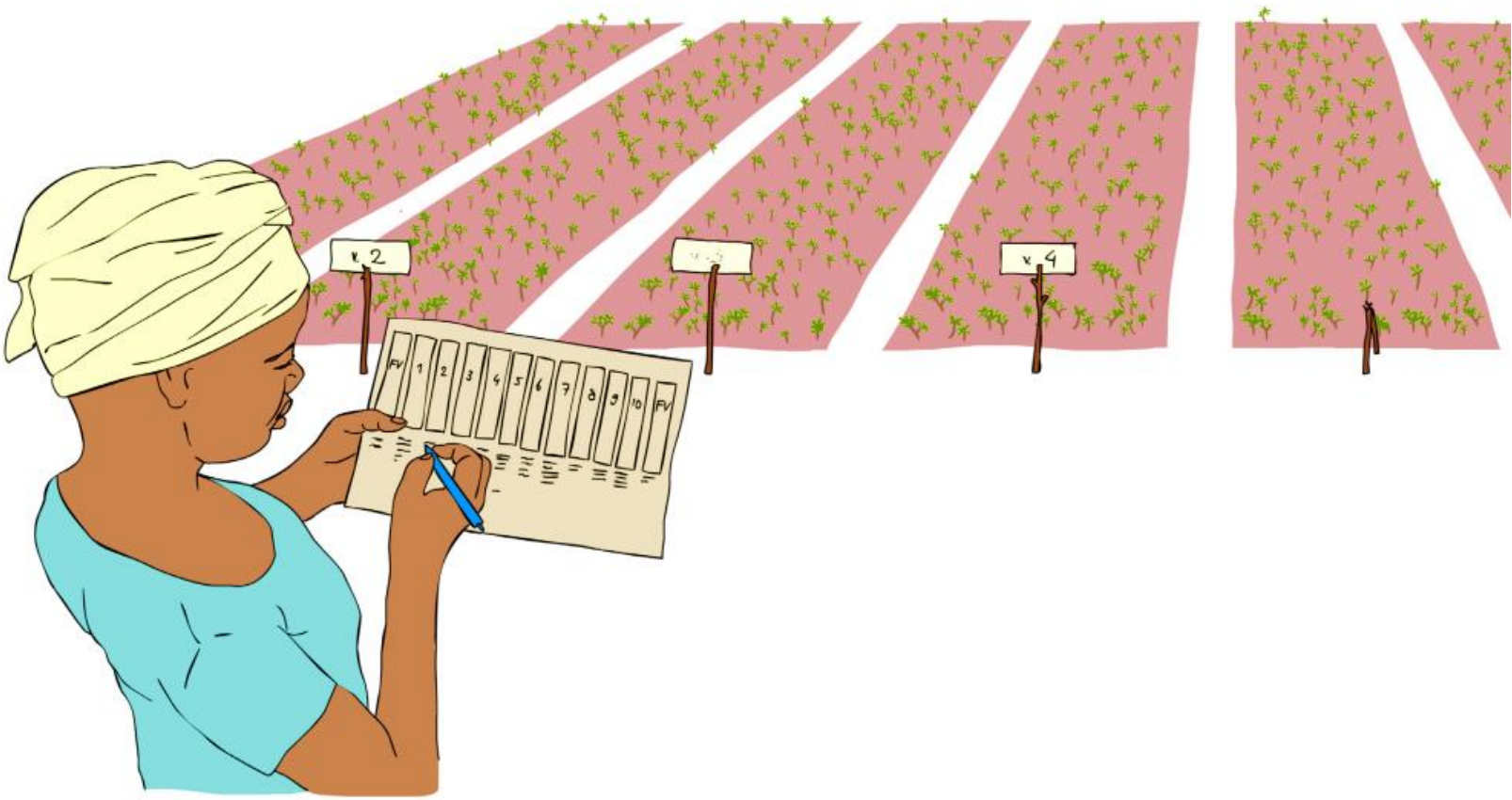
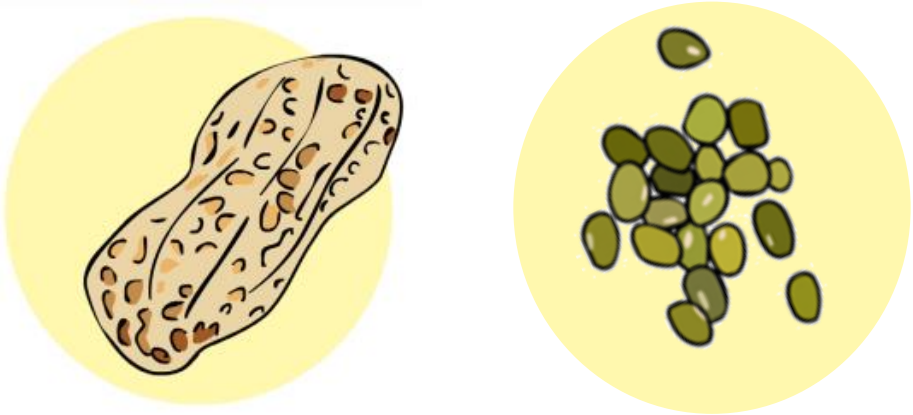
UGANDA BRIEFING NOTES

PARTICIPATORY PLANT BREEDING IN FARMER FIELD SCHOOLS





Introduction

The Sowing Diversity = Harvesting Security programme aims at improving farmers' access and use of crop diversity, strengthening farmers' seed systems, and supporting healthy nutrition in the community. The Farmer Field School (FFS) forms its central approach. One of the main activities carried out in the FFS is Participatory Plant Breeding (PPB): with the support of scientists and local extension staff, farmers learn breeding and selection methods, and in the process, they test new varieties, select, and improve existing ones or develop new lines.

This briefing note highlights the process and the most relevant results of the PPB efforts, which were conducted over the 2019-2023 period in the FFS in Uganda. We describe farmers' evaluation/adaptation of newly introduced diversity (**PVS** - participatory variety selection) for groundnut and the selection they undertook on existing local varieties (PVE) in common bean. For both crops and methods, we describe baseline information regarding the challenges communities face, the seed sources they depend on, the perceived changes in crop diversity; we then examine the priority traits and breeding objectives set by FFS participants at the start of the breeding process; finally, we evaluate the main results in each crop in terms of achievement of breeding objectives, yield improvements and performance, and highlight the potential of a FFS/PPB approach as complementary to conventional breeding. Finally, we describe the country's policy context and the initiatives which are under-way, or which could be established, to create an enabling environment for PPB and the rapid adoption of its products.

Study sites and observed changes in diversity

Three FFS in three different districts to undertook PVS to evaluate newly introduced stable groundnut lines from national breeding and conservation institutes. Another five FFS in the same three districts worked with local common bean varieties, in an effort to improve or restore some key traits and thus enhance their use (**PVE** – participatory variety evaluation). The PVS FFS fell into equatorial climate zones characterized by extended dry winters, with one FFS being in the Amuria district, characterized by low rainfall and greater dependence on dryland crops and agropastoral activities.

In terms of climate change, participants observed an increased incidence of drought and more erratic rainfall patterns throughout all areas, including sudden floods. While on the one hand climate is challenging the continued adaptation of small holders' farming systems, on the other hand infrastructure improvements such as better roads have enhanced farmers' access to markets. This, coupled with government seed and farm subsidies, has determined an increase in the diversity of marketable and cash. On the contrary, the diversity of local and traditional crops and varieties is declining, together with the associated traditional practices of seed saving and exchanging.

PPB in FFS - methods

Plot design, planting density and variety identification within the PVS and PVE plots followed the guidelines contained in the Facilitator's Field Guide for Farmer Field Schools

on Participatory Plant Breeding[1]. Weekly meetings of each FFS were dedicated to making observations and taking measurements during the entire cropping cycle[2]. The final evaluation of the lines was undertaken at maturity: for **PVS**, farmers evaluated the extent to which the lines responded to their breeding objectives or desired traits, the lines' yield, and their performance against the local control. For **PVE**, at maturity farmers evaluated the extent to which the varieties had improved after selection, any yield advantage they had acquired, which positive traits had been maintained and which negative traits remained to be worked upon. For expressing if the variety had improved, farmers could choose between the following responses: "the variety is no better", "the variety is slightly better", "the variety is better" and "the variety is much better". These options were assigned numeric values from 0 ("variety is no better") to 4 ("the variety is much better"), and the average result of this improvement score for each variety was calculated. For evaluating the changes in yield, the rate of increase between the initial and final yield was calculated.

Evaluating new diversity in groundnut (PVS)

Current seed sources

Before embarking on the actual PVS work, a seed system analysis was carried out, to understand farmers' current seed sources and the strengths/weaknesses of each. In the context of the Ugandan FFS involved in PPB, groundnut seed is obtained from a variety of sources. Farmers expressed greater appreciation of informal seed sources (particularly their own farm-saved seed and that from community seed banks and seed fairs) in terms of reliability, presence of desired traits, and quality. Seeds from the local market were also important, while Government seed was not particularly appreciated. Table 1 summarizes the commonalities and differences among the sources used for groundnut seed.

[1] Facilitator's Field Guide for Farmer Field Schools on Participatory Plant Breeding - SD=HS | SD=HS (sdhsprogram.org)

[2] On a weekly basis, each FFS performed an Agro-Eco-System Analysis AESA, which is a thorough study of the different components of the agricultural environment and its ecology. It facilitates proper decision-making by helping participants consider the complexity of their farms and the factors influencing the growth of crops. See Special Topic 10.4 in the Facilitator's Field Guide for Farmer Field Schools on Participatory Plant Breeding - SD=HS | SD=HS (sdhsprogram.org)

Source	Presence of desired traits	Quality	Reliability
Agro-input dealers / Seed companies	++	++	+++
Community Seed Banks	++++	++++	++
Exchange with others in other communities	+	++	++
Exchange with others in same community	+++	++	+++
Farm saved / Own stock	+++	+++	++++
Government	+	+	+
Local market	++	+++	+++
Seed fairs	+++	++++	++

Table 1. Evaluation of the different seed sources which farmers use in groundnut, in terms of presence of desired traits, quality of the seed and reliability of the supply.

Farmers' preferred traits

Understanding farmers' preferences is an important step for breeding programs that seek to develop acceptable varieties by farmers. The top preferred traits which farmers reported to seek in groundnut were related to drought tolerance and earliness (a trait which helps escaping drought). Processing quality and other qualitative traits such as oil content and taste followed closely. Narrowing down from the preferred traits to the actual breeding objectives (Table 2), two top objectives, namely earliness and oil content, corresponded to some of the most desired traits and their importance was shared between men and women. Other objectives were rated somewhat differently depending on the gender of the respondents: yield was mentioned more frequently by men, while disease tolerance and taste were more important among women.

Breeding objective	% WOMEN	% MEN
Early maturity	100.00	100.00
Oil content	100.00	100.00
Disease resistance/ tolerance	95.00	88.89
Taste	95.00	92.11
Yield	88.33	100.00
Drought tolerance	83.33	85.19
Germination	55.00	44.44
Pest resistance/tolerance	50.00	66.67

Table 2. Share of men and women who voted for each breeding objective at the beginning of the PVS process in groundnut.

Results of the post-season evaluation

Based on the breeding objectives and keeping in mind the other desirable traits, 15 PVS entries were evaluated across the FFS and over three years, using one among five possible local varieties as a control. Table 3 describes the results both in terms of breeding objectives fulfilled as well as yield.

Variety	N breeding objectives	Disease resistance/ tolerance	Drought tolerance	Early maturity	Oil content	Pest resistance/ tolerance	Taste	Yield score (1 to 3)
Serenut 8R	**6**	✓✓	✓✓	✓✓	✓	✓	✓	2.41
Naronut 1R	**4**	✓	✓	✓✓			✓	2.59
Naronut 2T	**4**	✓✓	✓	✓✓			✓	2.56
Serenut 14R	**4**	✓✓✓	✓✓	✓✓✓			✓✓	2.27
SGV0805	**4**	✓	✓	✓			✓	**3.00**
SGV10010	**4**	✓	✓	✓			✓	2.00
Serenut 9T	3	✓	✓	✓✓				**3.00**
Boss	3	✓	✓	✓				**3.00**
Naronut 1	3		✓	✓		✓		2.00
Serenut 11T	3	✓✓	✓✓	✓				2.53
Serenut 5R	3	✓		✓			✓	**3.00**
SGV990400	3		✓	✓			✓	2.00
Egolong	2		✓				✓	2.00
Serenut 6T	2	✓		✓			✓	2.00
Serenut 11R	1	✓						2.00
Total		63	126	101	141	7	12	85	2.00

Table 3. Groundnut post-season evaluation results. The number and type of breeding objectives that these lines fulfilled are described in the subsequent columns. Bold numbers in the second column indicate an above average number of breeding objectives. Bold numbers in the last column highlight the lines which were rated as high yielders.

The average number of breeding objectives or preferred traits met by the lines was 3.3. Six lines responded to an above average number of breeding objectives (see the bold numbers in column two) and only one responded to the maximum. In terms of productivity, four lines were considered high yielders, while the yield level of another five were rated as between medium and high. Only one of the highest yielding lines also fulfilled an above average number of breeding objectives while the medium yielders carried the highest number of farmers' target traits.

The most frequently found traits were those which had been chosen as the main breeding targets: early maturity, drought tolerance and disease resistance were each found in over 80% of the lines evaluated. This is somewhat obvious because the process of objective setting was conducted once the FFS groups were made aware of which materials, carrying which traits, were readily available for testing from the national institutions. Most of the advanced lines from the breeding program carry traits related to drought and abiotic stress tolerance, which are high priority within national breeding programs in the region. However, the widespread achievement of breeding objectives proves that the introduction of new materials from breeding programs can readily enhance the availability of key performance traits among small holders, who would not otherwise have such immediate access to these desired traits from other sources.

Regarding qualitative traits, over 60% of the entries were evaluated satisfactorily in terms of taste, but just one was rated well under the oil content aspect. Both these traits had been ranked as key breeding objectives, alongside the agronomic ones. It may be that the breeding lines that were readily available from the research institutions were not bred for increased quality traits as much as they were for improved performance under stress. Farmers declared that their future plans were to keep multiplying and making available the seed of the tested lines, with the highest priority given to Serenut 14 and Serenut 2T.

Participatory Variety Selection - Main highlights

1. Farmers' preferred seed sources for groundnut pertain to the informal sector. Farmers prefer these sources because they are more reliable than commercial or government aid sources and because the seeds carry the traits they need. This points to the importance of strengthening the supply and the diversity of local sources of seed, rather than increasing their dependence on external sources. Introducing new lines through PVS is a fast and efficient way to provide more useful diversity to farmers, integrating such diversity into their farmer-managed seed systems.

2. The PVS experiment was successful in rapidly introducing lines with drought and abiotic stress tolerance traits, hence responding to some of the priority breeding objectives set by farmers and making useful diversity readily available for further multiplication and diffusion.

3. In this experience, quality traits were not as successfully introduced (oil content and to some extent, taste): this is likely due to a bias in the traits that the national breeding programme is working on and in the lines that could be made available to farmers. Most national breeding programmes focus primarily on improving yield and enhancing "climate-smart" traits which are becoming so crucial for adapting to change. Other traits relevant for smallholder farmers, such as culinary quality and taste, can be a challenge for breeders to meaningfully assess unless there is a close collaboration with smallholders and social scientists and unless local materials are included in PVS trials.

4. While our evidence is not at all conclusive, some sort of trade-off may exist between maximizing a line's productivity and maintaining its capacity to fulfill a broader range of other traits. Indeed, only one of the top yielding groundnut lines evaluated here was capable of also responding to an above average number of breeding objectives, while medium yielding lines were the ones responding to most objectives. If this trade-off were real, it would be important for farmers to have access to a diversity of lines and varieties, which carry different suites of traits, some more focused on yield and others responding to farmers' multiple needs.

Evaluating locally available diversity in common bean (PVE)

Current seed sources

The Ugandan farmers involved in the program access common bean seed from a variety of sources. Commercial seed is considered reliable but is not appreciated because of average quality and unsatisfactory representation of farmers' preferred traits. Farmers rate seeds sourced on-farm, on the local market, at seed fairs and through community seed banks highly under all aspects (quality, presence of key traits and reliability). Table 4 gives more detail on the preferences which farmers expressed about the different sources of seed under the above-mentioned aspects.

Source	Presence of desired traits	Quality	Reliability
Agro-input dealers / Seed companies	++	++	+++
Community Seed Banks	+++	+++	+++
Exchange with others in other communities	+	++	+
Exchange with others in same community	++	++	++++
Farm saved / Own stock	+++	+++	++++
Government	+	+	--
Local market	++	++++	++
Seed fairs	++++	++++	++

Table 4. Evaluation of the different seed sources which farmers use for common bean, in terms of the presence of desired traits, quality of the seed and reliability of the supply.

Breeding objectives and the target PVE varieties

At the beginning of the PVE season, farmers prioritized their breeding objectives for the PVE experiment on common bean (Table 5). There were no widespread differences between women and men. Overall, the most important trait that farmers wished to improve was yield, followed by drought tolerance.

Breeding objective	% WOMEN	% MEN
Yield	0.29	0.31
Drought tolerance	0.22	0.20
Disease resistance/ tolerance	0.13	0.14
Early maturity	0.13	0.14
Tolerance to poor soils	0.13	0.14
Pest resistance/tolerance	0.10	0.08

Table 5. Breeding objectives listed for common bean at the start of the PVE process, segregated by gender.

FFS participants chose to work on five local open-pollinated varieties: Biyale, Ekibula, Kanyewa, Obilangit and Ocuc. Data on the varieties' positive and negative aspects at the start of the process is available only for Ocuc and Ekibula, both of which are appreciated for their earliness. Ocuc also does well in terms of taste, while Ekibula is appreciated for its capacity to strive in poor soils.

Results of the post-season evaluation

Table 7 presents the improvement score and the yield gain of the five target varieties. Farmers considered all varieties to have improved, after only four seasons of PVE. Most of the varieties were considered to have become *slightly better*, with an average improvement score of 2 (possible range: 1 to 3). A single variety (Kanyewa) ended up performing *much* better. All varieties also gained in yield, with the greatest yield gain being observed in Obilangit and Ocuc (it is likely that Kanyewa also experienced important yield gains but there was no data on its initial productivity). The fact that the highest improvement scores are awarded to the varieties with highest yields (although for Kanyewa yield improvements are only hypothesized) suggests that yield is the main driver of farmers' appreciation of a variety's enhancement. Yield had indeed been one of farmers' top breeding objectives.

Variety	Improvement score	Average yield before PVE	Average yield after PVE	Yield change
Kanyewa	3.00	NA	1.00	NA
Ocuc	2.04	1.00	2.00	x2
Obilangit	1.94	1.00	2.00	x2
Ekibula	1.61	1.07	1.33	x1.33
Biyale	1.48	1.00	1.50	x1.5

Table 7. Average improvement score, before and after yield estimates and yield change for each common bean variety after PVE.

In terms of changes under important traits (Table 8), the variety with the most positive traits after enhancement was Obilangit (7 traits), followed by Ekibula. The variety which responded to the smallest number of traits was Ocuc.

The most widespread positive traits restored or improved after PVE were drought tolerance (positively assessed in all five varieties), early maturity and disease tolerance (in 4 varieties each). These three traits were indeed among the most important breeding targets together with yield gains, indicating that the PVE was successful in restoring these priority features. The yield related traits of pod size and number of pods per plant clearly improved only in Kanyewa, which hence may also have experienced yield gains due to these two traits (although there is missing data for its yield, see Table 7). Traits related to the varieties' processing advantages (cooking time and quality) were much less represented after enhancement, possibly because they were not farmers' main selection targets and because they are harder to improve in the short term.

Variety	Disease resistance/ tolerance	Drought tolerance	Early maturity	Pest resistance/ tolerance	Cooking quality	Cooking time	Early plant vigour	Germination	Marketability	No. of pods/plant	Pod size
Biyale	✓	✓	✓✓				✓		✓		
Ekibula	✓	✓	✓✓✓		✓	✓		✓			
Kanyewa	✓	✓	✓							✓	✓
Obilangit	✓✓	✓✓	✓✓	✓		✓	✓	✓			
Ocuc		✓		✓							

Table 8. Positive traits which were maintained or improved in the five target varieties after PVE.

The relation between farmers' appreciation of overall improvements (highest in Kanyewa), the number of traits improved (highest in Obilangit), and the observed yield gain (most evident in Obilangit and Ocuc but probably high in Kanyewa too) was not straightforward. It seems that different varieties are appreciated for improvements under different traits or under a different number of traits. Kanyewa was scored as the variety with the greatest improvement score, likely because of a yield increase (although data on its yield gain is not available, see Table 7): indeed, it is the only variety where two yield related traits were positively assessed after PVE. Obilangit's high improvement score may reside, among others, in its positive response to selection under a broad range of traits. Despite its relatively narrow response to selection (i.e. only few traits improved), Ocuc was anyhow awarded a relatively good improvement score which may indicate high appreciation of its yield gain and its biotic and abiotic stress tolerance improvements.

Participatory Variety Enhancement - Main highlights

1. For common bean, seed source analyses indicate that local, informal seed sources are preferred by farmers under quality and reliability aspects, as well as in terms of preferred traits. Since local varieties are the predominant material circulating within these sources, the importance of further enhancing their value through PVE emerges clearly.
2. The little data we had on the target varieties' initial advantages suggest that these are already well adapted to the local climate, particularly in terms of their earliness which allows them to escape drought or their tolerance to soils with poor fertility. Indeed, upon embarking on PVE, farmers chose to work with their top performing varieties, to further improve, or restore, key traits.
3. It is known that achieving improvements through PVE is a long-term process. However, after only four seasons, farmers observed at least a slight improvement in all varieties. While the improvement score attributed to the varieties appears to be closely related to their yield gains, other aspects are also important in determining farmers' appreciation (such as the number of traits enhanced and, of course, improvements in the target traits).
4. Besides yield, positive changes were achieved in other key breeding targets, mostly drought tolerance and earliness. Once again, after only few PVE cycles, farmers were able to see their main priority traits much better reflected in their local varieties.
5. Quality traits related to processing and cooking were not well represented in the improved varieties. One the one hand, farmers had not set these traits as their breeding objectives; secondly, quality traits are harder to select for and take longer to change. However, it has been observed that participatory approaches involving breeders together with farmers, especially women, and social scientists, are the best option to tackle complex quality traits relevant for smallholder farmers.

Initiatives to enable policy change

In parallel to the field level implementation of PVS and PVE, seed policy dialogues and campaigns on the registration of farmers' varieties were organized, to raise awareness on the policy issues affecting small scale farmers engaged in PPB. Indeed, Uganda's current seed policy recognizes farmer managed seed systems as a form of seed supply, but does not provide any institutional support nor an enabling legal framework for PPB or the registration of farmer-bred varieties. While no actual legal change has been achieved yet, advocacy and awareness raising activities have contributed to spark an interest among breeders and policy makers.

This is testified by the increasing number of field visits by breeders to farming communities and by the signing of MOUs between district-level FFS networks and local governments. These agreements are aimed at strengthening the relationship with research institutions, thus facilitating farmers' access to plant genetic resources and technical assistance. Other joint initiatives between the national gene bank and the community seedbanks have also been developed.