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Participatory Varietal Selection of Common Bean (*Phaseolus vulgaris* L.) in Wolaita, Ethiopia

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ABSTRACT
Common bean (*Phaseolus vulgaris* L.) is an important grain legume in Ethiopia. Its yield is low partly because of low yield potential and low adoption of existing varieties. An experiment was conducted in Wolaita, Ethiopia, to identify farmers' varietal selection criteria and to determine the relationship among grain yield and yield components using fourteen common bean genotypes grown at randomized complete block design with three replications. Grain yield ranged from 183 (genotype Awash-Melka) to 343 g m^{-2} (genotype Ibbado), 100-seed weight from 16 (genotype Awash-1) to 51 g (genotype Ibbado), pods/plant from 7.87 (genotype Tatu) to 13.73 (genotype SARI-1) and seeds/pod from 3.53 (genotypes Ibbado and ETAW-01-L-3-15A) to 5.93 (genotype Tabor). The correlation of grain yield with 100-seed weight ($r = 0.72$, $p<0.01$) and grain filling period ($r = 0.68$, $p<0.01$) was positive whereas its correlation with that of pods/plant ($r = -0.59$, $p<0.05$) and days to flowering ($r = -0.71$, $p<0.01$) was negative. The 100-seed weight was positively correlated with grain filling period ($r = 0.54$, $p<0.05$) and negatively correlated with that of pods/plant ($r = -0.73$, $p<0.01$), seeds/pod ($r = -0.90$, $p<0.01$) and days to flowering ($r = -0.74$, $p<0.01$). Farmers mostly preferred genotypes which combined high yield, early flowering and maturity, large and red or red-speckled seeds and fast cooking time. Thus, genotypes Ibbado, Remeda and Tatu would be used to improve adoption and varietal diversity.

Key words: Common bean, grain yield, participatory varietal selection, *Phaseolus vulgaris*

INTRODUCTION
Common bean (*Phaseolus vulgaris* L.) is an important grain legume in Ethiopia occupying about 366, 877 ha of land (19.69% of the total crop area allocated to pulses) and producing about 463,008 t (16.83% of the total pulses production) (CSA., 2013). However, its yield is low partly because of low yield potential as well as low adoption of the existing varieties. The lack or low adoption of new varieties may be because farmers have limited access to those varieties (Witcombe *et al*., 1996; Courtois *et al*., 2001), their poor adaptation to specific environments (Courtois *et al*., 2001) or their failure to fulfill the post-harvest quality requirements of farmers (Joshi and Witcombe, 1996).

Varietal adoption may be increased with the integration of farmers' participation in selection process and in setting of selection criteria in breeding programs which are usually lacking in formal breeding approaches. Participatory varietal selection is the farmers' practice of making their choices among the finished and nearly finished breeding materials during on-farm trials or demonstrations (Witcombe and Joshi, 1996). This helps to fit varieties to farmers' local environmental conditions (Sthapit *et al*., 1996), reduces the time involved in releasing new varieties (Assefa *et al*., 2005), increases the adoption and dissemination of the new varieties (Bellon and Reeves, 2002), helps better understanding of farmers' criteria for variety selection (Sperling *et al*., 2001) and enhances varietal diversity (Sperling *et al*., 2001; Joshi and Witcombe, 2002). Participatory varietal selection approach has been used in many crops such as rice (Joshi and Witcombe, 1996, 2002), barley (Ceccarelli *et al*., 2001), maize (Mulatu and Zelleke, 2002; Tadesse *et al*., 2014), common bean (Assefa *et al*., 2005) and sorghum (Nkongolo *et al*., 2008). The present experiment was conducted to identifying farmers' varietal selection criteria and to determine the relationship among grain yield and yield components of common bean genotypes.

MATERIALS AND METHODS

This experiment was conducted on-farm at Waraza Lasho village, 8 km from Wolaita Sodo (6°51'36"N and 37°45'41"E), Ethiopia, at 1961 m above sea level, during 2014 main cropping season. Wolaita Sodo receives average annual rainfall of 1390 mm with the monthly average maximum and minimum temperatures of 25.4 and 14.7°C, respectively. During the experiment duration, May-August, 2014, the monthly average rainfall was 200 mm and the monthly average maximum and minimum temperatures were 23.6 and 15.1°C, respectively. The soil of the experimental site at the depth of 0-30 cm is clay loam (sand 32%, clay 32%, silt 36%) and has pH 6.25, organic carbon 0.98%, P7.4 ppm (Olsen), total N 0.10% and exchangeable Ca, Mg and K of 14.20, 7.80 and 1.56 cmol kg^{-1} soil, respectively.

Fourteen common bean genotypes (12 released and two advanced lines) obtained from Hawassa Agricultural Research Centre, Hawassa, Ethiopia, were planted in randomized complete block design with three replications on May 12, 2014. The common bean genotypes were planted in four rows with 2 m long separated by 40 cm, with 10 cm between plants. The distance between plots was 80 cm and that between replications was 1.2 m. The 27 kg ha^{-1} N and 69 kg ha^{-1} P_2O_5 were applied in the form of diammonium phosphate at the time of planting. Weeds were controlled with frequent hand weeding throughout the experiment.

Visual evaluation of genotypes was conducted at flowering and maturity stages using 8-10 farmers (host and neighbors) based on the farmers' knowledge on common bean and their interest in evaluating the experiment. The scores for the visual evaluation were 1-4 (1= poor, 2 = good, 3 = very good, 4 = excellent) for each of the selection criteria. The ranking procedure was explained to participating farmers and the final ranking was done on consensus where differences were resolved through discussion (De Boef and Thijssen, 2007).

Days to flowering and maturity, 100-seed weight (g), pods/plant (average of five random plants at maturity), seeds/pod (average for ten random pods) and grain yield (g m^{-2}) were recorded using the two central rows. These data were analyzed using Genstat software (VSN International, 2012).

RESULTS

The effect of genotype was significant for days to flowering and maturity, grain filling period, pods/plant, seeds/pod, grain yield (g m^{-2}) and 100-seed weight (g). Grain yield ranged from 183 (genotype Awash-Melka) to 342 g m^{-2} (genotype Ibbado), pods/plant from 7.87 (genotype Tatu) to 13.73 (genotype SARI-1) and 100-seed weight from 16 (genotype Awash-1) to 51 g (genotype Ibbado). There was also considerable variation among genotypes for seeds/pod, days to flowering and maturity and grain filling period (Table 1).

Table 1: Mean squares and mean values for seven grain yield and yield components of fourteen common bean genotypes grown during 2014 main cropping season

Genotypes[1]	Pods/plant	Seeds/pod	GY(g m^{-2})	SW (g)	DTF	DTM	GFP
Awash-1	13.00	5.37	206	16	55	88	33
Awash-Melka	9.30	5.50	183	18	56	90	34
Hawassa-Dume	11.40	5.40	291	26	47	80	34
Ibbado	8.00	3.53	342	51	44	79	35
Nasir	11.73	5.43	204	19	55	85	30
Omo-95	12.07	5.73	249	20	47	79	32
Red-Wolaita	13.33	5.53	280	20	49	80	31
Remeda	9.53	3.70	279	45	46	80	34
SARI-1	13.73	4.90	193	19	56	81	25
Tabor	10.53	5.93	228	21	55	85	30
Tatu	7.87	4.33	285	40	40	74	35
Waju	8.83	4.60	332	35	52	97	45
ETAW-01-L-1-25A	8.27	5.03	321	38	47	86	39
ETAW-01-L-3-15A	10.80	3.53	243	44	47	83	36
Mean	10.60	4.90	260	29	50	83	34
$LSD_{0.05}$	2.84	0.69	71	1.78	2.72	3.65	4.03
Mean squares[2]							
Replication (2)	1.47^{ns}	0.46^{ns}	2364^{ns}	2.90^{ns}	6.88^{ns}	13.31^{ns}	2.38^{ns}
Genotype (13)	12.18**	2.05**	8296**	436.13**	81.97**	98.39**	67.56**
Error (26)	2.86	0.17	1791	1.13	2.63	4.72	5.77
CV (%)	16.00	8.30	16.30	3.60	3.30	2.60	7.10

[1]Genotypes Awash-1 to Waju are released varieties, ETAW-01-L-1-25A and ETAW-01-L-3-15A are advanced lines, [2]Numbers in the parenthesis are degree of freedom, GY: Grain yield, SW: 100-seed weight, DTF: Days to flowering, DTM: Days to maturity, GFP: Grain filling period, *,**Significant at p<0.05 and p<0.01, respectively, ns: Not significant

Table 2: Simple correlation coefficients among seven grain yield and yield components of fourteen common bean genotypes grown during 2014 main cropping season

Traits	2	3	4	5	6	7
Pods/plant	0.49^{ns}	-0.59*	-0.73**	0.51^{ns}	-0.08^{ns}	-0.68**
Seeds/pod		-0.45^{ns}	-0.90**	0.56*	0.22^{ns}	-0.35^{ns}
Grain yield (g m^{-2})			0.72**	-0.71**	-0.10^{ns}	0.68**
100-seed weight (g)				-0.74**	-0.23^{ns}	0.54*
Days to flowering					0.64*	-0.35^{ns}
Days to maturity						0.50^{ns}
Grain filling period						

*, **Significant at p<0.05 and p<0.01, respectively, ns: Not significant

The correlation of grain yield with 100-seed weight (r = 0.72, p<0.01) and grain filling period (r = 0.68, p<0.01) was positive whereas its correlation with that of pods/plant (r = -0.59, p<0.05) and days to flowering (r = -0.71, p<0.01) was negative. The 100-seed weight was also positively correlated with grain filling period (r = 0.54, p<0.05) and negatively correlated with that of pods/plant (r = -0.73, p<0.01), seeds/pod (r = -0.90, p<0.01) and days to flowering (r = -0.74, p<0.01) (Table 2).

The mean scores for seven farmers' selection criteria ranged from 1.71 (genotypes Awash-1 and Awash-Melka) to 3.86 (genotype Remeda). The highest average scores (3.71) were also obtained for genotypes Ibbado and Tatu. The highest scores (4) for early flowering and maturity were obtained for genotypes Ibbado, Omo-95, Remeda and Tatu. The late flowering (1) and maturity (2) scores and that of late maturity score (1) were obtained for genotypes Awash-1 and Awash-Melka and genotype Waju, respectively. The highest scores (4) for pod and grain yield loads were obtained for genotypes Hawassa-Dume, Omo-95, Red-Wolaita and Remeda. The highest scores (4) for seed size were obtained for genotypes Ibbado and Remeda and the lowest score (1) for genotype Awash-1. Genotypes with either white (Awash-1, Awash-Melka, Waju, ETAW-01-L-1-25A) or creamy (genotype Tabor) seeds were given the lowest score (1) and those with red speckled (genotypes

Table 3: Farmers' scores and ranks of fourteen common bean genotypes using seven selection criteria

Genotypes[1]	Seed color	PL	GYL	Seed size	Seed color	Cooking time	DTF	DTM	Mean	Rank
Awash-1	White	3	2	1	1	2	1	2	1.71	10
Awash-Melka	White	2	3	2	1	1	1	2	1.71	10
Hawassa-Dume	Red	4	4	2	3	4	3	4	3.43	3
Ibbado	Red-speckled	3	3	4	4	4	4	4	3.71	2
Nasir	Red	3	3	2	3	3	2	3	2.71	6
Omo-95	Red	4	4	2	3	3	4	4	3.43	3
Red-Wolaita	Light red	4	4	2	2	2	3	4	3.00	5
Remeda	Red	4	4	4	3	4	4	4	3.86	1
SARI-1	Light red	3	2	2	2	2	2	4	2.43	7
Tabor	Creamy	3	3	2	1	1	2	3	2.14	9
Tatu	Red- speckled	3	4	3	4	4	4	4	3.71	2
Waju	White	1	3	3	1	3	3	1	2.14	9
ETAW-01-L-1-25A	White	2	3	3	1	2	3	2	2.29	8
ETAW-01-L-3-15A	Red	3	3	3	3	3	4	3	3.14	4
Mean		3	3.36	2.5	2.29	2.71	2.86	3.14	2.84	

[1]Genotypes Awash-1 to Waju are released varieties, ETAW-01-L-1-25A and ETAW-01-L-3-15A are advanced lines, DTF: Days to flowering, DTM: Days to maturity, PL: Pod load, GYL: Grain yield load, scores: 1: Poor, 2: Good, 3: Very good, 4: Excellent

Ibbado and Tatu) seeds were given the highest score (4). Genotypes Hawassa-Dume, Ibbado, Remeda and Tatu are said to be fast cooking (scores of 4), whereas Awash-Melka and Tabor are long cooking types (Table 3).

DISCUSSION

As to the present experiment, the existence of genotypic variation for grain yield and yield components has been reported in previous studies in common bean (Atuahene-Amankwa and Mechaels, 1997; Fageria *et al*., 2010; Balcha, 2010, 2014). This suggests the possibility of selection to improve grain yield in the materials studied. On the other hand, the positive correlation of grain yield with 100-seed weight ($r = 0.72$, $p<0.01$) and grain filling period ($r = 0.68$, $p<0.01$) would suggest the possibility of increasing grain yield by increasing the later traits. However, the progress in selection will be slow and complicated because of negative correlation of 100-seed weight with pods/plant ($r = -0.73$, $p<0.01$) and seeds/pod ($r = -0.90$, $p<0.01$) and that of pods/plant with grain filling period ($r = -0.68$, $p<0.01$). The negative correlation between seeds/pod and seed weight (Balcha, 2014) and positive correlation between the later and grain yield (Fageria *et al*., 2010; Balcha, 2014) have also been reported in previous studies in common bean.

Besides grain yield and fast cooking time, farmers most preferred large and red or red-speckled seeds which are expected to give high market values. The importance of seed size and cooking time for common bean (Assefa *et al*., 2005) and maize (Tadesse *et al*., 2014), seed size for faba bean (Mulualem *et al*., 2012) and seed color for barley (Ceccarelli *et al*., 2001), wheat (Workineh *et al*., 2014), maize (Mulatu and Zelleke, 2002; Tadesse *et al*., 2014), common bean (Assefa *et al*., 2005) and sorghum (Muui *et al*., 2013) have also been reported in previous studies as being farmers important selection criteria.

In present experiment, farmers preferred early flowering and maturity because it gives them early food security for the family in the season. Earliness has also been considered as the most important selection criterion of farmers particularly in drought prone areas. This has been reported for several crops such as maize (Mulatu and Zelleke, 2002; Tadesse *et al*., 2014), common bean (Assefa *et al*., 2005), faba bean (Mulualem *et al*., 2012), sorghum (Muui *et al*., 2013) and barley (Ceccarelli *et al*., 2001). Farmers mostly preferred genotypes which combined high yield, early flowering and maturity, large and red or red-speckled seeds and fast cooking time. Thus, genotypes Ibbado, Remeda and Tatu would be used to improve adoption and varietal diversity.

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