Research Article

Genetic Diversity in Common Beans (*Phaseolus vulgarus* L.) Collected from Different Ecological Zones of Malakand Division (A Part of the Sino Japanese Region of Pakistan)

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Abstract | This activity was aimed to analyze the level of genetic diversity (GD) of bean landraces collected from diverse ecological zones of Malakand division, Khyber Pakhtunkhwa, Pakistan. The qualitative traits showed significant level of diversity like seed shape was determined by two alleles, seed color was defined by 13 numbers of alleles and four alleles were responsible for flower color. Similarly, the quantitative traits showed 73% diversity in the parameters studied. However, it was different in individual characters. In overall, 59% of the yield contributing traits showed significant level of correlation in the present germplasm. The dendrogram in one-way cluster analysis distributed 55 lines into 2 lineages (I and II). The former was comprised of 24% bean landraces, while the latter was comprised of 76% landraces. In correlation coefficients 45 combinations were identified having strong positive correlation. The strongest correlations (above 50%) were computed 67% of all the combinations. The principal component analysis (PCA) identified quantitative variability of 55 common bean landraces. The eigenvalues of more than 60.8% accounted a total of 70% genetic variants. Finally, it was found that a high degree of variance was identified in all germplasm collected from Malakand sections with some additional unique characteristics, such as early cooking, high productivity and protein significance as compared to other parts of the world, which could be utilized for evolving better quality and high yielding cultivars of *P. vulgarus*.

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Introduction

The importance of genetic diversity in terms of today's development of new high yielding and resistant to insects pests and environmental stresses lies in the reality, that whether we can feed the world in 2050 and beyond? This most sensitive question is still unanswered by the scientific community since global population is exploding and will exceed 9 billion in 2050. At that time, the per capita availability of water and food will decrease if the level of production per unit area stays the same (Sher *et al*., 2019). Moreover, the life will become more miserable to compete with the horrors of global climate change resulting in increased evapotranspiration and vulnerability of existing varieties of crops. Therefore, it becomes more important to look at the evolution of tolerant genotypes to environmental vagaries for scrutiny of desired germplasms is inevitable. Keeping in view the above reality, efforts were made to decipher the available biodiversity in common beans existing in Malakand Division.

Common bean is a member of the family Papilanaceae in the flora of Pakistan (Ali and Nasir, 1977). This family contains almost 55 species. Out of which five species are broadly cultivated. These species are: *P. vulgaris* L. (Common bean, snap beans), *P. lunatus* L. (Lima bean), *P. coccineus* L. (Runner bean), *P. acutifolius* var. *latifolius* and *P. dumosus* (*P. polyanthus* Green) (Debouck *et al*., 1993). The growth habit of this plant is variable, ranging from bush (determinate) to high climbers (indeterminate) (Sher *et al*., 2019). Beans are grown in tropical, subtropical and temperate regions of the world, with a total cultivated area of 25.2 million ha with annual seed production of 19.7 million tons (Burle *et al*., 2010). Brazil remains the world's largest producer and consumer of the beans followed by Mexico (Sher *et al*., 2019). These countries are almost self-sufficient in bean crop, but their imports are necessary to supplement the production deficit periodically (Weiss *et al*., 2000).

Common bean is one of the most essential food nutrients having proteins, carbohydrates and certain minerals and vitamins (Boye *et al*., 2010) tannins, anthocyanin and flavonoids (Aparicio *et al*., 2005) anthocyanin in certain common beans like black and blue-violet beans (Vignolini, 2004), anthocyanin, polyphenols and antioxidant potential in 29 bean grains in the USA and CIAT (Akond *et al*., 2011), vitamins other minerals and unsaturated fatty acids (linoleic acid) and soluble fiber (Rodino *et al*., 2009). The common bean is also a source of certain other important elements like Fe, Zn, Cu, P, K, Mg and Ca. Moreover, there is no cholesterol at all and further studies suggest that regular use of common bean as part of meal reduces cholesterol levels in the body. Being a source of iron, it provides 22 to 30% of the daily recommended levels from a single diet (Weiss and Kelly, 2000).

In Pakistan, common bean grows well in those areas where the environments are appropriate for the cultivation and growth of maize crop especially the drier areas (Alghamdi, 2007). It is a hot seasonal crop and fails to grow under low temperature i.e. below 20 °C. It requires a temperature ranging from 20 to 25 °C for enhanced growth and fructification (Alghamdi and Ali, 2004). In most instances, local farmers in Pakistan are continuing the long-standing practice of planting seed they set aside from a previous year's harvest. Such locally harvested seeds mostly exhibit genetic adaptation to local environments (Pfeiffer *et al*., 2006). In Pakistan, common bean crop is cultivated on 141,000 ha area with total seed production till 2012 was of 93 thousand tons (Anonymous, 2012). Some of the landraces produced in the Pakistan are of prime importance due to their good quality and higher productivity. In Pakistan, this crop has a promising future, and is normally considered to be the neglected legume as far as the varietal improvement is concerned (Nisar *et al*., 2011) Therefore, attempts are needed to improve its yield by the development of high yielding varieties through molecular based practices for which identification promising parents is essential.

As far as the research area is concerned, Malakand division is a part of sinojapanese region located in the northern part of Pakistan. This country has endowed with a variety of habitat ranging from the sea shore at Arabian Sea to the peak of hamalya with K-2 in the north having 8,611 meters elevation above sea level and is the second highest mountain in the world, after Mount Everest at 8,848 meters (K2, Britannica.com. Retrieved 23 January 2010). The Altitude of Malakand division and that of Dir Kohistan ranges from 1600 meter of oak and scrub forest to Alpine and sub alpine zone (More than 6000 meters) above the average sea level (Khan *et al*., 2011). The huge differences in altitude and variation in topography produces drastic climate changes, which result in luxuriant vegetation ranging from sub-tropical to alpine regions having moist and dry temperate forests in the study area (Ali *et al*., 2010).

Materials and Methods

Collection of landraces of common beans

During the years 2014 and 2015, a number of tours were scheduled to collect seeds of common beans from numerous zones of Malakand division (Figure 1) and almost 150 entries were collected from different areas of the division. Out of 150 landraces, only 50 samples were selected based on certain visible characteristics of the seeds. Details of the endemic collected seeds are given in the Table 1.

Table 1: *Detail of the local common bean landraces of Malakand division.*

No.	Area of collection	District	Latitude	Longitude	Elevation
P 01	Lamoti	Dir upper	35°29'13.83"N	72°13'54.98"E	8590 ft.
P 02	Barawal khas	Dir upper	35° 7' 55.0614"N	71° 41' 27.8376"E	4753 ft.
P 03	Tar patar	Dir upper			
P 04	Merin	Dir upper			
P 05	Domail	Dir upper	33° 1'24.34"N	70°44'47.70"E	1173 ft.
P 06	Ouch	Dir Lower	34°43'49.88"N	72° 1'6.98"E	2834 ft.
P 07	Drosh	Chatral	35°34'6.41"N	71°48'13.55"E	4433 ft.
P 08	Kharkanii	Dir Lower	34°42'58.48"N	72° 0'2.65"E	2683 ft.
P 09	Thal	Dir upper	35°29'13.83"N	72°13'54.98"E	8590 ft.
P 10	Boni	Chatral	36°16'13.65"N	72°15'14.92"E	6698 ft.
P 11	Larpor	Shangla	34°53' 13.8520"N	72° 45' 25.2086"E	
P 12	Chakesar	Shangla	34° 47' 8.1575"N	72° 46' 2.4424"E	3765 ft.
P 13	Chakesar	Shangla	34° 47' 8.1575"N	2° 46' 2.4424"E	
P 14	Chakesar	Shangla			
P 15	Kalkot	Dir upper	35° 24'50.6862"N	72° 17' 1.5000"E	8949 ft.
P 16	Ashret	Chatral	35° 46'11.5795"N	71° 46'26.7971"E	10487 ft.
P 17	Bebyawar	Upper dir	35° 7'36.5326"N	71° 56'29.8176"E	3807 ft.
P 18	L. Banda	Upper dir	30° 22'31.1556"N	69° 20'42.4176"E	
P 19	Kharkanii	Dir Lower	71° 54'57.9704"N	71° 48'34.8988"E	
P 20	Benl	Upper dir	34° 57' 9.4338"N	72° 19' 52.0068"E	
P 21	L. Banda	Upper dir	34° 54'39.6176"N	72° 41' 44.4347"E	
P 22	Malam	Swat	34° 47'57.6373"N	72° 34'17.1127"E	8150 ft.
P 23	Maiselwa	Swat	34° 57'9.4338"N	72° 19'52.0068"E	
P 24	Aglain bean	Swat			
P 25	Kohistan	Swat	35° 15'40.0547"N	73° 16'35.5300"E	7882 ft.
P 26	Alporai	Shangla	34° 55'17.0627"N	72° 38' 3.6067"E	4889 ft.
P 27	Mastoj	Chatral	36° 17' 8.5165"N	72° 31' 45.6823"E	7612 ft.
P 28	Garam chashma	Chatral	35° 59'50.8798"N	71° 33' 48.5759"E	7757 ft.
P 29	Medan	Lower Dir	34°58'9.30"N	71° 50' 48.1780"E	3667 ft.
P 30	Takot		34° 74'16.9444"N	72° 55' 44.8223"E	1771 ft.
P 31	U. Gaonai		34° 57' 9.4338"N	72° 19' 52.0068"E	
P 32	Kishware				
P 33	Banda	Upper Dir	35° 9'7.24"N	72°34'54.68"E	6014 ft.
P 34	Batand	Upper Dir			
P 35	Domail		33° 1'24.34"N	70°44'47.70"E	1173 ft.
P 36	Mian Banda	Lower Dir			
P 37	Ilkopian				
P 38	Menin				
P 39	Mian Banda	Lower Dir			
P 40	Asbnar	Lower Dir			
P 41	Kharkanii	Lower Dir	71° 54'57.9704"N	71° 48'34.8988"E	
P 42	Khwago oboe	Upper Dir			
P 43	Malam Jaba	Swat	34° 47'57.6373"N	72° 34'17.1127"E	8150 ft.
P 44	Wari	Upper Dir	34°59'18.97"N	72° 2'27.36"E	3492 ft.
P 45	L. Banda				
P 46	Bamborat	Chatral			
P 47	Jagam	Upper Dir			
P 48	Mastoj	Chatral	36° 17' 8.5165"N	72° 31' 45.6823"E	7612 ft.
P 49	Chinarano	Upper Dir	35° 2'1.39"N	71°41'29.00"E	6709 ft.
P 50	Kadh	Upper Dir			

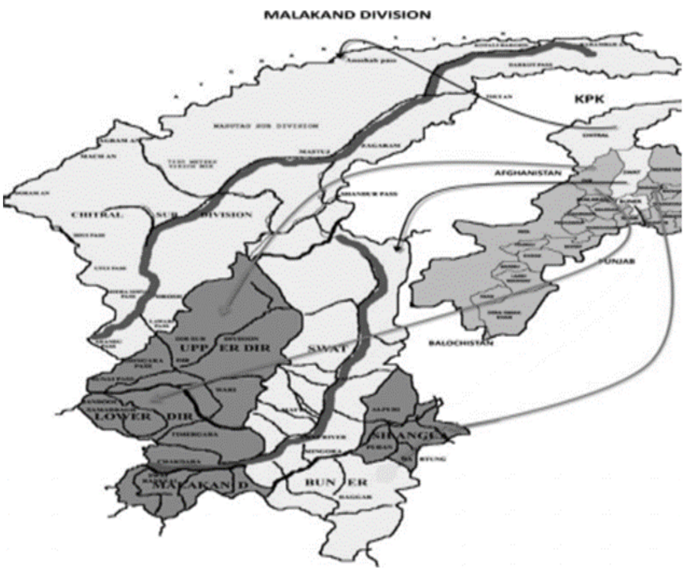

Figure 1: *Satellite map of Malakand Division.*

Table 2: *Seeds characteristics with codes scored.*

No.	Seed colour	Appearance	%	Freq.
1	Brown	15	27.3	0.273
2	Red	12	21.8	0.218
3	Black	9	16.4	0.164
4	Cream	5	9.1	0.091
5	Golden	3	5.5	0.055
6	Off white	3	5.5	0.055
7	Pink	2	3.6	0.036
8	Dark brown	1	1.8	0.018
9	Dark red	1	1.8	0.018
10	Gray	1	1.8	0.018
11	Green	1	1.8	0.018
12	Wood colour	1	1.8	0.018
13	White	1	1.8	0.018

Agronomical and experimental field layout

The evaluation of 50 entries of common bean were conducted in the experimental field of Shaheed Benazir Bhutto University, located at coordinates 35.2738° N, 72.0050° E (data taken by satellite image). Experiments were conducted during the planting seasons for two successive years (2016 and 2017). The Soil contents of the proposed area were studied in the Swat Agriculture Research Institute (SARI). The soil of the experimental field was slightly alkaline (pH 8.8), silty loam in texture and deficient in N (0.032%) and medium in both P_2O_5 (40.5 mg kg^{-1}) and K_2O (138 mg kg^{-1}). The research plot was laid out in triplicate randomized complete block design (RCBD). Row to row and plant to plant distance was kept as per standard agricultural practices for this crop. The size of each experimental unit was kept at 4 x 3 m^2.

Evaluation of qualitative and qualitative traits

A total of six qualitative traits were studied on 10 randomly selected plants in common bean lines. The quantitative morphological characteristics were numerically encoded along with allies Number for further analysis as shown in Table 2. The data for quantitative traits included six parameters viz. Leaflet Length (cm), No. of Pods plant-^{1}), No. of Seeds pod^{-1}, Dry Pod weight (g), Plant height (cm), Pod length (cm), total Biomass (kg ha^{-1}), Seed Yield (kg ha^{-1}) and Harvest Index. Harvest index (HI) was measured by the percent ratio of seed yield to the total biomass or above ground material by using the following formula.

*HI= (Seed Yield/Total Biomass)*100*

Statistical analysis

The most common parameters like Mean, Analysis of variance (ANOVA), Variance coefficient and Standard errors of basic statistics were computed by using Statistix 8.1. Software. The Pearson correlation coefficient was performed to determine the correlation between the different traits as well as between the groups using the SPSS software 18.0 (Keneni *et al*., 2005). Kruskal-Wallis software program was used to find the genetic diversity between the different groups on the basis of quantitative and qualitative traits (Kruskal and Wallis, 1952). Data matrix was processed using the Jaccard Similarity Coefficient and two way cluster analysis (TWCA) conducted using PC-ORD in order to find out the genetic association/ linkage (GA/L) within bean landraces.

Results and Discussion

Qualitative trait analysis

Two alleles were found responsible for the pod distal end, pointed (90%) and blunt distal end (10%). The pod shape was also controlled by two alleles; curved (88.10%) having 0.88 frequencies, and straight (11.90%) with 0.01 frequencies. Similarly, two alleles were also found responsible for pod colors; Green (97.62%) with 0.98 frequencies and purple tinge (2.38%) with 0.02 frequencies (Table 3). Two main traits of the seeds of common beans viz. seed shape and seed color (Table 3) were studied. Three alleles were found responsible for seed shape; cubed (52.17% with 0.57 frequencies), kidney (30.43% samples with 0.33 frequencies) and round seed shape (13.04% appearance and 0.14 frequencies), while in some other genotypes the Seed shape was Small oval 2.17% and large oval 2.17%. Amongst other variations found in common bean seed coat color was most frequent as shown in Table 4. Similarly, the seed coat colour was defined by 13 alleles; in majority of the cases the seed coat colour was brown (27.3 %) followed by red (21.3%), black (16.4 %), cream (9.1 %), golden (5.5%), off white (5.5%), pink (3.6%), dark brown (1.8%), dark red (1.8%), gray (1.8%), green (1.8%), wood colour and white (1.8% each) (1.8) (Table 5 and Figure 2).

Table 3: *Percentage and frequency distribution of pod characteristics.*

Pod character	Trait	No.	Allelic no.	% nt	Freq.
Pod distal end	Pointed	38	1	90.48	0.90
	Blunt	4	2	9.52	0.10
Pod shape	Curved	37	1	88.10	0.88
	Straight	5	2	11.90	0.01
Pod color	Blue	1	1	2.38	0.02
	Green	41	2	97.62	0.98

Table 4: *Percentage and frequency distribution of seed shape.*

Character	No.	Allelic No.	%	Frequency
Cuboid	24	1	52.17	0.57
Kidney	14	2	30.43	0.33
Round	4	3	8.7	0.14

Table 5: *Percentage and frequency distribution of seed coat color.*

S. No	Seed colour	Occ.	%	Freq.	S. No	Seed colour	Occ.	%	Freq.
1	Brown	15	27.3	0.27	8	Dark brown	1	1.8	0.02
2	Red	12	21.8	0.22	9	Dark red	1	1.8	0.02
3	Black	9	16.4	0.16	10	Gray	1	1.8	0.02
4	Cream	5	9.1	0.09	11	Green	1	1.8	0.02
5	Golden	3	5.5	0.06	12	Wooden	1	1.8	0.02
6	Off white	3	5.5	0.06	13	White	1	1.8	0.02
7	Pink	2	3.6	0.04					

Flower characteristics

In flower colour two floral characteristics were studied; standard and wing colors. In standard colour, 4 alleles were involved to express their phenotypic appearance. In most of the cases the floral color (standard colour) was white having 45.24 % and 0.45 frequencies followed by yellow floral colour having 14.29% with 0.14 frequencies. The pink and purple scored 3rd and 4th category having 11.90% and 9.52% cases, respectively. In 57.14% cases the anther colour was green with 0.57 frequencies followed by white colour having 14.29%, representation. The white anther colour comes on the 3rd position, having 9.52% appearance as shown in Table 6.

Table 6: *Percentage and frequency distribution of flower colour of the tested germplasms.*

S. No.	Character	Colour	%	Freq.	Allelic No.
1	Floral color (standard color)	White	45	0.45	1
		Pink	12	0.12	2
		Yellow	14	0.14	3
		Purple	10	0.1	4
2	Wing color	White	36	0.36	1
		Green	26	0.26	2
		Brown	17	0.17	3
		Pink	12	0.12	4

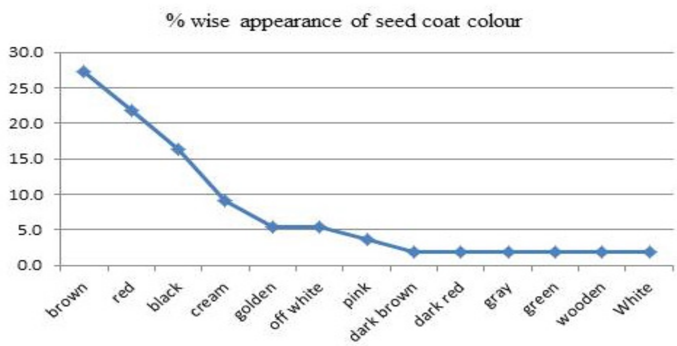

Figure 2: *Percentage distribution of seed coat color.*

Quantitative analysis

The quantitative data through Analysis of variance (ANOVA) revealed significant differences among the bean genotypes for morphological traits as given in the Table 9. The data of all the nine parameters were found highly significant with a p value less than 0.005. Terminal Leaflet Length was classified into 31 LSD groups. In 24 groups (A, B, etc.), the means are not significantly different from one another. The number of Pods Plant^{-1} was classified into 22 LSD groups, in 17 groups (A, B, etc.) the mean value was not significantly different from one another. Number of Seeds Pod^{-1}were classified into 22 LSD Groups, in 11 groups (A, B, etc.) the mean value was not significantly different from one another. The Dry Pod Weight was classified into 29 LSD Groups, in 21 groups (A, B, etc.) the mean value was not significantly different from one another. Plant Height was classified into 28 LSD groups, in 19 groups (A, B, etc.); the mean value was not significantly different from one another. Pod Length was classified into 31 LSD groups; in 21 groups the mean values were not significantly different from one another. Biomass were classified into 23 LSD groups, amongst all in 19 groups the mean values were not significantly different from one another. Grain Yield was classified into 31 LSD groups, in 26 groups the mean value was not significantly different from one another. And lastly Harvest Index was classified into 31 LSD groups; in 25 groups the means are not significantly different from one another. Similarly, the p values of all the parameters were found 0.0000. It showed that the data is highly significant. Similarly, the minimum values in all the cases were 0 explained that some of the accessions failed to survive in the changed environment. While the maximum values were 15.50, 56, 11.9, 3.7, 494.8, 11.9, 2201, 108.3 and 59.0 for Leaf Length, Number of Pods Plant^{-1}, Number of Seeds Pod^{-1}, Dry Pod Weigh, Plant Height, Pod Length, Biomass, Grain Yield and Harvest Index respectively. While the mean values of Leaf Length, Number of Pods Plant^{-1}, Number of Seeds Pod^{-1}, Dry Pod Weigh, Plant Height, Pod Length, Biomass, Grain Yield and Harvest Index were 7.7627, 17.020, 4.8055, 0.9464, 182.63, 6.2655, 56.973, 22.565 and 29.774 respectively (Table 7).

Table 7: *ANOVA and LSD test for quantitative traits.*

Variables	Values	Variable groups		Mean	P value
	Max value	LSD groups	Non sig groups		
Leaflet length	15.50	31	24	7.7627	0.0000
No. Pods per plant	56	22	17	17.020	0.0000
No. Seeds per pod	11.9	22	17	4.8055	0.0000
Dry pod weight	3.7	29	21	0.9464	0.0000
Plant height	494.8	28	19	182.63	0.0000
Pod length	11.9	31	21	6.2655	0.0000
Biomass	220.1	23	19	56.973	0.0000
Grain yield	108.3	31	26	22.565	0.0000
Harvest index	59.0	31	25	29.774	0.0000

Descriptive statistics

The overall mean coefficient of variation for all the variables were 73%, however it was different for individual parameters as given in Table 8. For terminal Leaf Length it was 61%, for a Number of Pods per Plant (64.6%), number of Seeds per Plant (81%), Dry Pod Weight (99%), Plant Height (78%), Pod Length (63%), Biomass study (67.6%), Grain Yield (79%), and Harvest Index (62%). Similarly, the mean value was 7.8, 4.8, 17, 1, 183, 6.3, 57, 22.6 and 30 for the terminal Leaf Length, Number of Pods Plant^{-1}, Number of Seeds Plant^{-1}, Dry Pod Weight, Plant Height, Pod Length, Biomass study, Yield per Plant and Harvest Index, respectively.

Table 8: *Descriptive statistics of all the parameters studied.*

Variables	Mean	Sd ± se	Min.	Max.	C.V%
Leaflet length	7.8	4.7653±0.6426	0.0	15.5	61.3
No. pods per plant	4.8	3.1066±0.4189	0.0	11.9	64.6
No. seeds per pod	17.0	13.832±1.8651	0.0	56.0	81.2
Dry pod weight	1.0	0.9453±0.1275	0.0	3.6	99.0
Plant height	182.6	142.71±19.243	0.0	494.8	78.1
Pod length	6.3	3.956±0.5334	0.0	11.9	63.1
Biomass study	57.0	38.528±5.1951	0.0	220.1	67.6
Grain yield	22.6	17.888±2.412	0.0	108.2	79.3
Harvest index	29.8	18.584±2.5058	0.0	58.9	62.4
Overall coefficient of variance					73.0

Correlation coefficient

The correlation coefficients among nine parameters including yield contributing traits of all the genotypes of common bean were computed for comparison. Forty five combinations were identified in this study having a strong correlation. All the combinations showed positive correlation as given in Table 9. The strong correlations above 50% existed in 30 combinations out of 45, which comprised 67% of all the combinations. The strong correlation exists in the Number of pods per plant to Terminal leaf length (r=0.74). Number of seeds Pod^{-1} to Terminal leaf length (r=0.81) and Number of pods per plant (r=0.60). Dry pod weight to Number of pods plant^{-1} (r=0.51). Plant height to Terminal leaf length (r=0.61) and number of seeds Pod^{-1} (r=0.61). Pod length to Terminal leaf length (r=0.84), Number of Pods Plant^{-1} (r=0.75), Number of seeds Pod^{-1} (r=0.76), dry pod weight (r=0.60) and plant height (r=0.62). Terminal leaf length to Biomass (r=0.86)), number of pods plant^{-1} (r= 0.69), number of seeds Pod^{-1} (r=0.71), Dry pod weight (r=0.51), Plant height (r=0.53) and pod length (r=0.80). Likewise, Seed Yield was strongly correlated to terminal leaflet length (r=0.77, Number of pods plant^{-1} (r=0.64), number of seeds Pod^{-1} (r=0.59), Pod length (r=0.75) and biomass (r=0.94). Harvest index was largely dependent on Terminal Leaf Length (r=0.85), Number of Pods Plant^{-1} (r=0.65), Number of

Table 9: *Correlations (Pearson) weighting variable rep.*

Variables	TLL	P/P	S/P	DPW	PH	PL	BM	SY	HI
Terminal leaf length (TLL)	1.00								
# of pods plant^{-1} (P/P)	0.74	1.00							
# of seeds pod^{-1} (S/P)	0.81	0.60	1.00						
Dry pod weight (DPW)	0.48	0.51	0.50	1.00					
Plant height cm (PH)	0.61	0.39	0.61	0.50	1.00				
Pod length cm (PL)	0.84	0.75	0.76	0.60	0.62	1.00			
Biomass plant^{-1} (g)	0.86	0.69	0.71	0.51	0.53	0.80	1.00		
Seed yield plant^{-1} (g)	0.77	0.64	0.59	0.47	0.47	0.75	0.94	1.00	
harvest index %	0.85	0.65	0.77	0.55	0.69	0.87	0.79	0.82	1.00

Cases Included 50 Missing Cases 0.

Seeds Pod^{-1} (r=0.77), Dry Pod Weight (r=0.55), Plant Height (r=0.69), Pod Length (r=0.87), Biomass (r=0.79) and Grain Yield (r=0.82) (Table 9).

Principal component analysis

The principal component analysis (PCA) identifying the quantitative variables of 50 common bean landraces are shown in Table 10. The eigenvalues of more than 60.8% counted a total of 70% genetic variability, which was contributed by four principal components.

Table 10: *Principal Component Analysis of 9 quantitative traits among common bean lines, Eigenvalue, percentage Variability explained by first 4 components.*

Factor	PC-1	PC-2	PC-3	PC-4
Percent of variance	71.5	8.3	6.8	5
Cumulative percent of variance	71.5	79.8	86.5	91.5
Terminal leaf length	-0.3656	0.1447	-0.169	0.1854
No. pods per plant	-0.312	0.262	0.4092	0.5104
No. seeds per pod	-0.3323	-0.1378	-0.2403	0.4569
Dry pod weight	-0.2593	-0.5133	0.734	-0.2147
Plant height	-0.2778	-0.6342	-0.4152	-0.1331
Pod length	-0.3659	0.0016	0.0428	0.1442
Biomass	-0.36	0.3003	-0.0268	-0.3178
Seed yield	-0.3409	0.3664	-0.0024	-0.5479
Harvest index	-0.3667	-0.0359	-0.1804	-0.103

In the first principal component (PC-1) No positive value was found. In PC-2 high positive values were found in terminal leaflet length (0.1447), Number of pods plant^{-1} (0.262), Pod length (0.0016), and Biomass (0.3003) and grain yield (0.3664). In PC-3 the high positive values were found for Number of Pods Plant^{-1} (0.4092), Dry Pod Weight (0.734) and Pod Length (0.0428). While in PC-4 the high positive values were found in the Terminal Leaf Length (0.1854), Number of Pods Plant^{-1} (0.5104), Number of Seeds Pod^{-1} (0.4569) and Pod Length (0.1442) (Table 10).

Table 11: *One-Way cluster bean landraces based on dendrogram.*

L-I	L-II						
C-I	C-II		C-III				
G-I	G-II	G-III	G-IV	G-V	G-VI	G-VII	G-VIII
49	18	25	28	7	51	10	1
50	47	36	44	9	--	31	39
6	--	32	16	2	--	29	17
41	--	21	42	43	--	55	27
45	--	22	11	4	--	12	35
38	--	19	34	5	--	14	15
40	--	26	--	3	--	48	33
30	--	46	--	52	--	13	--
37	--	--	--	54	--	--	--
23	--	--	--	53	--	--	--
24	--	--	--	--	--	--	--
8	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--

One way cluster analysis

One Way Cluster Analysis (OWCA) was performed to estimate the relation amongst the collected bean landraces. The dendrogram distributed 55 lines into 2 lineages. Lineage I (L-I) has been split into one cluster. C-I was comprised of accessions Number 49, 50, 6, 41, 45, 38, 40, 30, 37, 23, 24, 8 and 20. All these were missing accessions and failed to grow in the changed environment due to various factors. Lineage II (L-II) was classified into two clusters C-II and C-III. C-II was further classified into two groups G-II and G-III. G-II contains two accessions i.e. 18 and 47, while G-III was comprised of 25, 36, 32, 21, 22, 19, 26 and 46 accessions. C-III was further classified into five groups, G-IV to G-VIII. G-IV was comprised of 28, 44, 16, 42, 11and 34, G-V was comprised of 7, 9, 2, 43, 4, 5, 3 and 52. G-VI was comprised of 51. G-VII was comprised of 10,31,29,55,12,14,48 and 13 while the G-VIII was comprised of 1, 39, 17,27,35,15 and 33 as shown in the Table 11 and Figure 3.

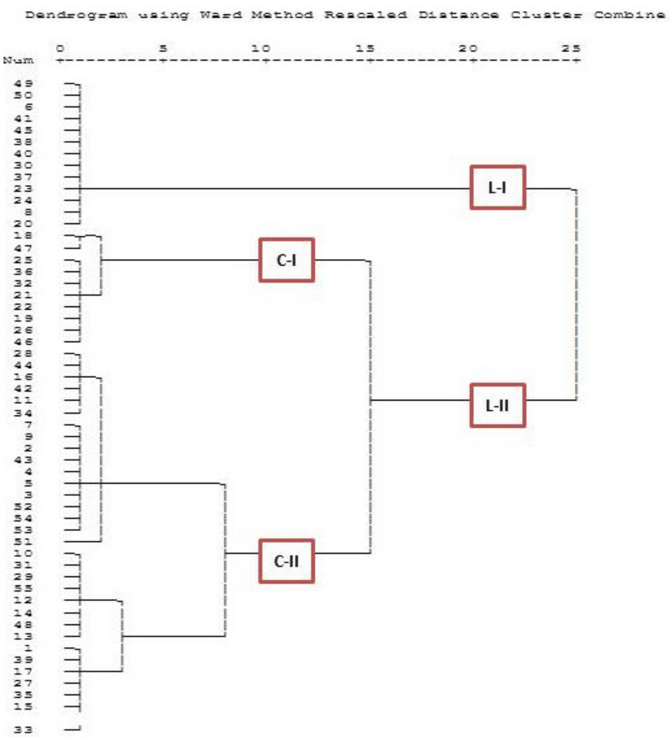

Figure 3: *One-Way cluster dendrogram of bean land races.*

Diversity or Variation is a complementary part of the nature and considered to be a universal tool of existence. Diversity brings better genotype (s) adapted to the changing environment. In this activity almost, all genotypes (50 in number) of the local climate showed open and visible genetic and morphological variation that is linked with many workers (Zeven, 1997). In breeding process, the initial germplasm collections are based purely on morphological and agronomic characteristics and having prime importance (Stoilova *et al*., 2005). Similarly, in common beans, the external exposure also plays important role in adaptation to the local environment (Wright and Kelly 2011). Furthermore, local garden-forms of common bean tend to reach towards homogeneity because, fewer plants in a year will be sufficient to produce seeds (Maxted *et al*., 2011). God Almighty has produced enormous number of legumes in the world, including common beans (*Phaseolus vulgaris* L.), which are the most consumed grains. In some countries beans are the only source of protein in human food. In Portugal and Bulgaria, beans are used as traditional food and farmers still depend on old varieties (Harlan, 1971). In Pakistan, common beans are abandoned legumes, and this research has been suggested to establish gene pool of this neglected crop. The preservation, study and use of indigenous plant materials are major breeding materials in various countries including Pakistan. Introduction, selection and hybridization are the basic principles of breeding. The most important of these problems include human factors that affect the genetic diversity like the instant endeavor is a valuable for evolution of high yielding, disease and insect pests resistant cultivars adapted to varying ago-ecological regions (Krasteva *et al*., 2002). The local landraces play important role in the development of new species (Stoilova *et al*., 2005); therefore, the attempt must be made in the long run to preserve the locally diverse genotypes for future use. As per prime objective of this work all the landmarks were collected from different areas of Malakand division. Moreover, the local landmarks were compared with some high yielding exotic landmarks that were acquired from the PGRI (NARC) Pakistan.

All landraces were sown in the botanical field of Shaheed Benazir Bhutto University, Sheringal Dir Upper and University of Malakand, Chakdara, Dir Lower for the estimation of morphological diversity and adaptability to the new environment. The data collected were then subjected to statistical analysis. Both quantitative and qualitative traits showed a high degree of diversity in all the accessions. The exotic landraces showed high variability in comparison with the local landmarks. The results are supported by many workers that vegetative characteristics, including pod or leaf variability exhibit greater environmental and cultivar effects than seed characters (Housley *et al*., 1982).

Lastly it was proved that a significant variation is found in the collected germplasm with some extra unique characteristics, like early cooking, high productivity and proteomic importance as compared to exotic landraces. Furthermore, it needs further experimentation to obtain best quality germplasm of this neglected crop in Khyber Pakhtunkhwa and Pakistan at large (Sher *et al*., 2019).

Novelty Statement

Our work was aimed to identify diversity of common bean grown/ cultivated in the hilly areas of malakand division, KP, Pakistan. This activity was novel and was not carried out in ths area.

Author's Contribution

Khan Sher: Result collection and foeld work, objective and title, configuration
Muhammad Subhan and Muhammad Nisar: Result callibration with softwares
Ali Hazrat: Discussion callibration with result
Zahid Fazal: Helped in collection of data from the field
Gul Rahim: Refrences designing according to the journal standarad.
Imran Ahmad and Riaz ul Haq: Review of literature.
Shamia Bibi: Overall compilation of the paper

Conflict of interest
The authors have declared no conflict of interest.

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