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Assessment of Farmers' Criteria for Common Bean Variety Selection: The case of Umbullo Watershed in Sidama Zone of the Southern Region of Ethiopia

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Abstract: Participatory variety selection (PVS) trials were conducted in 2004 and 2005 in Umbullo watershed of Sidama zone in the Southern region of Ethiopia to evaluate the performance of common bean (*Phaseolus vulgaris* L.) varieties and to assess farmers' criteria for bean variety selection, and thereby identify the most important farmers' criteria for future bean improvement work in the region. Six varieties including the local check were used for the study. Mother and baby design was employed and the trials were replicated over farmers. Yield data was subjected to analysis of variance and there was significant difference ($p<0.01$) among the varieties. GL and GLY interaction effects were also found to be significant ($p<0.05$). Awash-1 was the best genotype followed by Omo-95. But the farmers' selection criteria were beyond yield and most farmers gave priority for qualitative traits. Accordingly, five qualitative traits were ranked by farmers as the best criteria that are better than yield. These are seed color, drought tolerance, disease and pest resistance, marketability and seed size. Almost all farmers in the study area preferred Ibado as a number one variety due to its seed color (red speckled), seed size (large), demand in the market (high), early maturity (<90 days) and relatively good yield (>2 tons ha^{-1}). The local variety was ranked second due to its seed color (light red) and marketability. Therefore, our future bean improvement program should target at developing varieties that fulfill farmers' preferences especially for home consumption and local market.

Keywords: Common bean, PVS, selection criteria, qualitative traits

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INTRODUCTION

Legumes are the major sources of protein in Ethiopia where common bean (*Phaseolus vulgaris* L.) takes large proportion next to faba bean and field pea (CSA, 2010; 2011). It is one of the major grain legumes widely cultivated by the smallholder farmers in the Southern Nation, Nationalities and People's Region (SNNPR). The crop plays an important role in the livelihoods of the rural people of Sidama zone, in which 'Enset' [*Ensete ventricosum* (Welw.) Cheesman] and maize are dominant. Enset is a perennial root crop that is used as a food crop only in Ethiopia and mostly grown in the backyard with other crops such as coffee, common bean and maize. A food prepared from Enset (i.e 'Kocho') is consumed alone or by mixing with different crops such as boiled beans and maize. Common bean is an important income source; its straw serves as feed for livestock, and also improves soil fertility by its virtue of nitrogen fixation in the cropping system. Although the potential yield of beans is as high as 5 tons ha^{-1} (Graham and Ranalli, 1997), the average yield of local bean varieties in the study area is about 0.8 tons ha^{-1}, which is very low. This is attributed to combined effects of edaphic, climatic, disease, and pest problems. Of course, lack of improved varieties is one of the top problems for low yield (Gurmu, 2007).

Moreover, not all the released and high yielding varieties were equally accepted by farmers due to differences in farmers' preference for the varieties in different localities. This was because the varieties were developed through conventional breeding that didn't consider farmers' criteria. As stated by Gemechu *et al.* (2004), the rate of adoption of most of the varieties developed by the conventional breeding approach is believed to be far below expectations. They argue that farmers should participate in the research process right from the beginning, because farmers have their own selection criteria regardless of the yield potential of varieties. The other reason is the selected varieties are likely to perform well in environments similar to the research stations, but not in environments that are very different. This is because of genotype x environment interactions (Ceccarelli and Grando, 2006).

Therefore, farmer participatory research (FPR) is the best option to closely work with farmers and better realize their interest. FPR refers to the active participation of farmers in identifying the problems of the system, planning the research agenda, conducting research, evaluating potential technologies and applying the new technologies and practices (Tilahun *et al*., 2004). The reasons to promote FPR according to Gemechu *et al.* (2004) includes improving the efficiency and effectiveness of research through increased adoption rates of technology and techniques, and reduced research extension cost, increasing equity and insurance that stakeholders play a role in activities that affect them, and empowering the poor and strengthening their bargaining power. According to Desclaux (2005), the participatory approaches used in most cases are PRAs, farm recording, baseline surveys and interviews, focus group discussions, household level questionnaires, wealth ranking, matrix ranking, recording of perceptions and indigenous knowledge.

One of the methods used in FPR in crop improvement is participatory varietal selection (PVS). PVS is reported to be very successful both in facilitating adoption by poor farmers in marginal environments that were not previously reached by formal plant breeding, and in understanding farmers' preferences (Maurya *et a*l., 1988; Sperling *et al*., 1993; Joshi and Witcombe, 1996). It is a process by which the field testing of finished or nearly finished varieties, usually in a limited number, is done with the participation of different partners (Ceccarelli, 2012). PVS is always an integral part of Participatory Plant Breeding (PPB), representing the final stages of PPB where the final bred varieties are evaluated and selected with farmers. It may also be used as a starting point, as a sort of exploratory trial, to help partners assessing properly the amount of commitment in land and time that PPB program requires (Ceccarelli, 2012). According to Ashby (2009), the end product of PVS is varieties that are more desirable to producers, traders and consumers.

Gemechu *et al*. (2002) reported that farmers and researchers have their own unique and common know-how, which should be effectively exploited in the research process. It is based on the idea that farmers as well as professional plant breeders have important knowledge and skills that could complement one another. PVS is broadly defined as a range of approaches that involve a mix of actors (including scientists, breeders, farmers and other stakeholders) in plant breeding stages. Because the objective is to produce varieties, which are adapted not only to the physical but also to the socio-economic environment in which they are utilized. According to Ashby (2009), the outcome of PVS is that more farmers adopt PVS varieties over wider areas, leading to increased food and income benefits. Another impact is increased research efficiency due to more relevant and desirable research products. Ashby (2009) highlighted the impact of PPB and PVS on various crops in different countries by citing different authors. These are cassava in Brazil and Colombia; pearl millet in Namibia and India; beans in Colombia, Tanzania, Ethiopia and Rwanda; tree species in Burundi; potatoes in Rwanda, Bolivia, Peru and Ecuador; rainfed rice in India; paddy rice in Bangladesh, India and Nepal; maize in Mali, India, Ethiopia, Honduras and Brazil; and barley in Syria, Morocco and Tunisia.

In Ethiopia, efforts have been made to develop and popularize common bean varieties through both PPB and PVS (Asfaw *et al.,* 2004; Gurmu, 2007). However, the farmers' selection criteria for common bean varieties were not adequately assessed and well documented especially in the southern region of Ethiopia.

Therefore, the objectives of this study were to: (i) evaluate the performance of the released common bean varieties through PVS (ii) assess farmers' selection criteria for common bean varieties and (iii) identify the most important criteria for future bean improvement work in the region.

MATERIAL AND METHODS

The study area

The Umbullo watershed comprises three kebeles (villages), namely; Umbullo Wacho, Umbullo Tenkaka & Umbullo Kejima in Awassa Zuria district. The watershed is found at 25 km distance form Hawassa, the capital of SNNPR. The altitude ranges from 1750 to 2000 m.a.s.l. According to a report by Funtea et al. (2012), based on 13 years of cumulative rainfall data from the nearest meteorology station, the average annual rainfall for the study area is 1067 mm. The rainfall has bimodal pattern with two rainy seasons. These are the short rains between March and May and the long rains between June and October. The dry season usually occurs between

November and February. However, the rain is very little and erratic in nature. Some times the rain fall become torrential and so that destructive to crop production. The watershed is characterized by land degradation and food insecurity. The major crops produced in the watershed are; maize, 'enset', common bean and hot pepper. The farmers in the watershed use local landraces that have very low productivity.

FRG establishment

Farmer Research Group (FRG) was established during the year 2004 before starting the trial. The objective was to empower farmers so that they take part in the research process right from the beginning. This is designed to increase their participation in the research system. By doing so, it is possible to conduct researches that are based on the farmers' needs and conditions. The members of the FRG were male and female farmers, researchers, extension experts and development agents. The FRG was organized by researchers and led by farmers who have been elected as chairperson by the farmers themselves. The FRG was regularly discussing on the planning of the program, implementation and evaluation of the on-farm trials. The establishment of the FRG was a good opportunity for the farmers to work with each other, with researchers and extension agents and discuss on problems and give valuable ideas that contribute towards solutions. Moreover, the farmers share ideas on research progress and can act as researchers. Participatory methods have been developed in order to facilitate the involvement of farmers together with scientists as active and equal partners in research to generate relevant farm technology i.e. to maintain and conserve genetic diversity through attention to on-farm management of genetic resources, and to recognize the importance of, and protect and learn from, indigenous knowledge and traditional farming systems (Mettrich, 1993).

Design and methodology

Mother and baby design (Witcombe, 2002) was employed using farmers as replication. In the mother trial, six common bean varieties, five improved (Omo-95, Ibado, Roba-1, Awash-1 and Awash M.) and one local (Red wolayta) were used. All the six varieties were planted on a single farmer's farm and replicated on five farmers in each kebele (village). The plot size was 50 m^2 for a variety. Other non-experimental variables were used as per the recommendation, i.e. fertilizer rate of 100 Kg DAP ha^{-1} and inter and intra row spacing of 40 and 10 cm, respectively.

In the baby trial, a single variety was given to 15 farmers to plant along with the local variety. Therefore, the five varieties were given to 75 farmers in one kebele and to 225 farmers in the three kebeles. A total of 240 farmers were participated in the mother and baby trial for the varietal selection in the watershed each year. The trials were managed by farmers and frequent visit was made by researchers and experts from bureau of agriculture and rural development to monitor, evaluate and collect data on the mother trial. From the baby trial, only observation and farmer preference ranking data were taken using pair wise ranking matrix. The farmers used a score (1-6) for ranking the varieties and (1-15) to rank their selection criteria, where 1 is best and 6 is worst in the case of the varieties and 1 is best and 15 is the worst in the case of the selection criteria. The ranking was made in two ways. One was where the 15 farmers of the mother trials ranked the varieties for the major selection criteria they set, and the second is where a group of baby trial farmers were given chance to make pair-wise ranking of the varieties for the same criteria and finally compared the whole criteria using pair-wise ranking matrix.

Statistical analysis

Analysis of variance

Grain yield data of the mother trial were subjected to analysis of variance (ANOVA) separately for each environment and combined over environments and years. ANOVA was conducted by SAS GLM (SAS Institute Inc., 2003). The statistical model used for ANOVA is:

$$Y_{ijkr} = \mu + G_i + L_j + Y_k + B_r(LY)_{jk} + (GL)_{ij} + (GY)_{ik} + (LY)_{jk} + (GLY)_{ijk} + \varepsilon_{ijkr}$$

Where, Y_{ijkr} = the mean yield of the i^{th} genotype in the j^{th} location, in year k and block r; μ = grand mean, and the rest are main and interaction effects of genotypes, locations and years. ϵ_{ijkr}= error (residual) effects of genotype i in location j, year k and block r.

RESULTS AND DISCUSSION

Analysis of variance showed that there was significant difference ($p<0.01$) among the varieties in each year and combined over years (Table 1). GL and GLY interaction effects were also found to be significant ($p<0.05$). Location and year main effects and GY and LY interaction effects were not significant. Awash-1 was the best genotype followed by Omo-95 (Table 2). However, the farmers' selection criteria for common bean were beyond yield. They usually give priority to qualitative traits such as seed color, drought tolerance, disease and pest resistance, marketability, seed size, shattering tolerance, taste and cooking time.

Based on these criteria, all farmers who participated in the mother trial preferred the variety Ibado as a number one variety due to its seed color (red speckled), seed size (large), demand in the market (high), early maturity (<90 days) and relatively good yield (>2 tons ha^{-1}). The local variety was ranked second due to its seed color (light red), marketability and taste (Table 3). Farmers that were participated in the baby trial also came up with similar rankings as the 15 mother trial farmers (Table 4). This shows that almost all farmers in the watershed share similar criteria for common bean variety selection. The farmers were well aware of the selection criteria and they know how to select and rank the varieties. Some of the criteria match with the breeder's ones and some are beyond breeder's expectations. This is substantiated by the report of Gemechu *et al*. (2002), who reported that farmers and researchers have their own unique and common know-how, which should be effectively exploited in the research process.

Table 1. Analysis of variance of grain yield (kg ha^{-1}) of common bean varieties evaluated at three locations at Umbullo watershed in 2004 and 2005

Source	DF	SS	MS
Replication	3	287409.8	95803.3ns
Genotype (G)	5	4546446.0	909289.2**
Location (L)	2	498079.2	249039.6ns
Year (Y)	1	70251.5	70251.5ns
GL	10	2125269.6	212526.9*
GY	5	473899.3	94779.8ns
LY	2	264003.8	132001.9ns
GLY	10	1826862.8	182686.3*
Error	105	9771838.2	93065.1
Total	143	19864060.2	

*, ** = significant at 5% and 1%, respectively, ns = non-significant at 5% probability level.

Table 2. Grain yield (kg ha^{-1}) of common bean varieties tested across three locations at Umbulo Watershed in 2004 and 2005.

S. No	Varieties	Years x Locations								Overall mean	% yield advantage over the local variety	Overall Rank
		2004				2005						
		Umbulo Wacho	Umbulo Kejima	Umbulo Tenkaka	Mean	Umbulo Wacho	Umbulo Kejima	Umbulo Tenkaka	Mean			
1	Awash-1	2365.2	2350.5	2458.0	2391.2	2367.6	2112.3	2530.0	2336.6	2363.9	24.3	1
2	Awash M.	2226.3	1990.4	2094.6	2103.8	2205.6	2070.5	2109.7	2128.6	2116.2	11.3	4
3	Roba-1	1892.4	1595.2	1688.2	1725.3	1902.2	1984.2	1865.9	1917.4	1821.4	-4.2	6
4	Ibado	2065.0	2479.2	1894.4	2146.2	2004.5	2142.3	2163.3	2103.4	2124.8	11.7	3
5	Omo-95	2228.4	2117.7	2244.6	2196.9	2206.2	2292.4	1897.2	2131.9	2164.4	13.8	2
6	Local	2415.6	1264.0	1711.2	1796.9	2102.4	2036.7	1882.0	2007.0	1902.0	0.0	5
	CV (%)	14.7										
	LSD	74.6										
	SD	305.1										
	Mean yield	2082.1										

Table 3. Mother trial farmers' preference ranking of common bean varieties for different qualitative traits in Umbullo Watershed

Varieties	*F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	Av. R.	R.
Awash-1	4	4	3	3	4	2	4	4	4	4	3	3	2	2	3	3.3	4
Awash M.	2	3	3	4	3	2	1	5	3	3	4	3	2	2	3	2.9	3
Roba-1	6	6	4	5	5	4	2	2	5	3	5	4	3	4	4	4.0	6
Ibado	1	1	1	2	1	1	3	1	2	1	1	1	2	1	1	1.3	1
Omo-95	5	2	4	6	5	3	5	2	3	5	5	3	4	5	2	3.9	5
Local	3	2	2	1	2	3	3	3	1	2	2	2	1	3	2	2.1	2

F1= Farmer1, F2= Farmer2, F3= Farmer3…

Av. R. = Average rank, R.= Rank, Awash M. = Awash Melka

NB: The qualitative traits were seed color, drought tolerance, disease and pest resistance, marketability, seed size, shattering tolerance, taste and cooking time.

Table 4. Pair-wise ranking of common bean varieties by a group of farmers for different qualitative traits in Umbullo Watershed

Varieties	Awash-1	Awash M.	Roba-1	Ibado	Omo-95	Local	Points	Rank
Awash-1		Awash M.	Awash-1	Ibado	Awash 1	Local	2	4
Awash M.			Awash M.	Ibado	Awash M.	Local	3	3
Roba-1				Ibado	Omo-95	Local	0	6
Ibado					Ibado	Ibado	5	1
Omo-95						Local	1	5
Local							4	2

Pair-wise ranking of the farmers' selection criteria was made to rank the selection criteria and to identify the most important ones for future bean improvement. The farmers were so keen to compare the criteria and rank them in order of importance. Accordingly, the selection criteria were ranked by the farmers in the order: seed color, earliness, drought tolerance, disease resistance, marketability, pod load, insect pest resistance, seed size, shattering tolerance, vigorousity, growth habit (erect), pod length, first pod height from the ground, taste and cooking time (Table 5). Ceccarelli and Grando (2006) also reported that participatory research is important to understand traits or combinations of traits of interest to farmers, which are in a wider range than breeders expect.

Through the approach we used, participatory variety selection (PVS), we have got the chance to well understand the farmers' situation, their preferences and their indigenous knowledge in setting criteria and comparing and prioritizing the criteria without any confusion. Moreover, through this approach, we tried to address poor farmers and women headed households. Similar report showed that PVS has been very successful both in facilitating adoption by poor farmers in marginal environments, not previously reached by formal plant breeding, and in understanding farmers' preferences (Maurya *et al.,* 1988; Sperling *et al.,* 1993; Joshi and Witcombe, 1996).

Some of the important features of PVS that we came across during the study were community empowerment, biodiversity conservation (the farmers were able to keep the different varieties) and improved institutional linkage i.e. the project has been conducted with the collaboration of four institutions, namely Southern Agricultural Research Institute, Hawassa University, SNNPR Office of Agriculture and an NGO (Self-help Africa). Moreover, it has been proved that PVS is cost effective because the varieties were evaluated under farmers' input levels. It is also possible to consider farmers' evaluations and feedback and incorporate their preferences in the research processes. Faster rate of adoption of the technologies among users is also one of the key attributes of PVS. For example, the selected variety, Ibado, is now found in most of the houses of the farmers in the study area. Similar idea was also reported by Asfaw *et al*. (2008), where they indicated that participatory approach in bean breeding and variety diffusion resulted in increased on-farm diversity, improved farmers' breeding skills, helped to identify farmers' selection criteria and preferences, and reduced research costs.

We were also able to ascertain that it is desirable to participate farmers in the bean improvement program from the very beginning and exploit their indigenous knowledge and their criteria for bean variety selection so as to develop farmer preferred varieties that can be easily and quickly disseminated to farmers.

Table 5. Pair-wise ranking matrix of farmers' selection criteria for common bean varieties in Umbulo watershed

Selection criteria	A	B	C	D	E	F	G	H	I	Points	Rank
A		B	C	D	A	F	A	A	I	3	6
B			C	B	B	B	B	B	B	7	2
C				C	C	C	C	C	C	8	1
D					D	F	D	D	I	4	5
E						F	E	E	I	2	7
F							F	F	F	6	3
G								G	I	1	8
H									I	0	9
I										5	4

Where: A = Yield; B = Drought tolerance; C = Seed color; D = Seed size; E = Shattering tolerance; F = Disease and pest resistance; G = Taste; H = Cooking time and I = Marketability.

CONCLUSION

Including farmer criteria in plant breeding program is the best way of enhancing the rate of variety dissemination and adoption. In bean improvement program, we have learnt that the farmers' selection criteria are beyond yield and most farmers give priority for qualitative traits. They give priority for seed color, drought tolerance, disease and pest resistance, marketability and seed size than yield of the varieties. Therefore, it is advisable to participate farmers in the bean improvement program from the very beginning and exploit their indigenous knowledge and selection criteria so as to develop farmer preferred varieties that can be easily and quickly disseminated to farmers. Our future bean improvement program should target at developing varieties that fulfill farmers' preferences especially for home consumption and local market.

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