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Characterization of Morphological Traits in Common Bean (*Phaseolus vulgaris* L.) Landraces Collected from Ethiopia at Jimma

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Abstract: Common bean (*Phaseolus vulgaris* L.) also known as haricot bean, snap bean, navey bean, and kidney bean. It is seed propagated and true diploid (2n = 22). Low yield is a major problem of common bean in Ethiopia. So, the morphological characterization of common bean landrace is essential to improve yield and yield related character through selection. The objective of this study was to characterize Common bean of landraces collected from different parts of Ethiopia. In this study, one hundred common bean landraces were evaluated in simple lattice design at Jimma Agricultural Research Center, Melko. Considerable variation in plant growth habit, Type-II (indeterminate bush) was the most prevalent among the accessions (55%), followed by Type-I (determinate bush) (45%) growth habits. The percentage frequencies of the qualitative classes varied from 4%-84%. The H' values varied from 0.190 for pod beak position to 0.642 for seed color. Characters with wide phenotypic diversity index was observed in seed color (H'=0.642) seed coat color (H'= 0.624), pod color (H'=0.622), and seed shape (H'=0.582) indicating widely diversified for these characters. On the other hand, pod beak position (H'=0.190) showed relatively the lowest diversity. The high diversity of bean landraces observed in this study, is in part due to farmer's customary seed exchanges. Frequent mutations and genetic recombination are the other possible causes of high diversity of the bean landraces studied. In general, this study showed that the collection has a relatively important diversity. This genetic diversity can be exploited in improvement programmes. However, the present result based on morphological alone can't make definite conclusion. As a result, it is recommended that molecular and other quality traits like protein content studies have to be carried out.

Keywords: Common Bean, Diversity, Landrace, Qualitative Traits

1. Introduction

Common bean (*Phaseolus vulgaris* L.) also known as haricot bean, snap bean, navey bean, and kidney bean. It is seed propagated and true diploid (2n = 22). It is one of the most important pulse crops [1]. Common bean belongs to the genus *Phaseolus,* with pinnately compound trifoliate large leaves. The genus consists of some 70 species [2]. This legume is an annual and self-pollinated crop [3] which intensely grows throughout the whole tropical area and some temperate regions of the planet [4].

Common bean is grown for local consumption and for export as cash crops. In Ethiopia it is major sources of proteins in the lowlands (mainly in Eastern, Southern, South Western and the Rift valley areas of Ethiopia [5] where they are consumed as *Nifro, Wasa, Shirowat, Soup and Samosa*. In addition, common bean has health benefits being rich in protein content (about 23% for dried shelled beans and about 6% for green beans) and serving as a good source of iron and zinc (both of which are key elements for mental development) [5]. The crop is also significant source of fiber, calories and vitamins especially foliate. Also it is used as sources of feed. Common bean can improve soil fertility through the fixation of atmospheric nitrogen (N_2) in symbiosis with rhizobia and decomposition of its residues [6]. Moreover, it is an increasingly important crop in the cropping systems since it is used for nitrogen fixation [7].

To improve yield of common bean it is necessary to generate enough variability to increase the probability of successful selection in common bean [8]. In common bean, architectural, phonological and yield components are collectively influencing seed yield. To be useful for plant breeders, genetic resources must be characterized by morphological and agronomic traits [9]. In fact, morphological characterization allows clarification of some problems of synonymies that exist in local denomination of landraces and permits knowing the correlations between agronomic performances for breeding program [10]. The characterization of accessions also allows quantification of the genetic variability in the landraces [11]. Plant breeding is essentially selection of plants among the variables. Thus, an insight into the magnitude of variability present in a crop species is important as it allows effective selection. The total observable variation, phenotypic variation, is made up of genetic and environmental component of variations. Genotypic variation, which arises due to the genotypic difference and the base for selection is the main concern of plant breeders. Hence, in selection for yield, more emphasis has to be placed on those attributes with low environmental variability.

In order to increase common bean production in Ethiopia research efforts aimed at supplying farmers with improved varieties is one contribution. Currently Ethiopian lowland pulses improvement project collected large numbers of haricot landraces from different haricot bean growing regions of Most of the genetic variability of this species in the world is saved and stored *ex situ*, outside the centers of origin, in gene banks. Maintaining of this diversity in the collections is essential to develop and support breeding programs. Hence the present study was undertaken with the objectives of characterizing and estimating of genetic diversity among haricot bean landraces based qualitative traits.

2. Material and Methods

2.1. Description of Study Area

This study was conducted at Jimma Agricultural Research Center (JARC). It is located at a The research center is found at 7°40'05" N latitude, 36°47'09" E longitude. The study area is located at an altitude of 1753 m.a.s.l and receives an average rainfall 1561 mm per annum. The maximum and minimum annual temperature of the area is 28.8 and 11.8°C, respectively. The soil type is classified as Chromic Nitosoil and Cambisoil with PH of 5-6 and Cation exchange capacity (CEC) 28.6. The nitrogen, organic carbon, and the available P are 0.25%, 2.96% and 5 ppm respectively.

2.2. Experimental Materials

For this study, 100 common bean landraces were obtained From Melkasa Agriculture Research Center (MARC) that are collected from different major common bean producing regions of Ethiopia (Table 1).

Table 1. *List of landrace accessions used in the study.*

Serial	Accession	Serial	Accession	Serial	Accession	Serial	Accession
1	P#909	26	P#831	51	P#769	76	P#1227
2	P#1285	27	P#864	52	P#1063	77	P#1079
3	P#1078	28	P#1074	53	P#1078	78	P#1095
4	P#1070	29	P#1187	54	P#967	79	P#859
5	P#1316	30	P#1050	55	P#1139	80	P#157
6	P#1107	31	P#1046	56	P#82	81	P#945
7	P#882	32	P#14	57	P#984	82	P#1042
8	P#1083	33	P#1306	58	P#763	83	P#1071
9	P#760	34	P#1212	59	P#1049	84	P#1154
10	P#932	35	P#1298	60	P#1094	85	P#931
11	P#1315	36	P#1086	61	P#906	86	P#1270
12	P#1027	37	P#1043	62	P#1179	87	P#93
13	P#1097	38	P#1300	63	P#145	88	P#1102
14	P#1247	39	P#772	64	P#916	89	P#58
15	P#264	40	P#1158	65	P#901	90	P#811
16	P#1176	41	P#1182	66	P#133	91	P#1150
17	P#1157	42	P#40	67	P#1055	92	P#857
18	P#1250	42	P#1077	68	P#986	93	P#1124
19	P#1092	44	P#861	69	P#1309	94	P#1127
20	P#1232	45	P#1063	70	P#1103	95	P#999
21	P#1038	46	P#1268	71	P#934	96	P#13
22	P#1057	47	P#1124	72	P#1310	97	P#1117
23	P#1072	48	P#990	73	P#1211	98	P#1283
24	P#985	49	P#1314	74	P#1279	99	P#989
25	P#1275	50	P#989	75	P#941	100	P#872

2.3. Experimental Design and Management

The experiment was laid out in a 10m x 10m simple lattice-design with two replications. The plot area was 0.8 m x 2m=1.6 m^2. The total area was 701.8 m^2. The distance between block, plot, rows and plants was 1m, 50 cm, 40 cm and 10 cm, respectively. The experiment was carried out during main cropping season through July-September in 2020 G. C. Di-ammonium phosphate (DAP) was applied at the rate of 100 kg ha^{-1}, and all other agronomic practices were applied as per the recommendations of lowland pulses improvement program.

2.4. Data Collected: For This Analysis, the Phenotypes of Each Qualitative Trait Were Indexed According to the Proposed Minimum List of Descriptors [12-14]

Table 2. *Morphological (qualitative) characters collected.*

Traits	States
Seed coat color	1=White; 2=dull; 3=cream; 4=yellow; 5=brown; 6=pink; 7=red
Plant growth habit	1=determinate bush, 2=indeterminate bush, 3=indeterminate prostrate 4=indeterminate climbing
Seed shape	1= Round; 2=oval; 3=cuboid; 4= kidney; 5=markedly, 6=truncate fastiagte
Seed brilliance	3=Dull; 5=medium; 7=shiny
Pod color	1=Dark purple; 2=red, 3=pink; 4=yellow, 5=pale yellow, 6=persistent green
bracteole size	3=small, 5=medium, 7=large
bracteole shape	3=lanceolate, 5=intermediate 7=ovate
flower color	1=white, 2=yellow, 3=red, 4=purple
seed color	1=White, 2=red, 3=cream, 4=black, 5=grey 6= yellow, 7=pink purple
Seed size	3=Small, 5=medium, 7=large
Leaf shape	3=Triangular, 5=Quadrangular 7=Round
Leaf color of chlorophyll	3=pale green, 5=medium green, 7=dark green
Pod beak position	1=marginal, 2=non marginal
Pod curvature	3=straight, 5=slightly curved, 7=curved, 9=re-curving

2.5. Data Analysis

2.5.1. Phenotypic Frequency

Phenotypic frequency distribution of each qualitative trait was calculated to evaluate the variation within the entire genotypes.

2.5.2. Shannon Weaver Diversity Index

According to Shenon- Weaver diversity index the assumption is that the landraces considered in this study were population. Shenon- Weaver Diversity index (H') was used to analyze qualitative data [15]. It was computed using the phenotypic frequencies to assess the overall phenotypic diversity for each character. Frequencies of the various categories of 14 qualitative traits were computed using Microsoft XL. The number of phenotypic classes used in Shannon-Weaver Diversity index (H') normalized by the maximum value (log n) in each case [16] were computed as a measure of diversity. For an "n" class trait, the observed normalized H' was obtained as:

$$(H) = -\Sigma si{=}1\ piln\ (pi)$$

Where, S is the number of phenotypic classes for a character

Pi= is the proportional abundance of the ith landrace= (*ni/N*), and pi is the frequency of landrace i(*ni/N*).

3. Results and Discussion

For all accessions, the percentage of frequencies of the phenotypic classes of varied from 4% to 84% (Table 3). Considerable variation in plant growth habit, Type-II (indeterminate bush) was the most prevalent among the accessions (55%), followed by Type-I (determinate bush) (45%) growth habits. Similarly, Okii *et al*. [17] reported that Type-II and I were the most dominant ones in common bean landrace accessions from Uganda. Furthermore, Asfaw *et al*. [1] reported that landrace accessions with Type-II, and IV were more frequent in Ethiopian common bean genotypes. Nonetheless, the most dominant plant type identified in their study (i.e. Type-III) was not evident in the present study. This may be explained by the differences in plant material sampling and environmental factors between the two related studies.

In this study percentage frequency of the phenotypic classes of haricot bean accessions showed that dark purple pod colored (38%) were more common than red (34%), red flower colored (77%) were more common than green (14%). Large bracteole size (51%) than small (45%), ovate bracteole shape (51%) were more common than lanceolate (45%). Regarding variation in seed shape, the majority of haricot bean accessions had oval (37%) followed by kidney (30%). In agreements with this finding [18] reported that oval seeds were among the predominant seed shapes in common bean landrace accessions from Brazil, which is in agreement with the present findings. With respect to the observed variation in seed brilliance, shiny types (60%) were the most frequent (Table 3). Seed color is one qualitative character that is used for haricot bean classifications under the traditional and the modern system and it is easier for routine application. The types of seed color observed in this study were white, Red, black, cream, grey, yellow and pink purple. The majority of the landrace accessions studied had white seed colored (51%) common bean which is very important as cash crop.

With respect to the observed variation in seed size, large types (47%) were most frequent, while medium seed size types, were the second most frequent types (32%) (Table 3). In agreement with this study, results from characterization of germplasm collections from different eco-geographical locations showed existence of high genetic diversity for a number of traits including seed color, shape, and size [19, 20]. Percentage frequency of the phenotypic classes of haricot bean accessions showed that majority of haricot bean accessions had round leaf shape (47%), dark green leaf color (54%), and marginal pod beak position (84%) and curved pod curvature (34%).

Estimates of diversity for each qualitative character were indicated in (Table 3). The H' values varied from 0.190 for pod beak position to 0.642 for seed color. Characters with wide phenotypic diversity index was observed in seed color (H'=0.642) seed coat color (H'= 0.624), pod color (H'=0.622), and seed shape (H'=0.582)) indicating widely diversified for these characters. On the other hand, pod beak position (H'=0.190) showed relatively the lowest diversity. [21] observed considerable variations in landraces in Central Africa, in seed color which is in agreement with this study. The high diversity of bean landraces observed in this study, is in part due to farmer's customary seed exchanges [22]). CIAT. [21] reported farmer's preference for many landraces, where diversified bean types are used for various agronomic and cultural reasons [23]. The predominance of red and white seed colors might have emanated from users,, and market preferences (i.e. red accessions preferred for consumption, while white accessions fetch the maximum market income in Ethiopia), as a result, these led to maintaining bean diversity in Ethiopia. Frequent mutations and genetic recombination are the other possible causes of high diversity of the bean landraces studied.

Table 3. *Qualitative traits of hundred genotypes 2019/20.*

Traits	Classification	Frequency	Proportion	H'
Seed coat color	1 White	24	24	0.624
	2 dull	3	3	
	3 cream	7	7	
	4 yellow	22	22	
	5 brown	3	3	
	6 pink	41	41	
	7 red	0	0	
Plant growth habit	1 determinate bush	45	45	0.298
	2 indeterminate bush	55	55	
	3 indeterminate prostrate	0	0	
	4 indeterminate climbing	0	0	
Seed shape	1 Round;	23	23	0.582
	2 oval	37	37	
	3 cuboids	3	3	
	4 kidney	30	30	
	5 markedly	6	6	
	6 truncate fastiagte	0	0	
Seed brilliance	3 Dull	17	17	0.410
	5 medium	23	23	
	7 shiny	60	60	
Pod color	1 Dark purple	38	38	0.622
	2 red	34	34	
	3 pink	5	5	
	4 pale	9	9	
	5 yellow	2	2	
	6 persistent green	12	12	
flower color	1 White	4	4	0.327
	2 green	14	14	
	3 red	77	77	
	4 purple	5	5	
bracteole size	3 small	45	45	0.361
	5 medium	4	4	
	7 large	51	51	
bracteole shape	3 lanceolate	45	45	0.361
	5 intermediate	4	4	
	7 ovate	51	51	
seed color	1 white	51	51	0.642
	2 red	20	20	
	3 black	7	7	
	4 cream	3	3	
	5 grey	5	5	
	6 yellow	7	7	
	7 pink purple	7	7	

Traits	Classification	Frequency	Proportion	H'
Seed size	3 small	21	21	0.454
	5 medium	32	32	
	7large	47	47	
Leaf shape	3 Triangular	21	21	0.454
	5Quadrangular	32	32	
	7Round	47	47	
Leaf color of chlorophyll	3=pale green	42	42	0.358
	5=medium green	4	4	
	7=dark green	54	54	
Pod beak position	1=marginal	84	84	0.190
	2=non marginal	16	16	
Pod curvature	3=straight	19	19	0.591
	5=slightly curved	24	24	
	7=curved	34	34	
	9=re-curving	23	23	

4. Conclusions

In this study, one hundred common bean genotypes were evaluated using simple lattice design in a10m x 10m at Jimma Agricultural Research Center. The overall objective of the study was to characterize Ethiopian landraces based on morphological traits. For all accessions, the percentage of frequencies of the phenotypic classes of varied from 4% to 84%. Considerable variation in plant growth habit, Type-II (indeterminate bush) was the most prevalent among the accessions (55%), followed by Type-I (determinate bush) (45%) growth habits. Characters with wide phenotypic diversity index was observed in seed color (H'=0.642) seed coat color (H'= 0.624), pod color (H'=0.622), and seed shape (H'=0.582)) indicating widely diversified for these characters. However, the present result based on morphological alone can't make definite conclusion. As a result, it is recommended that molecular and other quality traits like protein content studies have to be carried out.

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Conflicts of Interest

The authors declare no conflict of interest.

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