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Genetic Progress for Yield and Yield Componnts of Small Seeded Food and Canning Types of Common Bean (Phaseolus Vulgaris L.) in Ethiopia

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Abstract
Twenty common bean (Phaseolus vlgaris L.) varieties that were released from 1973 to 2014 were evaluated as small seeded food and canning types of common bean varieties. The objectives of this study was to estimate the genetic progress made in improving yield potential of common bean in Ethiopia, to assess changes in associated traits in the genetic improvement of common bean varieties in last 40 years and to asses common bean varieties reaction to anthracnose disease. The study was conducted at two locations, Bako and Gute during 2014/2015 cropping season in randomized complete block design with three replications. The VXL interaction was highly significant different for biomass yield, days to maturity, number of seeds plant^{-1}, grain filling period and biomass production rate and significantly different for grain yield, anthracnose disease severity, yield gram plant^{-1}, seed growth rate and grain yield day^{-1}. The highest mean grain yield was 2601 kg ha^{-1} for Waju variety, and the lowest was for Argane, 217.3 kg ha^{-1} the grand mean being 1472.3 kg ha^{-1}. The annual rate of genetic progresses for grain yield was 10.56 kg ha^{-1} (0.19%). Generally, canning type varieties were more attacked by anthracnose disease during the study season. Grain yield day^{-1} explained more for the variation of grain yield; 85.1%. Anthracnose disease severity was played the major role as grain yield not respond significant increment by -26.4% from stepwise regression results.
Keywords: Anthracnose disease severity, Canning type, Genetic progress, Relative genetic gain, Stepwise Regression

1. INTRODUCTION

Common beans are grown throughout Ethiopia and are increasingly important commodity in the cropping systems of smallholder producers for food security and income. Among the total grain crops cultivated in the area of 12,407,473.46 ha and production of (251,536,62.39) tones, the share of pulse crops are 1,742,602.19 ha and yield 28,58880.59 tones in Ethiopia . the central part of the country, mainly the Rift Valley and lake areas rank first in coverage of land (48 %) and production (55 %) of low land pulses in Ethiopia. This part is particularly important for the white pea beans that are desired for export markets. Common bean production is constrained by several environmental stresses. Biotic (field and post-harvest pests and diseases) and a biotic (drought, excessive rain/flooding, poor soil fertility, heat and cold stress), each of which causes significant reductions in yield estimated that yield loss (tones year^{-1}) due to drought, nitrogen deficiency and phosphorus deficiency were 396000**,** 389900 and 355900, respectively. While losses due to angular leaf spot, anthracnose and bean stem maggot were 384200, 328000 and 297100 tones every year, respectively. Stresses such as poor soil fertility are long term and predictable , while others like drought, some pests and diseases spurred by climate change could be short-term, but acute in nature.

Knowing the Information on genetic progress achieved over time from a breeding program is absolutely essential to develop effective and efficient breeding strategies by assessing the efficiency of past improvement works in genetic yield potential and suggest on future selection direction to facilitate further improvement ; ; . Progress made in genetic yield potential and associated traits produced by different crops improvement program and the benefits obtained have been evaluated and documented in different crops in Ethiopia concluded that genetic improvement have produced modern cultivars with improved yield potential. , ; ; on faba bean; on wheat; on tef and on barley. Therefore, the objectives of the study were:-To estimate the genetic progress made in improving yield potential of common bean varieties; to assess changes in associated traits in the genetic improvement of common bean varieties released in Ethiopia, and to assess common bean varieties reaction to anthracnose disease.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The experiments were carried out at two locations, i.e. Bako and Gute, West Shoa Zone of Oromia Regional State, located 250 and 316 (km) to the west of Addis Ababa respectively. The weather (temperatures and relative humidity) and edaphic conditions of the test locations are summarized in Table 1

Table1. Description of the test locations for geographical position and physico-chemical properties of the soils

Parameter		Locations	
		Bako	Gute
Geographical position	Latitude	$09^0$6'N	$09^0$5'30,N
	Longitude	$37^0$09'E	$36^0$42'0'E
	Altitude (m.a.s.l.)	1650	1918
Edaphic characters	Soil type	Utisols	Nitosols
	Soil pH	4.8-5.8	4.5-5.5
Weather characters	Minimum temperature (^{0}C)	13.5	25
	Maximum temperature (^{0}C)	28.5	30
	Mean temperature (^{0}C)	21	27.5
	RH (%)	48.4	57.3
	Annual rainfall (mm)	1067.1	1350

Source: Meteorological Data of Bako Agricultural Research Center (2014)

3.2. Experimental Materials

Twenty common bean varieties released between 1973 and 2014 from different Agricultural Research Centers in different regions of Ethiopia were used. Seeds of the test varieties were obtained from Bako, Melkasa, and Sirinka Agricultural Research Centers and Haramaya University. The detailed descriptions of the varieties used in the experiment are summarized in Tables 2

Table 2. Description of the food and canning types of common bean varieties with different seed size used in the study

Variety	Year of release	Seed size	Crosses/ seed sources	Major Use of the Variety
Mexican 142	1973	Small	MARC	Canning Type
Red wolayta	1974	Small	MARC	Food Type
Awash 1	1990	Small	MARC	Canning Type
Roba	1990	Small	MARC	Canning Type
Awash melka	1999	Small	MARC/EIAR	Canning Type
Tabor	1999	Small	SRARI	Food Type
Nasir	2003	Small	MARC/EIAR	Food Type
Omo 95	2003	Small	SRARI	Food Type
Melka dima	2006	Small	MARC/EIAR	Food Type
Anger	2005	Small	BARC/OARI	Food Type
Argane	2005	Small	MARC/EIAR	Canning Type
Nazreth 2	2005	Small	MARC/EIAR	Canning Type
Chore	2006	Small	MARC/EIAR	Canning Type
Chercher	2006	Small	HU	Canning Type
Awasa dume	2008	Small	SRARI	Food Type
Dame	2008	Large	EIAR/MARC	Canning Type
Dursitu	2008	Small	HU	Food Type
Tr 13	2012	Small	MARC	Canning Type
Waju	2014	Medium	SRARI	Canning Type
Ramada	2014	Small	SARI	Canning Type

Where BARC = Bako Agricultural Research Center, HU = Haramaya University, EIAR = Ethiopian Institute of Agricultural Research Center, OARI = Oromia Agricultural Research Institute, MARC = Malkasa Agricultural Research Center and SARI = Sirinka Agricultural Research Institute

3.3. Experimental Design and Field Management

The experiments were conducted at Bako and Gute using a Randomize Complete Block Design (RCBD) with three replications during the main cropping season of 2014. A plot of 6.4m^2 consisting of 4 rows of 4m length with 0.4m spacing between rows was used. A distance of 0.5m was maintained between plots and 1m between blocks. A seed rate of 70 to 80 kg ha^{-1} was used; 160 and 40 seeds were administered to each plot and each row, respectively. Fertilizer was applied at the rate of 100 kg ha^{-1} diammonium phosphate (18 kg N ha^{-1}, 46 kg p_2o5 kg ha^{-1} and 0 k) and all other crop management practices were carried out as recommended. The two middle rows were used for data collection.

3.4. Data Collection

3.4.1. Collected data on plot basis

Days to 50% flowering (DF): Number of days from planting to the date on which 50 % of plants on the two middle rows produced at least their first flower.
Days to 90% maturity (DM): The number of days from planting to the stage when 90 % of the plants in a plot have reached physiological maturity, i.e., the stage at which pods lost their pigmentation and begin to dry.
Grain filling period (GFP): The number of days between days to flowering and days to physiological maturity.
Hundred Seed weight (HSW): Weight of 100 seeds were counted from each plot and weighted.
Biomass yield (BMY): Determined by weighing the total air dried above ground biomass yield of plants in the two middle rows.
Grain yield per plot (GY): Grain yield in kilogram of plants from the two middle rows adjusted to 10 % moisture level and then it was converted to kg ha^{-1}.
Harvest index (HI): Proportion of dry grain yield to the above ground biological yield (biomass yield).

i.e. HI= $\frac{\text{Grain yield}}{\text{Biomass yield}}$

Biomass production rate (kg/ha/day) = $\frac{\text{Above ground biomass yield}}{\text{Days to physiological maturity}}$

Seed growth rate (kg/ha/day) = $\frac{\text{Grain yield (Kg/ha)}}{\text{Days to grain filling period}}$

Grain yield per day (kg/ha/day) = $\frac{\text{Grain yield (kg/ha)}}{\text{Days to physiological maturity}}$

Anthracnose : Anthracnose disease severity (1-9 scales) were pre transformed in to percentage values and then percentage values were Arc Sine transformed for statistical analysis .

3.4.2. Collected data on plant basis

Plant height: The height of five randomly taken plants from each of the two middle rows were measured from the ground level to the tip of the plant at maturity and expressed as an average of five plants per plot.
Number of pods per plant: The number of pods per plant was counted from five randomly taken plants from the middle two rows and expressed as an average for each plot.
Number of seeds per pod: Number of seeds was counted from five random pods from each of five randomly taken plants per plot and expressed as an average of five plants per plot.
Number of seeds per plant: It was determined by multiplying the number of pods per plant and number of seeds per pod.
Grain yield per plant: The average seed yield in grams obtained from five randomly selected plants in each plot**.**

3.5. Statistical Analysis

All the measured variables were subjected to analysis of variance following Gomez and Gomez (1984). The General Linear Model (GLM) of SAS Statistical Package Version 9.2 Software (SAS, 2009) was employed for the analysis. The following model was used for computing the analysis of variance.
For over location Anova = $p_{ijk} = \mu + b_i + v_j + l_k + (vl)_{jk} + e_{ijk}$
Where p_{ijk}= phenotypic observation on variety j in block i at location k (i = 1…B, j = 1…V, and k = 1…L) and B, V and L stand for number of blocks, varieties and location, respectively, μ = grand mean, b_i= the effect of block i with in location k, v_j = the effect of variety j, l_k = the effect of location k, $(vl)_{jk}$ = the interaction effect between variety and location, and e_{ijk} = error.
For individual location Anova = $Y_{ij} = \mu + V_i + B_j + e_{ij}$
Where: Yij = observed value of variety i in block j, μ= grand mean of the experiment, Vi = effect of variety i, Bj = effect of block j, eij = error effect of variety i in block j.
Least significant difference (LSD) was used to separate treatment means when analysis of variance showed significant differences at 5% probability level. Least significance difference means for significantly different interaction effects were separated by SAS model (P = 0.05).
The homogeneity of error mean squares between the two locations were tested by F test on variance ratio and combined analyses of variance were performed for the traits whose error mean squares were homogenous (when the error mean square of one location less than by three fold the error mean square of the second location) using PROC GLM procedure of SAS.
The annual rate of genetic gain achieved from past breeding efforts in grain yield and the associated agronomic

traits was calculated by regressing the mean performance of each variety on the year of release (expressed as the number of years since 1973) for that variety.
The relative annual gains achieved over the years of releases in different characters were determined as the ratio of annual genetic gain, which was estimated from regression to the corresponding estimated values of the oldest variety and expressed as percentage.

Annual rate of gain (b): $\frac{CovXY}{VarX}$

Where X = the year of variety release, Y = the mean value of each character for each variety, Cov = covariance and Var = variance.
Correlation coefficients among all characters were calculated using means of each character as:

Correlation coefficient between X and Y (r_{xy}): $\frac{Cov(X,Y)}{\sqrt{Var(X)Var(Y)}}$

Where r_{xy} = correlation coefficient between X and Y, Cov(X, Y) = covariance between X and Y, Var (X) = variance of X and Var (Y) = variance of Y.
Stepwise regression analysis was carried out on the varietal mean using PROC STEPWISE in MINITAB to determine those traits that contributed much for yield variation among varieties by using grain yield (response) as dependent variable and the other characters (predictors) as independent variable

4. RESULTS AND DISCUSSION

4.1 Analysis of variance

The combined analysis of variance of VXL interaction showed highly significant differences for biomass yield, days to maturity, number of seeds plant^{-1}, grain filling period and biomass production rate and significantly differed for grain yield, anthracnose disease severity, yield gram plant^{-1}, seed growth rate and grain yield day^{-1} (Table 3).

Table 3. Mean squares from combined analysis of variance of small seeded food and canning types of common bean varieties evaluated over 2 locations during 2014/2015 cropping season

Characters	Source of Variations					Mean	CV (%)	R^2
	Location (1)	Replication (2)	Variety (19)	VxL (19)	Error (38)			
Days to Flowering (DF)	**	NS	**	NS	1.7	41.2	3.2	0.93
Days to Maturity (DM)	**	*	**	**	0.96	86.6	1.1	0.91
Plant Height (PH)	**	NS	**	NS	106.53	61.2	16.8	0.75
Number of Pods Per Plant (NPPP)	**	NS	**	NS	7.35	12.9	21	0.70
Number of Seeds Per Pod (NSPP)	**	NS	**	NS	0.47	4.5	15.3	0.68
Number of Seeds Per Plant (NSPPT)	NS	NS	**	**	280.1	60.5	27.7	0.71
Pod Length (PL)	NS	NS	**	NS	8.80	8.4	35.2	0.57
Grain Filling Period (GFP)	**	NS	**	**	2.52	46.4	3.4	0.85
Yield in Gram Per Plant (YGPT)	NS	NS	**	*	16.2	13.1	30.7	0.76
Biomass Production Rate in kg ha^{-1} day^{-1} (BMPR)	**	NS	*	**	284.73	72.2	23.4	0.69
Biomass Yield in Kg ha^{-1} (BMY)	**	NS	**	**	2188439	6255.2	23.6	0.69
Seed Growth Rate in Kg ha^{-1} day^{-1} (SGR)	**	NS	**	*	76.28	31.5	27.7	0.85
Grain Yield Per Day in Kg ha^{-1} (GYD)	**	NS	**	*	23.64	17	28.5	0.85
Grain Yield in Kg ha^{-1} (GY)	**	NS	**	*	180041.7	1472.3	28.8	0.85
Anthracnose disease severity (ADSIV)	*	NS	**	*	0.97	33.2	30	0.89

CV = Coefficient of variation, R^2 = Coefficient of determination, VXL = Variety by location and numbers in the parenthesis showed degree of freedo

4.2 Performance of the Varieties

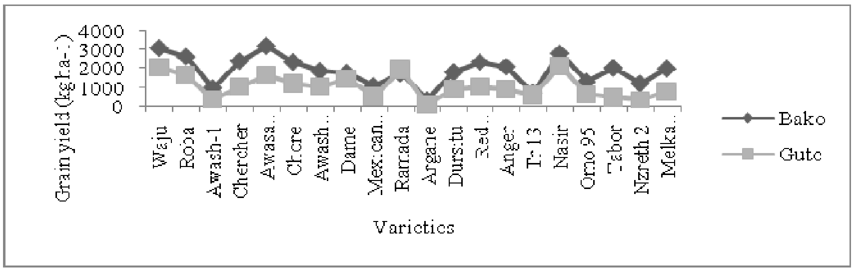
The combined mean grain yield performance of small seeded food and canning types of common bean varieties shown in (Table 4); it ranged from the lowest of 217.3 kg ha^{-1} for Argane variety to the highest of 2601 kg ha^{-1} for Waju, the grand mean being 1472.3 kg ha^{-1} (Table 4). The mean performance of biomass yield ranged from the lowest of 4479.2 kg ha^{-1} for Melka dima variety to the highest of 8177.1 kg ha^{-1} for Chore, the grand mean being 6255.2 kg ha^{-1} (Table 4). The mean performance of anthracnose disease severity ranged from the lowest of 10.14 % for three varieties (Nasir, Dame and Waju) to the highest of 80.9 % for Argane, with grand mean of 33.1 % (Table 4).

Table 4. Mean Performance of the varieties from combined analysis for some of the characters of small seeded food and canning types of common bean varieties at Bako and Gute.

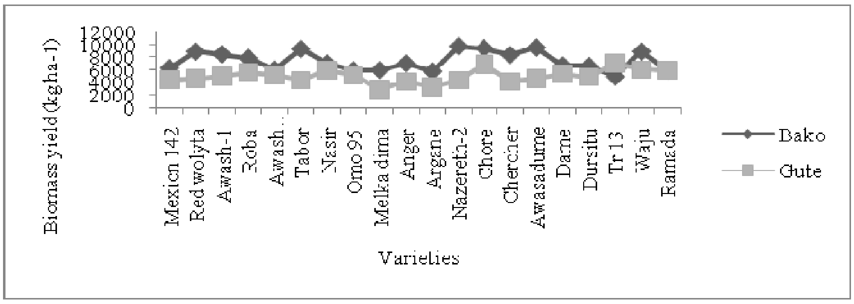
Varieties	Characters		
	Grain yield (kg ha^{-1})	Biomass yield (kg ha^{-1})	Anthracnose disease severity (%)
Mexican 142	809.4^{gh}	5416.7^{de}	63.82^{bc}
Red wolyta	1687.6^{b-e}	6770.8^{a-d}	15.2^{gh}
Awash 1	675.9^{hi}	6770.8^{a-d}	72.4^{ab}
Roba	2149.4^{ab}	6770.8^{a-d}	20.32^{gh}
Awash melka	1464.1^{cde}	5677.1^{cde}	45.28^{ef}
Tabor	1259.1^{efg}	6875^{a-d}	21.90^{g}
Nasir	2485^{a}	6510.4^{a-d}	10.14^{h}
Omo 95	972^{fgh}	5572.9^{cde}	50.76^{de}
Melka dima	1397.8^{c-f}	4479.2^{e}	13.57^{gh}
Anger	1515.7^{cde}	5625d^{ce}	20.27^{gh}
Argane	217.3^{i}	4583.3^{e}	81.00^{a}
Nazreth 2	771.4^{gh}	7083.3^{a-d}	65.28^{bc}
Chore	1782.7^{bcd}	8177.1^{a}	18.48^{gh}
Chercher	1721.2^{b-e}	6302.1^{bcd}	16.91^{gh}
Awasa dume	2438.8^{a}	7135.4^{abc}	11.85^{gh}
Dame	1633^{cde}	6093.8^{b-e}	10.14^{h}
Dursitu	1358.2^{def}	5781.3^{cde}	38.70^{f}
Tr- 13	655.9^{hi}	6041.7^{b-e}	56.86^{cd}
Waju	2601^{a}	7500^{ab}	10.14^{h}
Ramada	1850.4^{bc}	5937.5^{b-e}	20.28^{gh}
Mean	1472.3	6255.2	33.16
LSD (5%)	154.2	537.7	11.5
CV (%)	28.8	23.6	30

Where environmental differences are great, it may be expected that the V×L interaction will also be great 9 . In such cases, it is not only the average performance of varieties that is important but also the magnitude of the V×L interaction and the consistency of performance across environments. Among the unique features of the Ethiopian environmental conditions is the variation experienced both from season to season and from place to place in the same season over relatively small areas 8 .

The variety by location interactions of anthracnose disease severity (Fig 1c) of small seeded food and canning types of common bean varieties showed significant change and the rank order change among the varieties. (i.e. it was a cross over type of interaction). This means small seeded food type of common bean varieties responded different values at different locations and the locations favor and disfavor the tested varieties; while grain yield (Fig 1a), biomass yield (Fig 1b) of small seeded food and canning types of common bean varieties showed slightly rank order change and the crossover made for some of the varieties.



A



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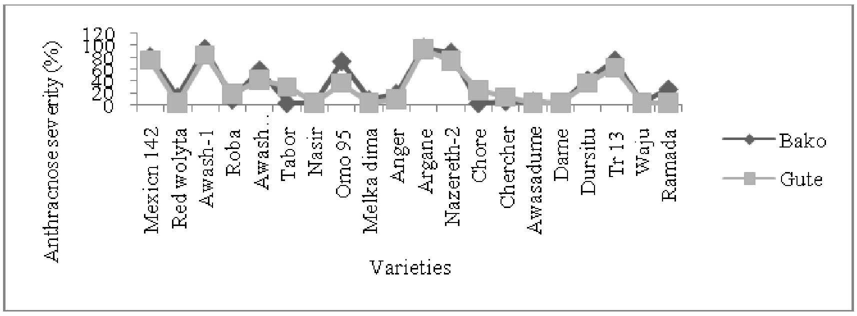


C

Figure1. Performances of grain yield (a), biomass yield (b) and anthracnose disease severity (c) of small seeded food and canning types of common bean varieties across two locations showing the existence of relative changes in ranks (cross-over) due to variety by locations (V×L) interactions

4.3. Genetic Progresses from Breeding

4.3.1. Grain yield

Small seeded food and canning types of common bean breeding efforts in Ethiopia have resulted in an average grain yield increment of 420 kg ha^{-1} (7.67%) or an annual genetic progress rate of 10.5 kg ha^{-1} (0.19% ha^{-1} year^{-1}) using the oldest variety Mexican 142, as a reference over the past 40 years of breeding period (Table 6 and Fig 2a). The result indicated that, past genetic progress made in grain yield in Ethiopia, was not satisfactory as grain yield of faba bean, 0.26 % ha^{-1} year^{-1}, [28], 0.45 % ha^{-1} year^{-1} from breeding soybean in Canada [18] and 0.39 % ha^{-1} year^{-1} from hundred years of barley breeding in England [20]; unlikely the genetic progress made for barley [10], (1.34 % ha^{-1} year^{-1}) and haricot bean (3.24 % ha^{-1} year^{-1}) [13], which stated high genetic progress made over the period of the varietal release. Therefore, applying different breeding strategies to bring attractive change for the grain yield and other important traits are required more for the present study. Except Awash-1, Argane, Nazreth 2 and Tr 13, the non-uniform increment of grain yield were recorded for the last forty years of breeding activities (Table 5). For example, the mean grain yield of Mexican 142, which is the oldest released variety was 809.4 kg ha^{-1} and the mean grain yield of the recently released varieties, Roba, Nasir, Awsadume, Waju and Ramada were 2149.4 kg ha^{-1}, 2485 kg ha^{-1}, 2438.8 kg ha^{-1}, 2601 kg ha^{-1} and 1850.4 kg ha^{-1} respectively, which exceeded the oldest released variety, Mexican 142 by 1340 kg ha^{-1} and 165.5 %, 1675.6 kg ha^{-1} and 207 %, 1629.4 kg ha^{-1} and 201.3 %, 1791.6 kg ha^{-1} and 221.3 % and 1041 kg ha^{-1} and 128.6 % respectively (Table 5).

In contrary, the mean grain yield of Awash-1, Argane, Nazreth-2 and Tr-13 were 675.9 kg ha^{-1}, 217.3 kg ha^{-1}, 771.4 kg ha^{-1} and 655.9 kg ha^{-1}; the means of these recently released varieties were lower than the mean grain yield of the first released variety, Mexican 142 by 133.5 and 16.5, 592.1 and 73.2, 38 and 4.7 and 153.5 and 19 in both kg ha^{-1} and % respectively (Table 5). These four recently released varieties are white small seeded canning types and which were seriously diseased during the growing season of the experiment. Therefore, future attention should be required for this small seeded food and canning types of common bean varieties; especially, for the canning type varieties with better disease resistance.

Table 5. Mean performance and their percentage increments of grain yield (kg ha^{-1}), seed weight (g), harvest index (%), biomass yield (kg ha^{-1}) and anthracnose disease severity (%) of small seeded food and canning types of common bean varieties released during the past 40 years compared to the first released variety Mexican 142

Varieties	Year of release	Characters												
		Grain yield (kg ha^{-1})			Seed weight (g)			Harvest index (%)		Biomass yield (kg ha^{-1})			Anthracnose severity (%)	
		Mean	Increment over Mexican 142 variety		Mean	Increment over Mexican 142 variety		Mean	Increment over Mexican 142 variety	Mean	Increment over Mexican 142 variety		Mean	Reduction from Mexican 142 variety
			Kg ha^{-1}	%		g 100^{-1} seeds	%		%		Kg ha^{-1}	%	Mean	%
Mexican 142	1973	809.4	-	-	14.83	-	-	0.14	-	5416.7	-	-	63.82	-
Red wolyta	1974	1687.6	878.2	108.5	21.16	6.33	42.7	0.24	71.4	6770.8	1354.1	25	15.20	76.2
Awash -1	1990	675.9	-133.5	-16.5	15.5	0.67	4.5	0.09	-25.8	6770.8	1354.1	25	72.40	-13.4
Roba	1990	2149.4	1340	165.5	16.83	2	13.5	0.31	121.4	6770.8	1354.1	25	20.32	68.2
Awash melka	1999	1464.1	654.7	80.9	15.83	1	6.7	0.25	78.5	5677.1	260.4	4.8	45.28	29.1
Tabor	1999	1259.1	449.7	55.5	18	3.17	21.4	0.15	7.1	6875	1458.3	26.9	21.90	65.7
Nasir	2003	2485	1675.6	207	24.5	9.67	65.2	0.38	171.4	6510.4	1093.7	20.2	10.14	84.2
Omo 95	2003	972	162.6	20.1	21	6.17	41.6	0.23	64.3	5572.9	156.2	2.9	50.76	20.5
Melka dima	2006	1397.8	588.4	72.7	41.5	26.67	179.8	0.30	114.3	4479.2	-937.5	-17.3	13.57	79.8
Anger	2005	1515.7	706	87.3	19.5	4.67	31.5	0.26	85.7	5625	208.3	3.8	20.28	68.3
Argane	2005	217.3	-592.1	-73.2	8.5	-6.33	-42.7	0.03	-79.6	4583.3	-833.4	-15.4	81	-26.9
Nazreth 2	2005	771.4	-38	-4.7	15.33	0.5	3.4	0.09	-25.8	7083.3	1666.6	30.7	65.28	-2.3
Chore	2006	1782.7	973.3	120.2	16.5	1.67	11.3	0.21	50	8177.1	2760.4	50.9	18.48	71.1
Chercher	2006	1721.2	911.8	112.6	16	1.17	7.9	0.27	92.8	6302.1	885.4	16.3	16.91	73.6
Awasa dume	2008	2438.8	1629.4	201.3	25.16	10.33	69.7	0.33	135.7	7135.4	1718.7	31.7	11.85	83.5
Dame	2008	1633	823.6	101.7	52.16	37.33	251.7	0.27	92.8	6093.8	677.1	12.5	10.14	84.2
Dursitu	2008	1358.2	548.8	67.8	16.16	1.33	9	0.22	57.1	5771.3	354.6	6.5	38.71	39.4
Tr 13	2012	655.9	-153.5	-19	17	2.17	14.6	0.11	-19.5	6041.7	625	11.5	57	10.7
Waju	2014	2601	1791.6	221.3	34.66	19.83	133.7	0.35	150	7500	2083.3	38.5	10.14	84.2
Ramada	2014	1850.4	1041	128.6	37.33	22.5	151.7	0.31	121.4	5937.5	520.8	9.6	20.28	68.3

4.3.2. Seed size

The annual rate of genetic progress from breeding common bean seed size in Ethiopia for small seeded food and canning type of common bean varieties was estimated to be 0.31 g 100 seeds^{-1} year^{-1} (Fig 2b), which entails that an increment of 0.08 % 100 seeds^{-1} year^{-1} (Table 5) or 12.4 g 100 seeds^{-1} (3.27 %) were obtained for four decades of the last breeding period (Table 6). When we compare the genetic progress made for grain yield and seed size, the progress made for yield through breeding was better than seed weight for the last four decades in Ethiopia. In contrary, more dramatic increments in seed size than in grain yield, was reported from chickpea breeding in Ethiopia 14 . Thus, the future direction of breeding in Ethiopian should focus on both grain yield and seed size 7 . Except Argane variety, the non uniform increment of seed weight for small seeded food and canning types of common bean varieties for the last four decades of breeding activities were recorded (Table 5). The mean seed weight of Mexican 142, the oldest released variety was 14.83 g and the mean seed weight of the recently released varieties were, 21.16 g, 24.5 g, 21 g, 41.5 g, 25.16 g, 52.16 g, 34.66 g and 37.33 g for Red wolyta, Nasir, Omo 95, Melkadima, Hawasadume, Dame, Waju and Ramada, respectively (Table 5). The increment of seed weight of these recently released varieties over the first released variety, Mexican 142 were, 6.33 and 42.7, 9.67 and 65.2, 6.17 and 41.6, 26.67 and 179.8, 10.33 and 69.7, 37.33 and 251.7, 19.83 and 133.7 and 22.5 and 151.7 in both g 100 seeds^{-1} and percent respectively (Table 5). The mean seed weight of Argane, recently released variety was 8.5 g, which is less than the first released variety, Mexican 142 by 6.33 and 42.7 in both g 100 seeds^{-1} and percent respectively (Table 5); this is because Argane variety was the most susceptible variety during the growing season of the experiment at both growing locations of Bako and Gute.

4.3.3 Harvest index

Harvest index of small seeded food and canning type of common bean varieties ranged from the lowest of 0.03 % for Argane variety to the highest of 0.38 % for Nasir (Table 5). The annual rate of harvest index changes in Ethiopia was estimated to be 0.001 % (Fig 3a) of HI year^{-1}, or 0.04 HI for the last 40 years of breeding period was obtained (Table 6). This is not significantly different from zero. This finding revealed that, there was insignificant genetic progress from breeding small seeded food and canning types of common bean varieties in Ethiopia for harvest index. Similarly, 13 and 27 the unchanged harvest index in the same crop, common bean and tef for the period of genetic improvement respectively and 19 for wheat was reported mean harvest index as low as 0.32. In contrary, the finding of 22 which describes higher harvest index value of 0.59 % for chickpeas, and significant change in the harvest index was observed with the release of modern varieties of wheat 19 ; 26 . The mean harvest index of Mexican 142, the first released variety was 0.14 % and the mean harvest index of recently released varieties, Roba, Nasir, Melkadima, Hawasadume, Waju and Ramada were, 0.31 %, 0.38 %, 0.30 %, 0.33 %, 0.35 % and 0.31 % respectively (Table 5). These recently released varieties exceeds Mexican 142 variety from 0.16 - 0.24 % (Table 5). On the other hand, the mean harvest index of the other recently released varieties, Awash-1, Argane, Nazreth-2 and Tr-13 were 0.09 %, 0.03 %, 0.09 % and 0.11 % respectively. These recently released varieties were lower than the Mexican 142 from 0.03 - 0.11 % (Table 5).

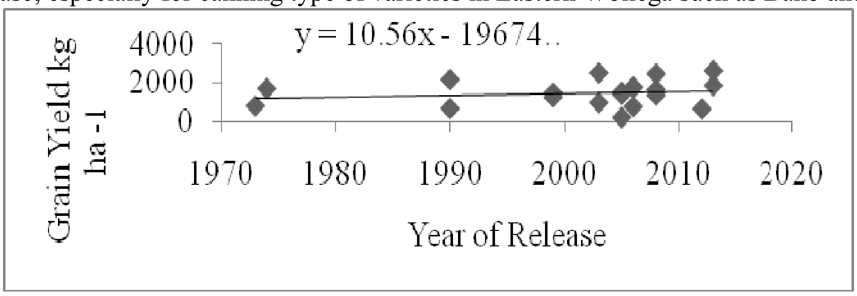
4.3.4 Biomass yield

The biomass yield of small seeded food and canning types of common bean varieties had annual genetic progress of 2.19 kg ha^{-1} $year^{-1}$ (0.04 %) or 87.6 kg ha^{-1} (1.76 %) for the last forty years of breeding period (Table 6 and Fig 3b). According to the result, biomass increment for the period of genetic improvement was insignificant; so, the study agreed with the finding of 24 who stated, that biomass yield of wheat was reduced during the period of genetic improvement. 13 and 12 on the other hand, reported that, the mean biomass yields of haricot bean variety on the year of release indicated that, 122.76 kg ha^{-1} $year^{-1}$ average annual rate of increase and higher biomass yield recorded in recently developed varieties than older ones respectively. Biomass yield ranged from the lowest of 4479.2 kg ha^{-1} for Melkadima variety to the highest of 8177.1 kg ha^{-1} for Chore (Table 5). The mean biomass yield of Mexican (5416.7 kg ha^{-1}), the first released variety exceeds the mean biomass yield of the recently released varieties, Melkadima and Argane by 937.5 and 833.4 (kg ha^{-1}) respectively; while the mean biomass yields of the rest recently released varieties were exceeds the mean biomass yield of Mexican 142 variety from 156.2 for Omo 95 to 2760.4 for Chore (kg ha^{-1}) respectively (Table 5).

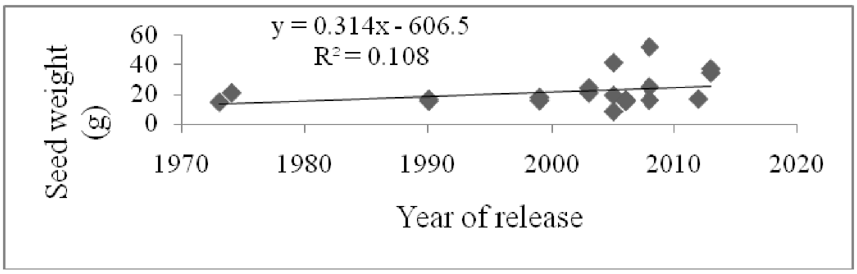
4.3.5 Anthracnose disease severity

According to the recent investigation, annually, the anthracnose disease severity development of small seeded food and canning types of common bean varieties reduced by 0.42 % (Fig 4) or an average temporal anthracnose disease severity reduction of 16.8 % through breeding in Ethiopia over the past 40 years (Table 6) using the first released variety, Mexican 142 as a reference (Table 5). This finding is in agreement with 28 stated that, the annual rate of reduction in chocolate spot disease severity was found to be 0.27 % on faba bean; the total reduction over the last thirty years of breeding was 21.5 %. In contrary, *unpublished data of 14* on Chick pea from Kabuli type, stated that, Shasho variety mainly released for its seed size and white colour, because of attractive for its seed quality, it has become more susceptible to ascochyta blight; *Ascochyta rabiei* Kovatsch. (Mycosphaerella-ceae).

Even though, the development of anthracnose disease reduced during the past 40 years, most of the canning types of varieties were more diseased than small seeded food type during the study season (Table 5). For example among canning type of varieties, Awash 1, Argane and Nazreth 2 were more diseased by 13.4, 26.9 and 2.3 (%) than Mexican 142; accordingly, small seeded food type of common bean varieties were better in resistance to anthracnose disease severity than canning type of common bean varieties. Therefore, future consideration on the production and productivity of these common bean varieties required for the resistant of anthracnose disease; especially for canning type of varieties in Eastern Wollega such as Bako and Gute areas



A



B

Figure 2. Bi plot of grain yield and seed weight of small seeded food and canning types (a and b) of common bean varieties against years of varietal release

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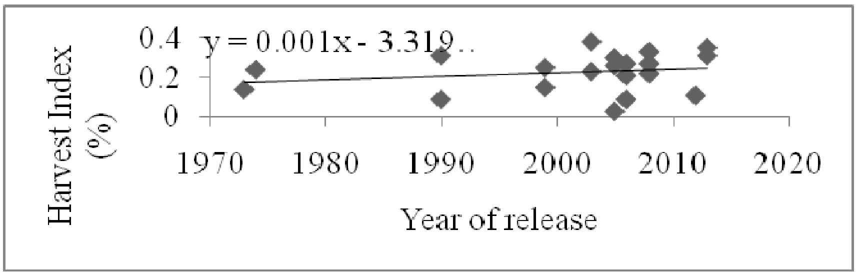

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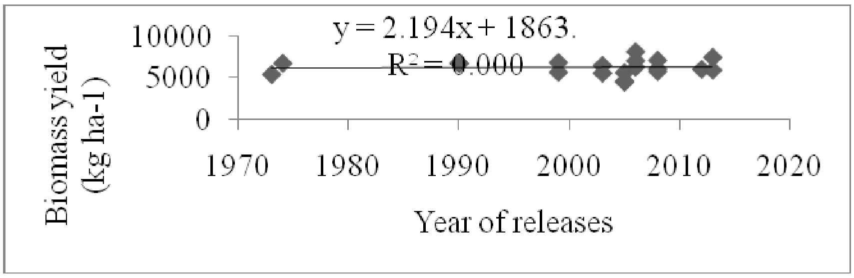

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Figure 3. Bi plot of harvesting index and biomass yield of small seeded food and canning types (a and b) of common bean varieties against years of varietal release

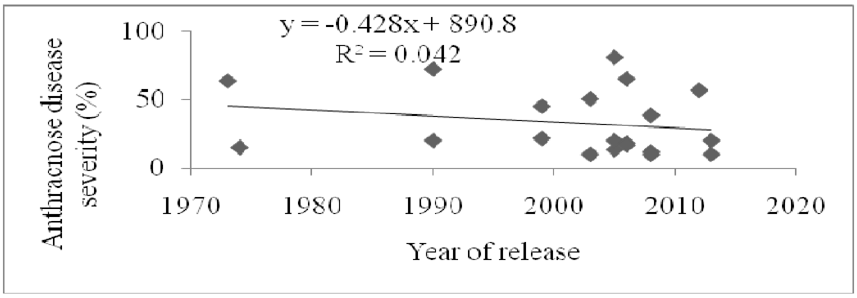

Figure 4. Bi plot of anthracnose disease severity of small seeded food and canning types of common bean varieties against years of varietal release

Table 6. Annual relative genetic gain (ARGG) and average relative genetic gain (ARGG) in % compared to the oldest variety Mexican 142 of small seeded food and canning types of common bean varieties. Trends in genetic progress obtained from breeding common bean for grain yield, seed size, harvest index, biomass yield and anthracnose disease severity during the past 40 years

Characters	Parameters						
	Mean square of regression	Regression coefficient (b)	P-value	Coefficient of determination (R^2)	Gain in 40 years kg ha^{-1}	ANRGG $year^{1}$ (%)	ARGG (%)
Grain yield (kg ha^{-1})	273172.1	10..5	0.44	0.03	420	0.19	7.67
Seed weight (g)	237.47	0.31	0.16	0.1	12.4	0.08	3.27
Harvest index (%)	0.007	0.001	0.39	0.04	0.04	0.95	38.06
Biomass yield (kg ha^{-1})	11787.7	2.19	0.96	0.00	87.6	0.04	1.76
Anthracnose disease severity (%)	449.6	-0.42	0.36	0.042	16.8	0.003	0.13

4.4. Associations of Characters

The correlation coefficient is the measures of degree of symmetrical association between two traits and it is used for understanding the nature and magnitude of association among yield and yield components. Association between any two traits or among various traits is of very importance to make desired selection of combination of traits 2 . Therefore, the correlated characters for each other of the three sets are indicated in Table 7.

The associations of characters of small seeded food and canning types of common bean varieties ranged from -0.78 to 0.99 and showed in (Table 7). Grain yield (kg ha^{-1}) had positively associated with Plant height (0.27**), number of pods $plant^{-1}$ (0.41**), grain filling period (0.28**), yield gram $plant^{-1}$ (0.47**), seed weight (0.41**), harvest index (0.78**), biomass production rate kg ha^{-1} day^{-1} (0.63**), biomass yield kg ha^{-1} (0.62**), seed growth rate kg ha^{-1} day^{-1} (0.99**) and grain yield day^{-1} kg ha^{-1} (0.99**). This result is supported with the idea of 27 and 29 stated that, correlation between grain yield with grain yield day^{-1} and with grain yield day^{-1} and biomass production rate highly correlated respectively. The same result were also obtained as grain yield was related positively (r=0.965, $P \leq 0.01$) with biomass yield by 13 on common bean 21 on soybean and 27 on tef. In contrast to the present finding, these authors stated that, grain yield showed no association with harvest index on their studied crop, and other authors reported that, grain yield to have positive association with both biomass yield and harvest index 20 , 29 ; 19 . On the other way 26 , stated that, no relation between grain yield and biomass yield and positive association between grain yield and harvest index were reported on bread wheat.

Similar to the present finding for these common bean varieties, Seed growth rate, grain yield day^{-1} and biomass production rate were positively associated with grain yield 13 . This also agreed with the work of 23 . Grain yield had slightly positively correlated with number of seeds $plant^{-1}$ (0.17*), pod length (0.20*); but, negatively correlated with days to flowering (-0.31**) (Table 7). Grain yield had not correlated with number seeds pod^{-1} and days to maturity; this result is supported with 13 , which stated that, there was no association between grain yields and number of seeds $pod-^{1}$. In contrast, the positive correlation were recorded for grain yield with the number of grains ear^{-1} in wheat 29 and 19 .

In this study, a strong associations were found between number of seeds $plant^{-1}$ and number of pods $plnt^{-1}$ (0.85**), biomass yield and biomass production rate (0.99**), grain yield day^{-1} and seed growth rate (0.99**), grain yield and seed growth rate (0.99**), grain yield and grain yield day^{-1} (0.99**), seed growth rate and grain yield (0.99**). Grain yield had highly negatively (-0.63**) correlated with anthracnose disease severity and some of the characters like number of pods $plant^{-1}$ (-0.36**), number of seeds $plant^{-1}$ (-0.30**), pod length (-0.31**), yield graham plant (-0.60**), seed weight (-0.53**), harvest index (-0.64**), seed growth rate (-0.64**) and grain yield day^{-1} (-0.62**) had negatively correlated with anthracnose disease severity. But, anthracnose disease severity had no association with days to flowering, days to maturity, plant height, number of seeds pod^{-1}, grain filling period, and biomass production rate and biomass yield. (Table 7). Generally, according to the study of these common bean varieties, improving of plant height, number of pods $plant^{-1}$, grain filling period, yield gram $plant^{-1}$, seed weight, harvest index, biomass production rate, biomass yield, seed growth rate and grain yield day^{-1}, leads to the increment of grain yield.

Table 7.Correlation coefficients of yield and yield related traits of small seeded food and canning types of common bean varieties

Varieties	Year of release	Grain yield (kg ha^{-1}) Mean	Grain yield Increment over Mexican 142 variety Kg ha^{-1}	Grain yield Increment %	Seed weight (g) Mean	Seed weight Increment over Mexican 142 variety g 100^{-1} seeds	Seed weight Increment %	Harvest index (%) Mean	Harvest index Increment over Mexican 142 variety %	Biomass yield (kg ha^{-1}) Mean	Biomass yield Increment over Mexican 142 variety Kg ha^{-1}	Biomass yield Increment %	Anthracnose severity (%) Mean	Anthracnose severity Reduction from Mexican 142 variety %
Mexican 142	1973	809.4	-	-	14.83	-	-	0.14	-	5416.7	-	-	63.82	-
Red wolyta	1974	1687.6	878.2	108.5	21.16	6.33	42.7	0.24	71.4	6770.8	1354.1	25	15.20	76.2
Awash -1	1990	675.9	-133.5	-16.5	15.5	0.67	4.5	0.09	-25.8	6770.8	1354.1	25	72.40	-13.4
Roba	1990	2149.4	1340	165.5	16.83	2	13.5	0.31	121.4	6770.8	1354.1	25	20.32	68.2
Awash melka	1999	1464.1	654.7	80.9	15.83	1	6.7	0.25	78.5	5677.1	260.4	4.8	45.28	29.1
Tabor	1999	1259.1	449.7	55.5	18	3.17	21.4	0.15	7.1	6875	1458.3	26.9	21.90	65.7
Nasir	2003	2485	1675.6	207	24.5	9.67	65.2	0.38	171.4	6510.4	1093.7	20.2	10.14	84.2
Omo 95	2003	972	162.6	20.1	21	6.17	41.6	0.23	64.3	5572.9	156.2	2.9	50.76	20.5
Melka dima	2006	1397.8	588.4	72.7	41.5	26.67	179.8	0.30	114.3	4479.2	-937.5	-17.3	13.57	79.8
Anger	2005	1515.7	706	87.3	19.5	4.67	31.5	0.26	85.7	5625	208.3	3.8	20.28	68.3
Argane	2005	217.3	-592.1	-73.2	8.5	-6.33	-42.7	0.03	-79.6	4583.3	-833.4	-15.4	81	-26.9
Nazreth 2	2005	771.4	-38	-4.7	15.33	0.5	3.4	0.09	-25.8	7083.3	1666.6	30.7	65.28	-2.3
Chore	2006	1782.7	973.3	120.2	16.5	1.67	11.3	0.21	50	8177.1	2760.4	50.9	18.48	71.1
Chercher	2006	1721.2	911.8	112.6	16	1.17	7.9	0.27	92.8	6302.1	885.4	16.3	16.91	73.6
Awasa dume	2008	2438.8	1629.4	201.3	25.16	10.33	69.7	0.33	135.7	7135.4	1718.7	31.7	11.85	83.5
Dame	2008	1633	823.6	101.7	52.16	37.33	251.7	0.27	92.8	6093.8	677.1	12.5	10.14	84.2
Dursitu	2008	1358.2	548.8	67.8	16.16	1.33	9	0.22	57.1	5771.3	354.6	6.5	38.71	39.4
Tr 13	2012	655.9	-153.5	-19	17	2.17	14.6	0.11	-19.5	6041.7	625	11.5	57	10.7
Waju	2014	2601	1791.6	221.3	34.66	19.83	133.7	0.35	150	7500	2083.3	38.5	10.14	84.2
Ramada	2014	1850.4	1041	128.6	37.33	22.5	151.7	0.31	121.4	5937.5	520.8	9.6	20.28	68.3

** and *, highly significant at $p \leq 0.01$ and significant at $P \leq 0.05$ respectively; and Values with no asterisk are insignificant;

DF = Days to flowering, DM = Days to maturity, PH = Plant height, NPPP = Number of pods plant^{-1}, NSPP = Number of seeds pod^{-1}, NSPPT = Number of seeds plant^{-1}, PL = Pod length, GFP = Grain filling period, YGPT = Yield gram plant^{-1}, SW = Seed weight, HI = Harvest index kg ha^{-1}, BMPR = Biomass production rate kg ha^{-1}, BMY = Biomass yield kg ha^{-1}, SGR = Seed growth rate kg ha^{-1}, GYD = Grain yield day^{-1} kg ha^{-1}, GY = Grain yield kg ha^{-1}, ANSIV = Anthracnose severity (%)

Grain yield as a dependent variable and the other left characters as an independent variable, the step wise regression analysis of the three sets of common bean varieties were indicated in (Table 8).

Grain yield day^{-1} had also a great contribution for the grain yield variation of small seeded food and canning types of common bean varieties, 85%. Anthracnose disease severity play high role as variation occurred by reducing the yield by 26.4%; seed size also contributed 7.9% for the reduction in grain yield (Table 8). A stepwise regression analysis tells us, grain yield day^{-1} contributed more for the variations of grain yield.

Table 8. Summary of selection from stepwise regression analysis of mean grain yield of set C of common bean varieties as dependent variable on the other traits as independent variables

Independent variable	Grain yield Interception	Regression coefficients (b)	R^2	VIF
Grain yield day^{-1}		0.123**	0.851	1.01
Seed weight	117	0.329**	-0.079	4.32
Anthracnose disease severity		-0.455**	-0.264	3.92

** = Significant difference at $p \leq 0.01$, R^2 = Coefficient of determination and VIF = Variance Inflation Factor

5. Conclusions

Grain yield of small seeded food and canning types of common bean varieties were increased by 10.5 kg ha^{-1} (0.19%) annually and 420 kg ha^{-1} (7.6%) over the past forty years of breeding period. Most of the mean grain yield of canning types of common bean varieties was lower than small seeded food type of varieties; however, the highest mean grain yield of Waju, which is the canning type variety rank first; but, mean of all of small seeded food type of common bean varieties exceeded the mean of reference variety Mexican 142. The average mean of grain yield, seed weight, harvest index and biomass yield of small seeded food and canning types were increased from older to recently released varieties; even though, the rate of increment were not consistent. Anthracnose disease severity reduced in the period of genetic improvement.

When we conclude the past improvement, genetic progress made for grain yield was increased for the past forty years of breeding; however, the grain yield of more of the canning types were reduced and attacked by anthracnose disease during the study time. Therefore, from stepwise regression point of view, grain yield day^{-1} will be focused by breeder to generate attractive yield; The homework for the next investigator should be further identification of the important character (s) that contribute more for the variation of grain yield of common bean varieties and those character (s) that contribute for the reduction of grain yield of common bean varieties that to be improved will be suggested by this author.

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