Phenotypic Characterization of Common Bean Landraces from Eastern Bhutan and their Potential Use

Karma Tenzin[x], Kezang Lhadon[x], Loday Phuntsho[x] and Yeshi Lhadon[x]

ABSTRACT

Common Bean (Phaseolus vulgaris L.) is one of the most important leguminous crops which have global adaptability and phenotypic diversity. It is also used for human consumption worldwide. It constitutes major source of protein, complex carbohydrates and micronutrients. In Bhutan, diverse types of beans are found and are an important source of income and food security for large section of the society. However, not many studies have been carried out to document the characteristics of this diverse crop. Hence, phenotypic characterization of local germplasm from eastern Bhutan was carried out to conserve the existing rich germplasm and exploit them for potential use in future. Out of more than fifty-two accessions, fifteen were selected and on-station field trial was established using randomized complete block design with three replications to assess phenotypic characteristics. Phenotypic characteristics were recorded following the UPOV standards. As expected, significant phenotypic variation was observed between determinate and indeterminate types regarding number of pods per plant, yield per plant and weight of dried seeds. The accessions also differed considerably in terms of seed weight. The cluster analysis based on 14 parameters allowed identification of beans into two large groups and four sub-groups. In terms of yield, accessions 24 and 27 recorded significantly higher yield than the others.

Keywords: *Common Bean; Phenotypic characteristics; Eastern Bhutan; Potential use*

1. Introduction

Common bean demonstrates a global adaptability, phenotypic diversity and is believed that cultivated common bean originated from the wild species *Phaseolus aborigineus* (Vidak et al 2015). Common bean is a major source of protein, complex carbohydrates, and micronutrients; the common bean is also one of the most important crops for human consumption worldwide (Broughton et al 2003).

Bhutanese diet is often dominated by carbohydrate rich crops like maize, rice, and potato that are poor in protein content. According to Blair et al (2003) eggs, milk and meat are primary source of proteins which can be substituted by leguminous crops like beans and peas. Dry beans contain high levels of chemically diverse components (phenols, resistance starch, vitamins, fructo-oligosaccharides) that provide protection against oxidative stress, cardiovascular disease, diabetes, metabolic syndrome, and many types of cancer positioning this legume as an excellent functional food (Schlegel 2013).

Beans, along with maize used to constitute staple diet for large part of eastern Bhutan. For instance, in early 1980s people used beans as staple food mixed with maize grits or often with bean porridges (Wangdi 2016). Common bean species may not be native to Bhutan yet

[x] Corresponding author: karmatenzin3@moaf.gov.bt. (Karma Tenzin), Agriculture Research and Development Centre, Wengkhar, Mongar

through naturalization greater diversity of crop varieties are found ranging from subtropical to temperate regions. This commodity represents age old country's rural farming pattern having best compatibility with maize. Hence, bean has become an element of cultural identity comparable with other crops like rice, maize and chilli (Dopola 2016).

However, lately, once beans rich place like Jurmey in Monggar has seen a decline in bean diversity due to change in food habits and modern farming systems with advent of rapid social economic development in the country. In many countries landraces are replaced by exotic crop through intervention by various agencies and departments through crop promotional program (CPP) and other commercial activities. For example, Giulia Paniconi (2010) mentioned that in country like Italy landraces dropped considerably in number from the National Register, due to lack of commercial interest from major seed companies that focused on the breeding of preferred few types by the market. Hence, there is a similar risk to our landraces as well. Krasteva et al (2002) expressed that conservation, study and use of local plant resources is a basic problem for breeding in many countries. In Bhutan, National Biodiversity Centre (NBC 2008) reported about 51 traditional varieties of beans as per oral report by farmers. However, till date, no phenotypic and morphological characterization has been reported, which is a crucial missing link in germplasm conservation strategies. Hence, Agriculture and Research Development Centre (ARDC) at Wengkhar initiated collection and characterization of existing beans landraces from Eastern Bhutan. It would provide valuable information and germplasm to agricultural researchers and other users. Further, landrace crop can contain phenotypic and genotypic variability that can be exploited to develop new lines (Abu-Amer 2011).

2. Materials and methods

Fifty-two cultivars were collected from different villages in Eastern Bhutan from April to May 2015. These were collected from various eastern ecological regions. Out of fifty-two, fifteen accessions (Table 1) were selected based on visual seed shape and color. On-station multiplication of selected samples was carried out from Jul-Oct 2015 for this study.

The study was conducted at Agriculture Research and Development Centre, Wengkhar, Mongar Bhutan. Seeds were sown in open field using randomized complete block design with 3 replications. A spacing of 0.5 meters between rows and 0.35 meters between plants was maintained. Irrigation was provided after sowing and thereafter depending on soil moisture through hand-feel method. Farm yard manures and fertilizers were applied as per the recommended practices for common beans. Experimental plots were covered with net to protect against birds during germination. Plants were protected against pests and fungal diseases with cypermethrin and Anvel (hexaconazole EC 10 and 5%; Syngenta, India) at 1 ml l:1. Hand weeding between and within rows was continued throughout the growing season.

Table 1. Accessions of common beans used for phenotypic characterization

Accession no	Place of collection	Accession name
13	Gomchu	Yadhipa Orey
06	Kerong	Orey Regtang
29	Laneree	Tulumpee Orey
38	Laneree	Orey Balingmin
12	Gomchu	Yadhipa Orey
08	Nanong	Zangki Orey
07	Kerong	Kerongree Orey
11	Gomchu	Orey Changlu
24	Kerong	Pinkulung Orey
27	Nanong	Orey Serbu
01	Tsamang	Shepen
03	Laneree	Orey
15	Kanglung	OreyBrokchilu
25	Tsamang	Brokpali
34	Norbugang	BorangmoOrey

From each plot, 10 plants per replication were randomly chosen for biometric measurements. Observations were made for 14 morphological characteristics as per the International Union for the Protection of new Varieties of plants (UPOV) guidelines : (1) days from sowing to flowering, (2) days from sowing to maturity, (3) average height of the pods, (4) biological yield, (5) number of pods per plant,(6) weight of pods per plant, (7) pod length, (8) pod color, (9) pod shape of distal part including beak, (10) pod curvature beak, (11) weight of seeds, (12)) terminal leaf shape, (13 seed coat color, (14) seed shape of medium longitudinal section (Table 2).

Data were analyzed using IBM SPSS version 22. For mean yield, number of pods and seed weight comparison, one-way ANOVA method was used. Multiple comparisons among the accessions were done using Duncan's Multiple Range Rest. The hierarchical cluster analysis method was used to construct dendrogram for categorization of the accessions.

Table 2. Morphological characteristics used in the study

Traits(Variables)	Growth stage
Leaf-Terminal leaf Shape	Fruiting
Leaf-Terminal leaf Apex	Fruiting
Pod – degree of curvature	immature pods (10 pods)
Pod – ground color (immature)	immature pods (10 pods)
Pod-shape	immature pods
Pod-Shape of Distal Part-Including Beak	immature pods
Pod-Curvature of Beak	immature pods
Pod- weight of Pod(gm.)	immature pods(10 pods)
Pod- Height of Pod (cm)	immature pods(10 pods)
Seed- Seed Coat colour	dried seed
Seed- Seed weight(gm)	100nos
Seed-Shape of median Longitudinal section	Dried seed
Vegetation period	from sowing to beginning of flowering (days)
Days of flowering	50% flowering from beginning of germination (days)
Vegetation period	from sowing to seed maturity (days)

3. Result and discussion

Common beans are largely grouped into two categories: Determinate and Indeterminate types. Determinate types are those that do not need staking to support their growth. Indeterminate types are climbers that require support in the form of staking to grow up. In Bhutan, among the two, indeterminate types are found in more abundance.

Among the indeterminate types, performance of accession number 24 and 27, in terms of yield, was significantly higher than most of the accessions whereas accession number 11 recorded the lowest of all. Accessions number 24 and 27 have the potential to produce 7.7 ton/acre whereas accession 11 can produce just about 1.2 ton. As in yield, accessions 24 and 27 had the highest numbers of pods per plant and accession 11 the least. In terms of seed weight, accessions number 12 has significantly higher than rest of the accessions, and accession 38 the least (Table 3).

Figure 1. Pods of different accessions

Figure 2. Seeds of different accessions

Table 3. Comparison of mean yield, number of pods and dried seed weight among indeterminate

Accession no	Mean yield/ plant (gm)	No of pods	Dried seed weight (gm.)
13	140.9a	26.8a	0.51g
06	161ab	36.8ab	0.26a
29	279.4abc	33.6ab	0.34d
38	279.5abc	22.0a	0.25a
12	289.7abc	35.4ab	0.69i
08	314.7bc	52.0bc	0.46f
07	315bc	38.8ab	0.30b
11	53.6d	19.4a	0.32c
24	331.4c	64.0c	0.60h
27	331.4c	59.8c	0.42e

The mean values in the table with same letter between the accessions indicates lack of statistically significant difference at 95% confidence level

Among the determinate types, accession number 1 had significantly higher yield whereas accession number 3 had the least. Accession 1 can produce as high as 4.4 ton while 3 can produce only about 1.5 ton per acres. In terms of pods per plant, accession 15 had the highest followed by 1 and 34 and the 3 the least. Accession 1 had the highest seed weight followed by 15 and 3 (Table 4).

Table 4. Comparison of mean yield, number of pods and dried seed weight among determinate

Accession no	Mean yield per plant (gm.)	No of pods	Dried seed weight (gm)
01	191.9c	22.2bc	0.70d
03	70.1a	10.8a	0.46b
15	159.2bc	23.2c	0.47b
25	64.6a	14.8ab	0.56c
34	136.9b	19.0bc	0.40a

Figure 1 depicts a dendrogram based on the hierarchical cluster analysis. The horizontal axis of the dendrogram measures dissimilarity among the entities. The analysis categorizes the accessions into two large groups at the top and about five sub-groups at the lower level. Though the number of accessions used for the study is fairly small, the number of cluster is relatively large indicating there could be wide range of beans diversity in the country.

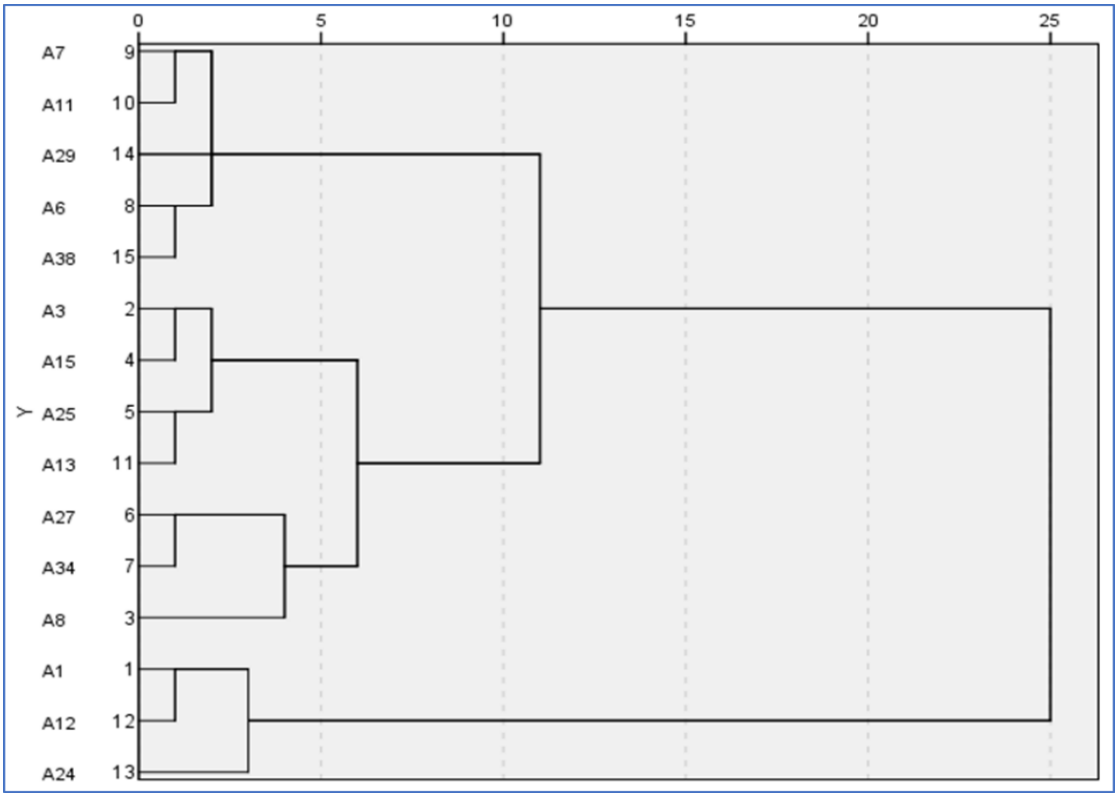

Figure 3. Dendrogram using average linkage between groups

4. Conclusion

The effort to study common bean diversity is one of the first in the country though beans were largely used in Bhutanese diets for ages. Common beans have vital role both in terms of food and nutrition security besides potential for income generation. Characterization and conservation of landraces have many benefits. Evaluation of quantitative and qualitative traits gives the possibility to choose and include the most adapted accessions in future breeding activities or to conserve and use them for production with high quality. Among the indeterminate types, accession number 24 (Pingkulung Orey from Kerong village) and 27 (Orey Serbu from Nanong village) were found to be most productive. Similarly, from determinate type, accession number 1 (Shepenorey from Tsamang village) and 34 (Borangmoorey from Norbugang village) were most productive. The cluster analysis shows lots of diversity even within the limited number of accessions indicating the greater potential for beans diversity in the country. Overall, the study provides a kind of springboard to further enhance research especially to characterize, document, conserve and judiciously utilize often underutilized rich agro-biodiversity in the country.

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