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REGULAR ARTICLE

PERFORMANCE EVALUATION OF GRAIN YIELD AND YIELD RELATED TRAITS IN COMMON BEAN GENOTYPES AT YABELLO AND ABAYA, SOUTHERN ETHIOPIA

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ABSTRACT

Common bean is among the major crops grown in southern Ethiopia including Borana zone where the majority of the farmers are Agro-pastoralist and produce the crop mainly for home consumption. The area has potential to the production of common bean for food and nutrition security as well as export commodity. However, scarcity of varieties that fit to the environment is one of the major constraints of production. Therefore, this experiment was conducted to evaluate 36 common bean genotypes including seven released varieties to evaluate performance of genotypes for yield and agronomic traits. The field experiment was conducted in 2015 at two locations (Abaya and Yabello) and genotypes were planted in triple lattice design. Data were collected on yield and important agronomic traits. Analysis of variance computed for individual locations and combined analysis over locations revealed significant variations among genotypes for all traits. Moreover, 16.67% of the genotypes had mean grain yield greater than the best performing released variety across locations and the genotypes showed a grain yield as high as 3.25 tons ha^{-1}. Based on results of this study it is recommended to test the high yielding and early maturing genotypes at many locations to develop preferred varieties across many locations.

Keywords: Mean performance, Yield and yield related traits

INTRODUCTION

Common bean is one among the widely cultivated bean species all over the world and it is a self-crossing species and some out crossing rate has also been observed (10). Common bean is an important pulse crop (15) and usually considered as “Grain of hope” and constitute a major part of African subsistence agriculture (20).

This crop is one of the major pulses cultivated in the lowland to mid-altitude sub-humid areas in Ethiopia (21). The cultivation practice of this bean is increasing now a days in Ethiopia (22). Common bean is becoming an essential legume of Ethiopian diet and a means of foreign earnings (9). In Ethiopia, this grain is largely cultivated next to faba bean and occupies 19.7% of the cultivated area to pulses with 16.8% of the total annual pulses production (6). It contains protein and minerals and has short maturity period so it is available for family consumption during the period when other crops are immature (21). It can be used for rotation crop with maize, sorghum, and vegetables and is a promising sustainable agriculture component in the country. The major constraints in the production of common bean is lack of high yielding and disease resistant varieties (21).

MATHERIAL AND METHODS

The experiment was conducted at Yabello and Abaya during 2015 cropping season. The two locations are the research sites and sub-sites of Yabello Pastoral and Dryland Agriculture Research Center, respectively. The experimental areas are located in the Southern part of the country in the Oromia Regional State. Yabello and Abaya are located at 561 and 365 km far from Addis Ababa city, respectively. The detail description of the study areas is listed in the table 1.

For this study, 36 common bean genotypes were obtained from Melkasa Agriculture Research Centre (MARC) and evaluated for correlations and path coefficient analyses of yield and yield related traits. Among the tested genotypes, seven are varieties released in the different years and for different areas. Description of the new common bean entries and released varieties are presented in Appendix table 1. The experiment was laid out in 6 x 6 triple lattice design. Each entry was planted in a plot having 6 rows of

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4-meter length. Four rows were harvested and two border rows were left to exclude border effect. The row and plant spacing was kept at 40 cm and 10 cm, respectively. Individual plot size was 2.4 m x 4 m=9.6 m^2 and 1m and 1.5m between replication and sub block, respectively. Fertilizer was applied as nationally recommended for the crop at the rates of 46 kg P_2O_5 and 18 kg N/ha (100 kg/ha DAP) at the time of planting. All other agronomic managements were applied uniformly in all experimental plots as per national recommendation for the crop.

Data collection

Data recorded on plant basis

Plant height at harvest (cm), number of primary branches, pod length (cm), number of pods per plant, number of seeds per pod and number of seeds per plant were calculated from five randomly selected plants.

3.4.2. Data collection on plot basis

Days to Flowering: The numbers of days from the date of emergence to the date on which about 50% of the plants in each plot produce flowers.

Days to maturity: The number of days from planting to the date when 90% of the morphological observation of the plant turned to yellow straw colour.

Grain yield (g/plot): Grain yield in grams obtained from the central four harvestable rows of each plot was harvested, threshed and weighted using sensitive balance and then adjusted to 10% moisture content.

Grain yield (ton/ha): Grain yield obtained from each plot was used to estimate grain yield (tons) per hectare.

Thousand seed weight (g): The weight in grams of 1000 seed was randomly taken from each experimental plot using sensitive balance and adjusted to 10% moisture content.

RESULTS AND DISCUSSION

Analysis of variance

The research was conducted at two locations viz. Yabello and Abaya. Analysis of variance was computed for each location before the combined analysis of variance computed. The analysis of variance was computed for days to flowering, days to maturity, plant height, number of primary branches, pod length, pods per plant, seeds per pod, seeds per plant, thousand seed weight and grain yield per hectare. The individual location and the combined analysis of variance results are presented in subsequent sections.

Individual location analysis of variance

Analysis of variance computed for each location revealed that variation among genotypes were highly significant ($P<0.01$) for all traits at both locations and significant ($P<0.01$) for the number of primary branches and pod length at Abaya (table 3 and table 4). The presence of variations among genotypes for all the traits studied indicated the presence of sufficient variability among common bean genotypes studied that would be exploited through selection to improve the crop for desired traits. This further justifies the importance of carrying out further genetic analysis for all traits.

There are reports in Ethiopia (11) about the variation among 100 common bean genotypes for quantitative traits and found variation among genotypes for studied paramters. Highly significant variation for days to flowering, days to maturity, pods per plant, seeds per pod, seeds per plant, and 100 seed weight in 26 common bean genotypes were also reported (3). The presence of significant variation among 100 common bean genotypes for days to flowering, grain yield and thousand seed weight was also reported (14).

Table 1: Description of the study area

Variables	Yabello	Abaya
Soil type	sandy	Sandy clay loam
Altitude (m. a. s. l.)	1631	1442
Latitude	02 °88'006"N	06 °43'520"N
Longitude	038 °14'761"E	038 °25'425"E
Annual Temperature °C		
Minimum	14.5	12.6
Maximum	26.3	29.9
Annual rainfall (mm)		
Minimum	400	500
Maximum	700	1100

Table 2: Mean squares from analysis of variance for 10 traits of 36 common bean genotypes grown at Yabello in 2015

Source of variation	DF	GY (t/ha)	FD	MD	PH (cm)	NPB	PL (cm)	PPP	SPP	SPNT	TSW (g)
Replications	2	0.357**	10.62ns	37.53**	664.45**	0.323ns	0.3504ns	7.307*	0.482*	32.34ns	599.3*
Blk within Rep.(Adj.)	15	0.028	3.36ns	2.083ns	45.87ns	0.140ns	0.1368ns	3.0307ns	0.152ns	12.95ns	76.0086ns
Treatments (Unadj.)	35	0.492**	11.72**	22.79**	623.39**	0.443**	1.866**	7.464**	1.069**	249.32**	1050.66**
Intra Block Error	55	0.053	3.65	2.128	51.78	0.194	0.2003	1.97	0.099	25.66	159.51
RCB Error	70	0.048	3.59	2.118	50.51	0.182	0.1867	2.1973	0.110	22.93	141.62
Total	107	0.199	6.38	9.541	249.38	0.270	0.7391	4.0156	0.431	97.16	447.52
ER to RCBD		89.97	98.17	100	97.55	94.01	93.98	103.76	103.77	89.16	88.78
CV (%)		8.36	4.35	1.79	11.74	11.9	5.14	7.68	8.74	7.81	5.51

Table 3: Mean squares from analysis of variance for 10 traits of 36 common bean genotypesgrown at Abaya in 2015

Source of variation	DF	GY (t/ha)	FD	MD	PH (cm)	NPB	PL (cm)	PPP	SPP	SPNT	TSW (g)
Replications	2	0.007	6.69ns	5.79ns	1158.07**	4.98**	1.051	6.085ns	0.18ns	4.34	32.27
Blk withn Rep.(Adj.)	15	0.112	22.42*	6.88ns	18.93	0.12	0.409	2.46*	0.23	54.88*	197.98
Treatments (Unadj.)	35	0.531**	33.93**	27.80**	211.53**	0.51*	1.379*	7.925**	0.77**	177.65**	1612.26**
Intra Block Error	55	0.077	11.28	6.85	26.22	0.19	0.676	1.972	0.12	28.73	160.73
RCB Error	70	0.085	13.67	6.85	24.66	0.19	0.619	2.075	0.15	34.33	168.71
Total	107	0.229	20.17	13.69	106.97	0.39	0.875	4.064	0.35	80.65	638.35
ER to RCBD		102.81	109.50	100.0	94.04	94.00	91.55	101.0	107.8	108.4	100.9
CV (%)		11.28	8.24	3.3	5.05	13.66	9.54	7.83	10.61	9.12	5.9

ns, * and **, non-significant, significant at P<0.05 and P<0.01, respectively. Blk within Rep.(Adj.) = blocks within replication mean squares adjusted, Treatments (Unadj.) = treatments unadjusted mean squares, ER to RCBD = efficiency ratio to randomized block design, DF= degree of freedom, FD= days to flowering, MD= days to maturity, PH(cm) = plant height in centimetre, NPB= number of primary branch, PL (cm) = pod length in centimetre, PPP= pod per plant, SPP= seed per pod, SPNT= seed per plant, TSW (g) = thousand grain weight in gram, GY (t/ha) = Grain yield ton per hectare at 10% moisture content.

Combined analysis of variance over location

Location wise analyses were performed and error variances were subjected to F-test for homogeneity of variance. Variables with homogeneous error variances were subjected to combined analysis, and genetic analyses as well as evaluation of genotypes performance were conducted using the pooled mean values over locations. Whereas, for those traits with heterogeneous error variances genetic analyses and evaluation of genotypes were conducted using each location mean values. Accordingly, days to flowering, days to maturity and pod length exhibited heterogeneous error variances and the mean squares for location were also significant indicating the performance of the genotypes cannot be evaluated on the basis of pooled mean values over locations. However, the homogeneity of error variances for plant height, number of primary branches, pods per plant, seeds per pod, seeds per plant thousand seed weight and grain yield were homogeneous that allowed evaluation of the genotypes on the basis of combined mean values over locations.

The ANOVA results of combined analysis over locations are presented in table 5. The result of combined analysis of variance revealed the presence of highly significant (P<0.01) difference among genotypes for all traits suggested the presence of sufficient genetic variability for these trait that can be exploited in breeding programs. Highly significant variation for grain yield in common bean genotypes was also reported by (16, 23). The significant differences were observed between locations for all traits except number of pods per plant. This indicates that the two locations were significantly different for the performance of genotypes for these traits. The significant differences between locations were reported in common bean by some authors (12, 16).

Significant (P<0.01) genotype x location interaction effect were observed for all traits except for number of primary brunches which had significant (P<0.05) interaction effect (table 5). The presence of significant genotype x location interaction suggested that genotypes had differential performance at the two locations for these traits. The differential performance of genotypes across environment varies significantly and the performance of plants depends directly on the environmental conditions (8). Other authors also reported the significant influence of genotype by location interaction on the performance of common bean genotypes (12) and (16).

Table 4: Mean squares from combined analyses of variance over locations for 7 traits of 36 common bean genotypes tested at Abaya and Yabello in 2015 cropping season

Sources of variation	DF	GY (t/ha)	PH (cm)	NPB	PPP	SPP	SPNT	TSW (g)
Location	1	6.92**	86400**	11.12**	6.07	3.89**	1938**	11131.8**
Rep within loc.	4	0.13	1778.01**	1.8**	13.20**	0.56*	13.06	246.76
Blk within Rep	30	0.04	32.13	0.18	2.017	0.13	31.9	95.55
Genotype	35	0.50**	563.91**	0.56**	9.37**	1.19**	239.01**	1464.69**
Loc* Geno	35	0.41**	233.48**	0.31*	4.65**	0.5**	152.07**	837.35**
Error	170	0.07	38.23	0.19	2.15	0.13	28.24	162.31
CV (%)		10.24	7.61	12.58	8.1	10.34	8.59	5.74

* and **, significant at P<0.05 and P<0.01, respectively. Loc = location, Rep = replication, Blk within Rep = blocks within replication, Geno = genotype, Loc* Geno= location within genotypes, CV (%) = coefficient of variation in percent, DF= Degrees of freedom, PH= plant height in centimetre, NPB= number of primary branch, PPP= pod per plant, SPP= seed per pod, SPNT= seed per plant, TSW (g) = thousand grain weight in gram, GY (t/ha) = Grain yield ton per hectare at 10% moisture content.

Table 5: Mean values and ranges for 10 traits of 36 common bean genotypes tested at Abaya and Yabello during 2015 cropping season

Trait	Abaya		Yabello	
	Range	mean±SE	Range	mean±SE
FD	37.0-49.0	40.72±2.74	41-47	43.96±1.56
MD	72.7-88.0	79.19±2.14	77.3-89.7	81.47±1.19
PH(cm)	84.7-115.3	101.30±4.18	43.2-95.7	61.30±5.88
NPB	2.4-4.3	3.25±0.36	2.5-4.7	3.70±0.36
PL (cm)	7.1-9.9	8.62±0.67	7.2-10.5	8.70v0.37
PPP	15.7-23.3	17.93±1.15	15.3-24	18.26±1.15
SPP	2.0-4.7	3.32±0.28	2.0-4.7	3.59±0.26
SPNT	46.7-74.7	58.85±4.38	48.0-78.7	64.84±4.14
TSW(g)	152.2-249.1	214.94±10.35	191.0-270.9	229.30±10.3
GY (t/ha)	1.44-3.12	2.39±0.23	1.89-35.37	2.75±0.19

SE= Standard error, FD= days to flowering, MD= days to 90% maturity, PH (cm) = plant height in centimetre, NPB= number of primary branch, PL (cm) = pod length in centimetre, PPP= pod per plant, SPP= seed per pod, SPNT= seed per plant, TSW (g)= thousand seed weight in gram, GY (t/ha)= Grain yield in tone per hectare at 10% moisture content.

Mean performance of genotypes

Crop phenology

Range and mean values of 10 traits for 36 common bean genotypes evaluated at Abaya and Yabello during 2015 cropping season are presented in table 6. The mean performances of genotypes for these traits are presented in Tables 7 and 8. Mean of genotypes for days to flowering were as low as 40.7 and as high as 44 d at Abaya and Yabello, respectively. Mean days to maturity was 79.3 and 81.47 d for the 36 genotypes at Abaya and Yabello, respectively. The genotypes showed early flowering and maturity at Abaya than Yabello. This might be due to the altitude and temperature differences of the two locations, where by Abaya is located at an altitude of 1442 m. a. s. l. with mean maximum temperature of 29.9 °C while Yabello is located at an altitude of 1631 m. a. s. l. with mean maximum temperature of 26.3 °C (table 1). Flowering and maturity of common bean genotypes are shorter at low altitude where the areas have high temperatures. The differences in days to maturity could also be caused due to other variation of environments where genotypes were studied (5).

One third of the tested genotypes was significantly earlier in flowering at Abaya with 37 and 38 d while only five genotypes were significantly early flowering at Yabello with 41 and near to 42 d. However, at both locations, only ALB58 and ALB149 were found to flower earlier. The earliest maturing genotype was BFS 34 at both locations. The genotypes took 74.3 and 77.3 d at Abaya and Yabello, respectively. Another 12 early maturing genotypes didn't take more than three days as compared to BFS 34 at both locations. At both locations, BFS 34 and ALB149 were found to be earlier in flowering and maturing genotypes (table 7 and 8). On the other hand, Mexican-142 and ALB167 were identified as the latest maturing genotypes than the others at both locations. Mexican 142 and ALB167 matured at 88.0 and 86.3 d at Abaya; and 89.7 and 87.7 d at Yabello, respectively.

Among the 36 genotypes evaluated under current study, 58.3 and 47.2% exhibited lower number of days to flowering and maturity, respectively at Abaya than the location mean. Among the 36 genotypes evaluated under current study, At Yabello, genotype exhibited 63.8% and 55.6% lower number of days to flowering and maturity, respectively than location mean. Most of earlier flowering genotypes matured early and also late maturing genotypes matured late at both locations. For seven of the released varieties used in this study, number of days to maturity was between 75.7 to 88.0 d at Abaya and 80 to 89 d at Yabello. Among the 29 new genotypes evaluated, 5 (13.89%) were earliest maturing than the earliest commercial variety (Awash melka) at both locations. This suggested that there is higher chance of selecting early maturing genotypes that can escape the terminal moisture stress which is one of the crop production constraints in the study area.

Growth traits

Mean performances of genotypes for plant height at Abaya ranged from 84.7 cm to 115.3 cm with location mean of 101.3 cm; whereas mean performance of genotypes for plant height ranged from 43.2 cm to 95.7 cm with location mean of 61 cm at Yabello (table 6). Similar result for mean and range for plant height in common bean genotypes was also reported previously (1, 11). Genotypes attained higher plant height at Abaya than at Yabello. The difference of common bean genotypes for plant height was previously reported (1).

Genotypes exhibited considerable variations for number of primary branches that ranged from 2.4 for Awash melka to 4.3 for ALB25 at Abaya (table 7); and 2.5 for Awash-2 to 4.7 for ALB25 at Yabello (table 8). Significantly higher number of primary branches were counted from ALB25 (4.7) followed by ALB151 (4.3) were as significantly lower number of primary branches were recorded from Awash-2, ALB207 and NASIR at Yabello (table 8). Higher number of primary branch was counted from ALB25 (4.3) and G21212 (3.9) whereas lower number of primary branches were recorded from Awash melka (2.4) and NASIR (2.7) at Abaya (table 7). Numbers of branches are contributing to yield because pods and then grains are produced on it. Existence of significant variations among common bean genotypes for number of primary branches was also reported by (4).

Yield and yield components

Mean performances of genotypes for pod length were as low as 7.1 and as high as 9.9 cm with mean value of 8.62 cm at Abaya were as it was as low as 7.2 and as high as 10.5

cm with a mean value of 8.7 cm at Yabello (table 7 and 8). The mean performance of genotypes for pod length was higher at Yabello than at Abaya though the mean difference of this trait between the two locations was small. Among released varieties Awash melka and ROBA-1 (8.8 cm) and Awash melka (8.8 cm); NASIR and Awash melka had the longer pods at Abaya and Yabello Respectively. Among the 29 new entries, ALB145 and BFS33; BFS23 (10.5 cm), SXb412 (10.3 cm) and BFS34 (10.1 cm) had longer pods at Abaya and Yabello, respectively (table 7 and 8). The presence of significant variation among common bean genotypes for pod lengt were also reported by (7) and (17).

Location wise mean performance of genotypes for number of seeds per pod ranged from 2.0 to 4.7 at each location with mean values of 3.3 and 3.6 at Abaya and Yabello, respectively were as the mean performance for thousand seed weight ranged from 152.2g to 249.1g; 190g to 270.9g (table 6) at Abaya and Yabello, respectively. This suggested the presence of considerable variations among the tested genotypes for number of seeds per pod ant 1000 seeds weight within and between locations. Other researchers also reported significant variation among common bean genotypes for the two traits mean performance within location and across locations (23).

Among the released varieties, ROBA-1 (227.6G) and Mexican-142 (248.5Gg) had higher 1000 seed weight at Abaya and Yabello, respectively. Among the new entries, ALB204 (249.1g) and BFS30 (260g); ALB204 (270.9) and BFS18 (263.9g) had higher 1000 seed weight at Abaya and Yabello, respectively (table 7 and 8). In common bean, the genotypes with higher thousand seed weight are preferred because the size is considered as quality parameter. The studied genotypes showed significantly different 1000 seeds weight (TSW). According to (19), common bean seeds weight can vary from 150-900g per 1000 seeds. Genotypes are grouped into small-seed common bean with TSW<250 g, medium up to 400g and large-seed over 400g. According to this category, 97.2 % of the genotypes used for this study were categorized as small seeded (<250g) and 2.8% were categorized as medium seeded. The presence of significant variation among common bean genotypes for thousand seed weight was also reported by (23) and (3).

The variation of genotypes for pods number per plant and seeds number per plant ranged from15.7 to 23.3; and 46.7 to 74. 7, respectively at Abaya. The variation of these two traits ranged from 15.3 to 24 and 48 to 78.7, respectively at Yabello. ALB167 had significantly higher pods number per plant at both locations. Higher seeds number per plant where recorded from ALB25 (74.7) followed by BFS34 (69.3), BFS 30(69.0), BFS24 (68.0) and BFS39 (68.0) at Abaya where as ALB204 (78.7) and BFS18 (76.7) had higher number of seeds per plant at Yabello. The existence of considerable genetic variations for pods/plant and seeds/pod was also reported by other authors in common bean (13; 18 and 2). The mean grain yield of locations averaged over genotypes was 2.39 t/haand 2.75

t/haat Abaya and Yabello, respectively (table 6). At Yabello the highest mean grain yield was measured from genotype ALB204 (3.54 t/ha) followed by BFS 18 (3.49 t/ha) and the lowest mean grain yield was obtained from BFS 27 (1.89 t/ha) followed by BFS10 (1.97 t/ha). At Abaya the highest grain yield was obtained from genotype BFS 39 (3.12 t/ha) followed by ALB25 (3.09 (3.12 t/ha) and the lowest grain yield was measured from Chorie (1.44 t/ha) followed by NASIR (1.68 t/ha). About 61% of the genotypes gave grain yields greater than the overall mean grain yield of genotypes at Yabello and 52.8% of the genotypes had grain yield greater than the overall mean yield of genotypes at Abaya. In all cases, BFS30 (3.12 ton/ha) and ALB25 (3.09 ton/ha) are significantly well performing genotypes at Abaya where as ALB204 (3.54 ton/ha) and BFS18 (3.49 ton/ha) are significantly well performing genotypes at Yabello (table 7 and 8).

Table 6: Mean value of yield and yield related traits of 36 common bean genotypes tested at Abaya in 2015 cropping season

Genotype	FD	MD	PH(cm)	NPB	PL(cm)	PPP	SPP	SPNT	TSW(g)	GY(t/ha)
ALB58	37.0e	81.0c-f	84.7 l	3.2 b-h	8.3a-g	17.7 c-g	3.0 cd	53.0 g-j	203.7 f-h	2.23f-m
ALB36	43.0a-e	78.7d-h	107.0 a-e	3.7 a-d	7.6e-g	17.0 e-g	3.3 b-d	56.7 c-j	195.2 g-i	2.20g-n
ALB25	37.0e	82.3b-e	91.7 i-l	4.3 a	7.8d-g	18.7 b-f	4.0 b	74.7 a	243.4 a-c	3.09ab
ALB61	39.3c-e	80.7f-e	107.9 a-e	3.3 b-h	8.1b-g	18.3 b-g	3.3 b-d	61.3 b-h	203.8 f-h	2.52c-j
ALB167	44.3a-d	86.3ab	107.8 a-e	3.0 c-h	8.7a-g	23.3 a	2.0 e	46.7 j	169.9 jk	1.80k-o
ALB163	42.0b-e	77.7d-i	114.6 a	3.6 a-f	9.6a-c	17.0 e-g	4.0 b	66.0 a-d	242.6 a-d	2.77a-f
ALB212	37.0e	78.7d-h	99.6 e-j	3.6 a-f	9.3a-d	17.0 e-g	3.7 bc	62.3 b-g	229.5 a-e	2.49c-j
ALB204	40.3c-e	79.3d-h	112.7 ab	3.9 a-c	8.6a-g	17.7 c-g	3.7 bc	64.7 a-e	249.1 a	2.95a-c
ALB145	38.0de	77.3e-i	104.6 b-g	3.8 a-d	9.9a	18.7 b-f	3.3 b-d	61.7 b-h	217.7 d-g	2.45c-j
ALB133	39.3c-e	76.0f-i	102.0 h-g	3.7 a-d	9.6a-c	17.7 c-g	4.0 b	69.3 ab	232.0 a-e	2.78a-f
ALB151	40.3c-e	79.7c-g	89.7 kl	3.3 b-g	8.6a-g	19.7 b-e	3.0 cd	59.0 b-i	217.4 d-g	2.16g-n
ALB149	38.0de	75.3g-i	100.2 e-j	3.1 b-h	8.3a-g	19.0 b-f	3.0 cd	57.0 c-j	229.7 a-e	2.63a-i
ALB179	37.0e	81.0c-f	104.4 e-d	3.3 b-h	8.8a-g	17.0 e-g	3.3 b-d	56.0 d-j	231.0 a-e	2.72a-g
ALB209	37.0e	76.0f-i	88.5 kl	3.2 b-h	8.3a-g	18.0 b-g	3.3 b-d	60.0 b-h	224.2 a-f	2.59a-i
ALB207	44.3a-e	78.3d-h	88.9 kl	3.1 b-h	8.4a-g	20.3 bc	3.3 b-d	67.0 a-c	221.4 b-f	2.62a-i
G21212	40.3c-e	78.3d-h	108.5 a-e	3.9 ab	8.6a-g	17.7 c-g	3.7 bc	64.3 a-f	227.8 a-f	2.69a-h
BFS 27	47.3ab	82.7b-d	96.7 f-k	3.4 b-g	7.8d-g	19.0 b-f	2.7 d	49.0 ij	170.7 jk	1.75l-o
BFS 320	37.68e-d	77.33e-i	105.67a-f	3.00c-h	8.93a-f	17.67c-g	3.67bc	64.67a-e	232.81a-e	2.69a-h

Means with the same letters in the same columns are not significantly different; means in the bracket is transformed value

FD= flowering date, MD= Maturity date, PH= plant height, NPB= number of primary branch, PL= pod length, PPP= pod per plant, SPP= seeds per pod, SPNT= seeds per plant, TSW= thousand grain weight, GY= Grain yield per hectare at 10% moisture contents.

Table 7: Mean value of yield and yield related traits of 36 common bean genotypes tested at Yabello in 2015 cropping season

Genotype	FD	MD	PH	NPB	PL	PPP	SPP	SPPNT	TSW	GY(t/ha)
ALB58	41.0 d	79.0 k-o	47.7 j-l	3.9 a-d	8.7 f-i	17.7 b-e	3.3 de	58.7 g-j	219.5 g-l	2.65f-k
ALB36	45.7 ab	83.0 d-h	70.9 c-g	4.2 a-c	7.2 o	17.3 b-e	4.0 bc	69.3 a-f	238.7 c-h	3.08b-f
ALB25	43.7 a-d	82.0 e-j	52.9 i-l	4.7 a	8.6f-l	19.0 b-d	4.0 bc	76.3 ab	250.2 a-d	3.22a-d
ALB61	43.0 b-d	85.3 b-d	56.5 h-i	3.7 b-e	7.7 l-o	17.7 b-e	3.0 ef	53.0 jk	191.0 m	2.30k-o
ALB167	45.7ab	87.7 ab	91.6 ab	3.7 b-e	8.8 e-i	24.0 a	2.0 h	48.0 k	198.5 k-m	2.52g-l
ALB163	44.3 a-d	79.7 j-o	57.5 h-l	3.2 d-f	9.6b-e	17.1 b-e	3.7 cd	63.7 f-i	223.8 f-j	2.47h-l
ALB212	43.0 b-d	81.7e-k	71.6 c-f	3.5 b-e	8.3 g-n	18.5 b-d	4.0 bc	74.3 a-e	255.3 a-c	3.19a-e
ALB204	43.7 a-d	81.7 e-k	78.6 cd	4.0 a-d	8.3h-n	19.7 b	4.0 bc	78.7 a	270.9 a	3.54a
ALB145	45.0 a-c	81.7 e-k	68.9 d-h	3.8 a-e	9.7 a-d	19.0 b-d	3.7 cd	69.0 a-f	221.0 g-k	2.76d-j
ALB133	41.0 d	78.3 m-o	47.9 j-l	3.7 b-e	9.2c-g	17.7 b-e	3.0 ef	53.0 jk	206.6 j-m	2.04m-o
ALB151	43.0 b-d	83.3 d-g	59.9 f-j	4.3 ab	7.8 j-o	18.0 b-e	3.7 cd	65.0 e-h	229.3 d-j	2.71f-k
ALB149	41.7 cd	78.3 m-o	55.9 h-l	3.8 b-e	8.6f-k	17.7 b-e	3.0 ef	53.0 jk	211.7 i-m	2.47h-l
ALB179	43.0 b-d	83.0 d-h	75.3 c-e	3.7 b-e	8.5f-l	17.0 b-e	4.0 bc	68.0 b-g	233.0 c-i	2.80d-i
ALB209	43.0 b-d	80.3 h-n	45.6 j-l	3.7 b-e	8.5f-l	16.3 de	4.0 bc	65.3 d-h	226.0 d-j	2.83c-i
ALB207	42.3 b-d	80.7 g-m	43.6 l	3.0 ef	8.4 f-m	18.7 b-d	3.7 cd	67.3 b-g	228.8 d-j	2.80d-i
G21212	47.0 a	82.7 d-i	84.2 a-c	3.3 c-f	8.6 f-k	17.0 b-e	4.0 bc	68.0 b-g	236.4 c-i	2.79d-i
BFS 27	45.7 ab	84.3c-e	81.0 b-d	4.0 a-d	8.1 i-n	19.3 bc	2.7 fg	50.3 jk	196.2 lm	1.890
BFS 320	42.33a-c	80.67g-m	59.4f-j	4.07a-d	9.04d-h	16.67c-e	4.3ab	71.67a-f	250.0a-e	3.08b-f
BFS 34	37.0e	74.3hi	89.6 kl	3.0 c-h	9.1a-e	17.3 d-g	4.0 b	69.3 ab	235.8 a-d	2.85a-d
BFS 24	40.3c-e	79.3d-h	101.3 d-i	3.2 b-h	9.3 a-d	17.0 e-g	4.0 b	68.0 ab	227.8 a-f	2.72a-g
BFS 55	38.0de	77.7d-i	101.2 d-i	3.4 b-g	8.9 a-f	20.7 b	3.0 cd	62.0 b-g	221.1 b-f	2.29d-l
BFS 35	45.0a-c	79.7c-g	94.9 g-k	3.2 b-h	8.7a-g	20.0 b-d	3.3 b-d	65.7 a-d	227.7 a-f	2.56b-i
BFS 10	42.7a-e	79.7c-g	93.3 l-k	2.8 e-h	8.2b-g	20.7 b	2.7 d	54.0 f-j	207.9 e-h	2.11i-n
BFS 30	41.0a-e	77.7d-i	103.9 h-g	3.6 a-f	9.0a-f	15.7 g	4.7 a	69.0 ab	243.7 ab	3.12a
BFS 39	39.0 c-e	76.7f-i	100.2 h-g	2.7 f-h	9.6 a-c	17.0 e-g	4.0 b	68.0 ab	238.8 a-d	2.83a-e
BFS 18	40.3c-e	81.0c-f	104.5 b-g	3.1 b-h	7.7d-g	15.7 g	3.0 cd	47.0 j	189.8 h-j	1.70m-o
SX b 412	39.3c-e	79.0d-h	88.9 kl	2.8 e-h	9.3a-d	d-g	3.0 cd	52.0 g-j	194.3 g-i	1.78k-o
BFS 23	41.0b-e	79.3d-h	113.1 ab	2.6 gh	8.6a-g	18.0 b-g	3.0 cd	54.0 f-j	218.4 c-g	2.30d-k
BFS 33	37.0e	77.7d-i	90.9 j-l	3.3 b-g	9.7 ab	17.1 e-g	3.0 cd	51.3 h-j	218.1 d-g	2.15h-n
NASIR	49.0a	79.3d-h	107.9 a-e	2.7 gh	8.2b-g	15.7 g	3.0 cd	47.0 j	172.5 i-k	1.68n-o
ROBA	41.7b-e	77.3e-i	101.9 c-h	3.7 a-e	8.8a-g	18.3 b-g	3.0 cd	55.0 e-j	227.6 a-f	2.66a-i
Awash 1	42.0b-e	80.3c-g	111.9 a-c	3.3 b-h	7.4fg	16.3 fg	3.0 cd	49.0 ij	192.5 h-j	2.01j-n
Awashmelka	44.3a-d	75.7g-i	102.0 c-h	2.4 h	8.8a-f	17.3 d-g	3.0 cd	52.0 g-j	209.0 e-h	2.28e-l
Awash 2	38.0de	79.7c-g	100.0 e-j	2.7 f-h	8.6a-g	17.0 e-g	3.3 b-d	56.3 d-j	209.1 e-h	2.19g-n
Mexican-142	41.7b-e	88.0a	115.3 a	2.9 d-h	7.1g	17.3 d-g	3.3 b-d	58.7 b-i	209.7 e-h	2.25f-l
Chorie	49.0a	84.7a-c	110.8 a-d	3.1 b-h	8.0c-g	15.7 g	3.0 cd	47.0 j	152.2k	1.440
CV (%)	8.24	3.30	5.05	13.67	9.54	7.83	10.61	9.11	5.9	11.64

Means with the same letters in the same columns are not significantly different; means in the bracket is transformed value
FD= flowering date, MD= Maturity date, PH= plant height, NPB= number of primary branch, PL= pod length, PPP= pod per plant, SPP= seeds per pod, SPNT= seeds per plant, TSW= thousand grain weight, GY= Grain yield per hectare at 10% moisture contents.

Table 8. Mean value of yield and yield related traits

Genotype	FD	MD	PH	NPB	PL	PPP	SPP	SPPNT	TSW	GY(t/ha)
BFS 34	47.0 a	77.3 o	44.3 l	3.7 b-e	10.1 ab	17.0 b-e	4.0 bc	68.0 b-g	240.1 b-g	2.96c-g
BFS 24	43.0 b-d	78.3 m-o	50.6 i-l	3.7 b-e	8.6f-j	19.0 b-d	3.7 cd	69.0 a-f	232.4 c-i	2.78d-j
BFS 55	42.3 b-d	80.0 i-o	47.7 j-l	3.8 a-e	8.7 f-i	15.3 e	4.7 a	71.0 a-f	246.8 b-f	3.20a-e
BFS 35	47.0 a	83.7 c-f	74.7 c-e	3.9 a-e	9.9 a-c	16.7 c-e	4.3 ab	70.0 a-f	238.8 c-h	2.89c-h
BFS 10	43.0 b-d	82.7 d-i	67.1 d-h	3.6 b-e	7.7 k-o	22.7 a	2.3 gh	51.3 jk	196.3 lm	1.97n-o
BFS 30	41.0 d	77.7 no	48.0 j-l	4.0 a-d	8.5 f-l	18.3 b-d	4.0 bc	73.0 a-f	248.5 a-f	3.21a-e
BFS 39	41.7 cd	78.3 m-o	43.2 l	3.9 a-d	9.3 c-f	17.5 b-e	3.0 ef	53.0 jk	214.1 h-m	2.09l-o
BFS 18	47.0 a	82.0 e-j	76.9 c-e	3.7 b-e	8.4 f-m	19.3 bc	4.0 bc	76.7 ab	263.9 ab	3.49ab
SX b 412	42.3 b-d	81.3 f-l	59.9 f-j	3.7 b-e	10.3 ab	17.5 b-e	3.0	52.7 jk	228.9 d-j	2.55g-k
BFS 23	46.0ab	79.3 j-o	69.5 f-e	3.5 b-e	10.5 a	18.6 b-d	3.0 ef	55.7 i-k	225.7 d-j	2.40i-m
BFS 33	42. b-d	78.7 l-o	46.5 j-l	3.4 b-e	8.7 f-j	17.8 b-e	3.0 ef	53.7 jk	223.5 f-j	2.34j-n
NASIR	47. a	81.3 f-l	58.7 f-k	3.4 b-e	9.7 a-d	18.1 b-e	4.0 bc	72.7 a-f	228.3 d-j	2.76e-j
ROBA	44. a-d	80.3 h-n	45.1 kl	4.1 a-d	8.4 f-m	18.3 b-d	3.7 cd	67.0 b-g	224.2 f-j	2.79d-j
Awash 1	43. a-d	81.3 f-l	64.1 e-i	3.5 b-e	7.6 m-o	18.9 b-d	3.0 ef	56.7 h-k	211.5 i-m	2.49h-l
AwashMelka	47. a	80.3 h-n	50.9 i-l	4.1 a-d	9.0d-h	18.8 b-d	4.0 bc	75.3 a-d	233.0 c-i	3.02c-f
Awash 2	43. b-d	81.3 f-l	47.9 j-l	2.5 f	8.3h-n	18.5 b-d	4.0 bc	74.0 a-e	238.7 c-h	2.81d-i
Mexican-142	43. a-d	89.7 a	95.7 a	3.5 b-e	7.5 no	19.1 b-d	4.0 bc	76.0 a-c	248.5 a-f	3.26a-c
Chorie	47. a	86.0 bc	67.3 d-h	3.2 d-f	8.4 f-m	17.9 b-e	3.7 cd	66.0 c-h	224.9 e-j	2.77d-j
CV (%)	4.35	1.79)	11.74	11.90	5.1	7.68	8.74	7.81	5.51	8.36

Means with the same letters in the same columns are not significantly different; means in the bracket is transformed value

FD= flowering date, MD= Maturity date, PH= plant height, NPB= number of primary branch, PL= pod length, PPP= pod per plant, SPP= seeds per pod, SPNT= seeds per plant, TSW= thousand grain weight, GY= Grain yield per hectare at 10% moisture contents.

CONCLUSIONS

The results of this investigation showed significant variation among genotypes for all traits as well as significant effect of genotype by location interaction for grain yield and most yield related traits, which indicated the differential performance of genotypes across environments. The highest mean grain yield was exhibited by ALB204 (3.54 ton ha^{-1}) and BFS 18 (3.49 tone ha^{-1}) at Yabello and Abaya, respectively. ALB204 (3.25 ton ha^{-1}) had the highest mean grain yield over locations. About 61% of the genotypes gave grain yields greater than grand mean at Yabello and 52.8% of the genotypes had grain yield greater than the grand mean at Abaya. About 16.67% the new entries gave mean grain yield greater than the best performing released variety (Mexican-142) across locations. This suggested the higher chance of obtaining high yielding genotype to be released for the area.

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