Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 16 Issue 7 Version 1.0 Year 2016
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

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Keywords: *common bean, yield, stability, environment, interaction.*

GJSFR-D Classification : FOR Code: 079999

EVALUATIONOFREDCOMMONBEANPHASEOLUSVULGARISLGENOTYPESFORYIELDANDYIELDTRAITSINBORECHADISTRICTOFSIDAMAZONESOUTHERNETHIOPIA

Strictly as per the compliance and regulations of :

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Abstract- Eight red common bean varieties were evaluated in Borecha district of Sidama Zone using Randomized complete block design replicated in four villages. Phenotypic traits such as yield and yield component was measured and evaluated. Significant ($P < 0.05$) to highly significant ($P < 0.01$) were observed in days to 50% flowering, days to 95% physiological maturity, plant height, Biomass, grain yield, pod length, pod per plant, 100 seed weight, seed per pod and branch per plant. Genotypes yield stability across the villages was estimated by Additive Main Effects and Multiplicative Interaction Analysis (AMMI). The genotype named 'Nasir' is stable variety across the villages (environment). However, Dimtu and Hawassa dume was stable and out performed at village 1 & 3 even if high environment interaction was observed on village 4.

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I. Introduction

Common bean is the most important crop for soil health due its excellent biological nitrogen fixation and food security crops for its source of starch, protein, dietary fiber, minerals and vitamins (Broughton, 2003). It is also an important source of income for the farmers and an export commodity that generates foreign currency for the country. It ranks third as an export commodity in Ethiopia, contributing about 9.5 % of total export value from agriculture (FAOSTAT, 2010). In Ethiopia Production ranges 100-200 thousand tons per year with yield highly dependent on rain fall. Given current trends of climate change and bean consumption as well as demand in increase of bean market, the productivity of local variety is limited due to biotic and a biotic factor. For instance, *'Red woliata'* Borecha district popular common bean landraces have passed many generations of natural and human selection for end-use quality and found to be low yielding and susceptible to pest (farmer's personnel communication). The average national yield of common bean in Ethiopia is estimated at 1300kg/ha on smallholder farms in contrast to a production potential of 3000 to 4000kg/ha in research field (Darkwa *et al., 2016)*. The yield gap is partly due to lack of information for farmers to use improved genotypes released from research centers.

As reported by Katungi *et al.* (2009) through Ethiopian national bean breeding program number of common bean varieties had been released since 1970s and 2009. However, a few varieties (i.e. Mexican 142 and Red wolaita) released in early 1970s still dominate the area allocated for common bean production in Ethiopia. For instance, Mexican 142 occupy 50 percent of area allocated to common bean in the central rift valley, while Red wolita accounts for about 70 percent of area allocated for common bean production in Southern Nation and Nationalities peoples Regional state.

According to this report, the improved varieties of 1990s (i.e Awash one, Awash melka) provided farmers with little incentive to switch from Mexican 142 to new varieties. They were either inferior to Mexican 142 in important market traits (e.g Awash melka) or not significantly different (e.g Awash one). The study further indicates that within the more recently released varieties and evaluated by a significant number of farmers, Argene (also referred to as AR04GY released in 2005) demonstrate a high potential to replace Mexican 142 because it is equally as good as Mexican 142 in terms of market traits while outperforms it in terms of yield.

Hence, the best way to minimize the yield gap is to conduct on farm evaluation of improved genotype so that the yield is enhanced and smallholder farmers get the full benefit. Therefore, the present study is conducted to evaluate on farm performance of red common bean for yield and yield traits potential and to identify the best yielding variety to be used by Kayyo seed producer cooperative in Borecha district.

II. Materials and Methods

a) *Descriptions of Experimental site*

The experiment was conducted in four villages of Borecha district namely Sidamo chala, Shello Belela, Shello Abore and Hanja Goro in 2010/2011 cropping season. The altitude of the site lies within the range of

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1710 to 1900 m asl. Centre of the village is located at 06^0 56.454'N and $38^0$15.175'E. The average annual rainfall is 700mm and annual temperature is 17.6-22.5^{0}C (LSB, 2010).

b) Experimental design and trial management

Pre released common bean varieties were planted on four *village* of Borecha *district*. The trial consists of seven improved genotypes and one locally popular variety as a control. The experimental design used was RCB design; where seed producers' villages were used as replications. Before planting, the land was oxen ploughed three times. At each *village* seven genotypes with their local control were grown on plot size of 324m^2 by dividing the plots in to six rows for each variety (with 40 cm between rows and 10 cm plant spacing). Two seeds were sown per hole and 10 days after emergency it was thinned. DAP was applied with rate of 100kg per hectare and weeding was carried out three times.

c) Common bean Traits measurement

i. *Traits measurement from plot basis*

Understated plot based traits were measurements from the two central rows.

1. Days to flowering: Days from planting up to the time when 50% of plants bear flower.
2. Days to physiological maturity: Days from planting up to the time when 95% of plants matured.
3. Hundred seed weight: weight of 100 seeds in gram drawn randomly from the bulk of seeds of each plot when seed moisture content was adjusted to10.5%.
4. Biomass yield: determined by weighing the total sun dried above ground biomass of plants in the two middle rows per plot.
5. Grain yield: grain yield in kilogram of plants from the three middle rows adjusted to 10.5% moisture level
6. Harvest index: Calculated as the ratio of grain yield to above ground biomass measured at physiological maturity.

ii. *Common bean traits measurement from single plant basis*

Plant based traits were measurements from six randomly sampled plants of the two middle rows on each plot.

1. Number of branches per plant: The numbers of primary branches of six randomly taken plants from each of the two middle rows excluding the main plant were counted at maturity and the average was taken per plot.
2. Pod length: pod length from base to tip of four random pods from each of ten random plants per plot was measured and expressed as average of ten plants per plot.
3. Pods per plant: Average number of mature pods, counted at harvest on 6 randomly taken plants.
4. Number of Seeds per pod: Average number of seeds per pod, counted at harvest on 6 randomly taken plants, in five randomly taken pods per plant.
5. Plant height (cm): Length of the central axis of the stem, measured from the soil surface up to the tip of the stem
6. Hundred Seed weight: the weight of 100 seeds in gram per plant was taken at moisture of 10.5%.

d) Statistical Analysis

Combined analysis of variance over each village was done as per Gomez and Gomez, (2004) using PROC GLM SAS software version 9.0 (SAS, 2002). The villages (as replication) and varieties were used as fixed variables, therefore fixed model was used. Mean separation was done by Duncan Multiple range test (DMRT) at probability level 0.05. Correlation analysis was carried out to determine association of yield to its components. Phenotypic correlation was computed by PROC CORR of SAS software.

e) Stability analysis for grain yield

Stability statistics for the grain yield were computed by SAS GLM procedures using a program written by Hussein *et al*., (2000). Angles between environment vectors were used to judge correlations (similarities/dissimilarities) between pairs of environments (Yan and Kang, 2003). It is important to identify and select genotypes with consistent (stable) performance across diverse environments (broad adaptation). The results can be graphed in a useful bi-plot that shows both main and interaction effects for both genotypes and environments (Guach and Zobel, 1998).

III. Result and Discussion

a) Phenological parameters and Growth Parameters

A very highly significant difference was observed between varieties for days to flowering and physiological maturity (Table 1). Varieties Dinkinash, Omo-95, Nasir, Hawassa dume, Dimtu and Red woliata flowered later than Melka dima and Ibado (Table 2). Kassu, (2009) and Daniel, (2007) made similar observation on different common bean varieties. The observed difference in days to flowering and maturity were due to varieties difference in genotypic makeup, as common bean show variability in growth habit, seed characteristics, maturity and adaptation.

Table 1 : Variation of red common bean genotypes for crop phenology and growth parameters

	Source of Variation			
Traits	Replication (df=3)	MSv(df=7)	MSe (df=21)	CV
Days to flowering (no. days)	43.91***	28.57***	1.79	2.92
Days to maturity (no. days)	11.19^{ns}	67.74***	6.05	2.70
Plant height (cm)	1021.56 ***	643.55***	142.62	21.92
Pod length (cm)	1.23**	2.80***	0.25	4.91
Branch per plant	0.31^{ns}	0.54*	0.16	10.79

df =degree of freedom, MSv =mean square of variety, MSe=Mean square of error

CV= coefficient of variation

There was a very highly significant genotypic difference in plant height and pod length (Table 1). The mean values of plant height ranged from 45.30 for Ibado to 83.12cm for Omo-95 (Table 2). Kassu, (2009) observed the same result for Omo-95 for plant height. The highest plant height observed for Omo-95 was due to the climbing nature of the variety. Significant association (r=0.437*) of plant height was observed with number of pods per plant (Table 5). The highest pod length (12.00) was recorded for Ibado and the lowest (9.09) for Nasir. The differences in plant height and pod length between varieties were due to genotype and environment.

Significant difference was observed between varieties for branch per plant (Table 1). The result was in contrast of Amanullah and Asim (2011), who reported insignificant variation between common bean germplasm collected from Pakistan. Significant difference observed across location (replication across villages) for days to flowering, plant height and pod length was due to variability in growing environment. Insignificant difference between replication for days to flowering might be due to offset of rainfall in the villages at the same time.

Table 2 : Means of common bean genotypes for crop phenology and growth parameters

Varieties	Days to flowering	Days to maturity	plant height	Pod length	Branch per plant
Melka dima	41.00e	88.25cd	45.74b	10.84b	4.00ab
Dinkinash	45.0dc	93.75b	57.81b	10.00bc	3.16c
Omo-95	48.00ab	87.00d	83.12a	10.03bc	3.78abc
Nasir	46.00bc	88.25cd	47.24b	9.09d	3.50
Ibado	43.25d	98.75a	45.30b	12.00a	3.83ab
Hawassa dume	47.00abc	91.00cb	48.60b	10.21bc	4.16a
Dimtu	48.00ab	87.50cd	49.15b	10.02a	4.21a
Redwoliata[1]	48.75a	93.75b	58.80b	10.16bc	3.44
CV	2.92	2.70	21.92	4.91	10.79

1= control cv=coefficient of variation

b) Yield and yield components

Significant difference was number of pods per plant was observed among common bean varieties (Table 3). Dimtu and Hawassa dume produce highest mean number of pods per plant while the lowest was produced by Red woliata (Table 4). The observed difference in number of pod per plant was probably due to their genetic potential. Difference in productivity is primarily associated with number of pods per plant as observed from their significant correlation (r=0.667**) and (r=0 .646**) for biomass yield, grain yield respectively (Table 5). Similarly, Daniel (2007) observed significant correlation between common bean cultivars at Awassa and Tefera (2006) observed differences in number of pods per plant among haricot bean cultivars at Eastern Ethiopia. Seed number per pod was highly significant among varieties and insignificant across location (Table 3). The range was from 4.85 for Melka dima and 6.60 for Omo-95. Hundred seed weight was negatively correlated (r=-0.617**) with number of seed per pod (Table 5). Thus there is evidence that selection for a larger number of seeds per pod increase grain yield and decrease seed size.

Varieties showed significant difference in 100 seed weight (Table 3). The highest hundred seed weight of 42 and 40.60 g was recorded from Ibado and Melka dima respectively. Lowest hundred seed weight was recorded from Dinkinash (18.40 g), Omo-95 (18.55 g) and Red woliata (control) (19.13 g). The highest difference was observed was due to maximum seed size nature of the varieties which was actually influenced by growth environment (Gallagher *et al*., 1975).

Table 3 : Mean square values for yield components, grain yield, biomass yield, and harvest index

Traits	location (df=3)	MSv(df=7)	MSe (df=21)	CV
Pod per plant	362.43**	116.30**	47.34	23.90
Seed per pod	0.47^{ns}	1.38 **	0.37	10.03
100 seed weight (g)	16.26*	371.92**	4.09	7.73
Biomass yield (kg)	8137196.01**	16412925.96**	2483466.6	33.00
Grain yield (kg)	3277475.52**	2074856.63**	473941.22	32.80
Harvest index	6.62^{ns}	2.27^{ns}	0.40	26.74

df =degree of freedom, MSv =mean square of variety, MSe=Mean square of error

CV= coefficient of variation

Biomass: Significant differences have been observed for shoot biomass accumulation among common bean varieties (Table 3). Highest biomass yield was obtained from Hawassa dume (6770.83kg/ha) while the lowest (2317.70 kg/ha) was from Red woliata (Table 4). Similar observation was made by Daniel, (2007) in which Red woilata was resulted in lower biomass than Awash-1 at Awassa. There was a positive and significant correlation of biomass yield with grain yield (r=0.834**), plant height (r=0.375*), pod per plant (r=0.667**) and branch per plant (r=0.441*) (Table 5). Shoot biomass accumulation was considered as important trait to attain high seed yield in grain legumes (Saxena *et al*., 1990).

Grain yield: Significant cultivar differences were observed for grain yield (Table 3). Highest grain yield of (3098.95kg/ha) and (3046.87kg/ha) was obtained from Hawassa dume and Dimtu respectively. Whereas the lowest mean grain yield (1093.74 kg/ha) was obtained from local check Red woliata (Table 4). In larger extent biomass yield, plant height, pods per plant, and branch per plant were determined the differences in yielding levels of tested genotypes. There was positive and significant correlation of grain yield with biomass yield (r=0.834**), plant height (r=0.375*), pod per plant (r=0.667**) and branch per plant (r=0.441*) (Table 5). Greater productivity of the varieties may have been partly associated with growing environment. In contrast to Kebere *et al*., (2006), positive correlation coefficients were obtained for grain yield with pod per plant (r=0.667**) and branch per plant (r=0.589**); however, pod length, hundred seed weight and seed per pod did not show association with grain yield (Table 5). Several authors also observed lack of association between grain yield and hundred seed weight of different crops (Riggs *et al.,* 1981; Waddington *et al.,* 1987; White and Izquierdo, 1991; Tarekegne, 1994; Teklu, 1998).

Harvest index: Differences in harvest index were insignificant among varieties (Table 3). The mean harvest index of Melka dima and Hawassa dume was high (0.50 and 0.53) respectively (Table 4), which was probably associated with greater shedding of leaves aggravated by high temperature, occurred around maturity before harvesting. Likewise, higher harvest index value of 0.59 for chickpeas (Saxena *et al*., 1983) was reported as the result of greater loss of leaves before measurements. However, harvest index was insignificant between genotypes which were the same with finding of Daniel, (2007). Harvest index was positively correlated with biomass and insignificantly correlated with grain yield (Table 5). Similarly, Laing *et al*., (1984) on haricot bean, Salado-Navaro *et al*., (1993) on soybean and Teklu (1998) on teff found positive correlation between grain yield and biomass yield but no correlation between grain yield and harvest index. In contrast, no relation between grain yield and biomass yield and positive association between grain yield and harvest index were reported on bread wheat (Tarekegne, 1994). Other authors also reported grain yield to have positive association with both biomass yield and harvest index (Riggs *et al*., 1981; Waddington *et al*., 1987; Perry and D' Antuono, 1989). Hence, the result reported herein indicated that grain yield improvement resulted from biomass production rather than the harvest index. These findings suggest that the characters showing positive correlation could effectively utilized in crop improvement program and develop new common bean genotypes.

Table 4 : Means of genotypes for yield components, grain yield, biomass yield and Harvest index

Varieties	Pod per Plant	Seed per pod	100 seed weight	Biomass yield	Grain yield	Harvest index
Melka dima	25.98bc	4.85b	40.60a	3880.20bc	1943.55bc	0.50ab
Dinkinash	26.60bc	6.20a	18.40c	3802.08bc	1432.29bc	0.38ab
Omo-95	30.84abc	6.60a	18.55c	5677.08ab	1718.75bc	0.30b
Nasir	25.23bc	6.13a	23.20b	4322.91bc	2031.24bc	0.47ab
Ibado	26.04bc	5.59ab	42.00a	5442.70ab	2421.87ab	0.44ab
Hawassa dume	35.45ab	6.43a	22.47b	6770.83a	3098.95a	0.46ab
Dimtu	37.78a	6.27a	24.90b	5781.25ab	3046.87a	0.53a
Red woliata[1]	22.37c	6.55a	19.13c	2317.70c	1093.74c	0.47ab
CV	23.90	10.03	7.73	33	32.80	26.74

1= control CV=coefficient of variation

Table 5 : Correlation (r) analysis between common bean traits

	BM	GY	HI	PH	PL	PPP	HSW	SPP	PPP	DF
BM										
GY	0.834**									
HI	-0.263	0 .248								
PH	0.375*	0.030	-0.365*							
PL	0. 287	0.244	-0.002	0.149						
PPP	0.667**	0 .646**	0.047	0.437*	0.189					
HSW	0.105	0 .209	0.075	-0.313	0.627**	-0.059				
SPP	0.287	0.156	-0.185	0.423*	-0.223	0.346	-0.617**			
BPP	0.441*	0.589**	0 .143	-0.080	0.207	0.437*	0.145	-0.002		
DF	0.043	0.100	0.059	0.164	-0.473**	0.034	-0.579**	0.420*	0.171	
DM	0.14	0.014	0.078	-0.067	0.562**	-0.093	0.232	0.008	-0.100	-0.155

*BM=Biomass, GY=Grain Yield, HI=Harvets Index, PH=Plant height, PL= Pod Length, PPP=Pod per plant,HSW=Hundred seed weight, SPP= Seed per Pod, BPP=Branch Per plant, DF=Days to flowering, DM=Days to maturity, *,**, *** ,significant, highly significant and very highly significant respectively*

c) *Grain Yield Stability*

Since the presence of genotype environment interaction (GEI) effects hinder the identification and recommendation of genotypes over wide environments, performing stability analysis to identify stable genotypes based on the traits of interest is crucial. Several statistical models including uni-variate and multivariate have been developed to evaluate genotype stability. This paper concentrates on the most popular one, the AMMI model. Grain yield stability analysis was conducted for eight genotypes of common bean.

Variability in yield and interaction principal components (IPCA 1) of environments and genotypes are presented on (Figure 1). According to this IPCA 1, two environments (village) Shello Balela and Hanja Goro are high yielding environments that were favorable for the for common bean production. The remaining two environments, Shelo Abore and Sidamo Chala were the lowest yielding environments that were the least favorable to the tested genotypes.

Highest yield was obtained from Hawassa dume and Dimtu at village 1, 3 and 4. Variety located near to origin of the plot was less responsive than the vertex variety (Figure 1). Accordingly, Nasir is stable variety in all villages. Red woliata and Melka dima are found outside the vertex which indicates unstable of the nature varieties. Villages 1 and 3 near to the origin and relatively exhibit low interaction with varieties. Such environment is good for variety selection with average adaptation. Villages 2 and 4 show high interaction with varieties which is not good for variety selection.

Variety located near to origin of the plot is stable and less responsive than the vertex variety (Figure 1). Genotype named 'Nasir' is found near to the vertex, so that it is the stable variety in all villages. Red woliata and melka dima are found outside the vertex which indicates unstable nature of the varieties. Villages 1 and 3 near to the origin and relatively exhibit low interaction. These environments are good for variety selection with average adaptation. Villages 2 and 4 show high interaction with varieties which is not good for variety selection.

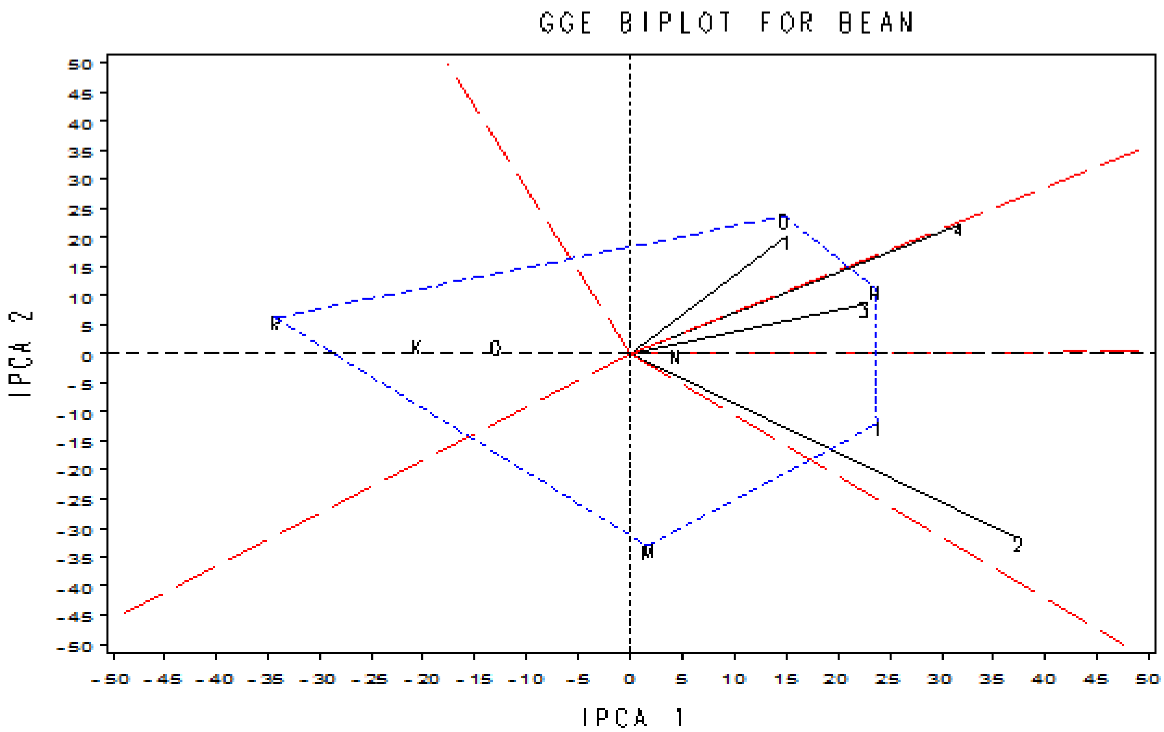

Figure 1 : Grain Yield biplot of 8 genotypes and four environments

1– 4 are the four villagess; D – Dimtu, H- Hawassa Dume, I – Ibado, N – Nasir M – Melkadima, K – Dinknesh, O – Omo95, R – Red Wolayita)

IV. Conclusion and Recommendation

A significant genotype difference was observed for days to flowering and days to physiological maturity. Hawassa dume, Dimtu and Melka dima were matured than other genotypes. The analysis also indicated a significant difference regarding plant height and pod length. The mean values of varieties for plant height ranged from 45.30 for Dimtu to 83.13 cm for Omo-95. The maximum pod length 12.0 was recorded for Ibado while the minimum 9.03 cm was for Nasir. Significant different was observed among genotypes for branch per plant. Positive correlation was observed between branch per plant and pod per plant (r=0.437*), biomass yield (r=0.441*) and grain yield (r=0.589**) indicating greater impact of branch per plant on yield and yield components. These finding suggest that the characters showing positive correlation could effectively be utilized in crop improvement program and develop new common bean varieties.

Significant different among genotypes were observed for number of pods per plant, 100 seed weight, biomass yield and grain yield. Highest pod number per plant was obtained from Dimtu and Hawassa dume. Following the same trend, relatively highest grain yield was obtained from Hawassa dume (3098.95kg/ha) and Dimtu (3046.87kg/ha). The lowest pod per plant and grain yield (1093.74 kg/ha) was obtained from Red woliata (local check). However, best yield performance alone could not be enough to recommend varieties across environments. Since significant genotype environment interaction effects were observed for most of the traits studied, there should be stability analysis to identify the most stable varieties across the test environments and unstable varieties for narrow adaptation. There for stability analysis is conducted for grain yield which is major traits of interest for common bean users using the most popular stability analysis; AMMI. Accordingly, one variety called Nasir was identified as stable for grain yield. The two top yielding varieties, Hawassa dume and Dimtu were found to be unstable and could be recommended for narrow adaptation (village 1, 2 & 3)

V. Acknowledgements

The authors acknowledge financial support of Local seed Business Project of Hawassa University to conduct this study. Authors are also grateful to Ministry of Education and farmers who participated on the study.

References Références Referencias

1. Amanullah and Asim Muhammad. (2011). Evaluation of common bean germplasm collected from the neglected pockets of Nothwest Pakistan at Kalam (SWAT). *Pak. J. Bot*. 43(1): 213-219
2. Broughton W.J., G.Hernadez, W.W.Blair, S.E.Beebe, P.Gepts. J.Vanderleyden, (2003). Beans (*Phaseolus Spp.)* Model food legumes, Plant Soil 252 (55-128)

3. Daniel Assefa G/Giorgis. 2007. Response of Haricot bean (*Phaseoulus vulgrais L.*) cultivars to shading Awassa. M.SC Thesis. Hawassa University. Ethiopia. 140 pp
4. FAO. (2010). Food and Agriculture Organization of the United Nations. Statistical database. http://faostat.fao.org/default.htm.
5. Gallagher, J.N, P.V. Biscoe and R.K. Scott. 1975. Barley and its enviroemtn.V. Stability of grain weight. *Journal of Applied Ecology* 12:319-339.
6. Guach, H.G. and R.W. Zobel. (1998). Predictive and postidictive success of statistical analysis of yield trials.*Threo.Appl.Genet.*76:1-10.
7. Hussein, M.A., Bjornstad, A. and Aastveit, A.H. (2000). Sasg x estab, A SAS Program for Computing Genotype x Environment Stability Statistics. *Agronomy Journal* 92:454–459.
8. Kassu Kaske Kacharo. 2009. Effect of population density on yield and yield component of Haricot bean (*Phaseoulus vulgarias* L.) varieties at Damot Gale Woreda, South Ethiopia. M.Sc Thesis.Hawassa University. Ethiopia. Pp .
9. Kebere Bezaweletaw, Ketema Belete and Prapa Sripichitt. (2006). Genetic Gain in Grain Yield Potential and Associated Agronomic traits in Haricot Bean (*Phaseolus vulgaris* L.). *Kasetsart J. (Nat. Sci*.) 40: 835 – 847
10. Laing, D.R., P.G. Jones and J.H.C. Davis. (1984). Common bean (*Phaseolus vulgaris* L.), pp. 305-351.*In* P.R. Goldsworthy and N.M. Fisher (eds.). *The Physiology of Tropical Field Crops*. John Wiley, New York.
11. Local Seed Business (LSB) Project. (2010). Documentation and analysis of Kayyo Innovation Site. (Unpublished).
12. Perry, M.W. and M.F.D'Antuono.(1989).Yield improvement and associated characteristics of some Australian spring wheat cultivars introduced between 1960 and 1982. *Aust. J. Agric. Res.* 50: 457-472.
13. Riggs,T.J., P.R. Hanson, N.D. Start, D.M. Miles, C.L. Morgan and M.A. Ford. (1981). Comparison of spring barley varieties grown in England and Wales between 1880 and 1980. *J. Agric. Sci. (Camb.)* 97: 599-610.
14. Saxena, N.P., M. Natarajan and R.S. Reddy. (1983). Chickpea, pigeon pea and groundnut, pp. 218- 305. In Potential Productivity of Field Crops under Different Environments. IRRI, Los Banos.
15. Saxena, C.M., S.N. Silim and B.K. Singh. 1990. Effects of supplimaentary Irrigation during reproductive growth on winter and spring chickpea (*Cicer arientinum*) in a Mediterranean environment. *Journal of Agricultural Science* 114:285-293.
16. Tafere Taddale. 2006. Yield of common bean cultivars under semi-arid conditions. *Journal of Agronomy and crop Science*.188:212-218.
17. Tarekegne, A. 1994. Yield Potential of Rainfed Wheat in the Central Highlands of Ethiopia. M.Sc. Thesis. Alemaya University of Agriculture, Alemaya, Ethiopia.
18. Teklu Y. 1998. Genetic Gain in Grain Yield Potential and Associated Agronomic Traits of Tef (*Eragrostis tef* (Zuss) Trotter). M.Sc. Thesis. Alemaya University of Agriculture. Alemaya, Ethiopia.
19. Salado-Navarro, L.R., T.R. Sinclair and K. Hinson. 1993. Changes in seed yield and seed growth traits in soybean cultivars released in southern USA from 1945 to 1983. *Crop Sci.* 33: 1204-1209.
20. SAS (Statistical Analysis System). 2004. Statistica Method. SAS Institute, Inc., Cary, N. C., USA.
21. Waddington, S.R., M. Osmanzi, M. Yoshida and J.K. ransom. 1987. The yield of durum wheats released in Mexico between 1960 and 1984. *J. Agric. Sci*. (Camb.) 108: 469-477.
22. White, J.W. and J. Izquierdo.1991. Physiology of yield potential and stress tolerance, pp. 287- 382. *In*: A. Van Schoonhoven and O. Voysest (eds.). Common Bean: Research for Crop Improvement. C.A.B. International. Nillingford, UK.

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