PA from Alemaya (Eastern Ethiopia). Participating farmers in area were classified as rich at Efabate, average at Ararso and poor at Tinike.

Following the identification of sites, using PRA techniques and interview with key informants, researchers and development agents of bureau of agriculture selected participating farmers from three communities (sites). Selection of farmers was based primarily on position of resources, soil variation and willingness to participate in the research.

Research designs: Research designs for comparing conventional and PPB were developed during an initial

Table 1: Number of entries and categories of initial germplasm pool at experimental sites

Site	Bush	Climbers	Populations	Total
Eastern Ethiopia (Alemaya)	238	25	0	263

Table 2: Number of farmer selectors and non-selector evaluators during the selection cycles at Alemaya, eastern Ethiopia

Cycle	RPF[1]	RRF[2]	WF[3]	Type of selection[4]
C_1 (1998)	22	10	18	Communal
C_2 (1999A)	6	6	10	Communal
C_3 (1999B)	6	6	10	Communal
C_4 (2000A)	6	6	10	Individual
C_5 (2000B)	6	3	6	Individual
C_6 (2001A)	7	2	6	individual
Evaluators				

RPF = Resource poor farmers,
RRF = Resource rich farmers,
WF = Women farmers,
Communal = Group selection in a jointly owned plot,
individual = A farmer evaluating lines selected by him/herself. Season A is the Belg season (February to April) and season B is the main season (July to October)

workshop in 1998 and reviewed for all teams during the March 2000 workshop. The standard breeding design used at each site was adopted as the conventional design and applied by the breeder. Farmer selectors followed the PPB design.

Germplasm: Each team constituted germplasm pool with a wide range of colours, seed sizes and growth habits from germplasm provided by CIAT. Local cultivars and improved varieties were included for comparison. The composition of germplasm pools is shown in Table 1.

Selection procedures: Farmers were invited to Alemaya Agricultural Research Center to evaluate and select from a germplasm pool of 263 lines at flowering, podding and at harvesting stages during the 1998 main season (Table 1). The breeder also made his selections from the same pool for comparison. The germplasm pool comprised of climbers with red and cream seed types and red, cream and black colored bush bean lines. The three farmer user groups were invited to evaluate the germplasm pool. Farmers sow the initial germplasm pool in communal plots in 1998.

During the first and second season of 1999, each of the three user-groups (identified through diagnostic methods) selected lines from the communal plot for sowing in one farmer's field in the group. In subsequent seasons, each farmer selected lines for evaluation in his/her individual plot. Open-ended evaluation was employed to identify farmers' selection criteria.

Breeders selected and advanced lines from the same germplasm pool as the farmers but followed the conventional breeding scheme and selection by breeder was carried on-station in replicated trials. Non-selector farmers evaluated breeders' and farmers' selection at three communities was presented (Table 2).

RESULTS AND DISCUSSION

Characteristics of initial germplasm pool: The gene pool for the initial study was constituted from the 1996 haricot bean nursery that included 595 entries. Lines from this initial gene pool were selected based on preliminary studies made earlier with farmers where some information was collected on their preferences either for export types or other beans used for local consumption. The initial germplasm pool was separated into three nurseries (PPB I, II and III) based on growth habit, seed size, colour and potential in cropping systems (Table 3).

Selection of acceptable and productive varieties by farmers: C_1 (1998). The initial selection phases were conducted communally, as is the normal practice in the preliminary assessment of 'new technologies' in this region. In 1998, three user-groups, initially comprising 22 resource-poor farmers (RPF), 10 resource-rich farmers (RRF) and 18 women farmers (WF), initiated communal selection in a germplasm pool comprising two nurseries of 25 climbers and 239 lines of bush growth habit.

Table 3: Characteristics of the three bean nurseries used in the conventional and participatory breeding programs

	Nursery		
Characters	PPB-I	PPB-II	PPB-III
Growth habit	Climbers (type IV)	Bush (types I and II)	Bush (types 1 and II)
Seed colour	Mixed, red and cream	Mixed colours, cream and black	red
Seed size	Large and medium	Large, medium and small	Large, medium and small
Current production	low	high	Very high
Importance in farming system	Around home yards, can be array cropped in chat (*Chata edulis*) and coffee (*Coffea arabica*)	For intercropping with sorghum and maize; bean sole crops	For intercropping and relay cropping with sorghum and maize; bean sole crops
Cropping season	Main (*Meher*)	*Belg* and main season	*Belg* and main season
Number of lines	25	59	183

Table 4: Number and growth habit of lines sown for evaluation by farmer-selectors in three user groups and on-station by the breeder in 1999/2000 and selections for 2001 at Alemaya, Ethiopia

	Resource-poor (6)		Resource-rich (6)		Women (10)	
Year/Season	Communal[1]	Individual[2]	Communal	Individual	Communal	Individual
1999A	39	None	31	None	52	None
1999B	39	None	31	None	52	None
2000A	None	40	12	None	14	None
2000B	None	29	None	9	None	13

- All farmers in a user-group undertake communal evaluation on one of the group's farms
- Individual evaluation is a farmer evaluating lines selected by him/her

Table 5: Frequency of bush and climbing lines selection, 1999-2001

	1999A			2000B			2001		
	Poor	Rich	Women	Poor	Rich	Women	Poor	Rich	Women
Bush	35	28	44	33	10	12	33	8	11
Climbing	4	3	8	4	2	2	4	2	2

Table 6: Number of lines sown and selected (Sel) in the first season of 2000 by farmer-selectors (FS) in the three user groups[1]

RPF			RRF			WF		
Farmer name	Sown	Sel	Farmer name	Sown	Sel	Farmer name	Sown	Sel
Mohammed	21	8	Mahadi	12 sown communally	10	Rumia Umer	13 sown communally	9
Abrahim	24	16	Hasan Mume		10	Annisa Mussse		10
Jemal	27	12	Tili Sadiq		10	Rumia Adem		9
Elias Abdurahman	26	13	Adam Usman		10	Mardia Abdulah		9
Idris Bakar	19	13	Aliy Abdi		10	Deneba Abrahim		10
Ibsa Aliy	27	15	Usman Kamal		5	Rumia Musse		13
						Mako Yusuf		6
						Kimia Ali		7
						Hindia Mume		9
						Fatuma Umer		8
Total	144	77			55			90
Mean	24	13			9			9

RRF: Resource poor, RPF: Resource rich, WF: Women farmers, respectively

From these nurseries the breeder selected 24 bush lines and 8 climbers to enter the conventional breeding programme.

In the two seasons of 1999 the groups respectively evaluated 39, 31 and 52 lines; all showing a marked preference for bush types (Table 4). In the first and second season of 1999 the farmer-selectors in each user-group communally evaluated their selected lines on one farmer's field in the group (Table 4). As crop growth in first season was poor due to little and poorly distributed rain, the farmer-selectors re-evaluated all lines in the second (main) rain season. The resource-poor group individually selected 40 lines, ranging from 19 to 27 lines per farmer, for evaluation on their own farms in the first season of 2000. Farmers in the resource-rich and women's groups communally selected 12 and 14 lines, respectively, for communal evaluation.

In 2000A, the six resource-poor selectors chose a mean of 13 lines, ranging from 8 to 16 per farmer, amongst their individual selections sown on their own farms (Table 4). The resource-rich and women's groups sowed fewer lines than the resource-poor, but proportionally selected more and rejected fewer lines (Table 5). Results showed that RPF farmers selected one line in common, compared to five and three lines between the RRF and women farmers' respectively, among their individual selections. Yield, drought tolerance, seeds per pod, pods per plant, pod filling and seed colour were the major selection criteria. By the second season of 2000, however, the resource-poor had selected a much higher number of bush lines at 29 compared to the resource-rich and women at 9 and 11, respectively; climbing lines selected by the three groups for 2000b were 4, 1 and 2, respectively (Table 6).

In 2001A, farmers conducted the last individual selection and ranked their final selections for colour, seed size, cooking time and taste (Table 7). They also ranked their selection criteria. In decreasing order of importance, the RPF group ranked yield, marketability, drought tolerance, disease resistance and eating quality as the most important selection criteria. The WF group ranked (in decreasing order of importance) yield, eating quality, marketability and forage yield and drought tolerance as their most important criteria.

Table 7: Ranking of lines selected by RPF and WF groups in 2001A

	RPF					WF			
Genotype	Colour	Seed size	Cooking time[1] (h:min)	Taste	Genotype	Colour	Seed size	Cooking time (h:min)	Taste
DOR 575	5	8	1:24 (1)	3	SUG-137	7	6	1:22 (2)	1
DOR 564	2	1	1:47 (8)	6	AND 1051	4	5	1:48 (8)	10
DOR 761	9	9	1:34 (6)	11					
SUG-136	8	4	1:51 (9)	9	AFR 722	1	1	1:40 (4)	6
812-BRC-28	6	2	1:51 (9)	10	DRK 137	3	3	1:47 (7)	4
DICTA-105	3	7	1:45 (7)	4	AND 1066	5	7	1:45 (6)	5
DOR 711	10	10	1:32 (5)	7	CAL 160	6	2	1:30 (3)	2
AFR 707	4	5	1:32 (5)	5	DOR 564	10	9	1:55 (9)	9
XAN 314	1	6	1:31 (4)	2	849-BRC-6	9	8	1:30 (3)	7
DAF 47	7	3	1:28 (2)	8	874-BRC-12	2	4	1:12 (1)	8
Red Wolayta (check)	11	11	1:29 (3)	1	Red Wolayta	8	10	1:43 (5)	3

[1]Cooking time ranks are in parenthesis

Table 8: Frequency (%) of selection criteria used by farmer-selectors (FS) in the three user groups

Rank	Selection criterion	Resource-poor (6 FS)	Resource-rich (6 FS)	Women (10 FS)	All FS
1	Pods/plant	100	100	100	100
2	Drought resistance	100	100	100	100
3	Yield	100	83	100	95
4	Seeds/pod	100	100	80	91
5	Seed size	83	83	90	86
6	Seed colour	67	100	70	77
7	Plant height	50	17	100	77
8	Pod length	83	0	100	68
9	Forage yield	17	50	90	59
10	Cooking quality	17	50	70	50
11	Growth habit	50	17	70	50
12	Pod filling	100	50	20	50
13	Stalk strength	50	67	40	50
14	Market value	17	17	80	45
15	Seed shape	0	50	50	36
16	Seed plumpness	67	17	30	36
17	Synchrony of maturity	83	17	10	32
18	Disease resistance	67	17	10	27
19	Insect resistance	67	17	10	27
20	Pod appearance	50	0	20	23
21	Stand uniformity	83	0	0	23
22	Green leaf persistence	17	50	40	36
23	Multiple harvesting	17	0	50	27
24	Cooking time	0	0	40	18
25	Suitability for local stew	17	33	0	14
26	Shattering	50	0	0	14
27	Seed weight	17	17	0	9
28	Earliness	33	0	0	9
29	Boiled grain volume	0	0	20	9
30	Lodging	33	0	0	9
31	Green pod consumption	17	0	10	9
32	Germination	33	0	0	9
33	Days to podding	33	0	0	9
34	Leafiness	0	0	20	9
35	Height basal pod to soil	17	0	0	5
36	Leaf shedding	17	0	0	5
37	Storage life	0	0	10	5
38	Rejuvenation capacity	17	0	0	5
39	Termite resistance	17	0	0	5
40	Vigor	0	0	10	5

Climbers were not preferred because they caused lodging in maize when intercropped. Farmers are now evaluating them in sole stands. In the conventional program, three climbing bean lines, three coloured and four red seeded lines were selected in 2001A. Both breeder's and farmer user group's selections were sown on-station and on-farm in 2001B for evaluation by FS and non-selector farmer evaluators.

Farmers' selection criteria: Selection criteria, elicited from all farmer-selectors and user-groups in the first season of 2000 and 2001, emphasised yield and yield components (pods/plant, seeds/pod, seed size) across user groups. Drought resistance ranked as the next criterion. Within user-groups, 83% or more of farmer-selectors rated these criteria in the top five (Table 8). Cooking quality, market value and cooking time ranked 10th, 14th and 24th, respectively, across user-groups, reflecting their relative lack of importance to both male-dominated groups. These criteria are, however, of importance to women farmer-selectors with 70, 80 and 40%, respectively, noting these criteria to be important. Farmers did not value some criteria usually of importance to breeders.

Strategies to multiply and disseminate seeds: Strategies were developed for application as farmer selections become available for dissemination in late in 2001.

PPB lines will be popularized among other farmers in all three peasant association sites and other neighboring villages by village-level peasant associations, farmer's service co-operatives, Alemaya University Research Centre and the office for agricultural development in Alemaya district. Basic seed of PPB lines will be given to farmer selectors for further multiplication. The seed multiplied by these farmers will be disseminated through farmer-to-farmer dissemination and through the assistance of the office for agricultural development. The quality of the seed produced will be ensured by the quality control department in the minister of Agriculture in collaboration with Alemaya University Research Centre.

This study was initiated to evaluate participatory plant breeding in bean improvement. The project among other things, sought to target and disseminate more acceptable and productive bean varieties for poor women and men farmers.

The selection process demonstrated that farmers were capable of making significant contributions to identification of superior cultivars within a relatively short period. They effectively evaluated and selected from large numbers of advanced lines. They applied up to 40 distinct selection criteria indicating the complexity of the user needs and production conditions. However, yield tolerance to biotic and abiotic stresses, drought, earliness, marketability, cooking characteristics, seed colour and size and growth habit were considered key criteria across sites. In some cases, farmers appeared overwhelmed by the amount of variability within the germplasm pool to which they have not been previously exposed. For example, farmers indicated the number of entries they could accommodate in future PPB trials for effective selection. These were 6 to 8 for women farmers and 10 to 15 entries for resource poor farmers. This partly reflects their small farm sizes and additional demands for time, labour and competition with other activities. Lack of an effective seed delivery system and supporting policy is likely to constrain release and rapid dissemination of PPB varieties especially in eastern Ethiopia. However, efforts are underway to seek solution this problem.

The project activities had considerable process impacts at these communities site. Involving farmers in the selection process had several impacts, not only on farmer perceptions and skill building but also on the formal breeding procedures.

The farmer selection criteria in now better understood and are being utilized in research. For example seed colour, seed shape, seed size, vegetative yield and pod clearance were included as additional criteria in breeding program. Participating farmers recorded production increases at these communal site. A participating farmer sold grain of a PPB line at a price higher by 20 Birr (about $2.5) compared to the local variety. PPB lines were more acceptable to other farmers and consumers partly because of their higher yield potential and seed characteristics. Farmers in eastern Ethiopia had limited exposure to diversity of bean germplasm compared to other countries in the east African region. Farmer-held bean diversity increased at this project site.

Farmer variety selection and trial management skills were enhanced through practical training during on-station and on-farm visits. Communities got wider access to information and related information during the PRAs and other meetings.

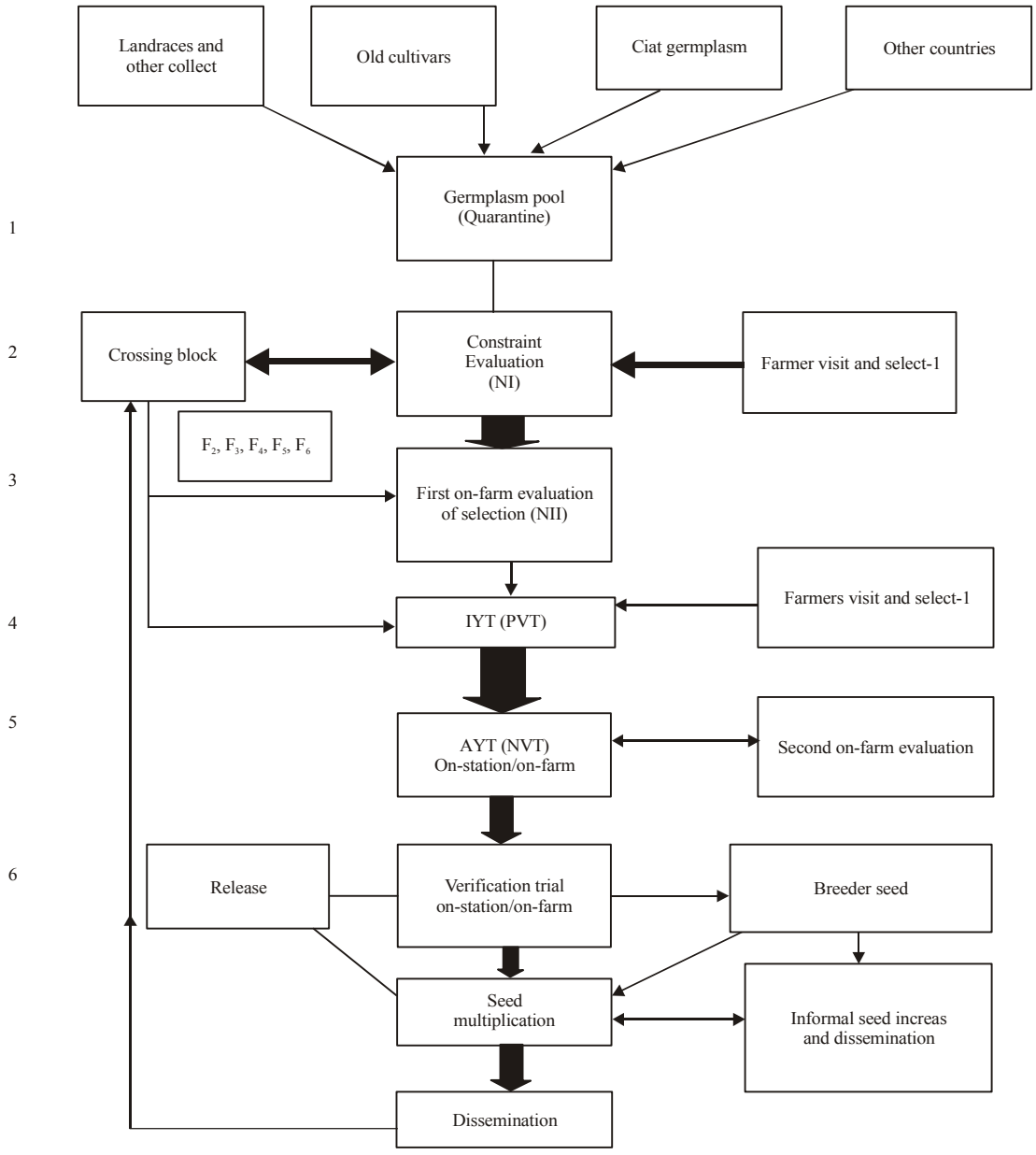

Fig. 2: A generalized scheme linking formal and participatory bean breeding

The study conducted at the three communities implied that there is a need to combine the two approaches for efficient use of resources, effectiveness and to addressing farmers' diverse needs. Thus, a new formal and breeding scheme is proposed that incorporates farmer participation (Fig. 2).

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