ORIGINAL ARTICLES

Participatory variety selection of common Bean (*Phaseolus vulgaris L.*) Released varieties for productivity and resistance to major diseases in Halaba Special District, Southern Ethiopia

Berhanu Abate[1], Alemayehu Chala[2] and Kalkidan Dabi[3]
[1,2]School of Plant and Horticultural Sciences, Hawassa University, Ethiopia.
[3]Plant Sciences Department, Dembidolo University, Ethiopia.

Corresponding author: berhanuabate@yahoo.com

ABSTRACT

Common bean (Phaseolus vulgaris L,) is the second important legume crops, next to faba bean in Ethiopia. However, its national average yield (1.6 t ha^{-1}) is far below the yield of improved varieties in research fields (3.5 t ha^{-1}). This is, mainly, due to inadequate supply of quality seeds of the improved varieties and disease problem. Participatory variety selection on common bean was conducted in Halaba district in Southern Ethiopia with the objectives of identifying disease resistant and farmers-preferred varieties, and investigating farmers' variety selection criteria. In the study, 10 varieties were laid out in a grandmother and mother trials. Analysis of variance showed that varieties were significantly different for yield and yield components. The mean separation for the combined yield data analysis revealed that varieties Hawassa-dumme (4.91 t ha^{-1}) and SER-119 (4.70 t ha^{-1}) produced significantly highest yield. The varieties were also highly significantly different in disease reaction. Angular Leaf Spot was the most prevailed disease, followed by Ascochyta Blight. Highest angular leaf spot incidence was observed on varieties Kat-B9, Nasir, SAB-632 and Remeda with 100, 95, 93.33 and 93.33%, respectively; while SER-125 and Ibado had least incidence of 31.67 and 46.67, respectively. Generally, Kat-B9 was susceptible, while SER-119, Tatu and SER-125 were resistant. During pre and post harvest variety evaluation farmers preferred varieties Hawassa-dumme and SER-119, because of their more pods per plant, upright growth, dark red seed color, highest yield and market demand. Therefore, we recommend them for Halaba and similar districts.

Keywords: common bean, disease resistance, farmers preferred varieties, yield

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is one of the most important cash and protein source crops of farmers in many lowlands and hot-humid regions, as well as, mid-altitudes of Ethiopia (Tamene and Tadesse, 2014). Pulses, mainly, common bean has, recently, became an important export crop and diversifying source of foreign currency from the agricultural sector.

It is the largest agricultural export crop after coffee and sesame (Mekuria, 2015). Common bean in Ethiopia is second in area of production of pulses, next to faba bean, and fifth in national average yield (1.6 t ha^{-1}), following soybean, chickpeas, faba bean and grass peas. In Southern Nations Nationalities and Peoples Regional State (SNNPRS), common bean is first in area coverage of 117,969.97 ha and total production of 170,162.42 tones followed by faba bean, field peas and chickpeas (CSA, 2016).

So far, the Lowland Pulse Breeding Programs of Ethiopia have released 57 improved common bean varieties with yield potentials of 2.5 to 3.5 t ha^{-1} at research fields (MoANR, 2016). However, the national average yield of common bean of 1.6 t ha^{-1} is far below its potential (CSA, 2016). This wider yield gap is due to several production constraints. The most important ones are drought, disease, poor agronomic practices and insufficient availability of quality seeds of the improved varieties suited for the major common bean production agro-ecologies. Tafere *et al*. (2012) reported that low crop production in Ethiopia is, mainly, attributed to inadequate availability of quality seeds of improved varieties for majority of the farmers. CSA (2012) reported that the supply of quality seeds of the improved varieties for farmers, through the formal seed system is below 10%. Most farmers, especially, in remote areas depend on locally available seeds, either recycled from their harvest or bought from the local markets.

In Ethiopia, recommendation of varieties for release has been based, mainly, on their average yield across experimental locations. Almekinders and Elings (2001) reported that formal crop improvement in developing countries focused on the development of varieties for favorable and high-input agriculture, with the expectation that the improved varieties would also be productive in low-input and drought prone environments. Farmers in potential areas, and those who use improved agricultural inputs, have been more benefited from the formal crop improvement than the poorest farmers (Ceccareli and Grando, 2007). The formal crop improvement programs have been criticized for ignoring indigenous knowledge of the farmers on crop species, varieties and cropping systems important for their specific areas. The less emphasis on improving crops for the poor productive environments of the smallholder farmers might result in slow progress of yield on marginal areas (Atline et al, 2001). On the other hand, the skill of farmers in identifying varieties that well adapt to their production environments has been recognized and utilized by many plant breeders. Farmers have a broad knowledge on their environments, crops and cropping systems, and do experiments on their farms and generate innovations (Banziger and Cooper, 2000). Participating farmers in the process of crop improvement and variety evaluation also fasten variety identification and adoption, increase crop and variety diversity, yield and farmers' income, facilitate farmers learning and empowering, and strengthen collaboration between breeders and farmers (Almekinders and Elings, 2001).

Therefore, participatory variety evaluation and selection of common bean was done with the objectives of identifying high yielding and farmers' preferred varieties, understanding farmers' variety selection criteria and studying the disease reaction of common bean varieties in Halaba special district.

MATERIALS AND METHODS

Research site description

The field experiment was conducted at Halaba special district in the SNNPRS in the 2016 cropping season. Halaba special district is located at latitude of 7.3^0 41′49″ N and longitude of 38^{0}10′47″E with altitude range of 1547-2149 m.a.s.l in the Rift valley region. The ten years metrological data of the district shows that Halaba receives mean annual rainfall ranging between 800-1200 mm, and has a monthly minimum and maximum temperature of 17 and 27^{0}C, respectively. The rainy season usually starts in March, and ceases at the end of September or rarely in early October. The soil is clay loam and sandy loam. The major crops grown in the district are maize, tef, pepper and common bean. Common bean is the only pulse crop in Halaba, which might be produced twice in a year; i.e., planted in April for July harvest and in July for October harvest. The cropping systems in the district are maize–common bean, maize-pepper, tef-pepper rotation, and double cropping of tef, following common bean and maize–common bean intercropping (Halaba district BoANRDO, 216).

Varieties and experimental design

Ten improved varieties obtained from Melkassa and Hawassa Agricultural Research Centers were used for this study (Table 1). The design for the grandmother trial was a randomized complete block with three replications and 9.6m^2 (4m x 24m) plot size for each variety. The mother trials were carried out in an un-replicated block at three different villages. Two seeds per hill were planted in rows with 0.40 and 0.10 meter inter-and intra-row spacing. Thinning of one of the seedlings per hill was done two weeks after seedling emergence. The Di-ammonium phosphate (DAP) fertilizer at the rate of 100 kg per hectare was applied in rows, just before sowing, and other field managements were done as required.

Table 1. Common bean varieties

Variety	Seed color	Year of release	Released by
Nasir	Red	2003	MARC
Ibado	Speckled	2003	SARI
Hawassa-dume	Dark red	2008	SARI
SER-119	Dark red	2014	MARC
SER-125	Dark red	2014	MARC
Remeda	Red	2014	SARI
Tatu	Speckled	2014	SARI
Wajo	White	2014	SARI
Kat-B9	Red	2013	MARC
SAB-632	Speckled	2015	MARC

MARC and SARI are Melkassa Agricultural Research Center and South Agricultural Research Institute

DATA COLLECTION AND ANALYSIS

Disease

The disease severity scoring for angular leaf spot and ascochyta blight was done visually in a 1-9 scale. Disease scoring was done on three trifoliate leaves at the bottom, middle and top of each plant from each plot. Varieties receiving a disease severity score of 1-3 were regarded as resistant, 4-6 as intermediate resistant and 7-9 as susceptible (CIAT, 1987).

The incidence of these two major diseases was calculated as

$$\text{Disease incidence} = \frac{\text{Number of symptomatic plants}*100}{\text{Number of plants in a plot}}$$

Log data transformation of disease severity and incidence was done to the base 10 to make their distribution normal.

Yield and yield components

The yield components, such as number of pods and seeds per plant and number of seeds per pod were determined using five random plants from the central rows of each plot. Grain yield was harvested from the central four rows of each plot and adjusted to standard grain moisture content of pulses (10%), using the equation below as described by (Tesfaye and Amin, 2014)

$$\text{Adju. yield } (t^{-ha}) = \frac{\text{actual plot yield (kg)}*(100\text{-actual moisture content of the grain})*10{,}000m^2}{6.4m^2*(100\text{- standard moisture content of pulse})*1000kg}$$

Hundred seed weight (HSW) was determined by counting hundred randomly picked seeds of each plot through hand counting and weighted with a digital sensitive balance.

Evaluation and selection of varieties by farmers

The participatory evaluation and selection of varieties were done at maturity stage and after harvest by 30 farmers (20 men +10 women) selected with the help of the development workers in the kebele (county). First, the farmers sat at the skirt of experimental field and discussed what common bean traits they preferred to select varieties.

The discussion was participatory and guided by the researcher, and finally, they reached at a consensus, and identified their important traits of interest, which included: earliness, upright growth, pods per plant, resistance to diseases, seed color, seed size, market preference and yield. During pre-harvest evaluation, farmers were provided with pieces of papers with different colors that helped ease selection of the varieties. So, every farmer put a single piece of paper for each variety he selected.

The color of the papers represented as green for the best variety, blue for the second, red for the third, rose for the fourth, yellow for the fifth rank, and white for the worst variety, respectively. The researcher, then, collected and counted the papers based on their colors given for each variety, and made use of it to determine the rank of the varieties, accordingly.

For post-harvest evaluation, the farmers sat in the front yard of the owner of the experimental field, and the seeds of the varieties were displayed with equal-size trays. Then, pair wise comparison was done, in which every variety was compared with the other varieties for identified characters. Immediately after the farmers chosen one of the two varieties, the researcher recorded the winner variety. Then, the number of records for each variety is summed and converted to rank from 1 to 10, considering the number of varieties studied. The variety which has nine records meant that it won nine varieties, so it received first rank. Otherwise, if it has one record, it won only one variety from ten, and it received ninth rank.

Data Analysis

Analysis of variance on yield and yield related data, disease incidence and severity score was done using a general linear model of Statistical Analysis System (SAS), version 9, 2002.

The models used were:

Yij= μ + gi + bj + eij:

Where, Yij=yield of genotype i in block j; μ=grand mean; gi= effect of genotype i; bj= effect of block j and eij=error effect, and

Yijk = μ + Gi + Lj + GLij + Bkj + Eijk for combined yield data analysis

Yijk = yield of genotype i in block k and location (village) j; μ = grand mean of the experiment;

Gi = effect of genotype i; Lj = effect of location j; (GL)ij = the interaction effect of genotype i with location j and Bkj = effect of block k in location j and Eijk = error effect.

RESULT AND DISCUSSION

Analysis of variance

Analysis of variance revealed that common bean varieties were significantly ($P \leq 0.01$) different in incidence and severity of Angular leaf spot, severity of Ascochyta blight, grain yield and yield components such as pods per plant (PPP), seeds per pod (SPPd), seeds per plant (SPP) and hundred seed weight (HSW). The combined yield data analysis also showed the significant difference ($p<0.01$) of varieties, however the interaction effect of varieties–by- village on yield were none significant ($p= 0.06$).

Angular leaf spot (*Phaeoisariopsis griseola*) (Sacc.) and Ascochyta blight (*Ascochyta spp.*) were the most prevailed diseases on all the studied varieties. Angular leaf spot (ALS) was found the most widespread bean disease comparing to Ascochyta blight. The mean incidence of the disease ranged from 1.50 for variety SER-125 to 2.00 for the variety Kat-B9 (Table 2). It was high on varieties Kat-B9, Nasir, SAB-632, and Remeda; while varieties SER-125 and Ibado had the least incidence of Angular leaf spot. The mean value of severity of angular leaf spot was in the range of 0.20 for varietySER-119 to 0.82 for variety Kat-B9. Those varieties with high incidence of angular leaf spot were also severely infected with this leaf disease, while varieties SER-119, SER-125, and Tatu were resistant. The incidence and severity of Angular leaf spot disease was damagingly associated with grain yield. Pamela (2014) reported that severity of Angular leaf spot is an important disease of common bean in the tropics causing yield loss up to 100%. Growing genetically resistant varieties is the most appropriate, safe and cost-effective way to control Angular leaf spot for smallholder farmers (Ddamulira *et al*., 2014 a).

Ascochyta blight was observed as the second important disease next to Angular leaf spot, however its incidence was not significantly varied among the varieties. Its mean severity was ranged from 0.10 for variety Hawassa-dume to 0.63 for variety SAB-632 (Table 2). The variety Kat-B9 was less infected with Ascochyta blight, but the incidence was high on variety SAB-632. The varieties Hawassa-dumme and SER-119 were more resistant; while the varieties SAB-632, Wajo and Nasir were found less resistant (Table 2). These three varieties had plant logging problem which might created conducive environment for the disease Ascochyta blight.

Table 2. Incidence and severity of Angular leaf spot and Ascochyta blight on common bean

VARIETY	IALS	SALS	IAB	SAB
Nasir	1.98[a]	0.77[ab]	1.52[ab]	0.52[ab]
Ser-119	1.71[bc]	0.20[d]	1.52[ab]	0.36[bc]
Ibado	1.65[cd]	0.56[c]	1.63[ab]	0.46[abc]
H-dumme	1.84[ab]	0.59[bc]	1.48[ab]	0.10d
Sab-632	1.97[a]	0.69[abc]	1.69[a]	0.63[a]
Wajo	1.92[a]	0.59[c]	1.60[ab]	0.56[ab]
Remeda	1.97[a]	0.67[abc]	1.59[ab]	0.46[abc]
Ser125	1.45[d]	0.30[d]	1.49[ab]	0.26[cd]
Tatu	1.72[bc]	0.20d	1.57[ab]	0.36[bc]
Kat-B9	2.00 [a]	0.84[a]	1.42[b]	0.42[bc]
Mean	1.83	0.54	1.55	0.41
CV (%)	5.77	19.82	8.98	30.27

IALS=Incidence of Angular leaf spot, SALS= severity of Angular leaf spot, IAB= incidence of Ascochyta blight, SAB=severity of Ascochyta blight

Yield and yield components of common bean

In grandmother trial, the grain yield was ranged from the lowest yield of variety Remeda (2.67 t ha^{-1}) to the highest yield of variety Hawassa-dumme (5.16 t ha^{-1}), while in mother trial it was from 2.67 to 4.65 t ha^{-1} from both Remeda and Hawassa-dumme. The varieties Hawassa-dumme, SER-119 and Wajo had highest similar yields in both trials with significant difference from the rest of the varieties (Table 3).

Table 3. Grain yield (t ha^{-1}) from grandmother and mother trials

Variety	Grandmother	Mother	Mean	Rank
Nasir	3.37[d]	4.0[ab]	3.68[de]	8
SER-119	5.02[a]	4.39[ab]	4.70[ab]	2
Ibado	4.33[bc]	4.06[ab]	4.19[bcd]	4
H-Dumme	5.16[a]	4.65[a]	4.91[a]	1
SAB-632	3.54[d]	3.01[cd]	3.29[e]	9
Wajo	4.77[ab]	3.99[ab]	4.38[bc]	3
Remeda	2.67[e]	2.67[d]	2.67[f]	10
SER-125	4.19[bc]	3.96[ab]	4.08[cd]	5
Tatu	3.87[cd]	3.70[bc]	3.79[de]	7
Kat-B9	3.79[cd]	4.08[ab]	3.94[cd]	6
Mean	4.07	3.85	3.96	
CV%	8.75	13.26	11.07	

CV= coefficient of Variation

In mother trial, varieties Remeda, SAB-632 and Tatu gave significantly lower yield than other varieties which were performed similarly. The variety Hawassa-dumme was better in both trials comparing to others, and the average yield of the two trials showed varieties Hawassa-dumme, SER-119 and Wajo had 1st 2nd and 3rd ranks respectively (Table 3). Teame *et al*. (2017) reported that common bean genotypes showed significant difference for yield and yield components.

The average number of pods of these varieties was in the range of 9.5-28. The highest pods per plant was counted from varieties Hawassa-dumme and SER-119 followed by SER-125, while the minimum pods per plant was recorded from varieties Remeda, Ibado, SAB-632, Tatu and Wajo (Table 4). Seeds per pod of the varieties ranged from 3.5 for variety Ibado to 4.6 for variety SER-125. The varieties SER-125, SER-119 and Hawassa-Dumme had more seeds per pod followed by Nasir and Wajo (Table 4). Seeds per plant of the varieties were in the range of 37-128 (Table 4). The variety SER-125 had high seeds per plant (128.3) followed by Hawassa-dumme (114.6) and SER-119(93.3), and the smallest was recorded for Remeda (37) (Table 4). Wowondsen and Tamado (2017) also reported that number of pods per plant, seeds per pod and seeds per plant was highly significantly varied among common bean genotypes.

The highest hundred seed weight was recorded for varieties Remeda (49.4g), SAB- 632(49g) and Ibado (48.13g) followed by Kat-B9 (44.43g) and Tatu(42.1g), while variety Nasir had least seed weight of 20.4 g.(Table 4). Amanullah and Asim (2011) reported that hundred seed weight varied significantly among haricot bean varieties from 19.5 to 61.5g. According to CIAT (1987) bean seeds were classified based on their hundred seed weight as large (greater than 35 g), medium (25 to 35 g) and small (less than 25 g). Therefore, Varieties Remeada, SAB-632, Ibado, Kat-B9, Tatu and Wajo are in larger seed size group, other varieties except variety Nasir which is under smaller seed size are in medium seed size group.

Table 4. Yield components of common bean

Variety	PPP	SPPd	SPP	HSW
Nasir	16.1^{de}	4.2^{abc}	67.7^{c}	20.40^{e}
SER-119	20.7^{bc}	4.5^{a}	93.3^{b}	26.83^{d}
Ibado	13.5^{ef}	3.5^{d}	46.5^{cd}	48.13^{a}
H-dumme	25.1^{ab}	4.5^{a}	114.6^{ab}	26.90^{d}
SAB-632	13.9^{ef}	3.8^{cd}	53.2^{cd}	49.00^{a}
Wajo	14.1^{ef}	4.2^{abc}	58.2^{cd}	37.60^{c}
Remeda	9.5f	3.9^{bcd}	37.0^{cd}	49.40^{a}
SER-125	28.0^{a}	4.6^{a}	128.3^{a}	27.03^{d}
Tatu	13.7^{ef}	3.7^{cd}	51.2^{cd}	42.10^{b}
Kat-B9	18.8^{cd}	3.6^{cd}	68.37^{c}	44.43^{b}
Mean	17.4	4.1	71.82	37.183
CV (%)	15.44	7.2	18.35	3.94

Where PPP= pods per plant; SPPd= seeds per pod; SPP= seeds per plant; HSW= hundred seed weight and CV= coefficient of Variation.

Evaluation and Selection of Varieties by Farmers (Analysis of Matrix Ranking)

Participatory evaluation and selection of ten varieties was done by 30 participant farmers at physiological maturity for pod clearance and pods per plant using direct ranking; and after harvesting for grain yield, seed size, color, and market preference using pair wise matrix ranking. Fekadu (2013) reported that the farmers' selection criteria for common bean were beyond yield. They usually give priority to traits such as seed color, drought tolerance, disease and pest resistance, marketability, seed size, shattering tolerance, taste and cooking time. In this study, farmers selected varieties SER-119 and SER-125, Ibado, and Hawassa-dumme as best, very good and good for their upright growth; and SER-119 and Hawaas-dumme were also selected as best and very good varieties for their highest pods per plant respectively. The farmers explained that varieties with poor pod clearance have seed shattering and seed rotting problems when there is rainfall at crop maturity. Rotting and germination of seeds of the variety Wajo were observed in the field.

It was also mentioned that varieties producing high pods per plant can also give high seed yield. Mulu et al., (2016) reported that farmers in Borecha district of southern Ethiopia selected common bean varieties at field considering earliness, pod load and up right growth habit plant characters, but the best selection criterion of varieties after harvest was uniform red seed color.

Farmers estimated the amount of grain yield of every pair of varieties displayed in trays with equal- size simply by judging the depth of the trays filled with seeds by their hands and chosen the better one. In the pair wise ranking of varieties, the participants gave 1st to 5th rank for varieties SER-119, Hawassa-dumme, Wajo, Ibado and SER-125 respectively for their high yield (Table-5). The seed weight of every two varieties was evaluated by scooping up handful seeds from each of them turn by turn and compared each other. The varieties Remeda, Ibado, SAB-632, Kat-B9 and Wajo received from 1st to 5th rank respectively for larger seed size; whereas varieties Hawassa-dumme, SER-125 and Nasir got least rank from 8th to 10th (Table 5). Teshale *et al*. (2005) reported that farmers applied up to 40 selection criteria; however yield, drought tolerance, healthiness, earliness, marketability, seed color and size are key plant traits of common bean.

The pair wise ranking showed that farmers had selected varieties SER-119, like SER-119, Hawassa-Dumme, SER-125, Nasir and Kat-B9 were preferred by farmers from 1st to 5th rank, because of high price for red seeded types at local markets and for house consumption with the reason that red type common beans give red color for grains like maize boiled together with it. The beans with speckled and white colors were not preferred by farmers, because they are not popular in the farming community as well as in local markets in Halaba district. The participant farmers finally gave overall ranks for the Hawassa-Dumme, SER-125 and Kat-B9 by giving rank from 1st to 4th respectively for their dark red seed color. Varieties Wajo and SAB-632 which have white seed color received 7th and 9th rank, whereas varieties Ibado and Tatu which have speckled seed color received 8th and 10th rank. Varieties Remeda and Nasir which have light red seed color had 5th rank (Table 5). In Ethiopia, most of common bean varieties are red and white seeded, and the largest share of the production areas allocated for common bean production is covered by red color common bean varieties (CSA, 2016). However, Alemayehu and Rahel (2015) reported that farmers preferred common bean varieties with red-speckled seed color in Wolayta area.

The local and foreign markets have determinant influence on the production of common bean in Ethiopia in general and in Southern Nations, Nationalities and Peoples Regional State in particular. The local markets demand red common bean, and currently in Ethiopia the white common beans are produced for export purpose. Smallholder farmers typically grow the red bean types for household consumption and local markets, while white common beans are produced almost exclusively for the export market (Ferris and Kaganzi, 2008). Similarly, Mekibi (1997) reported that farmers in western Hararghe who were export-oriented preferred white beans, however in eastern Hararghe red beans were selected. So, varieties having uniform dark red color varieties by giving major emphasis to red seed color and local markets' need. Accordingly, varieties SER-119, Hawassa-dumme, and SER-125 ranked first, second to third respectively.

Table 5. Ranking of varieties for yield and seed characters by 30 farmers

Variety	Yield	Seed size	color	Market preference	Over all rank
Nasir	9	10	5	4	4
SER-119	1	7	1	1	1
Ibado	4	2	8	8	9
H-dumme	2	8	2	2	2
SAB-632	8	3	9	8	8
Wajo	3	5	7	6	5
Remeda	10	1	5	7	7
SER-125	5	9	3	3	3
Tatu	6	6	10	10	10
Kat-B9	7	4	4	5	6

CONCLUSION AND RECOMMENDATION

High grain yield is achieved by growing disease resistant and high yielding varieties which are adapted to the environment and preferred by the farming community. For this purpose participation of farmers in variety evaluation and selection process is necessary. In addition, the knowledge on economically important plant diseases of a particular crop in a particular area is required to grow disease resistant varieties with less production cost or to apply a pesticide on the right time. In this study, the participant farmers used many plant and seed characters in common bean variety selection, however red seed color of haricot bean is a highly preferred seed character, because it has high demand in the local markets. Thus, varieties Hawassa-dume and SER-119 which are disease resistant and have upright growth, dark-red seed color and high yield were selected by participant farmers as best varieties for home consumption and local markets in Halaba special district. Therefore we recommend these two varieties for Halaba and similar districts.

ACKNOWELEDGMENT

We thank the Norwegian Government for supporting us research fund through NORHED project. We also thank participant farmers and development workers for their active involvement in variety evaluation process. Hawassa and Melkass Agricultural Research Centers provided us seeds of the varieties, So we thank them.

REFERENCES

Almekinders, C.J.M and Elings, A. 2001. Collaboration of farmers and breeders: Participatory crop improvement in perspective. Euphytica 122:425-438.

Amanullah. M &Asim. M. 2011. Evaluation of common bean germplasm collected from the neglected pockets of Northwest Pakistan at Kalam (Swat). Pakistan J. Botany. 43(1): 213-219.

Atlin, G.N., Cooper, M. and Bjornstad, A. 2001. A comparison of formal and participatory breeding approaches using selection theory. Euphytica 122: 463-475

Alemayehu, B. and Rahel, T. 2015. Participatory varietal selection of common bean in Wolayta, Ethiopia. Asian journal of crop science, 7: 295-300.

Banziger, M. and Cooper, M. 2000. Breeding for low input conditions and consequences for participatory plant breeding: Examples from tropical maize and wheat.

Ceccareli, S. and Grando, S. 2007. Decentralized participatory plant breeding: an example of demand driven research. Euphytica 155: 349-360.

Central Statistical Agency (CSA), 2012 and 2016. Agricultural sample survey report on area and production of major crops, Addis Ababa, Ethiopia.

International Center for Tropical Agriculture (CIAT) 1987. Standard system for the evaluation of bean germplasm. Van Schoonhouen A. & Pastor-Corrales M. A. (compilers). Cali, Colombia.54pp.

Ddamulira, G., Mukankusi, C., Ochwo-Ssemakula, M., Edema, R., Sseruwagi, P. & Gepts, P. 2014a. Identification of new sources of resistance to angular leaf spot among Uganda common bean landraces. Canadian Journal of Plant Breeding. 2(2): 55-65.

Ferris, S.& Kaganzi, E. 2008. Evaluating marketing opportunities for haricot beans in Ethiopia. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 7. ILRI (International Livestock Research Institute), Nairobi, Kenya. 68pp.

Fekadu, G. 2013. Assessment of Farmers' Criteria for Common Bean Variety Selection, the case of Umbullo Watershed in Sidama Zone of the Southern Region of Ethiopia. Ethiopian e-journal for research and innovation sight. 5(2): 4-13.

Halaba district Bureau of Agriculture and Natural Resources Development Office (BoANRDO), 2016. Annual crop production progress report.

Mekibi, F. 1997. Farmer participation in common bean genotype evaluation: The case of Eastern Ethiopia. ExplAgric, 33: pp399-408.

Mekuria, A. 2015. UNIQUE Forestry and Land Use and Kulima Integrated Development Solutions Good Agricultural Adaptation Practices in Ethiopia. www.kulima.com/agriculturaladaptation

Ministry of Agriculture and Natural resource (MoANR) 2012 and 2016, Animal and Plant Health Regulatory Directorate crop variety register, ISSUE No. 15 and 19, Addis Ababa, Ethiopia.

Mulu, A., Andargachew, G. and Hussein, M. 2016. Participatory variety evaluation of red common bean in Borecha district of Southern Ethiopia.Adv crop sci tech: 4.

Pamela, P., Mawejje, D. & Ugen, M. 2014.Severity of angular leaf spot and rust diseases on common beans in Central Uganda. Uganda Journal of Agricultural Sciences, National Crops Resources Research Institute, Namulonge, Kampala, Uganda.15 (1): 63 – 72.

Salcedo, J.M. 2008. Regeneration guidelines: common bean. In: Dulloo M.E., Thormann I., varietal selection, a case study in India. Exp. Agric. 32: 461-477.

Tamene, T & Tadesse, G. 2014. Sites Regression GGE Biplot Analysis of Haricot Bean Genotypes in three Contrasting Environments. *World Journal of Agricultural Research*. 2(5): 228-236.

Tafere, M., Tadesse., D & Yigzaw,. D. 2012. Participatory varietal selection of faba bean for yield and yield components in Dabat district, Ethiopia. Wudpecker Journal of Agricultural Research. 1(7): 270-274.

Teame, G., Ephrem, S. & Getachew, B. 2017. Performance evaluation of common bean varieties in Raya Valley, Northern Ethiopia, African Journal of Plant Science. 11(1): 1-5.

Tesfaye, A and Amin, M. 2014. The Chemical Management of Weeds in Common Bean. Greener Journal of Agricultural Sciences. 4(7):288-294

Teshale, A., Girma, A., Chemeda, F., Bulti, T., Abdel-Rahman M. and Al-Tawaha, 2005. Participatory Bean Breeding with Women and Small Holder Farmers in Eastern Ethiopia World Journal of Agricultural Sciences 1 (1): 28-35.

Wondwosen, W. & Tamado, T. 2017. Yield Response of Common Bean (*Phaseolus vulgaris* L.) Varieties to Combined Application of Nitrogen and Phosphorus Fertilizers at Mechara, Eastern Ethiopia. J Plant Biol Soil Health. 4(2): 1-7.