www.iiste.org

Heterosis and Combining Ability of Fruit and Bean Characters in Ethiopian Origin Coffee (Coffea arabica L.) Hybrids

Ashenafi Ayano*, Sentayehu Alamirew, and Abush Tesfaye

*Corresponding author E-mail: ashenafiayanof@yahoo.com , Jima Agricultural Research Center, P.O.Box 192, Jimma, Ethiopia.

Abstract

A half diallel analysis involving five parents, ten F1 hybrids and one check hybrid was studied for fruit and bean traits to generate information on heterosis and combining ability. The genotypes were evaluated in a randomized complete block design (RCBD) with three replications at Melko, Metu and Tepi research centers. The analysis of variance revealed highly significant difference among genotypes at ($p<0.05$) for all fruit and bean characters. This consistent significant difference for different traits suggests the presence of genotypic difference among parental lines and hybrids evaluated. Majority of fruit and bean characteristics showed negative heterosis over mid-parent and better-parent values. This may generally suggesting dominance of the small sized fruit and bean character over large sized parents. Both the additive and non-additive gene actions were involved in the control of the characters studied for fruit length, fruit width, fruit thickness, bean length, bean width, bean thickness and 100-bean weight.
Keywords: Heterosis**,** Combining ability**, G**ene action, GCA, SCA,

INTRODUCTION

Coffee (Coffea arabica L.) is the most important crop, and one of the most enjoyed beverages throughout the world. As a result several hundred millions of people in the world drink coffee. It is one of the leading commodities in the international trade, and currently generates revenue of about US$ 14 billion annually for the producing countries. More than 80 countries, including Ethiopia cultivate coffee, which is exported the product for more than 165 countries worldwide providing a livelihood for some 100 million people around the world (ICO, 2001). Coffee is still continues to be an important source of foreign exchange earnings, and primary export of many developing countries. Cultivation, processing, trading, transportation and marketing of coffee provides employment for millions of people worldwide (ICO, 2005).

In Ethiopia, coffee is one of the major and leading export items. Ethiopia is currently producing an estimated 9.8 million bags that would rank the country as the third largest coffee producer in the world after Brazil and Vietnam (ICO, 2012). Apparently coffee is at the center of Ethiopian culture and economy, and contributing to about 35% of the country's foreign currency earnings. It accounts for 10% of the gross domestic product, and supports the livelihoods of around 25% of the population of Ethiopia (representing around 20 million people) in one way or another (Gole and Senebeta,2008)**.**
It has been certain that Ethiopia is both the center of origin and diversification of C. arabica L. (Fernie, 1966; Bayetta, 2001). The crop spreads widely from the river bank of Gambella plain (550 m.a.s.l) stretching to the central and Eastern highlands of the country, where it exists in the great range of types within species (Bayetta, 1986). Due to the fact that Ethiopia is the center of origin and diversity, there is immense genetic variability that offers great potential for improvement of the crop.

In spite of arabica coffee being such a great importance having great economic value to many countries and having such large genetic variability in Ethiopia research work on genetic and breeding of coffee is relatively rare.

Heterosis occurred widely in both self and cross-pollinated crop species (Allard, 1960; Welsh, 1981). In crosses among varieties of C.arabica L., however, heterosis for yield and other desirable characters was found to be lacking (Carvalho et al., 1969) or low (Van der vossen and Walyaro, 1981).

On the other hand, in Ethiopia with the first attempt of crossing program made among five indigenous pure lines, heterosis of up to 60% for yield (Mesfin and Bayetta, 1983) and 30% for components of yield (Mesfin, 1982) was reported over the better parent. Such appreciable results were obtained mainly due to presence of high genetic variability since Ethiopia is both the center of origin and diversity for C.arabica L.

Currently, the analysis of combining ability has become an important and integral part of all breeding program. It helps to identify the best combining parent, to know the type of gene action and to choose appropriate breeding methods (Sprague and Tatum, 1942; Mathur and Mathur, 1983). Indeed diallel analysis for combining ability suggested by (Griffing, 1956) is one of the powerful tools to provide the above information. In arabica coffee, information in this regard is very scarce.

Thus, the phenomenon of heterosis has not been exploited extensively in coffee. Combining ability of the pure lines is the ultimate factor determining future usefulness of these lines for hybrids. Combining ability analysis provides information on the relative importance of additive and non-additive gene effects involved in the expression of the quantitative traits.

From the few crossing works done so far encouraging heterotic effects were obtained in crosses among indigenous coffee lines and this has stimulated the Ethiopian coffee breeders to continue the crossing program among diverse parents. Cognizant to this, the present study was conducted to investigate the extent of heterosis and combining ability of parents in crosses between lines from south western region of Ethiopia with the following objectives:

- To determine the magnitude of heterosis in fruit and bean characters
- To determine the types of gene action involved in the inheritance of fruit and bean characters on the relative contribution of GCA and SCA

Materials and Methods

The study was conducted at Jima Agricultural Research Center (JARC), Metu Agricultural Research Sub-Center and Tepi National Spice Research Center (TNSRC). Jima is located on latitude $7^{0}40'N$ longitude $36^{0}47'E$, altitude of 1753 masl, minimum and maximum temperature of the area is 11.6 and 26.3 ^{o}C respectively with annual rainfall of 1572 mm/annum. Metu is located on latitude $8^{0}19'N$ longitude $35^{0}35'E$, altitude of 1580 masl, minimum and maximum temperature of the area is 12.7 and 28.9 ^{o}C respectively with annual rainfall of 1829 mm/annum. Tepi is located on latitude $7^{0}11'N$ longitude $35^{0}25'E$, altitude of 1220 masl, minimum and maximum temperature of the area is 15.7 and 29.9 ^{o}C respectively with annual rainfall of 1594 mm/annum. The study locations are among major coffee producing areas in south western Ethiopia. Generally the study locations are in wet humid

sub-tropical region of southwestern Ethiopia. The bulk of the soil in the south west coffee growing region in general described as Eutric Nitosol and clay; deep and well drained, with PH of 5-6 medium to high in exchangeable cation (Paulos, 1994; Brhanu, 1978; Tesfu and Zebene, 2006).
Five pure lines that were selected from the national collection trials representing the different agro ecologies of southwestern Ethiopia and different canopy classes were used as parents in half diallel crosses. The parental lines included were 75227(P1), 744(P2), 74148(P3), F-34(P4) and 206/71(P5) among which P1, P2 and P4 are open canopy classes P3 and P5 are compact in their canopy classes (table 1). The released hybrid coffee Ababuna was used as a check.

Table 1. Coffee pure lines, their origin and descriptions

	Line	Origin	Altitude (m)	Description
1	75227 (P1)	Gera	1900	Open canopy, Highly resistant to CBD and released pure line variety, high yielder
2	744 (P2)	Washi, Kefa	1700	Open canopy, Highly resistant to CBD, bold bean size and released, high yielder
3	74148 (P3)	Bishari, Illuababora	1600	Compact canopy, Highly resistant to CBD and high yielder, released pure line, small bean size
4	F-34 (P4)	Mizan-Teferi	1430	Open canopy, moderate resistant to CBD, quality, not released (pipeline variety)
5	206/71 (P5)	Maji	1600	Compact canopy, moderate resistance to CBD, high yielder, small bean size, bronze leaf tipped, not released (pipeline variety)

Source: Extracted from data base of coffee breeding and genetics research division, JARC

Data collection from the experimental plots was done in December 2011 to January 2012. All the fruit and bean characteristics data considered in this study were statistically analyzed based on randomized complete block design using XLSTAT, Computer program and SAS (SAS, 2002) version9.2 software. Least Significant Difference (LSD at P = 0.05) was employed to identify accessions that are significantly different from each other. Combining ability analysis was performed using SAS DiallAll05 program of SAS statistical software 9.2 version (Zhang et al., 2005).

Data recorded

a) Fruit characteristics. Average of five normal matured fruits measured as recommended by IPGRI (1996)
- Fruit length (mm) – Average of five normal matured fruits measured at the longest part using digital caliper.
- Fruit width (mm) - Average of five normal matured fruits measured at widest part using digital caliper.
- Fruit thickness (mm) - Average of five normal matured fruits measured at the thickest part using digital caliper.

b) Seed/bean characteristics - Average of five normal matured beans measured as recommended by IPGRI (1996)

- Bean length (mm) – Average length of five normal matured beans measured at maximum longest part using digital caliper.
- Bean width (mm) - Average of five normal matured beans measured at the widest part using digital caliper.
- Bean thickness (mm) - Average of five normal matured beans measured at the thickest part using digital caliper.
- 100-bean weight at 11% moisture (gm) –calculated as: (“bean weight at 0% moisture content” X 100)/ (Bean No X 0.89). Oven was used for drying of beans to make 0% moisture and weight recorded using sensitive balance.

Results and Discussion

i) Performance of parents and their crosses across three environments

All fruit and bean characters recorded and analyzed. Analysis of variance results for genotype was highly significant at ($P<0.01$) for fruit length (FL), Bean length (BL) , Bean thickness (BT) Hundred bean weight at 11% moisture (HBW). And also significant difference at ($P<0.05$) for fruit width (FW), fruit thickness (FT) and bean width (BW). , indicating the variation among genotypes and study locations (Table 2).
Except bean width (BW) for all other fruit and bean characters; crosses with one of their parents is P2 have shown relatively the highest mean value. The relative lower value of cross P2XP3 may be due to the small bean sized nature of P3. With Regard to the bean width the widest cross appeared to be the check hybrid Ababuna followed by cross P2XP5 and parental line P2 with the average value of 7.49, 7.37 and 7.35 mm width respectively at Melko. For the trait BT cross P2XP4 at Melko, parent P2 at Tepi and cross P2XP5 at Melko were the highest with respective value of 4.46, 4.37 and 4.35 mm.

Fruit length also showed significant difference for genotypes but there is no as such clear difference in mean value of hybrids from that of parental mean. Even the highest value observed for parental line P2 and its cross P1XP2 exhibiting 17.66 and 17.33 mm length respectively. Parental line P2 has large bean size yet all of its crosses have shown less mean value than this parent (Table 2). This result may give some clue in that fruit length may not be improved by crossing or long bean length may not be dominant over short.

For the traits bean length(BL), bean width(BW), bean thickness (BT) and hundred bean weight (HBW) even though an interaction of GXE is significant and environment contributed for the difference, the size of parental line P2 was high for most of these traits. Still parental line P2 showed the higher BL at Tepi and Melko with the mean value of 11.42 and 11.37 mm length respectively. Except cross P2XP3 all other crosses with one of their parents is P2 have shown relatively the highest mean value. The relative lower value of cross P2XP3 may be due to the small bean sized nature of P3. With Regard to the bean width the widest cross appeared to be the check hybrid Ababuna followed by cross P2XP5 and parental line P2 with the average value of 7.49, 7.37 and 7.35 mm width respectively at Melko. For the trait BT cross P2XP4 at Melko, parent P2 at Tepi and cross P2XP5 at Melko were the highest with respective value of 4.46, 4.37 and 4.35 mm.

Coste (1968) suggested 100 bean weight is in an average range of 18-22 gm for arabica coffee. The result observed in this study was almost in this range, of course it was observed that some upper and lower results for some crosses and parental lines. Hundred bean weight (HBW) was computed at 11% moisture bases and the highest record was 22.97 gm for P2 followed by cross P2XP4 with value 21.37 gm and cross P2XP5 with value of 21.27 gm at Melko. Likewise cross P2XP4 at Tepi with the average value of 21.13 gm showed better results.

Table 2: Mean performance of parents and their crosses across three environments for fruit and bean characters

Entries	Fruit Length (mm)	Fruit width (mm)	Fruit thickness (mm)	Bean length (mm)	Bean width (mm)	Bean thickness (mm)	Hundred bean weight at 11% moisture (gm)
P1XP2	17.33	12.30	14.21	10.58	7.00	4.12	19.86
P1XP3	15.75	11.40	13.23	9.19	6.85	4.06	17.34
P1XP4	16.03	11.69	13.71	9.77	6.83	4.07	18.72
P1XP5	15.66	11.61	13.21	9.87	6.98	4.04	18.97
P2XP3	16.02	11.50	13.47	9.60	6.92	4.09	17.76
P2XP4	16.59	12.08	14.25	10.23	7.09	4.21	20.12
P2XP5	16.65	11.85	13.54	10.44	7.19	4.11	19.99
P3XP4	15.78	11.22	13.36	9.53	6.89	4.09	18.22
P3XP5	15.48	11.41	12.97	9.68	6.89	3.96	17.05
P4XP5	15.93	11.47	13.18	9.62	6.84	3.99	17.20
Hybrids Mean	**16.12**	11.65	13.51	9.85	6.95	4.07	18.52
P1	15.98	12.04	13.43	9.54	6.94	3.97	17.34
P2	17.66	12.54	14.47	11.17	7.08	4.32	20.22
P3	14.89	10.89	12.63	8.75	6.76	3.83	14.98
P4	15.75	11.34	13.26	9.44	6.80	3.99	16.56
P5	15.81	11.42	12.73	9.46	6.80	3.71	16.29
Parents Mean	**16.02**	11.64	13.30	9.67	6.87	3.96	17.08
Ababuna	16.33	11.93	13.46	9.99	7.28	3.89	17.90
Mean	**16.1**	11.67	13.44	9.80	6.95	4.03	18.03
F test	**	*	*	**	*	**	**
LSD (5%)	0.79	0.33	0.34	0.27	0.14	0.12	0.89
CV(%)	5.25	3.06	2.71	2.93	2.08	3.17	5.3

* ,** significant at 0.05 and 0.01 probability level

Estimates of percent heterosis across locations

Percentage heterosis of the F1's relative to the mid parent and better parent for fruit and bean characters is indicated in Table 3.

Majority of fruit and bean characteristics showed negative heterosis over mid-parent and better-parent values. This may generally suggesting dominance of the small sized fruit and bean character over large sized parents. Results obtained from cross made between P2 and P3

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.11, 2015

can be a very good example. These two parents have contrasting fruit and bean size in that P2 is big sized and P3 is smaller sized fruit and bean. The exhibited heterosis percentage from the cross of these two parents is either consistently negative or negligible. Similarly, majority of hybrids with one of their parents P2 showed negative heterosis, indicating the fruit and bean size of the offspring is reduced and probably suggesting smaller bean has dominant character over the big sized parent. All hybrids for bean width showed negative heterosis over check hybrid Ababuna suggesting high bean width value of the check. On the other hand, all hybrids in the study showed positive heterosis for bean thickness over check hybrid indicating thin bean nature of check than all hybrids even though they are not statistically significant.

For the trait hundred bean weight all crosses showed positive MP value, six of them showing significant positive high value. Out of these cross P3XP4 and P1XP5 showed high heterosis percentage of 15.6 and 12.8, respectively.

Table 3: Estimates of mid-parent (MP), better parent (BP) and standard heterosis for yield, fruit and bean characteristics of coffee hybrids across locations

Crosses	Heterosis percentage																				
	Fruit length			Fruit width			Fruit thickness			Bean length			Bean width			Bean thickness			Hundred bean Wt at 11% moisture		
	OMP	OBP	OCH	OMP	OBP	OCH	OMP	OBP	OCH	OMP	OBP	OCH	OMP	OBP	OCH	OMP	OBP	OCH	OMP	OBP	OCH
P1XP2	3	-1.9	6.1	0.1	-2	3.1	1.9	-1.8	5.6*	2.2	-5.3	5.9*	-0.2	-1.2	-3.8	-0.6	-4.7	5.9*	5.7	-1.8	10.9*
P1XP3	2.1	-1.4	-3.6	-0.6	-5.3	-4.4	1.5	-1.5	-1.7	0.4	-3.8	-8.1	0	-1.3	-5.9	4	2.2	4.4	7.3	0	-3.1
P1XP4	1	0.3	-1.8	0	-2.9	-2.0	2.7	2.1	1.9	2.9	2.3	-2.2	-0.6	-1.6	-6.2	2.2	1.9	4.6	10.5*	7.9	4.6
P1XP5	-1.4	-2	-4.1	-1	-3.6	-2.7	1	-1.6	-1.9	3.8	3.4	-1.2	1.6	0.5	-4.1	5.3*	1.8	3.9	12.8**	9.4*	6.0
P2XP3	-1.6	-9.3	-1.9	-1.9	-8.3	-3.6	-0.6	-6.9	0.1	-3.6	-14.1	-3.9	0	-2.3	-4.9	0.4	-5.3	5.1	0.9	-12.2	-0.8
P2XP4	-0.7	-6.1	1.6	1.2	-3.7	1.3	2.8	-1.5	5.9**	-0.8	-8.5	2.4	2.1	0	-2.6	1.4	-2.4	8.2**	9.4*	-0.5	12.4**
P2XP5	-0.5	-5.7	2.0	-1.1	-5.5	-0.7	-0.4	-6.4	0.6	1.2	-6.6	4.5	3.6*	1.5	-1.2	2.6	-4.7	5.9*	9.5*	-1.2	11.7**
P3XP4	3	0.2	-3.4	0.9	-1	-6.0	3.2	0.8	-0.7	4.8*	1	-4.6	1.5	1.2	-5.4	4.4*	2.3	5.1	15.6**	10.1*	1.8
P3XP5	0.8	-2.1	-5.2	2.3	-0.1	-4.4	2.3	1.9	-3.6	6.3*	2.3	-3.1	1.6	1.3	-5.5	5.1*	3.4*	1.8	9.1*	4.7	-4.7
P4XP5	1	0.8	-2.4	0.8	0.5	-3.9	1.4	-0.6	-2.2	1.8	1.6	-3.7	0.6	0.5	-6.0	3.7	-0.1	2.6	4.7	3.9	-3.9

*,** significant at 0.05 and 0.01 probability levels, respectively

Combining ability analysis across locations

GCA and SCA mean squares of fruit and bean characters are displayed in Table 4. For Fruit length, fruit width, fruit thickness, bean length, bean width, bean thickness and 100-bean weight additive and non-additive gene actions were involved in the control of the characters studied. For the fruit and bean traits studied relative contribution of GCA was predominant suggesting additive gene action contributed more for these traits. But for majority of fruit and bean characters GCA x E and SCA x E for all bean characters was significant indicating inconsistent results across locations and better to depend on GCA & SCA effects of each locations.

Table 4: Mean squares due to general combining ability (GCA) and specific combining ability (SCA) for yield, fruit & bean characters in coffee diallel crosses across location
* = significant at P<0.05, **= significant at P<0.01, and ***= significant at 0.001

General combining ability effects across location analysis

General combining ability effects of parents for fruit and bean characters are given in Table 5. In across location GCA effects for all fruit and bean characters parental line P2 showed consistently positive and significant GCA effects indicating the good combining ability of this

Source of variation	Traits							
	Df	Fruit length	Fruit width	Fruit thickness	Bean length	Bean width	Bean thickness	100- bean weight
GCA	4	12.384***	4.775***	7.216***	8.098***	0.322***	0.345***	47.105***
SCA	10	0.563***	0.142	0.311**	0.553***	0.064**	0.068***	9.623***
GCA X E	8	0.662***	0.344**	0.263*	0.973***	0.022	0.046**	7.771***
SCA X E	20	0.277	0.130	0.139	0.176*	0.041*	0.027*	1.724*
Error	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Relative contribution of GCA		89.8	93.1	90.3	85.4	66.9	67.0	66.2
Relative contribution of SCA		10.2	6.9	9.7	14.6	33.1	33.0	33.8

parent. This is probably emanated from the bold fruit and bean nature of this parental line. This result give directions for the improvement of fruit and bean characters parental line P2 found to be good general combiner. In contrary to P2 parental line P3 showed significant negative GCA effects for all fruit and bean size characters, indicating the fruit and bean size reducing character of P3. This result may be emanated from its small fruit and bean nature of this parental line.

Table 5: Estimates of General combining ability (GCA) effects of parental lines for yield, fruit and bean characters in coffee diallel crosses across location

parents	GCA effects of each Traits						
	Fruit length	Fruit width	Fruit thickness	Bean length	Bean width	Bean thickness	100-bean weight
P1	0.0503	0.154**	0.086	-0.025	-0.0133	-0.0012	0.2124
P2	0.7505***	0.404***	0.516***	0.590***	0.125***	0.118***	1.355***
P3	-0.519***	-0.366***	-0.337***	-0.466***	-0.072***	-0.047**	-1.163***
P4	-0.0866	-0.0906	0.0797	-0.0994	-0.0438*	0.0191	-0.0698
P5	-0.1954	-0.1012	-0.345	-0.0005	0.0042	-0.0889	-0.3342
SE (gi)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SE (gi-gj)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

= significant at P<0.01, and *= significant at 0.001, SE (gi)= standard error of general combining ability effects, SE (gi-gj)= standard error of the difference of general combining ability effects

Specific combining ability (SCA) effects across locations

Specific combining ability (SCA) effects of crosses for fruit and bean characters are given in Table 6. For hundred bean weight, only three crosses P1xP5, P3xP4 and P2xP5 were best combinations as they showed positive and significant SCA effects for this trait.

Table 6**:** Estimates of specific combining ability (SCA) effects of F1 Hybrids of coffee for Yield, Fruit & Bean characters across location

Crosses	SCA effects of each Traits						
	Fruit length	Fruit width	Fruit thickness	Bean length	Bean width	Bean thickness	100- bean weight
P1XP2	0.4317	0.0868	0.1348	0.2047	-0.0422	-0.0528	0.0542
P1XP3	0.1200	-0.0407	0.0116	-0.1393	0.0013	0.0529	0.0609
P1XP4	-0.0356	-0.0252	0.0714	0.0756	-0.0469	0.0009	0.3453
P1XP5	-0.0689	-0.1747	0.2100	0.3011	0.0202	0.1611*	2.1689**
P2XP3	-0.3136	-0.1874	-0.1786	-0.3391*	-0.0624	-0.0344	-0.6702
P2XP4	-0.1758	0.1193	0.1823*	-0.0797	0.0749	0.0247	0.6031
P2XP5	-0.0653	-0.1880	-0.0653	-0.1447	0.2240**	0.0051	1.4556*
P3XP4	0.2791	0.0273	0.1470	0.2796*	0.0696	0.0616	1.2209**
P3XP5	0.2631	0.2462	0.3456	0.4627*	0.0471	0.1727*	1.2489
P4XP5	0.2920	0.1418	0.3413	0.0822	-0.0136	0.1047	0.9089
SE(S_{ij})±	0.1531	0.10491	0.10866	0.12194	0.058725	0.047476	0.38202
SE(S_{ij}-S_{ik})±	0.2296	0.15736	0.16299	0.18292	0.088087	0.071214	0.57303
SE(S_{ij}-S_{kl})±	0.2097	0.14365	0.14879	0.16698	0.080412	0.065010	0.52311

* = significant at P<0.05, **= significant at P<0.01, and ***= significant at 0.001, S.E (Sij)± =standard error of specific combining ability effect; S.E (Sij-Sik)± =standard error of the difference of specific combining ability having one parent in common and S.E (Sij-Skl) ± =standard error of the difference of specific combining ability effects of the crosses having no parents in common

Summary and Conclusions

The present study was conducted with objectives of: (1) To determine the magnitude of heterosis in fruit and bean characters (2) To determine the types of gene action involved in the inheritance of fruit and bean characters on the relative contribution of GCA and SCA.

The experimental material consisting of five indigenous coffee (Coffea arabica L.) lines namely P1(75227), P2 (744), P3 (74148), P4 (F34) and P5(206/71) were selected from south western coffee growing areas of the country based on yield, quality, disease resistance and different morphological characteristics. The lines were crossed in half diallel fashion as per Griffing (1956) model I method 2 to produce 10 F1 hybrids. The F1's, parental lines and check hybrid Ababuna planted at Melko, Metu and Tepi research centers in RCB design in three replications were used for study. The data were recorded for seven fruit and bean characters.

The analysis of variances indicated highly significant difference among genotypes for almost all characters clearly indicating the presence of genotypic difference among parental lines and hybrids evaluated. Parental line P2 has large bean size yet all of its crosses have shown less mean value than this parent. This result may give some clue in that fruit length may not be improved by crossing or long bean length may not be dominant over short.

Majority of fruit and bean characteristics showed negative heterosis over mid-parent and better-parent values. This may generally suggesting dominance of the small sized fruit and bean character over large sized parents. For the hybrids with one of their parents P2 (big fruit and bean sized) showed negative heterosis, indicating the fruit and bean size of the offspring is reduced and probably suggesting smaller bean has dominant character over the big sized parent. Yet this calls further study to confirm inheritance undergoing crossing between known big sized parents with that of known small sized bean parent.

The analysis of variance due to GCA and SCA was significant for fruit and bean characters. For the fruit and bean traits studied relative contribution of GCA was more suggesting predominance of additive gene action. For hundred bean weight, P1xP5, P3xP4 and P2xP5 were also good combiners.

Acknowledgements

Authors acknowledge all colleagues in coffee breeding staffs at Jima Agricultural Research Center who rendered their support during study period.

REFERENCES

Allard, R.W. 1960. Principles of Plant breeding. John Willey and Sons Inc., New York, pp 1-485.

Bayetta Bellachew. 1986. Exploration and collection of coffee germplasm from Gambella plain. IAR news letter. Addis Ababa. 1 (2) 3-5.

Baytta Belachew. 2001. Arabica Coffee Breeding for Yield and Resistance to Coffee Berry Disease (colletotrichum kaahawae sp.nov). Ph.D dissertation, Imperial College at Wye, University of London, England. P136-141.

Brhanu Debele. 1978. Preliminary report for detailed soil survey of Jima Agricultural Research Station, IAR. Appendex No. 1, Addis Abeba.

Carvalho, A., F.P. Ferwereda, J.A. Frahm-leliveld, D.M. Medina, A.J.I. Mendes and L.C.Monaco. 1969. Coffee (C. arabica L. and c. canephora pierre ex froehner). Pp. 186-224. In: F.P. Ferwerda and F.wit (eds) Out lines of perennial crop breeding in the tropics. Landbouwhoge school (Agricultural university) Wageningen, The Netherlands.

Coste, R. 1968. Le cafieier , G.P. Maisonne Uve & Larose, Paris

Fernie L. M., 1966. Some Impressions of Coffee in Ethiopia. Kenya Coffee 31: 115-121.

Gole, T.W. and Senebeta, F., 2008. Sustainable management and promotion of forest coffee in Bale, Ethiopia. Bale Eco-Region Sustainable Management Programme SOS Sahel/FARM-Africa, Addis Ababa.

Griffing, B. 1956. Concept of general combining ability and specific combining ability in relation to diallel crossing system. Austr. Jour. Biol. Sci., 9: 463-493.

International Coffee Organization (ICO), 2012. Ethiopian coffee production exceeds expectation. International coffee organization London

International Coffee Organization (ICO), 2005. Exports by exporting countries to all destinations. Available at: http://www. ico.org/trade/m1.htm.

International coffee organization (ICO), 2001. Positively coffee. International coffee organization, London.

IPGRI. 1996. Descriptors for coffee (coffea spp and psilanthus spp). International plant Genetic Resources Institute, Rome, Italy.

Mathure, P.N., and J.R. Mathur. 1983.Combining ability for yield and its components in pearl millet.IndianJ. Genet. Pl. Breeding., 43:299-303.

Mesfin Ameha and Bayetta bellachew. 1983. Heterosis in crosses of indigenous coffee (coffee Arabica L.). Selected for yield and resistance to coffee berry disease II- First three years. Ethiopian Journal of Agricultural Science, V: 13-21. Addis Ababa, Ethiopia.

Mesfin Ameha. 1982. Heterosis in crosses of indigenous coffee (coffee Arabica L.). Selected for yield and resistance to coffee berry disease at first bearing stage. Ethiopian Journal of Agricultural Science. 4: 33-45. Addis Ababa

Paulos, D. 1994. Mineral fertilization of coffee in Ethiopia. Institute of Agricultural Research, Addis Abeba.

SAS (statistical Analysis System Institute). 2002. Statstical Analysis System Software. V.g. SAS institute Inc., Cary, NC USA.

Sprague, G.F and Tatum, L.A. 1942. General versus specific combining ability in single crosses of corn. J. American Soc. Agron. 34: 923-932.

Tesfu Kebede and Zebene Mikru. 2006. The nutrient status of long term fertilized soils of coffee plantation in south western Ethiopia. Paper presented on 22nd International Conference on Coffee Science, ASIC, 11 to 15 September 2006. Monpellier, France.

Van der vossen, H.A.M. and D.J.A. Walyaro. 1981. The coffee breeding program in Kenya: A review of progress made since 1971 and plan of action for the coming years. Kenya coffee, 46: 113-130

Welsh, J.R. 1981. Fundamentals of plant genetics and breeding. John Wiley and sons inc., pp. 1-290.

Zhang, Y., Kang, M.S., and Lamkey, K.R. 2005. Diallel SAS05. A comprehensive program for Griffing's and Gardener-Eberhart. Analysis. Agronomy Journal 97: 1097-1106.