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RESEARCH ARTICLE

Identification of potential alleles contributing for yield attributing traits in common bean (*Phaseolus vulgaris* L.) grown under Western Himalayan Kashmir Valley

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Abstract

Common bean is increasingly recognized as a highly beneficial global food source due to its rich nutritional and medicinal properties. The present study assessed the genetic variability among unexplored common bean germplasm using morphological parameters. Phenotypic coefficient of variation values were consistently greater than genotypic coefficient of variation values in both the locations, Wadura and Shuhama emphasized the significant variation. For genotyping and association analysis, 100 SSR markers spanning all chromosomes were employed, which resulted in the amplification of 534 alleles, with an average of 5.34 alleles per marker. The Polymorphism Information Content (PIC) values ranged from 0.5325 to 0.8926, averaging 0.7553. Using both the Mixed Linear Model (MLM) and General Linear Model (GLM) approaches, 4 SSR markers were found to be associated with days to flowering, number of pods per plant, and harvest index, explaining 14-48% of phenotypic variation. Notably, markers BM185 and BMB742 were identified as common in both models. The findings provide valuable genetic insights that can support breeding programs focused on enhancing yield-related traits in the North-Indian Himalayan region.

Keywords: Common bean, morphological parameters, coefficient of variation, association analysis, polymorphism information content.

Introduction

Common bean (*Phaseolus vulgaris* L.) has self-diploid genome, 473 Mb in size and comprised of 11 pairs of chromosomes (Rathna et al. 2020). It is one of the most important grain legumes in the *Phaseolus* genus, mostly produced by developing countries. Domestication in common bean took place in two different gene pools (Shii et al.1981). The classification of gene pools is based on the differences in size, mineral content, phaseolin proteins, allozymes, morphological traits, and DNA markers. In India, it is grown in the mountainous regions of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, and the North-Eastern provinces, and also in plains of Uttar Pradesh, Maharashtra, Karnataka, and Andhra Pradesh (Kumar et al. 2021). The Himalayas have most diverse germplasm of common beans despite the fact thatbeans are grown all over India (Zargar et al. 2016). Common beans are widely grown throughout the districts of Jammu and Kashmir including Rajouri, Poonch, Doda, Kishtiwar, Bhaderwah, Budgam, Ganderbal, and Ramban. Over 7.5 million hectares of common bean are grown in Africa, compared to a global average of 30 Mha and 26.8 million metric tonnes (FAO Stat 2022). In Jammu & Kashmir, India, a total production of 1600 tonnes per year with a yield of roughly 0.8 tons/ha was obtained.

Common bean is unique among plant-based diets from a nutraceutical perspective, as it is an inexpensive source

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of high-quality protein (21–25%), essential vitamins and minerals, soluble fiber, starch, phytochemicals, and has a low fat content (Zargar et al. 2016). Its nutritional value, particularly the high concentration of protein, minerals, and antioxidant properties is a key factor contributing to its widespread success (Hayat et al. 2014). It is also reported that beans with more intensely coloured coats (red, cream, black, pink, and brown) demonstrated the highest antioxidant presence. Phenolic chemicals in beans with coloured coats were found to be more effective antioxidants than those with entirely white coats. After peanut and soybean, the crop is ranked third in terms of significance, but it is the most important crop in term of direct human consumption (Wu et al. 2020, 2021). The common bean is therefore, referred to as the "grain of hope" in emerging and underprivileged nations (Zargar et al. 2017). Genetic resources of common bean needs morphological and agronomic qualities in order to be valuable for plant breeders (Martins et al.2015). Morphological characterization helps to understand the relationships between agronomic performances for breeding programmes (Balkaya et al. 2006). According to Bode et al. (2013) the process of characterizing accessions facilitates the measurement and organization of genetic variability within the germplasm. Due to high polymorphism, multi-allelic co-dominant character, and uniform distribution throughout the genome in both gene-coding and non-coding sections, SSRs are typically favoured over other molecular markers (Sudan et al. 2016; Torkamaneh et al. 2020). Despite the nutritional and economic importance of common bean (*Phaseolus vulgaris* L.), limited efforts have been directed towards exploring its genetic diversity within the North-Himalayan region of India. To address this gap, the present study was aimed at the evaluation the extent of genetic variability among a diverse core set of 150 indigenous germplasm through morphological and molecular characterization, with a focus on identifying potential marker-trait associations related to yield and nutraceutical traits.

Materials and methods

Germplasm collection

The germplasm comprised 150 genotypes (Table 1) collected mainly from North- Himalayan regions. The collected genotypes were grown at two locations viz; SKUAST-Kashmir, Shuhama (latitude 35º 30'N, longitude 75º 15'E, altitude of 1,700 meters) and SKUAST-Kashmir, Wadura, (34.34º N latitude, 74.40º E, altitude of 1590 meters) during the months of May of 2022 and 2023 year respectively. All the accessions were grown in Randomized Complete Block Design with three replications. The material was planted in 2 meter rows, 30cm apart with plant to plant distance of 15cm at 3cm depth to ensure proper emergence at each location.

Phenotypic evaluation and statistical analysis

The germplasm were evaluated for various yield attributing traits. For data collection, three plants were selected randomly according to guidelines mentioned in common bean descriptor of International Plant Genetic Resources Institute (IPGRI 1994) and data were taken from the tagged plants at the end of harvest in each plot and the number of pods were counted and recorded carefully. Additionally, ten pods were randomly collected from the bottom, middle, and upper parts of the plants during harvesting time. The number of seeds per pod was meticulously counted. Pod length and pod width were recorded as the average length and width of pods collected. Harvest Index was calculated in per cent, as the ratio of economic yield (grain yield) to biological yield of harvested row multiplied by 100. Heritability, genetic variance, correlation coefficient between the traits and ANOVA analysis were performed using R software and OPSTAT software.

DNA isolation and SSR analysis

Genomic DNA was extracted using CTAB method with little modification (Doyle 1990). About 6-8 days young and actively growing fresh leaves were harvested for genomic DNA extraction. The quality and quantity of genomic DNA was evaluated by Nanodrop and agarose gel electrophoresis. DNA was diluted to a concentration of 25ng/µl for use in the PCR experiment after being quantified. PCR was carried out in 96 well Universal Gradient Thermal Cycler in a 5 µl reaction mixture. The following programme was used to execute the amplification: 94°C for 4 minutes, followed by 30 cycles of 94°C for 30 seconds, 50°–55°C for 30 seconds, and 72°C for 30 seconds, with a final extension of 72°C for 12 minutes. The PCR product was resolved on PAGE.For scoring alleles for each SSR locus, PCR products produced within the anticipated size range of SSR were employed

Population structure and diversity analysis

Perrier and Jacquemoud-Collet (2013) method was used to construct a phylogenetic tree using a pairwise distance matrix generated by constructing a dissimilarity matrix using a common allele index with DARwin software (Perrier and Jacquemoud 2013). In order to create an unweighted neighbour joining tree, the estimated dissimilarity index was used. The NEI coefficient and bootstrap process of re-sampling (1000) across markers and individuals from allele frequencies were used to determine the genetic distances across accessions (Nei 1972).

Model-based methodology and the STRUCTURE version 2.3.4 software were used to evaluate population structure (Pritchard et al. 2000). The actual number of subpopulation denoted by K was found using Markov Chain Monte Carlo (MCMC) replications and after 150,000 burn-ins. To account for the possibilities of admixture and correlated allele frequency correlation, the data was run ten times for each

Table 1. List of common bean genotypes used in the study

S.No.	Geno-type	Sl. No.	Genotype	Sl.No.	Genotype	Sl. No.	Genotype	Sl. No.	Genotype	Sl. No.	Genotype
1	CBZ1	26	CBZ26	51	CBZ51	76	CBZ76	101	WB22	126	WB923
2	CBZ2	27	CBZ27	52	CBZ52	77	CBZ77	102	WB54	127	WB952
3	CBZ3	28	CBZ28	53	CBZ53	78	CBZ78	103	WB83	128	WB956
4	CBZ4	29	CBZ29	54	CBZ54	79	CBZ79	104	WB102	129	WB966
5	CBZ5	30	CBZ30	55	CBZ55	80	CBZ80	105	WB112	130	WB1006
6	CBZ6	31	CBZ31	56	CBZ56	81	CBZ81	106	WB115	131	WB1129
7	CBZ7	32	CBZ32	57	CBZ57	82	CBZ82	107	WB185	132	WB1137
8	CBZ8	33	CBZ33	58	CBZ58	83	CBZ83	108	WB195	133	WB1187
9	CBZ9	34	CBZ34	59	CBZ59	84	CBZ84	109	WB206	134	WB1190
10	CBZ10	35	CBZ35	60	CBZ60	85	CBZ85	110	WB216	135	WB1282
11	CBZ11	36	CBZ36	61	CBZ61	86	CBZ86	111	WB222	136	WB1318
12	CBZ12	37	CBZ37	62	CBZ62	87	CBZ87	112	WB257	137	WB1319
13	CBZ13	38	CBZ38	63	CBZ63	88	CBZ88	113	WB335	138	WB1402
14	CBZ14	39	CBZ39	64	CBZ64	89	CBZ89	114	WB341	139	WB1436
15	CBZ15	40	CBZ40	65	CBZ65	90	CBZ90	115	WB352	140	WB1446
16	CBZ16	41	CBZ41	66	CBZ66	91	CBZ91	116	WB371	141	WB1492
17	CBZ17	42	CBZ42	67	CBZ67	92	CBZ92	117	WB379	142	WB1518
18	CBZ18	43	CBZ43	68	CBZ68	93	CBZ93	118	WB435	143	WB1634
19	CBZ19	44	CBZ44	69	CBZ69	94	CBZ94	119	WB482	144	WB1643
20	CBZ20	45	CBZ45	70	CBZ70	95	CBZ95	120	WB489	145	WB1664
21	CBZ21	46	CBZ46	71	CBZ71	96	CBZ96	121	WB634	146	WB1678
22	CBZ22	47	CBZ47	72	CBZ72	97	CBZ97	122	WB651	147	WB1679
23	CBZ23	48	CBZ48	73	CBZ73	98	CBZ98	123	WB832	148	WB1680
24	CBZ24	49	CBZ49	74	CBZ74	99	CBZ99	124	WB864	149	WB5176
25	CBZ25	50	CBZ50	75	CBZ75	100	CBZ100	125	WB877	150	WB21529

K value between 2 and 10. Plotting the mean estimate of the log posterior probability of the data L (K) against the specified K value allowed us to identify the ideal K value. The maximum value of L (K) was used to determine the true number of subpopulations. The best ΔK value has also been clearly identified using an ad hoc quantity, K, provided by Evanno et al. (2005) is based on the second order rate of change of the probability function with regard to K (Evanno et al. 2005). This estimate was made using Structure Harvester (Earl et al. 2012). When the proportion of a genotype's genome in a specific cluster (qK) was higher than a typical cutoff value of 50%, the genotypes were assigned to that cluster. According to Wright et al. 2011 the STRUCTURE programme was also used to estimate the degree of genetic divergence, or the wright fixation index of F statistics (Fst), simultaneously between the several bean subpopulations (Wright et al. 2011).

Association analysis

In the present study, TASSEL 3.0 was used to identify markers associated with morphological traits, days to flowering (DF), days to maturity (DM), number of pods/plant (NPPP), number of seeds/pod (NSPP), pod length (PL), pod width (PW) and Harvest Index (HI). Genotypic microsatellite data analysis and phenotypic data were considered to be associated with the traits if the markers are significant ($P<0.05$).

Results and discussion

Morphological data analysis

Analysis of variance (ANOVA) for seven morphological traits showed highly significant differences ($p < 0.001$) among genotypes indicating the presence of broad phenotypic diversity (Supplementary Table S1). In Shuhama, PCV values consistently exceeded GCV values, highlighting the influence of environmental factors on trait expression. A similar pattern was observed at Wadura, where phenotypic variance surpassed genotypic variance. Among the traits, DM exhibited the highest genotypic and phenotypic variance in Shuhama, whereas PW showed the least. This trend was reversed in Wadura, where NSPP displayed the highest genotypic variance. The relatively narrow difference between PCV and GCV for certain traits suggests strong genetic control and makes these traits promising candidates for selection in breeding programs.

The performance of genotypes showed wide variation based on the analysis of variance which showed highly significant differences among the genotypes for all the recorded traits. The mean performance for (DF) varied from 41.0 days in WB435 to 75.0 days in CBZ99 at Shuhama and 47.0 days in CBZ60 to 59.0 days in CBZ26 at Wadura with overall general mean of both the location 55.83. Data DM revealed that genotype WB1518 matured quickly and genotype CBZ80 required the most time in Shuhama with an average number of days ranging from 133.5 to 165.0, but in Wadura, DM ranged between the 81 to 103.3 days (Supplementary Table S2).

The PL in the collected common bean germplasm from Shuhama trail varied greatly, ranging with an average size of 11.3 cm. In Shuhama, the WB21529 genotype had the shortest pods, while CBZ59 had the longest. In Wadura, PL in WB877 and WB634 averaged 10.99 cm. Genotype CBZ86 had the narrowest pods in Shuhama, while CBZ28 had the widest, averaging 0.9 cm. In Wadura, CBZ50 had the highest PW and CBZ46 had the lowest, with a mean of 1.33 cm. CBZ8 had the fewest NPP in Shuhama and CBZ35 had the most, with an average of 12.99. In Wadura, WB1446 had the higher number of pods, and CBZ8 had the fewest, with an average of 19.83.WB1319 produced the most seeds per plant in Shuhama, while CBZ13 had the least, averaging 33.66. In Wadura, WB651 recorded the highest seed count, and CBZ55 had the lowest at 39.5.The HI showed notable variation. In Shuhama, the average was 12.23%. In Wadura, CBZ64 had the highest value at 19.64%, and WB435 had the lowest at 9.67%, with an average of 14.65% (Supplementary Table S3).

Mean and range of various traits along with genotypes having highest performances for these traits (Table 2). Analysis of variability parameters phenotypic coefficient variation (PCV), genotypic coefficient variation (GCV), heritability (BS) and genetic advance for Shuhama location indicated that PCV values were invariably greater than GCV values, indicating greater role of environment for the expression of these traits (Table 2). Similarly in Wadura, the phenotypic variation recorded was greater than genotypic variation. Genotypic variance showed highest value for days to maturity followed by NSPP (220.98 and 95.66) and lowest value for PW (0.098) for Shuhama and also showed highest value for NSPP (62.10) followed by DM (35.15). While phenotypic variance showed highest value for DM followed by NSPP (257.14 and 106.26, respectively) and were recorded highest for NPPP (98.00) followed by NSPP (68.04). Heritability in Shuhama ranged from 0.83 for PW to 0.91 for DM, while as in Wadura this component ranged from 0.001(NPPP) to 0.99 (HI). Similarly genetic advance was low for traits like PW (0.59 %) and high for traits like DM (28.38 %).While as in Wadura it was recorded lowest for NPPP, i.e., 0.30% and highest for NSPP (15.50%). The analysis revealed substantial variation among the genotypes for multiple yield attributing traits. The use of diverse locations allowed the assessment of the stability and adaptability of the genotypes under distinct environmental conditions. In a study of genotype x environment interaction, Sheeba and Yogameenakshi (2024) reported the most discriminating environment, which provided much information about differences among genotypes and is considered as good test environment for selecting widely adapted genotypes for yield per se of greengram (*Vigna radiata* L.).

Correlation and principal component analysis (PCA)

The Pearson correlation analysis using R software version 4.3.1 on genotypes showed a difference in correlation pattern at two different locations. In case of Shuhama, a positive correlation was found between HI and biological yield, while the negative correlation was found between PL and biological yield, PL and HI and NPPP and NSPP. The germplasm grown in Wadura, showed a positive correlation between PL and NPPP, PW and DM, and DF and NSPP, while HI and PL, HI and NPPP and HI and NSPP showed significantly negative correlation (Fig. 1). Principal component analysis (PCA) is a size reduction method using the data set of the studied agricultural characteristics. The total variation has

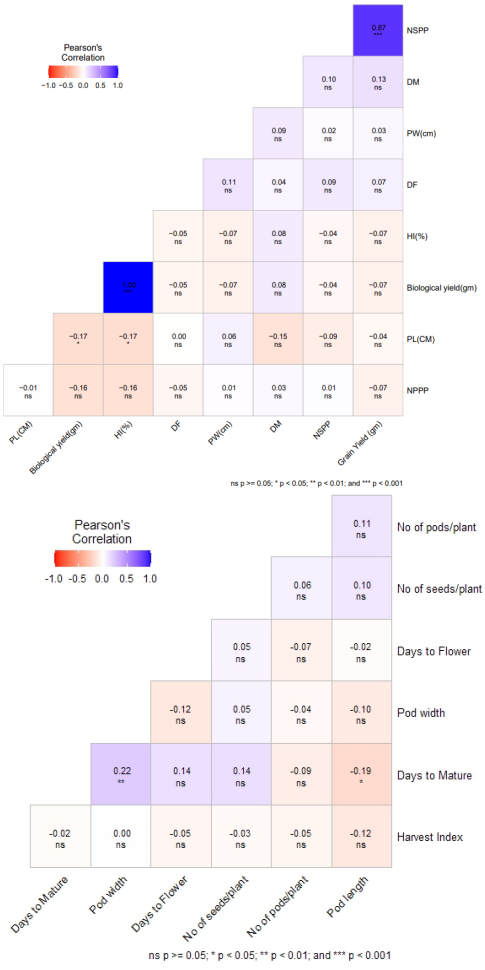

Fig. 1. The correlation between various morphological traits at two different locations (a) Shuhama and (b) Wadoora

Table 2. Estimate of mean, range, phenotypic variance, genotypic variance, PCV, GCV, heritability, genetic advance, expected genetic gain (percent of mean) for morphological traits of common bean (*Phaseolus vulgaris L.*)

Components	Location	DF	DM	NPP	PL	PW	NSPP	HI
Mean	Shuhama	59.02	137.93	12.65	11.68	1.17	31.9	13.75
	Wadura	52.65	91.29	26.63	11.87	1.40	38.78	15.99
	Pooled	55.83	114.61	19.64	11.77	1.28	35.34	14.87
Range	Shuhama	40.0-75.0	102.0-165.0	5.3-20.6	8.56-14.16	0.43-1.56	14.0-53.33	7.5-16.97
	Wadura	47.33-59.00	81.00-103.00	11.00-28.66	7.80-14.90	0.43-2.23	25.33-53.33	10.25-19.65
	Pooled	44.50-66.33	94.00-128.00	8.16-21.00	8.68-14.48	0.80-1.77	22.00-54.50	11.13-17.78
Phenotypic Variance (σ^2p)	Shuhama	49.2186	257.1435	12.4627	2.6629	0.1178	106.2629	2.7194
	Wadura	8.8627	53.1566	98.0076	2.7353	0.1405	68.0418	5.6676
	Pooled	29.040	62.060	55.231	2.699	0.129	87.15	4.193
Genotypic Variance (σ^2g)	Shuhama	45.0936	220.9889	10.8255	2.4090	0.0984	95.6644	2.4719
	Wadura	4.7956	35.1583	14.7654	2.6731	0.1196	62.1047	5.6226
	Pooled	24.944	128.073	12.795	2.541	0.109	78.884	4.047
PCV (Phenotypic coefficient of variation)	Shuhama	11.89	11.64	27.87	13.96	29.19	32.17	11.93
	Wadura	5.65	7.98	372.16	13.928	26.7653	21.2621	14.8805
	Pooled	8.77	9.81	200.015	13.944	27.977	26.715	13.405
GCV (Genotypic coefficient of variation)	Shuhama	11.38	10.79	25.97	13.28	26.68	30.52	11.38
	Wadura	4.15	6.49	14.4193	13.7695	24.6945	20.3133	14.8213
	Pooled	7.765	8.64	17.694	13.524	25.487	25.416	13.100
h^2(Broad Sense)	Shuhama	0.9162	0.8594	0.8686	0.9047	0.8353	0.9003	0.9090
	Wadura	0.5411	0.6614	0.0015	0.9773	0.8512	0.9127	0.9921
	Pooled	0.728	0.760	0.534	0.938	0.843	0.906	0.950
Genetic Advance	Shuhama	13.2409	28.3890	6.3170	3.0411	0.5906	19.1173	3.0879
	Wadura	3.3184	9.9338	0.3067	3.3295	0.6573	15.5097	4.8652
	Pooled	8.275	19.161	3.311	3.185	0.623	17.313	3.976
Expected Genetic Gain (per cent of Mean)	Shuhama	22.4430	20.6099	49.8711	26.0225	50.2401	59.6670	22.3556
	Wadura	6.3029	10.8836	1.1509	28.0408	46.9351	39.9780	30.4102
	Pooled	14.371	15.746	25.510	27.031	48.587	49.822	26.383

been derived from seven principal component axis, Eigen values, variability values (%) and cumulative values (%) (Supplementary Table 4). In Shuhama, the first principal component had 26.785% of the total variation (PC1) and the cumulative ratio of the three primary components in total variation was 64.495%. As a result of the PCA analysis, 7 principle component axes were obtained and these axes represented all of the total variation. While in Wadura, the first principal component had 20.206% of the total variation (PC1) and the cumulative ratio of the three primary components in total variation was 53.547%. The biplot analysis and principal component analysis showed a positive relationship between the closely angle traits (HI and biological yield), (PL and NPPP) and narrow angle traits (NSPP with grain yield), (PW with DM) (Fig. 2). Right angle traits are not related to each other (HI with NSPP), (PL with PW), (DM NPPP), whereas wide-angle features have negative relationships with each other (HI with NPPP and PL), (HI with PL, NPPP, NSPP and DM).

Correlation analysis further elucidated the inter-relationships among traits. These relationships reflect location-specific interactions and provide insights for trait-based selection. The correlation patterns observed present study are consistent with the findings of Mukeshimana et al. (2014), confirming the reliability of these relationships. Similar reciprocal relationships between traits, such as the negative association of HI with other yield components,

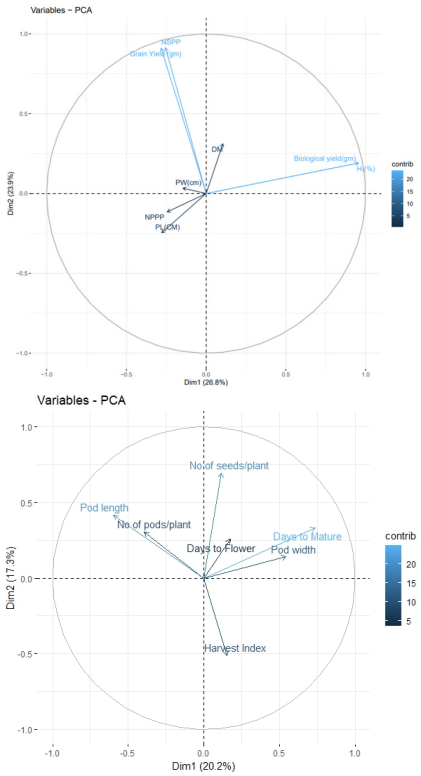

Fig. 2. PCA for various morphological traits at two different locations (a) Shuhama) and (b) Wadura

have been noted in previous reports. The use of principal component analysis (PCA) and biplot visualization enabled the identification of key contributing traits to overall variability and their interrelationships, offering a comprehensive view of trait dynamics across environments.

Population diversity and structure analysis

Levels of polymorphism and discriminating power of 100 SSR markers was determined using power marker (Liuand Muse 2005). The markers amplified a total of 534 alleles, an average of 5.34 alleles per locus ranging from 4 (79722 and Bmd8) to 19 (BM159). (Table 4). The discriminatory parameters of the markers were also used for association mapping study. The polymorphism information content (PIC) values ranged between 0.5325 and 0.8926, with a mean of 0.7553, confirming the high discriminative power and informativeness of the selected SSR markers. There are several reports on the detection of number of alleles per locus. In a similar study, Helena et al. (2025) detected 139 alleles using 56 SSR markers in rice; the allele number per locus ranging from 2-5 with an average of 2.48 alleles per marker. The overall PIC value ranged from a minimum of 0.18 to a maximum of 0.69 with an average value of 0.39. Low PIC values might be a result of closely related genotypes and high PIC values were an indication of highly diverse genotypes. These values differ according to the environment and the type of material used.

Gene diversity ranged from 0.628 to 0.900, averaging 0.784. These values are consistent with previous findings in common bean (Özkan et al. 2022) suggesting that the markers used effectively captured the underlying genetic variation in this core set. The major allele frequency ranged from 0.173 (PVBR93) to 0.560 (PVBR69) with an average of 0.331 for all SSR markers. Only 4% of SSR markers were found to have value of more than 0.50 which means that the major allele in most of the markers is not shared by most of the common bean germplasm used in the present study. Overall, the unique genetic architecture of common bean, as revealed by SSR analysis, highlights their potential as valuable breeding materials.

Population structure analysis using STRUCTURE software grouped the genotypes into three distinct subpopulations (K = 3), supporting the presence of significant genetic stratification. The Evanno test found a maximum of delta K at 3 in the plots of L (K) versus delta (Fig. 3a). This was further confirmed through a neighbour-joining dendrogram and bootstrap analysis. Such population differentiation enhances the resolution of association mapping by minimizing false positives due to population stratification. It is generated by STRUCTURE confirming a likely assignment of the bean germplasm to three sub-groups. The individual membership coefficient at K = 3 from the STRUCTURE run had maximum mean probability of likelihood value of L(K) = -1073.7667 (Supplementary Table S5) which led to assignment of

Table 3. Various discriminatory parameters of SSR markers used for association mapping study

S. No.	Marker	Major allele frequency	Genotype No	Allele No	Gene diversity	Heterozygosity	PIC
1	BM159	0.200	17.000	19.000	0.900	0.193	0.893
2	BM151	0.200	13.000	13.000	0.867	0.000	0.853
3	PVBR182	0.433	10.000	10.000	0.755	0.000	0.732
4	BM185	0.300	10.000	10.000	0.784	0.000	0.752
5	PVBR113	0.367	13.000	13.000	0.782	0.000	0.755
6	BM156	0.393	12.000	12.000	0.771	0.000	0.745
7	PVBR93	0.173	18.000	18.000	0.897	0.000	0.888
8	U77935	0.293	16.000	16.000	0.830	0.000	0.811
9	BM153	0.333	12.000	12.000	0.804	0.000	0.782
10	PVBR213	0.340	8.000	8.000	0.768	0.000	0.733
11	BM157	0.193	16.000	16.000	0.862	0.000	0.846
12	X57022	0.320	11.000	11.000	0.760	0.000	0.724
13	BM154	0.313	13.000	13.000	0.821	0.000	0.801
14	BM150	0.293	15.000	15.000	0.840	0.000	0.823
15	J04555	0.353	7.000	7.000	0.781	0.000	0.752
16	BM149	0.313	11.000	11.000	0.802	0.000	0.777
17	BMb654	0.373	11.000	11.000	0.785	0.000	0.759
18	PVBR185	0.487	7.000	7.000	0.680	0.000	0.637
19	X96999	0.353	8.000	8.000	0.782	0.000	0.753
20	X04660	0.393	13.000	13.000	0.781	0.000	0.758
21	Bmb152	0.353	10.000	10.000	0.790	0.000	0.764
22	Bmb742	0.373	12.000	12.000	0.775	0.000	0.746
23	BMC292	0.320	12.000	12.000	0.800	0.000	0.775
24	BM200	0.280	15.000	15.000	0.850	0.000	0.835
25	X59469	0.320	14.000	14.000	0.790	0.000	0.764
26	X74919	0.267	13.000	13.000	0.831	0.000	0.812
27	P1v111	0.253	11.000	11.000	0.855	0.000	0.840
28	Pvbr87	0.287	9.000	9.000	0.796	0.000	0.767
29	X60000	0.180	17.000	17.000	0.875	0.000	0.862
30	PVBR5	0.293	13.000	13.000	0.840	0.000	0.823
31	BM152	0.380	8.000	9.000	0.723	0.047	0.676
32	BMc234	0.240	9.000	9.000	0.827	0.000	0.804
33	K03289	0.380	7.000	7.000	0.726	0.000	0.683
34	BMC121	0.427	8.000	8.000	0.737	0.000	0.703
35	PVBR20	0.367	7.000	7.000	0.732	0.000	0.687
36	PVBR69	0.560	9.000	9.000	0.592	0.000	0.532
37	BMb793	0.313	10.000	10.000	0.772	0.000	0.736
38	BMb115	0.247	12.000	12.000	0.841	0.000	0.823
39	BMb152	0.500	5.000	5.000	0.628	0.000	0.564
40	X79722	0.420	4.000	4.000	0.703	0.000	0.652

Cont...

41	PVM097	0.240	11.000	11.000	0.832	0.000	0.810
42	BM158	0.420	6.000	6.000	0.737	0.000	0.702
43	M99497	0.380	12.000	12.000	0.714	0.000	0.669
44	Bmd45	0.247	9.000	9.000	0.813	0.000	0.786
45	BM172	0.360	6.000	6.000	0.748	0.000	0.708
46	BM164	0.300	13.000	13.000	0.827	0.000	0.807
47	BM210	0.367	5.000	5.000	0.732	0.000	0.684
48	BM161	0.313	10.000	10.000	0.813	0.000	0.790
49	Bmd12	0.340	9.000	9.000	0.763	0.000	0.727
50	Bmd8	0.407	4.000	4.000	0.707	0.000	0.656
	Mean	0.331	10.620	10.680	0.784	0.005	0.755

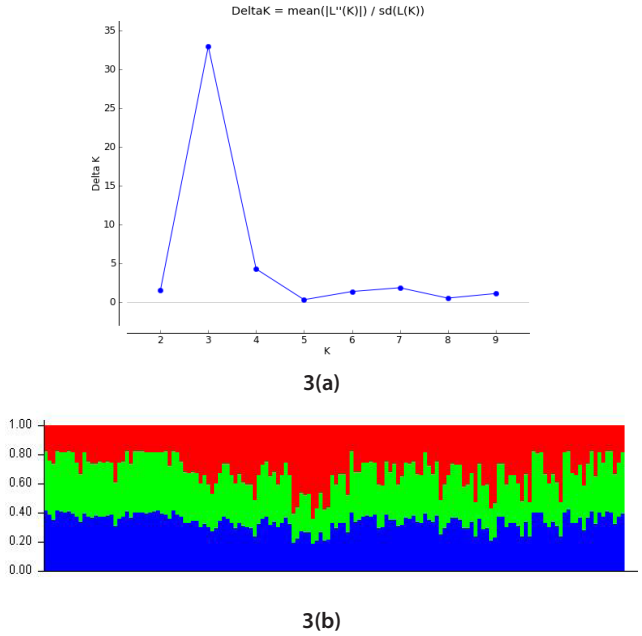

Fig. 3. (a) Graphical representation of optimal number of groups in the program STRUCTURE Harvester inferred; (b): Bar plot of individual ancestry proportion for genetic clusters inferred using K=3 and data set of 150 individuals and 100 SSR markers. Vertical bars represents the individuals of population, Red, Green and blue indicates sub population I, II and III, respectively

common bean germplasm to three (K=3) sub population (Fig. 3b). Graphical representation of optimal number of groups in the program STRUCTURE Harvester inferred using the criterion of (Evanno et al. 2005). The marker data was also used to construct the dendrogram showing genetic relationship among different genotypes (Fig. 4). Vertical bars represent the individuals of population, red, green and blue indicates sub population I, II and III, respectively.

Association mapping analysis

In the present study, TASSEL 3.0 was used to identify markers associated with morphological traits in common bean. Using

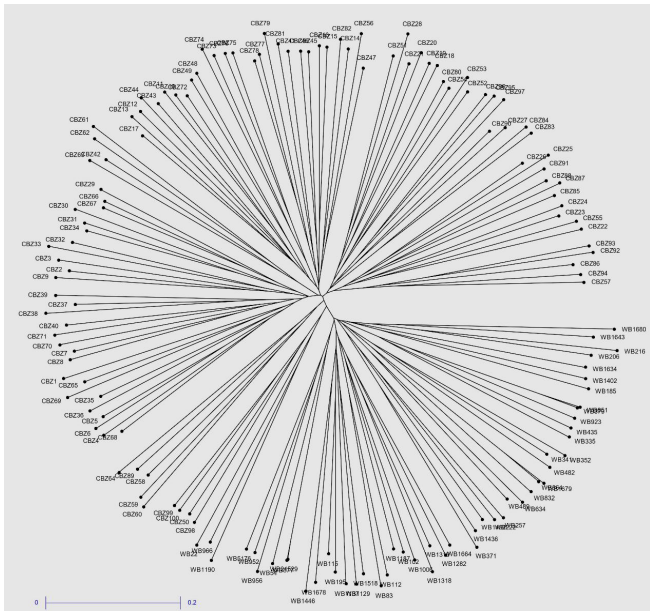

Fig. 4. UPGMA dendrogram showing genetic relationship among different common bean genotypes

both GLM and MLM approach, four SSR marker loci were identified associated with DF, NPPP and HI, at the $p<0.05$ probability and contributing 14-48 % of the phenotypic variation for Wadura, whereas for Shuhama, no significant association were found. Out of 4 significant SSR markers from Wadura, 2 markers (BM185, Bmb742) were associated with NPPP was found common, while using both the approaches (GLM and MLM), 1 marker (PVBR182) was associated with DF trait with R^2 value of 0.18 was found using GLM approach. When the pooled data of both the location were subjected to analysis, 2 markers (BM185, Bmb742) were associated with NPPP was found common while using both the approaches (GLM and MLM) and 1 marker (BM172) was associated with harvest index was found using GLM approach (Table 4). The association mapping of yield and yield-related traits was studied in landraces of rice by Verma et al. (2024) that

Table 4. Marker trait association with p value and marker trait regression derived from SSR markers

Location	Trait	Trait ID	Approach	Marker	Chromosome No.	P Value	Marker R^2 value
Location 1			MLM	BM185	7	0.04232	0.48044
	No of pods/plant	NPPP1		Bmb742	5	0.02463	0.33506
			GLM	BM185	7	0.021622	0.480442
				Bmb742	5	0.003524	0.335069
	Days to Flower	DF	GLM	PVBR182	10	0.020246	0.189434
Pooled			MLM	BM185	7	0.03242	0.47497
	No of pods/plant	NPPP1		Bmb742	5	0.05365	0.33879
			GLM	BM185	7	0.02412	0.34661
				Bmb742	5	0.82533	0.24698
	Harvest Index	HI	GLM	BM172	3	0.047262	0.144483

revealed seven significant marker-trait associations with R^2 ranging from 0.035 to 0.119 using MLM analysis. The R^2 value can indeed be important as an evidence of high marker-trait association in genetic studies. The p-value determines the association of QTLs with markers and the R^2 value predicts the magnitude of the QTL effects (Table 4). Based on marker-trait association, Kaldate et al. (2023) reported several QTLs for yield and related traits, while Zhang et al. (2014) also reported many marker-trait associations having R^2 value less than 0.10 for grain quality and yield contributing traits in rice using 274 SSR markers.

Marker-trait association analysis was conducted using both General Linear Model (GLM) and Mixed Linear Model (MLM) approaches in TASSEL software. Four SSR loci were significantly associated with traits such as days to flowering, number of pods per plant, and harvest index in Wadura with markers BM185 and BMB742 consistently identified by both models. The absence of significant marker-trait associations at Shuhama as compared to Wadura, highlighted the influence of location-specific environmental factors on trait expression and marker performance. This suggests that genotype × environment interactions played a major role potentially masking the genetic effects of certain loci under the environmental conditions prevailing at Shuhama thereby affecting the detection of significant associations. These findings reinforce the importance of conducting multi-environment trials when identifying stable QTLs and markers for use in marker-assisted selection. Future studies should integrate G×E interaction models to better dissect these effects and validate associations across diverse environments. The present findings aligned with the previous findings (Mahajan et al. 2017), who reported that markers associated with mineral and protein content in common bean germplasm from the same region. Together, these studies underscore the potential of unexplored Himalayan germplasm as a valuable resource for improving yield and nutritional quality in common bean. The identified SSR markers and associated traits serve as promising tools for marker-assisted selection, enabling targeted breeding for enhanced performance under diverse environmental conditions. The integration of morphological and molecular analyses revealed extensive genetic variability within the North-Himalayan common bean germplasm. The study provides new insights into population structure, trait correlations, and stable QTLs, which can significantly contribute to molecular breeding efforts aimed at enhancing the agronomic and nutritional performance of common bean varieties.

Supplementary material

The supplementary Tables S1 to S5 are provided, which can be accessed at www.isgpb.org.

Authors' contribution

Conceptualization of research (SMZ, AA); Designing of the experiments (SMZ, AA); Contribution of experimental materials (MMP, AZ, JS); Execution of field/lab experiments and data collection (MMP, JS); Analysis of data and interpretation (PAS, SMZ); Preparation of the manuscript (AA, PAS, SMZ).

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References

Balkaya A and Karaagac O.2006. Vegetable genetic resources of Turkey. J. Veg. Sci., **11**: 81-102.

Benchimol L.L., Campos T.D., Carbonell S.A., Colombo C.A., Chioratto A.F., Formighieri E.F., Gouvêa L.R. and Souza A.P. 2007. Structure of genetic diversity among common bean (*Phaseolus vulgaris* L.) varieties of Mesoamerican and Andean origins using new developed microsatellite markers. Genet. Resour. Crop Evol.,**54**: 1747-62.

Bezaweletaw K., Belete K. and Sripichitt P. 2006. Genetic gain

in grain yield potential and associated agronomic traits in haricot bean (*Phaseolus vulgaris* L.). J. Agric. Nat. Resour., **40**: 835-47.

Bode D., Elezi F. and Gixhari B. 2013. Morphological characterisation and interrelationships among descriptors in Phaseolus vulgaris accessions. Agri. For., **59**.

Bressani R. 1983. Research needs to up-grade the nutritional quality of common beans (Phaseolus vulgaris). Plant Foods Hum. Nutr., **32**: 101-10.

Devi J., Sharma A., Singh Y., Katoch V. and Sharma K.C. 2015. Genetic variability and character association studies in French bean (*Phaseolus vulgaris* L.) under North-Western Himalayas. Legume Res., **38**: 149-56.

Doyle J.J. 1990. Isolation of plant DNA from fresh tissue. Focus, **12**: 13-5.

Earl D.A. and VonHoldt B.M. 2012. STRUCTURE HARVESTER: a website and program for visualizing STRUCTURE output and implementing the Evanno method. Conserv. Genet. Resour., **4**: 359-61.

Evanno G., RegnautS., and Goudet J. 2005. Detecting the number of clusters of individuals using the software STRUCTURE: a simulation study. Mol. Ecol., **14**(8): 2611-2620.

Ganesan K. and Xu B. 2017. Polyphenol-rich dry common beans (*Phaseolus vulgaris* L.) and their health benefits. Int. J. Mol. Sci., **18**.

Hayat I., Ahmad A., Ahmed A., Khalil S. andGulfraz M. 2014. Exploring the potential of red kidney beans (*Phaseolus vulgaris* L.) to develop protein based product for food applications. JAPS: J. Anim. Plant Sci., **24**.

Helena D.S., Rohilla M., Mondal T.K., Roy P., Kumar S., Chowdhury D. and Sen P. 2025. Evaluation of the genetic architecture utilizing simple sequence repeat (SSR) markers in deep water rice (*Oryza sativa* L.) landraces of Assam, India. Indian J. Genet. Plant Breed., **85**(3): 376-388. doi.org/10.31742/ISGPB.85.3.3

Kaldate R., Verma R.K., Chetia S.K., Dey P.C., Mahalle M.D., Singh S.K., Baruah A.R. and Modi M.K. 2023. Mapping of QTLs associated with yield and related traits under reproductive stage drought stress in rice using SNP linkage map. Mol. Biol. Rep., **50**(8): 6349-6359

Kumar S., Shukla V., Dubey M.K. and Upadhyay R.S. 2021. Activation of defense response in common bean against stem rot disease triggered by *Trichoderma erinaceum* and *Trichoderma viride*. J. Basic Microbiol., **61**: 910-22.

Liu K. and Muse S.V. 2005. PowerMarker: an integrated analysis environment for genetic marker analysis. Bioinformatics, **21**: 128-9.

Lyngdoh Y.A., Thapa U., Shadap A. and Tomar J. 2018. StSudies on genetic variability and character association for yield and yield related traits in french bean (*Phaseolus vulgaris* L.). Legume Res., **41**: 810-5.

Mahajan R., Zargar S.M., Salgotra R.K., Singh R., Wani A.A., Nazir M. and Sofi P.A 2017. Linkage disequilibrium based association mapping of micronutrients in common bean (*Phaseolus vulgaris* L.): a collection of Jammu & Kashmir, India. 3 Biotech., 1-3.

Martins S.J., de Medeiros F.H., de Souza R.M., de Faria A.F., Cancellier E.L., de Oliveira Silveira H.R., de Rezende M.L. and Guilherme L.R. 2015. Common bean growth and health promoted by rhizobacteria and the contribution of magnesium to the observed responses. Appl. Soil Ecol., **87**: 49-55.

Messina M.J. 1999. Legumes and soybeans: overview of their nutritional profiles and health effects. Am. J. Clin. Nutr., **70**: 439S-50S.

Mukankusi C., Raatz B., Nkalubo S., Berhanu F., Binagwa P., Kilango M., Williams M., Chirwa R. and Beebe S. 2019. Genomics, genetics and breeding of common bean in Africa: A review of tropical legume project. Plant Breed., **138**: 401-14.

Mukeshimana G., Butare L., Cregan P.B., Blair M.W. and Kelly J.D. 2014. Quantitative trait loci associated with drought tolerance in common bean. Crop Sci., **54**: 923-38.

Nei M. 1972. Genetic distance between populations. The American Naturalist, **106**: 283-92.

Özkan G., Haliloğlu K., Türkoğlu A., Özturk H. I., Elkoca E. and Poczai P. 2022. Determining genetic diversity and population structure of common bean (*Phaseolus vulgaris* L.) landraces from Türkiye using SSR markers. Genes., **1410**: 13

Perrier X. and Jacquemoud-Collet J.P. 2013. DARwin software: Dissimilarity analysis and representation for windows. Website http://darwin. cirad. fr/darwin.

Pritchard J.K., Stephens M. and Donnelly P. 2000. Inference of population structure using multilocus genotype data. Genetics, **155**: 945-59.

Rathna Priya T.S. and Manickavasagan A. 2020. Common bean, Pulses: Processing and Product Development. 77-97.

Scarano D. and Rao R. 2014. DNA markers for food products authentication. Diversity, **6**(3): 579-596.

Sharma P.N., Diaz L.M. and Blair M.W. 2013. Genetic diversity of two Indian common bean germplasm collections based on morphological and microsatellite markers. Plant Genetic Resources., **11**: 21-30.

Sheeba A. and Yogameenakshi P. 2024. Dissection of genotype x environment interaction and yield stability analysis in greengram using (*Vigna radiata* L.) AMMI and GGE biplot. Indian J. Genet. Plant Breed., **84**(2): 304-307.doi.org/10.31742/ISGPB.84.2.21

Shii C.T., Mok M.C., Temple S.R. and Mok D.W. 1981. Expression of developmental abnormalities in hybrids of *Phaseolus vulgaris* L. Interaction between temperature and allelic dosage. J Hered., 218-222.

Sudan J., Singh R. andSalgotra R.K. 2022. Microsatellites-based population analysis revealed micro-diversity in two major genepools of Brassica juncea. The Nucleus, **65**(1): 19-24.

Sudan, J., Khajuria P., Gupta S. K.and Singh R. 2016. Analysis of molecular diversity in Indian and Exotic genotypes of *Brassica juncea* using SSR markers. Indian J. Genet. Plant Breed., **76**(03): 361-364.

Talukder Z.I., Anderson E., Miklas P.N., Blair M.W., Osorno J., Dilawari M. and Hossain K.G. 2010. Genetic diversity and selection of genotypes to enhance Zn and Fe content in common bean. Can. J. Plant Sci., **90**: 49-60.

Torkamaneh D., Chalifour F.P., Beauchamp C.J., Agrama H., Boahen S., Maaroufi H., Rajcan I. andBelzile F. 2020. Genome-wide association analyses reveal the genetic basis of biomass accumulation under symbiotic nitrogen fixation in African soybean. Theor. Appl. Genet. Theor. Appl. Genet., **133**: 665-76.

Verma H., Theunuo S., Das S.P., Kumar A., Aochen C., Devi L., Sarika K., Baishya L.K., Rajkhowa D.J., Kalita H., Mishra V.K., Behera P.P. and Sarma R.N. 2024. Genetic diversity and marker-trait association analysis for grain quality, yield and yield

attributes in hill rice (*Oryza sativa* L.). Indian J. Genet. Plant Breed., **84**(4): 587-601. doi.org/10.31742/ISGPB.84.4.9

Wright E.M. and Kelly J.D. 2011. Mapping QTL for seed yield and canning quality following processing of black bean (*Phaseolus vulgaris* L.). Euphytica, **179**: 471-84.

Wu J., Wang L., Fu J., Chen J, Wei S., Zhang S., Zhang J., Tang Y., Chen M., Zhu J. and Lei L. 2020. Resequencing of 683 common bean genotypes identifies yield component trait associations across a north–south cline. Nat. Genet., **52**: 118-25.

Wu L., Chang Y., Wang L., Wu J. and Wang S. 2021. Genetic dissection of drought resistance based on root traits at the bud stage in common bean. Theor. Appl. Genet., **134**: 1047-61.

Zargar S.M,, Gupta N., Nazir M., Mahajan R., Malik F.A., Sofi N.R., Shikari A.B. andSalgotra R.K. 2017. Impact of drought on photosynthesis: Molecular perspective. Plant Gene., **11**: 154-9.

Zargar S.M., Sharma A., Sadhu A., Agrawal G.K. andRakwal R. 2014. Exploring genetic diversity in common bean from unexploited regions of Jammu & Kashmir-India. Mol. Plant Breed., **24**:5(2).

Zhang P., Liu X., Tong H., Lu Y. and Li J. 2014. Association mapping for important agronomic traits in core collection of rice (*Oryza sativa* L.) with SSR markers. PLoS One, **9**(10): e111508.

Supplementary Table S1. Analysis of Variance for morphological traits of common bean

Source of Variation	Days to flowering							Days to Maturity					
	Shuhama				Wadoora			Shuhama			Wadoora		
	df	SS	MS	F. Ratio	SS	MS	F. Ratio	SS	MS	F. Ratio	SS	MS	F. Ratio
Replication	2	119.231			27.004			11.004			22.698		
Treatment	149	20,673.291***	138.747	127.573**	2,756.944***	18.503***	4.643***	94,112.864***	631.630	397.944**	18,454.358***	123.855**	6.942
Error	298	324.102	1.088		1,187.662	3.985		11.004	1.587		5,316.636	17.841	
Total	449	21,116.624			3,971.611			94,596.864			23,793.691		
Source of Variation	No. of Pods per Plant							Pod Length					
	Shuhama				Wadoora			Shuhama			Wadoora		
	df	SS	MS	F. Ratio	SS	MS	F. Ratio	SS	MS	F. Ratio	SS	MS	F. Ratio
Replication	2	3.258			19,862.218			0.289			0.498		
Treatment	149	3,259.428***	21.875	3.115***	1,460,101.958***	9,799.342***	0.994***	708.025***	4.752	2.637	1,205.667***	8.092***	365.945
Error	298	2,092.816	7.023		2,936,503.782	9,854.040		536.964	1.802		6.589	0.022	
Total	449	5,355.502			4,416,467.958			1,245.278			1,212.754		
Source of Variation	Pod Width							No. of Seeds per Plant					
	Shuhama				Wadoora			Shuhama			Wadoora		
	df	SS	MS	F. Ratio	SS	MS	F. Ratio	SS	MS	F. Ratio	SS	MS	F. Ratio
Replication	2	7.284			0.006			18.756			19.538		
Treatment	149	558.596***	3.749	1.047**	56.504***	0.379***	19.152***	29,809.199***	200.062	3.500***	28,362.758	190.354	32.125
Error	298	1,067.343	3.582		5.901	0.020		17,034.722	57.163		1,765.796	5.925	
Total	449	1,633.223			62.410			46,862.677			30,148.091		
Source of Variation	Harvest Index												
	Shuhama				Wadoora								
	df	SS	MS	F. Ratio	SS	MS	F. Ratio						
Replication	2	2.557			3.363								
Treatment	149	832.478***	5.587	3.450**	2,499.269***	16.774***	440.991**						
Error	298	482.648	1.620		11.335	0.038							
Total	449	1,317.683			2,513.967								

Df-degree of freedom
SS-Sum of square
MS-Mean squares
F.Ratio-MS/MSError
Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Supplementary Table S2. Mean values of 150 common bean genotypes with respect to different morphological parameters (Days to Flowering, Days to Maturity and No. of Pods/plant)

Genotypes	Days to Flowering			Days to Maturity			No. of Pods/Plant		
	Shuhama	Wadoora	Pooled	Shuhama	Wadoora	Pooled	Shuhama	Wadoora	Pooled
CBZ1	70.00 ± 0.57	53.00 ± 0.57	61.50 ± 3.81	142.33 ± 0.33	96.00 ± 0.57	119.16 ± 10.36	14.66 ± 0.33	22.00 ± 1.52	18.33 ± 1.78
CBZ2	63.00 ± 0.57	54.33 ± 0.33	58.66 ± 1.96	134.00 ± 0.57	86.33 ± 0.88	110.16 ± 10.66	20.33 ± 0.66	23.66 ± 2.40	22.00 ± 1.34
CBZ3	63.00 ± 0.57	55.66 ± 0.88	59.33 ± 1.70	137.00 ± 0.57	98.33 ± 1.20	117.66 ± 8.66	9.33 ± 0.33	13.66 ± 0.88	11.50 ± 1.05
CBZ4	48.00 ± 0.57	51.66 ± 0.88	49.83 ± 0.94	124.00 ± 0.57	83.66 ± 1.85	103.83 ± 9.06	10.33 ± 0.33	14.33 ± 0.66	12.33 ± 0.95
CBZ5	61.00 ± 0.57	57.00 ± 0.57	59.00 ± 0.96	140.00 ± 0.57	93.66 ± 0.88	116.83 ± 10.37	14.33 ± 0.33	21.33 ± 1.45	17.83 ± 1.70
CBZ6	60.66 ± 0.88	59.00 ± 10.0	59.83 ± 4.51	156.00 ± 0.57	97.00 ± 0.57	126.50 ± 13.19	14.33 ± 0.33	23.00 ± 0.57	18.66 ± 1.96
CBZ7	62.00 ± 0.57	50.00 ± 0.57	56.00 ± 2.70	155.00 ± 0.57	100.33 ± 0.88	127.66 ± 12.23	8.67 ± 0.33	13.66 ± 1.85	11.16 ± 1.40
CBZ8	72.00 ± 0.57	48.33 ± 0.33	60.16 ± 5.30	137.00 ± 0.57	103.66 ± 1.85	120.33 ± 7.50	5.33 ± 0.33	11.00 ± 0.57	8.16 ± 1.30
CBZ9	66.00 ± 0.57	50.00 ± 0.57	58.00 ± 3.59	134.00 ± 0.57	87.66 ± 0.88	110.83 ± 10.37	10.33 ± 0.33	16.66 ± 1.20	13.50 ± 1.52
CBZ10	72.00 ± 0.57	55.00 ± 1.15	63.50 ± 3.84	140.00 ± 0.57	85.66 ± 1.20	112.83 ± 12.16	11.33 ± 0.88	16.33 ± 0.88	14.66 ± 0.98
CBZ11	49.33 ± 0.88	55.66 ± 0.66	52.50 ± 1.50	115.00 ± 0.57	93.00 ± 1.52	104.00 ± 4.97	10.33 ± 1.20	17.33 ± 1.20	13.66 ± 1.56
CBZ12	49.66 ± 0.88	54.00 ± 1.15	51.83 ± 1.16	125.00 ± 0.57	91.66 ± 1.45	108.33 ± 7.48	9.66 ± 1.20	11.66 ± 0.88	10.66 ± 1.30
CBZ13	60.00 ± 0.57	56.00 ± 1.15	58.00 ± 1.06	147.33 ± 0.33	101.66 ± 0.88	124.50 ± 10.22	12.33 ± 1.85	18.33 ± 1.45	15.50 ± 2.07
CBZ14	49.00 ± 0.57	50.00 ± 0.57	49.50 ± 0.42	135.00 ± 0.57	97.33 ± 1.20	116.16 ± 8.44	15.33 ± 0.88	22.33 ± 0.88	18.66 ± 1.70
CBZ15	64.00 ± 0.57	55.66 ± 0.88	59.83 ± 1.92	124.33 ± 0.33	100.33 ± 0.88	112.33 ± 5.38	14.00 ± 1.52	20.66 ± 0.33	19.00 ± 1.52
CBZ16	64.66 ± 0.88	53.66 ± 0.88	59.16 ± 2.52	134.33 ± 0.33	87.66 ± 0.88	111.00 ± 10.44	12.00 ± 1.15	23.33 ± 1.20	16.16 ± 2.41
CBZ17	61.66 ± 0.88	50.33 ± 0.66	56.00 ± 2.58	117.00 ± 0.57	84.33 ± 1.20	100.66 ± 7.32	13.00 ± 0.57	20.33 ± 2.40	16.66 ± 2.12
CBZ18	64.00 ± 0.57	55.00 ± 0.57	59.50 ± 2.04	123.66 ± 0.88	96.33 ± 1.45	110.00 ± 6.15	10.00 ± 2.51	20.00 ± 2.08	16.00 ± 1.65
CBZ19	60.00 ± 0.57	55.66 ± 0.88	57.83 ± 1.07	137.33 ± 0.33	99.66 ± 0.33	118.50 ± 8.42	9.00 ± 3.51	17.33 ± 0.66	11.50 ± 2.79
CBZ20	53.00 ± 0.57	53.33 ± 0.88	53.16 ± 0.47	145.66 ± 0.33	99.00 ± 1.00	122.33 ± 10.44	16.66 ± 2.18	18.00 ± 1.52	16.33 ± 0.91
CBZ21	54.00 ± 0.57	54.66 ± 0.33	54.33 ± 0.33	135.00 ± 0.57	84.66 ± 1.45	109.83 ± 11.27	17.66 ± 2.84	19.33 ± 2.40	21.33 ± 1.40
CBZ22	64.66 ± 0.33	52.00 ± 1.52	58.33 ± 2.91	136.00 ± 0.57	90.66 ± 0.88	113.33 ± 10.14	14.00 ± 0.57	24.33 ± 1.20	18.33 ± 2.43
CBZ23	60.33 ± 0.88	56.66 ± 1.45	58.50 ± 1.11	136.00 ± 0.57	95.66 ± 1.20	115.83 ± 9.03	15.00 ± 1.52	24.00 ± 1.15	20.16 ± 1.95
CBZ24	60.00 ± 0.57	57.33 ± 0.88	58.66 ± 0.76	126.66 ± 0.88	101.00 ± 0.57	113.83 ± 5.75	12.00 ± 1.52	23.66 ± 0.88	17.66 ± 2.14
CBZ25	64.00 ± 0.57	53.33 ± 0.88	58.66 ± 2.43	123.00 ± 0.57	97.66 ± 0.88	110.33 ± 5.68	9.33 ± 0.88	23.00 ± 1.52	16.50 ± 3.54
CBZ26	47.00 ± 0.57	56.00 ± 0.57	51.50 ± 2.04	130.00 ± 0.57	95.66 ± 0.33	112.83 ± 7.68	10.66 ± 0.88	24.66 ± 0.33	17.33 ± 2.74
CBZ27	59.66 ± 0.33	50.00 ± 0.57	54.83 ± 2.18	116.00 ± 0.57	97.66 ± 0.33	106.83 ± 4.11	10.66 ± 1.20	21.00 ± 1.15	15.16 ± 2.66
CBZ28	47.00 ± 0.57	48.00 ± 0.57	47.50 ± 0.42	133.66 ± 0.33	95.00 ± 0.57	114.33 ± 8.65	10.33 ± 2.18	18.66 ± 1.45	14.66 ± 1.05
CBZ29	61.33 ± 0.88	51.33 ± 0.33	56.33 ± 2.27	146.00 ± 0.57	101.00 ± 0.57	123.50 ± 1.06	8.33 ± 1.33	17.33 ± 1.20	13.00 ± 2.86

CBZ30	59.66 ± 0.33	52.66 ± 0.88	56.16 ± 1.62	153.33 ± 0.33	85.33 ± 0.33	119.33 ± 15.20	12.00 ± 1.52	22.33 ± 0.88	17.16 ± 2.93
CBZ31	62.00 ± 0.57	53.66 ± 0.88	57.83 ± 1.92	146.66 ± 0.33	81.66 ± 0.88	114.16 ± 14.54	13.00 ± 1.52	24.00 ± 1.52	18.66 ± 1.94
CBZ32	58.66 ± 0.66	55.33 ± 0.88	57.00 ± 0.89	136.00 ± 0.57	86.33 ± 1.20	111.16 ± 11.12	11.66 ± 1.76	22.33 ± 1.33	16.66 ± 3.04
CBZ33	61.00 ± 0.57	53.00 ± 0.57	57.00 ± 1.82	117.00 ± 0.57	84.33 ± 0.33	100.66 ± 7.31	13.33 ± 0.66	21.00 ± 1.73	17.16 ± 1.35
CBZ34	63.33 ± 0.88	53.33 ± 0.88	58.33 ± 2.30	122.00 ± 0.57	86.33 ± 0.66	104.16 ± 7.98	16.00 ± 3.00	19.66 ± 0.88	15.83 ± 1.44
CBZ35	63.00 ± 0.57	49.66 ± 0.88	56.33 ± 3.01	103.33 ± 0.33	85.33 ± 0.33	94.33 ± 4.03	20.66 ± 2.33	17.00 ± 1.00	20.16 ± 1.35
CBZ36	54.00 ± 0.57	49.00 ± 0.57	51.50 ± 1.17	114.00 ± 0.57	84.66 ± 0.66	99.33 ± 6.57	13.66 ± 0.88	24.66 ± 1.85	20.33 ± 2.43
CBZ37	54.00 ± 0.57	47.33 ± 0.33	50.66 ± 1.52	105.00 ± 0.57	85.33 ± 1.33	95.16 ± 4.44	10.66 ± 0.33	22.66 ± 0.88	17.16 ± 2.66
CBZ38	50.00 ± 1.15	52.00 ± 1.52	51.00 ± 0.96	114.00 ± 0.57	86.33 ± 0.66	100.16 ± 6.19	12.00 ± 0.57	24.00 ± 1.52	17.50 ± 2.99
CBZ39	49.33 ± 0.88	55.00 ± 1.00	52.16 ± 1.40	138.33 ± 0.33	92.00 ± 1.73	115.16 ± 10.39	12.66 ± 1.85	23.33 ± 1.20	18.16 ± 1.92
CBZ40	60.66 ± 0.66	51.66 ± 0.88	56.16 ± 2.07	145.66 ± 0.33	95.00 ± 0.57	120.33 ± 11.33	10.00 ± 1.52	22.66 ± 1.20	16.33 ± 3.49
CBZ41	63.00 ± 0.57	53.33 ± 0.33	58.16 ± 2.18	125.00 ± 0.57	98.33 ± 0.33	111.66 ± 5.97	14.33 ± 0.33	26.33 ± 0.33	20.00 ± 2.70
CBZ42	61.00 ± 0.57	55.00 ± 1.00	58.00 ± 1.43	114.00 ± 0.57	99.66 ± 0.88	106.83 ± 3.23	13.00 ± 2.51	24.00 ± 0.57	19.33 ± 1.96
CBZ43	60.33 ± 0.33	55.66 ± 0.33	58.00 ± 1.06	155.00 ± 0.57	92.00 ± 0.57	123.50 ± 14.09	10.00 ± 1.00	23.66 ± 0.88	16.50 ± 3.54
CBZ44	65.00 ± 0.57	57.00 ± 0.57	61.00 ± 1.82	136.00 ± 0.57	93.66 ± 0.88	114.83 ± 9.47	11.66 ± 1.33	27.00 ± 0.57	19.83 ± 3.21
CBZ45	61.66 ± 0.88	55.66 ± 0.88	58.66 ± 1.45	107.33 ± 0.88	84.00 ± 1.52	95.66 ± 5.27	10.33 ± 0.88	25.00 ± 0.57	16.33 ± 3.18
CBZ46	56.33 ± 2.84	49.33 ± 0.33	52.83 ± 2.02	125.00 ± 0.57	82.00 ± 1.15	103.50 ± 9.63	9.66 ± 1.33	23.66 ± 1.45	18.33 ± 3.14
CBZ47	54.00 ± 0.57	49.00 ± 0.57	51.50 ± 1.17	135.00 ± 0.57	85.00 ± 1.52	110.00 ± 11.20	8.33 ± 1.85	24.66 ± 0.88	15.33 ± 3.88
CBZ48	61.00 ± 0.57	53.66 ± 0.88	57.33 ± 1.70	125.00 ± 0.57	90.00 ± 0.57	107.50 ± 7.83	13.66 ± 1.20	23.33 ± 1.20	17.33 ± 2.31
CBZ49	65.66 ± 0.33	53.33 ± 1.20	59.50 ± 2.81	152.00 ± 0.57	86.33 ± 0.88	119.16 ± 14.69	16.33 ± 1.45	21.33 ± 0.88	19.00 ± 1.78
CBZ50	53.00 ± 0.57	53.33 ± 0.33	53.16 ± 0.30	126.00 ± 0.57	84.00 ± 1.15	105.00 ± 9.40	18.00 ± 2.00	23.66 ± 0.88	21.00 ± 0.73
CBZ51	49.66 ± 0.88	51.66 ± 0.33	50.66 ± 0.61	126.00 ± 0.57	92.00 ± 1.52	109.00 ± 7.63	16.00 ± 1.00	22.33 ± 1.85	18.66 ± 1.96
CBZ52	61.00 ± 0.57	54.00 ± 0.57	57.50 ± 1.60	150.00 ± 0.57	95.66 ± 2.02	122.83 ± 12.18	17.00 ± 2.00	21.33 ± 1.20	19.33 ± 0.76
CBZ53	49.00 ± 0.57	52.00 ± 1.15	50.50 ± 0.88	136.00 ± 0.57	99.66 ± 0.33	117.83 ± 8.13	15.00 ± 1.00	17.00 ± 0.57	15.50 ± 0.92
CBZ54	49.00 ± 0.57	48.66 ± 0.33	48.83 ± 0.30	127.00 ± 0.57	87.00 ± 0.57	107.00 ± 8.95	14.66 ± 2.40	19.00 ± 0.57	17.33 ± 0.71
CBZ55	54.00 ± 0.57	53.00 ± 1.52	53.50 ± 0.76	112.00 ± 0.57	86.33 ± 1.33	99.16 ± 5.77	9.00 ± 1.52	16.33 ± 0.88	12.83 ± 1.37
CBZ56	60.00 ± 0.57	55.33 ± 0.88	57.66 ± 1.14	132.00 ± 0.57	85.66 ± 1.20	108.83 ± 10.37	8.00 ± 1.52	12.00 ± 1.15	9.83 ± 1.75
CBZ57	66.00 ± 0.57	54.33 ± 1.45	60.16 ± 2.70	113.00 ± 0.57	102.33 ± 1.45	107.66 ± 2.48	10.33 ± 1.20	16.66 ± 0.66	14.16 ± 1.30
CBZ58	61.00 ± 0.57	54.66 ± 0.33	57.83 ± 1.44	106.66 ± 1.20	85.66 ± 1.20	96.16 ± 4.75	10.66 ± 2.18	16.00 ± 0.57	12.83 ± 2.18
CBZ59	60.33 ± 0.33	53.00 ± 0.57	56.66 ± 1.66	121.66 ± 0.88	85.33 ± 0.33	103.50 ± 8.13	16.00 ± 1.00	21.00 ± 0.57	18.83 ± 1.51
CBZ60	61.00 ± 0.57	47.00 ± 1.15	54.00 ± 3.18	116.00 ± 0.57	86.33 ± 0.66	101.16 ± 6.64	14.33 ± 0.66	22.66 ± 0.88	19.16 ± 1.79
CBZ61	61.66 ± 0.88	51.00 ± 0.57	56.33 ± 2.43	147.66 ± 0.88	87.66 ± 0.88	117.66 ± 13.42	13.33 ± 1.33	25.66 ± 0.66	18.50 ± 2.83

CBZ62	67.00 ± 0.57	52.00 ± 1.52	59.50 ± 3.43	154.00 ± 0.57	87.00 ± 0.57	120.50 ± 14.98	14.00 ± 1.00	23.00 ± 0.57	19.00 ± 1.69
CBZ63	60.00 ± 0.57	53.33 ± 0.88	56.66 ± 1.56	154.00 ± 0.57	86.33 ± 1.33	120.16 ± 15.14	12.00 ± 0.57	21.33 ± 0.88	17.50 ± 2.59
CBZ64	59.33 ± 0.33	54.33 ± 0.33	56.83 ± 1.13	138.00 ± 0.57	87.00 ± 0.57	112.50 ± 11.41	11.33 ± 0.88	26.00 ± 0.57	19.00 ± 3.62
CBZ65	54.00 ± 0.57	51.33 ± 0.33	52.66 ± 0.66	154.00 ± 0.57	94.00 ± 1.15	124.00 ± 13.42	13.33 ± 0.88	28.00 ± 0.57	20.16 ± 2.94
CBZ66	54.00 ± 0.57	56.00 ± 0.57	55.00 ± 0.57	153.00 ± 0.57	100.00 ± 0.57	126.50 ± 11.85	10.00 ± 2.08	26.33 ± 0.88	19.00 ± 3.18
CBZ67	60.33 ± 0.88	54.33 ± 0.33	57.33 ± 1.40	138.00 ± 0.57	103.00 ± 0.57	120.50 ± 7.83	9.00 ± 2.51	24.00 ± 0.57	14.66 ± 3.76
CBZ68	60.00 ± 0.57	51.33 ± 0.33	55.66 ± 1.96	126.00 ± 0.57	86.33 ± 0.88	106.16 ± 8.88	13.66 ± 0.66	21.00 ± 0.57	17.83 ± 1.77
CBZ69	61.33 ± 0.88	49.00 ± 0.57	55.16 ± 2.79	151.00 ± 0.57	91.66 ± 1.45	121.33 ± 13.28	14.66 ± 1.20	23.33 ± 0.33	18.66 ± 2.40
CBZ70	61.66 ± 0.88	54.00 ± 1.52	57.83 ± 1.88	155.00 ± 0.57	86.00 ± 1.15	120.50 ± 15.44	15.33 ± 3.18	24.00 ± 1.52	21.00 ± 1.52
CBZ71	54.33 ± 0.88	54.66 ± 0.66	54.50 ± 0.50	153.00 ± 0.57	94.00 ± 1.15	123.50 ± 13.20	12.66 ± 2.18	25.00 ± 1.15	17.16 ± 3.27
CBZ72	55.33 ± 0.33	53.66 ± 0.88	54.50 ± 0.56	156.00 ± 0.57	98.66 ± 0.88	127.33 ± 12.82	19.00 ± 0.57	23.00 ± 0.57	21.00 ± 1.46
CBZ73	61.00 ± 0.57	54.00 ± 0.57	57.50 ± 1.60	148.00 ± 0.57	86.00 ± 1.52	117.00 ± 13.88	16.33 ± 2.18	23.66 ± 1.45	21.50 ± 1.38
CBZ74	59.00 ± 0.57	53.66 ± 2.18	56.33 ± 1.56	155.00 ± 0.57	93.66 ± 0.88	124.33 ± 13.72	13.66 ± 0.66	26.00 ± 0.57	18.83 ± 2.77
CBZ75	61.66 ± 0.88	52.66 ± 1.20	57.16 ± 2.12	157.00 ± 0.57	85.00 ± 0.57	121.00 ± 16.10	15.66 ± 0.33	25.66 ± 0.88	20.50 ± 2.34
CBZ76	61.00 ± 0.57	54.66 ± 0.88	57.83 ± 1.49	156.33 ± 0.88	97.00 ± 1.15	126.66 ± 13.28	15.00 ± 0.57	25.66 ± 0.88	20.16 ± 2.18
CBZ77	49.66 ± 0.88	56.00 ± 0.57	52.83 ± 1.49	150.00 ± 0.57	95.66 ± 1.20	122.83 ± 12.16	14.33 ± 1.20	22.66 ± 0.88	19.50 ± 2.04
CBZ78	61.00 ± 0.57	52.00 ± 0.57	56.50 ± 2.04	155.00 ± 0.57	100.00 ± 1.15	127.50 ± 12.31	16.00 ± 2.51	23.33 ± 1.20	18.33 ± 2.48
CBZ79	61.66 ± 0.88	55.00 ± 0.57	58.33 ± 1.56	152.00 ± 0.57	92.66 ± 3.38	122.33 ± 13.35	19.00 ± 1.52	24.33 ± 0.88	22.00 ± 0.63
CBZ80	66.00 ± 0.57	55.66 ± 0.88	60.83 ± 2.35	165.00 ± 0.57	94.33 ± 1.45	129.66 ± 15.81	15.00 ± 1.52	22.00 ± 0.57	19.33 ± 1.40
CBZ81	61.00 ± 0.57	52.33 ± 0.33	56.66 ± 1.96	123.33 ± 0.88	95.33 ± 0.33	109.33 ± 6.27	13.00 ± 0.00	22.66 ± 0.88	17.33 ± 2.10
CBZ82	66.66 ± 0.88	55.00 ± 0.57	60.83 ± 2.65	124.00 ± 2.08	97.00 ± 1.15	110.50 ± 6.13	15.00 ± 0.57	23.33 ± 0.88	19.00 ± 2.26
CBZ83	49.00 ± 0.57	51.00 ± 0.57	50.00 ± 0.57	124.00 ± 0.57	59.66 ± 25.83	91.83 ± 18.45	17.33 ± 0.88	22.66 ± 0.88	19.50 ± 1.47
CBZ84	60.00 ± 0.57	56.00 ± 0.57	58.00 ± 0.96	148.66 ± 0.33	87.00 ± 1.15	117.83 ± 13.80	16.66 ± 1.33	25.66 ± 0.88	21.00 ± 1.75
CBZ85	48.33 ± 0.33	53.00 ± 0.57	50.66 ± 1.08	157.33 ± 0.33	97.33 ± 1.20	127.33 ± 13.42	13.66 ± 1.85	19.33 ± 0.88	17.66 ± 1.25
CBZ86	61.00 ± 0.57	56.33 ± 1.20	58.66 ± 1.20	145.00 ± 0.57	96.33 ± 1.45	120.66 ± 10.90	8.66 ± 0.33	20.66 ± 0.33	14.33 ± 2.43
CBZ87	49.66 ± 0.88	55.00 ± 0.57	52.33 ± 1.28	154.66 ± 0.33	102.00 ± 1.15	128.33 ± 11.78	9.33 ± 0.57	19.66 ± 0.88	13.66 ± 1.48
CBZ88	49.66 ± 0.88	56.33 ± 0.88	53.00 ± 1.59	149.00 ± 0.57	96.00 ± 1.52	122.50 ± 11.87	11.00 ± 1.33	18.00 ± 1.15	15.50 ± 1.25
CBZ89	61.00 ± 0.57	50.33 ± 0.88	55.66 ± 2.43	134.33 ± 0.88	85.66 ± 0.33	110.00 ± 10.89	9.66 ± 3.18	15.66 ± 0.88	11.83 ± 2.62
CBZ90	61.00 ± 0.57	52.00 ± 0.57	56.50 ± 2.04	150.66 ± 0.88	87.33 ± 1.20	119.00 ± 14.17	12.33 ± 2.18	22.66 ± 0.88	19.50 ± 2.04
CBZ91	49.66 ± 0.88	53.00 ± 0.57	51.33 ± 0.88	141.00 ± 0.57	93.66 ± 1.20	117.33 ± 10.60	11.00 ± 2.51	23.33 ± 1.20	14.33 ± 2.88
CBZ92	61.66 ± 0.88	49.00 ± 0.57	55.33 ± 2.87	140.00 ± 0.57	95.00 ± 0.57	117.50 ± 10.06	15.00 ± 0.57	16.00 ± 0.57	16.66 ± 0.91
CBZ93	66.00 ± 0.57	51.00 ± 0.57	58.50 ± 3.37	140.00 ± 5.00	84.33 ± 1.20	112.16 ± 12.65	11.66 ± 1.33	21.00 ± 0.57	17.16 ± 1.74

CBZ94	66.00 ± 0.57	52.66 ± 0.66	59.33 ± 3.00	140.00 ± 0.57	90.66 ± 0.88	115.33 ± 11.04	10.66 ± 0.66	21.66 ± 0.33	16.16 ± 2.92
CBZ95	61.66 ± 0.88	52.66 ± 0.88	57.16 ± 2.08	141.33 ± 0.33	83.00 ± 1.73	112.16 ± 13.06	14.33 ± 0.88	22.66 ± 0.88	18.16 ± 2.41
CBZ96	54.00 ± 0.57	53.66 ± 0.33	53.83 ± 0.30	137.33 ± 0.88	85.66 ± 0.88	111.50 ± 11.56	14.00 ± 1.00	25.00 ± 0.57	19.33 ± 1.87
CBZ97	49.66 ± 0.88	51.66 ± 0.33	50.66 ± 0.61	155.00 ± 0.57	99.00 ± 0.57	127.00 ± 12.52	12.66 ± 0.88	23.33 ± 1.20	19.16 ± 2.79
CBZ98	72.00 ± 0.57	55.33 ± 0.88	63.66 ± 3.75	157.33 ± 0.33	83.00 ± 1.52	120.16 ± 16.63	11.00 ± 1.52	27.00 ± 0.57	16.33 ± 3.45
CBZ99	75.00 ± 0.57	49.66 ± 0.33	66.33 ± 5.33	147.00 ± 0.57	86.66 ± 0.88	126.66 ± 12.71	9.00 ± 0.57	23.66 ± 1.45	16.33 ± 3.60
CBZ100	54.00 ± 0.57	48.00 ± 0.57	51.00 ± 1.39	135.33 ± 0.33	90.00 ± 0.57	112.66 ± 10.14	11.66 ± 1.76	22.66 ± 0.88	17.00 ± 3.23
WB22	61.00 ± 0.57	52.00 ± 0.57	56.50 ± 2.04	145.00 ± 0.57	86.66 ± 0.88	115.83 ± 13.05	13.00 ± 0.57	26.00 ± 0.57	20.16 ± 2.79
WB54	49.33 ± 0.88	53.33 ± 0.66	51.33 ± 1.02	135.66 ± 0.33	93.66 ± 0.88	114.66 ± 9.40	12.33 ± 1.85	27.00 ± 0.57	18.33 ± 3.31
WB83	72.00 ± 0.57	55.66 ± 0.88	63.83 ± 3.68	142.00 ± 0.57	91.66 ± 0.33	116.83 ± 11.25	13.66 ± 2.40	24.33 ± 0.33	20.66 ± 2.14
WB102	54.00 ± 0.57	55.66 ± 1.20	54.83 ± 0.70	128.00 ± 0.57	96.00 ± 1.52	112.00 ± 7.19	11.6 ± 0.33	26.00 ± 0.57	18.50 ± 3.54
WB112	66.00 ± 0.57	51.33 ± 0.33	58.66 ± 3.29	126.00 ± 0.57	97.33 ± 1.20	111.66 ± 6.43	12.33 ± 1.20	25.66 ± 1.20	18.33 ± 2.43
WB115	66.66 ± 0.88	49.00 ± 0.57	57.83 ± 3.97	140.00 ± 0.57	96.66 ± 0.66	118.33 ± 9.69	10.33 ± 0.88	23.00 ± 0.57	16.83 ± 3.21
WB185	54.00 ± 0.57	53.66 ± 0.88	53.83 ± 0.47	140.33 ± 0.66	96.66 ± 0.88	118.50 ± 9.77	13.00 ± 0.57	25.66 ± 0.33	19.66 ± 2.99
WB195	49.00 ± 0.57	53.66 ± 0.88	51.33 ± 1.14	153.33 ± 0.88	92.66 ± 0.33	123.00 ± 13.57	11.67 ± 1.20	24.66 ± 1.20	17.66 ± 3.01
WB206	52.66 ± 0.33	53.00 ± 1.52	52.83 ± 0.70	153.66 ± 0.88	98.00 ± 0.57	125.83 ± 12.45	12.33 ± 0.33	25.00 ± 0.57	19.50 ± 2.99
WB216	70.00 ± 0.57	53.00 ± 0.57	61.50 ± 3.81	155.66 ± 0.33	99.33 ± 0.33	127.50 ± 12.59	13.66 ± 0.33	27.00 ± 1.52	19.66 ± 3.04
WB222	72.00 ± 0.57	53.3330.88	62.66 ± 4.20	151.00 ± 0.57	96.66 ± 0.88	123.83 ± 12.15	13.00 ± 0.00	26.33 ± 0.33	19.33 ± 2.70
WB257	54.00 ± 0.57	49.00 ± 0.57	51.50 ± 1.17	127.33 ± 0.33	86.33 ± 1.45	106.83 ± 9.19	11.66 ± 2.48	23.00 ± 1.00	18.33 ± 1.99
WB335	61.66 ± 0.88	53.66 ± 0.88	57.66 ± 1.87	136.00 ± 0.57	86.00 ± 0.57	111.00 ± 11.18	8.66 ± 2.18	20.00 ± 1.52	12.50 ± 2.76
WB341	54.66 ± 0.33	50.33 ± 0.88	52.50 ± 1.05	155.00 ± 0.57	84.00 ± 1.52	119.50 ± 15.89	13.00 ± 1.00	17.66 ± 0.66	15.00 ± 0.68
WB352	61.00 ± 0.57	52.00 ± 0.57	56.50 ± 2.04	142.33 ± 0.33	85.00 ± 0.57	113.66 ± 12.82	10.00 ± 0.00	15.00 ± 0.57	12.16 ± 0.98
WB371	67.00 ± 0.57	48.66 ± 0.33	57.83 ± 4.11	152.66 ± 0.88	92.00 ± 1.15	122.33 ± 13.58	11.66 ± 0.33	12.00 ± 0.57	12.00 ± 0.73
WB379	54.00 ± 0.57	47.66 ± 0.88	50.83 ± 1.49	157.00 ± 0.57	93.66 ± 1.85	125.33 ± 14.18	12.33 ± 1.20	16.00 ± 0.57	15.50 ± 1.33
WB435	41.00 ± 0.57	48.00 ± 1.00	44.50 ± 1.64	146.33 ± 0.33	93.00 ± 2.08	119.66 ± 11.96	13.00 ± 1.52	22.66 ± 0.88	16.83 ± 2.65
WB482	54.00 ± 0.57	53.00 ± 1.52	53.50 ± 0.76	125.00 ± 0.57	87.66 ± 0.88	106.33 ± 8.36	13.66 ± 2.40	21.33 ± 0.33	19.16 ± 1.49
WB489	61.00 ± 0.57	53.33 ± 0.66	57.16 ± 1.75	135.00 ± 0.57	83.00 ± 1.52	109.00 ± 11.65	10.66 ± 3.18	22.33 ± 0.88	15.16 ± 3.24
WB634	62.66 ± 0.88	54.33 ± 0.66	58.50 ± 1.92	134.66 ± 0.33	87.00 ± 0.57	110.83 ± 10.66	15.00 ± 0.57	23.00 ± 0.57	19.66 ± 1.70
WB651	57.00 ± 0.57	51.66 ± 0.33	54.33 ± 1.22	145.00 ± 0.57	86.00 ± 1.52	115.50 ± 13.21	12.00 ± 1.00	24.00 ± 1.52	19.00 ± 2.67
WB832	54.00 ± 0.57	53.00 ± 0.57	53.50 ± 0.42	153.66 ± 1.33	86.66 ± 1.20	120.16 ± 15.00	11.33 ± 0.88	26.33 ± 1.20	18.16 ± 3.54
WB864	60.00 ± 0.57	52.66 ± 1.20	56.33 ± 1.74	152.00 ± 0.57	92.33 ± 1.45	122.16 ± 13.36	11.33 ± 0.66	25.66 ± 0.88	18.16 ± 2.72

WB877	61.66 ± 0.88	51.66 ± 1.20	56.66 ± 2.33	141.33 ± 0.33	94.66 ± 1.45	118.00 ± 10.45	10.66 ± 0.88	23.33 ± 1.20	17.66 ± 2.99
WB923	61.00 ± 0.57	52.66 ± 0.88	56.83 ± 1.92	140.00 ± 0.57	87.00 ± 1.15	113.50 ± 11.86	8.66 ± 0.33	23.66 ± 1.45	16.16 ± 3.42
WB952	62.00 ± 0.57	47.33 ± 0.88	54.66 ± 3.31	156.00 ± 0.57	96.00 ± 0.57	126.00 ± 13.42	11.33 ± 1.33	25.00 ± 0.57	16.83 ± 3.28
WB956	52.00 ± 0.57	49.66 ± 0.88	50.83 ± 0.70	150.00 ± 0.57	98.00 ± 1.15	124.00 ± 11.64	13.33 ± 0.33	22.66 ± 0.88	18.83 ± 2.33
WB966	40.66 ± 0.88	50.00 ± 1.00	45.33 ± 2.17	157.00 ± 0.57	98.66 ± 2.02	127.83 ± 13.07	13.33 ± 1.85	23.66 ± 0.88	18.16 ± 2.84
WB1006	57.00 ± 0.57	52.66 ± 0.66	54.83 ± 1.04	156.33 ± 0.33	93.66 ± 3.84	125.00 ± 14.19	18.00 ± 1.52	25.66 ± 0.88	20.16 ± 1.70
WB1129	49.00 ± 0.57	54.66 ± 0.33	51.83 ± 1.30	150.00 ± 0.57	85.66 ± 1.85	117.83 ± 14.41	16.33 ± 4.17	23.33 ± 1.20	21.00 ± 1.43
WB1137	57.00 ± 0.57	55.66 ± 0.88	56.33 ± 0.55	154.33 ± 0.33	86.33 ± 2.84	120.33 ± 15.25	9.66 ± 0.66	14.66 ± 0.88	11.66 ± 1.40
WB1187	61.00 ± 0.57	52.66 ± 1.20	56.83 ± 1.95	151.66 ± 0.33	91.33 ± 0.88	121.50 ± 13.49	11.00 ± 1.00	13.33 ± 0.88	11.66 ± 0.42
WB1190	54.00 ± 0.57	49.00 ± 0.57	51.50 ± 1.17	135.00 ± 0.57	91.00 ± 2.51	113.00 ± 9.90	8.66 ± 0.33	12.33 ± 1.20	11.50 ± 1.14
WB1282	61.66 ± 0.88	50.00 ± 0.57	55.83 ± 2.65	134.33 ± 0.33	86.66 ± 1.45	110.50 ± 10.67	11.00 ± 1.52	13.66 ± 0.88	11.50 ± 1.25
WB1318	71.66 ± 0.33	53.33 ± 0.66	62.50 ± 4.11	141.66 ± 0.33	88.33 ± 2.18	115.00 ± 11.96	14.33 ± 1.85	17.66 ± 0.88	16.16 ± 1.49
WB1319	65.33 ± 0.33	55.33 ± 0.88	60.33 ± 2.27	135.00 ± 0.57	84.00 ± 1.15	109.50 ± 11.41	14.33 ± 2.66	22.66 ± 0.88	20.66 ± 1.52
WB1402	70.00 ± 0.57	51.00 ± 0.57	60.50 ± 4.26	155.00 ± 0.57	86.00 ± 0.57	120.50 ± 15.43	11.00 ± 2.51	25.00 ± 0.57	17.16 ± 3.82
WB1436	70.00 ± 0.57	52.33 ± 0.33	61.16 ± 3.96	137.33 ± 0.88	84.00 ± 0.57	110.66 ± 11.93	17.00 ± 1.15	24.66 ± 1.85	20.50 ± 2.32
WB1446	62.00 ± 0.57	52.00 ± 0.57	57.00 ± 2.26	126.00 ± 0.57	84.00 ± 1.15	105.00 ± 9.40	17.00 ± 2.51	28.66 ± 0.33	23.33 ± 1.94
WB1492	61.66 ± 0.88	50.33 ± 0.88	56.00 ± 2.59	135.33 ± 0.33	85.66 ± 1.20	110.50 ± 11.12	12.33 ± 0.33	23.33 ± 1.20	18.16 ± 2.70
WB1518	57.66 ± 0.88	48.33 ± 0.33	53.00 ± 2.12	102.00 ± 0.57	86.00 ± 0.57	94.00 ± 3.59	12.00 ± 0.57	25.00 ± 0.57	18.50 ± 2.93
WB1634	59.66 ± 0.88	50.66 ± 0.88	55.16 ± 2.08	126.00 ± 0.57	87.66 ± 1.76	106.83 ± 8.61	12.33 ± 0.66	27.00 ± 0.57	20.33 ± 3.44
WB1643	54.00 ± 0.57	52.66 ± 0.66	53.33 ± 0.49	113.00 ± 0.57	95.33 ± 2.40	104.16 ± 4.10	12.66 ± 0.33	26.33 ± 1.45	19.16 ± 3.28
WB1664	61.66 ± 0.88	49.33 ± 0.88	55.50 ± 2.81	110.00 ± 0.57	101.33 ± 0.88	105.66 ± 1.99	12.33 ± 1.66	28.33 ± 0.33	20.33 ± 3.01
WB1678	49.33 ± 0.88	48.33 ± 0.88	48.83 ± 0.60	103.00 ± 0.57	103.33 ± 1.20	103.16 ± 0.60	8.00 ± 0.00	25.33 ± 0.33	16.66 ± 3.73
WB1679	71.33 ± 0.88	52.00 ± 0.57	61.66 ± 4.34	143.00 ± 0.57	100.33 ± 0.88	121.66 ± 9.55	9.33 ± 0.33	25.00 ± 0.57	16.50 ± 3.43
WB1680	71.00 ± 0.57	53.00 ± 1.55	62.00 ± 4.06	126.00 ± 0.57	87.00 ± 0.57	106.50 ± 8.72	12.66 ± 2.18	22.66 ± 0.88	16.50 ± 2.93
WB5176	49.66 ± 0.88	53.00 ± 0.57	51.33 ± 0.88	134.00 ± 0.57	92.66 ± 1.20	113.33 ± 7.28	14.66 ± 1.33	23.66 ± 0.88	20.66 ± 1.96
WB21529	48.00 ± 0.57	52.66 ± 0.88	50.33 ± 1.14	158.00 ± 0.57	95.00 ± 0.57	126.50 ± 14.09	12.03 ± 1.49	27.00 ± 0.57	17.03 ± 3.40
CD ± SE	1.67 ± 0.60	3.21 ± 1.53	4.63 ± 1.66	2.025 ± 0.72	6.79 ± 2.43	9.93 ± 3.57	4.26 ± 1.53	5.47 ± 3.32	6.45 ± 4.64

Supplementary Table S3. Mean values of 150 common bean genotypes with respect to different morphological parameters (Pod length, pod width, no. of seeds/plant and harvest Index)

Genotypes	Pod Length			Pod Width			No. of Seeds/Plant			Harvest Index		
	Shuhama	Wadoora	Pooled	Shuhama	Wadoora	Pooled	Shuhama	Wadoora	Pooled	Shuhama	Wadoora	Pooled
CBZ1	9.73 ± 0.48	8.23 ± 0.08	9.21 ± 0.44	0.93 ± 0.15	1.20 ± 0.06	1.07 ± 0.09	35.00 ± 7.00	51.33 ± 0.88	43.17 ± 3.16	15.47 ± 0.66	17.37 ± 0.09	16.42 ± 0.35
CBZ2	10.17 ± 0.38	11.30 ± 0.05	10.78 ± 0.19	1.17 ± 0.07	0.73 ± 0.09	0.95 ± 0.13	22.00 ± 1.53	32.67 ± 0.88	27.33 ± 2.23	14.85 ± 0.70	15.36 ± 0.06	14.59 ± 0.26
CBZ3	9.53 ± 0.14	10.20 ± 0.05	9.73 ± 0.16	1.10 ± 0.15	1.20 ± 0.06	1.15 ± 0.04	22.33 ± 0.88	31.00 ± 1.16	26.67 ± 2.74	15.32 ± 0.95	14.24 ± 0.01	15.63 ± 0.44
CBZ4	9.70 ± 0.05	9.70 ± 0.05	9.70 ± 0.03	1.00 ± 0.25	0.90 ± 0.06	0.95 ± 0.09	24.33 ± 0.33	34.33 ± 0.33	29.33 ± 2.25	13.71 ± 0.27	16.50 ± 0.09	15.11 ± 0.76
CBZ5	9.90 ± 0.17	9.83 ± 0.14	9.88 ± 0.11	1.40 ± 0.12	1.37 ± 0.07	1.38 ± 0.10	26.67 ± 2.73	34.00 ± 0.58	30.33 ± 3.10	14.26 ± 0.01	17.40 ± 0.06	15.50 ± 0.64
CBZ6	9.96 ± 0.13	10.16 ± 0.06	10.06 ± 0.05	1.40 ± 0.06	0.90 ± 0.06	1.15 ± 0.11	30.00 ± 2.08	42.33 ± 0.88	36.17 ± 2.15	15.27 ± 0.97	15.30 ± 0.03	14.95 ± 0.34
CBZ7	10.30 ± 0.70	9.70 ± 0.05	9.98 ± 0.34	1.33 ± 0.22	1.47 ± 0.03	1.40 ± 0.07	28.67 ± 3.18	35.67 ± 0.33	32.17 ± 3.24	16.39 ± 0.94	16.34 ± 0.06	17.14 ± 0.29
CBZ8	11.46 ± 0.08	11.53 ± 0.08	11.50 ± 0.58	0.87 ± 0.12	1.83 ± 0.03	1.35 ± 0.24	32.33 ± 2.73	45.00 ± 0.58	38.67 ± 2.06	15.43 ± 0.90	18.34 ± 0.06	16.29 ± 0.80
CBZ9	10.83 ± 0.31	11.30 ± 0.05	11.08 ± 0.16	1.20 ± 0.06	2.00 ± 0.06	1.60 ± 0.20	22.00 ± 3.06	36.33 ± 0.33	29.17 ± 2.20	16.35 ± 092	17.42 ± 0.11	16.86 ± 0.47
CBZ10	10.46 ± 0.27	10.23 ± 0.06	10.35 ± 0.15	1.23 ± 0.09	2.20 ± 0.06	1.72 ± 0.24	17.00 ± 0.58	27.00 ± 0.58	22.00 ± 2.27	14.81 ± 0.24	14.39 ± 0.19	14.63 ± 0.19
CBZ11	11.36 ± 0.37	11.03 ± 0.06	11.18 ± 0.18	1.23 ± 0.09	0.80 ± 0.06	1.02 ± 0.12	21.00 ± 4.00	26.67 ± 0.33	23.83 ± 3.67	14.67 ± 0.62	15.44 ± 0.11	15.18 ± 0.18
CBZ12	11.46 ± 0.78	12.10 ± 0.05	11.78 ± 0.37	1.43 ± 0.7	1.50 ± 0.06	1.47 ± 0.05	27.00 ± 5.57	34.67 ± 0.33	30.83 ± 1.25	13.94 ± 0.30	14.52 ± 0.17	14.24 ± 0.31
CBZ13	9.66 ± 0.03	9.86 ± 0.03	9.76 ± 0.04	1.30 ± 0.06	1.43 ± 0.09	1.37 ± 0.10	14.00 ± 0.58	27.33 ± 0.88	21.83 ± 3.27	14.39 ± 0.09	15.34 ± 0.05	15.17 ± 0.47
CBZ14	9.20 ± 0.65	9.73 ± 0.08	9.46 ± 0.31	1.10 ± 0.27	1.73 ± 0.09	1.42 ± 0.07	20.67 ± 5.18	35.00 ± 2.31	26.17 ± 5.03	13.67 ± 0.72	17.44 ± 0.12	16.10 ± 0.77
CBZ15	9.63 ± 1.88	7.73 ± 0.08	8.68 ± 0.94	0.53 ± 0.03	1.50 ± 0.06	1.02 ± 0.20	32.00 ± 0.58	38.67 ± 0.33	36.00 ± 1.86	13.08 ± 0.72	18.40 ± 0.11	15.51 ± 1.43
CBZ16	13.43 ± 0.28	13.16 ± 0.12	13.30 ± 0.15	0.73 ± 0.29	0.87 ± 0.03	0.80 ± 0.12	28.67 ± 0.88	43.00 ± 1.53	36.50 ± 3.00	14.36 ± 0.06	19.23 ± 0.01	16.01 ± 1.02
CBZ17	13.26 ± 0.73	14.03 ± 0.03	13.65 ± 0.37	1.53 ± 0.07	1.27 ± 0.03	1.40 ± 0.14	28.33 ± 2.58	44.33 ± 1.20	33.33 ± 3.94	14.34 ± 0.09	14.36 ± 0.09	14.99 ± 0.68
CBZ18	11.63 ± 0.03	11.630.08	11.78 ± 0.14	1.53 ± 0.03	0.63 ± 0.03	1.08 ± 0.08	29.67 ± 3.84	34.33 ± 1.76	34.83 ± 0.60	13.97 ± 0.32	18.34 ± 0.05	16.03 ± 0.80
CBZ19	11.63 ± 0.24	12.40 ± 0.05	11.86 ± 0.18	1.40 ± 0.06	1.27 ± 0.09	1.33 ± 0.05	18.67 ± 2.85	37.67 ± 0.88	25.83 ± 4.24	13.75 ± 0.38	16.39 ± 0.08	15.04 ± 0.77
CBZ20	12.66 ± 0.41	12.23 ± 0.08	12.43 ± 0.19	1.13 ± 0.12	1.33 ± 0.03	1.23 ± 0.10	15.67 ± 3.18	30.00 ± 8.51	26.00 ± 5.98	13.56 ± 0.74	17.44 ± 0.10	15.06 ± 0.82
CBZ21	12.56 ± 0.68	13.30 ± 0.05	12.95 ± 0.35	1.03 ± 0.29	0.80 ± 0.06	0.92 ± 0.07	29.67 ± 2.73	44.00 ± 1.53	35.67 ± 4.70	13.21 ± 070	12.37 ± 0.08	13.02 ± 0.65
CBZ22	11.53 ± 0.23	11.36 ± 0.12	11.45 ± 0.12	1.40 ± 0.06	1.33 ± 0.09	1.37 ± 0.10	34.00 ± 0.58	48.00 ± 0.58	41.33 ± 3.00	14.31 ± 0.05	16.43 ± 0.10	15.61 ± 0.55
CBZ23	12.80 ± 0.75	12.00 ± 0.05	12.40 ± 0.38	1.07 ± 0.09	0.87 ± 0.03	0.97 ± 0.08	29.33 ± 6.69	40.67 ± 3.18	36.50 ± 0.89	14.74 ± 0.13	17.45 ± 0.10	15.37 ± 0.72
CBZ24	14.00 ± 0.52	14.20 ± 0.10	14.08 ± 0.14	0.73 ± 0.03	1.13 ± 0.09	0.93 ± 0.08	15.33 ± 1.20	39.67 ± 0.67	27.83 ± 5.16	14.49 ± 0.11	13.47 ± 0.12	14.33 ± 0.28
CBZ25	12.83 ± 0.71	13.56 ± 0.08	13.21 ± 0.36	0.97 ± 0.12	0.83 ± 0.03	0.90 ± 0.07	14.67 ± 0.33	43.00 ± 2.52	30.17 ± 7.25	14.28 ± 0.15	15.38 ± 0.02	15.24 ± 0.46
CBZ26	12.16 ± 0.61	11.43 ± 0.03	11.61 ± 0.14	1.10 ± 0.12	1.33 ± 0.09	1.22 ± 0.15	14.33 ± 0.88	41.33 ± 3.38	26.00 ± 4.95	15.23 ± 1.03	17.46 ± 0.08	15.45 ± 0.68
CBZ27	11.73 ± 1.66	13.03 ± 0.37	12.71 ± 0.68	1.07 ± 0.22	2.00 ± 0.06	1.53v0.22	21.00 ± 6.00	36.33 ± 0.88	25.67 ± 5.08	16.97 ± 0.32	15.43 ± 0.11	16.92 ± 0.49
CBZ28	9.16 ± 0.66	9.40 ± 0.05	9.13 ± 0.33	1.57 ± 0.03	1.40 ± 0.06	1.48 ± 0.03	36.67 ± 2.19	38.00 ± 0.58	37.33 ± 1.80	16.55 ± 0.29	18.64 ± 0.02	17.57 ± 0.58

CBZ29	11.33 ± 0.88	10.53 ± 0.14	10.98 ± 0.49	1.50 ± 0.06	1.73 ± 0.09	1.62 ± 0.07	35.67 ± 5.36	46.33 ± 0.88	43.17 ± 1.28	15.99 ± 0.28	19.30 ± 0.06	17.78 ± 0.51
CBZ30	11.90 ± 1.25	13.26 ± 0.06	12.53 ± 0.62	1.10 ± 0.31	1.50 ± 0.12	1.30 ± 0.08	24.00 ± 0.58	45.00 ± 1.73	35.50 ± 5.17	13.49 ± 0.03	16.51 ± 0.17	14.71 ± 0.63
CBZ31	10.73 ± 1.23	9.56 ± 0.08	10.20 ± 0.66	0.73 ± 0.19	1.23 ± 0.03	0.98 ± 0.15	27.33 ± 3.84	48.00 ± 0.58	34.33 ± 4.87	13.84 ± 0.34	14.44 ± 0.15	14.40 ± 0.60
CBZ32	13.50 ± 0.35	13.30 ± 0.11	13.36 ± 0.18	1.13 ± 0.12	1.20 ± 0.06	1.17 ± 0.08	40.67 ± 7.17	36.67 ± 0.88	35.17 ± 0.65	13.42 ± 1.12	17.37 ± 0.09	15.28 ± 0.71
CBZ33	13.90 ± 0.35	14.36 ± 0.06	14.11 ± 0.18	0.87 ± 0.12	0.77 ± 0.09	0.82 ± 0.11	44.33 ± 10.17	38.00 ± 0.58	45.33 ± 4.33	12.26 ± 1.13	13.43 ± 0.11	12.62 ± 0.71
CBZ34	13.90 ± 0.50	13.40 ± 0.10	13.65 ± 0.25	1.10 ± 0.15	1.27 ± 0.09	1.18 ± 0.11	22.00 ± 3.51	30.00 ± 0.58	27.00 ± 0.97	13.06 ± 1.30	15.34 ± 0.05	15.06 ± 0.33
CBZ35	13.33 ± 1.41	14.76 ± 0.08	14.06 ± 0.69	1.07 ± 0.22	0.77 ± 0.09	0.92 ± 0.13	17.67 ± 3.67	28.00 ± 0.58	22.67 ± 3.97	11.30 ± 0.88	16.34 ± 0.05	12.88 ± 1.18
CBZ36	10.80 ± 0.30	10.53 ± 0.06	10.65 ± 0.15	1.27 ± 0.09	1.43 ± 0.09	1.35 ± 0.10	24.67 ± 0.67	38.00 ± 0.58	31.33 ± 3.14	13.11 ± 0.07	13.34 ± 0.09	13.78 ± 0.57
CBZ37	10.73 ± 0.71	11.53 ± 0.06	11.16 ± 0.37	0.97 ± 0.19	0.70 ± 0.06	0.83 ± 0.11	28.00 ± 3.06	38.00 ± 0.58	32.33 ± 3.21	12.79 ± 0.37	16.46 ± 0.07	14.60 ± 0.68
CBZ38	9.43 ± 0.43	9.10 ± 0.11	9.25 ± 0.23	0.87 ± 0.27	1.27 ± 0.03	1.07 ± 0.14	26.00 ± 6.51	43.67 ± 0.88	37.83 ± 2.33	13.03 ± 0.60	15.43 ± 0.11	14.35 ± 1.02
CBZ39	11.43 ± 0.98	10.43 ± 0.03	10.95 ± 0.53	1.13 ± 0.27	0.73 ± 0.07	0.93 ± 0.15	20.67 ± 6.69	38.00 ± 0.58	26.17 ± 5.62	14.23 ± 0.12	18.34 ± 0.05	16.14 ± 0.84
CBZ40	13.10 ± 0.30	13.43 ± 0.12	13.23 ± 0.15	0.87 ± 0.12	1.20 ± 0.06	1.03 ± 0.23	30.33 ± 2.67	42.00 ± 0.58	38.50 ± 2.38	13.94 ± 0.45	17.57 ± 0.18	15.76 ± 0.71
CBZ41	11.33 ± 1.26	12.46 ± 0.08	11.86 ± 0.65	1.17 ± 0.15	2.07 ± 0.03	1.62 ± 0.21	26.00 ± 0.00	46.00 ± 0.58	32.83 ± 4.19	13.66 ± 0.18	16.45 ± 0.07	15.40 ± 1.01
CBZ42	10.16 ± 1.51	8.66 ± 0.06	9.50 ± 0.80	1.23 ± 0.18	1.77 ± 0.09	1.50 ± 0.17	24.33 ± 0.88	28.00 ± 0.58	28.17 ± 1.89	14.60 ± 0.35	19.48 ± 0.18	16.32 ± 1.08
CBZ43	13.00 ± 0.35	13.50 ± 0.05	13.68 ± 0.30	0.97 ± 0.22	0.73 ± 0.09	0.85 ± 0.09	30.33 ± 5.84	36.00 ± 0.58	31.83 ± 3.98	14.96 ± 0.28	16.45 ± 0.20	16.18 ± 0.49
CBZ44	12.76 ± 0.36	15.30 ± 0.05	13.33 ± 0.63	1.13 ± 0.12	1.30 ± 0.06	1.22 ± 0.09	35.67 ± 7.33	48.00 ± 1.16	42.50 ± 2.59	14.40 ± 0.08	18.53 ± 0.17	15.83 ± 0.90
CBZ45	13.06 ± 0.24	12.16 ± 0.08	13.06 ± 0.31	1.07 ± 0.22	0.80 ± 0.06	0.93 ± 0.08	29.67 ± 5.18	35.33 ± 2.19	32.17 ± 4.29	14.38 ± 0.06	14.41 ± 0.08	15.03 ± 0.65
CBZ46	11.70 ± 0.75	14.16 ± 0.08	13.20 ± 0.35	1.40 ± 0.06	0.43 ± 0.03	0.92 ± 0.22	42.67 ± 0.67	47.00 ± 0.58	42.50 ± 1.41	14.68 ± 0.30	18.44 ± 0.11	16.48 ± 0.80
CBZ47	10.90 ± 0.70	13.30 ± 0.05	11.60 ± 0.64	1.47 ± 0.07	1.50 ± 0.06	1.48 ± 0.03	36.67 ± 5.84	38.00 ± 0.58	41.83 ± 1.35	14.48 ± 0.04	17.64 ± 0.18	15.82 ± 0.67
CBZ48	12.20 ± 0.05	12.26 ± 0.03	12.10 ± 0.12	1.37 ± 0.07	1.50 ± 0.06	1.43 ± 0.12	29.67 ± 5.70	46.67 ± 0.67	34.00 ± 4.59	14.39 ± 0.08	16.34 ± 0.05	15.48 ± 0.45
CBZ49	12.40 ± 0.05	11.40 ± 0.05	12.03 ± 0.21	1.33 ± 0.12	2.13 ± 0.09	1.73 ± 0.18	35.00 ± 7.02	34.67 ± 1.45	37.50 ± 1.93	14.66 ± 0.29	16.77 ± 0.06	15.62 ± 0.58
CBZ50	11.66 ± 0.73	12.43 ± 0.03	12.05 ± 0.37	1.03 ± 0.32	2.23 ± 0.03	1.63 ± 0.22	27.33 ± 2.85	34.33 ± 0.88	30.83 ± 3.72	15.14 ± 0.33	17.37 ± 0.13	16.72 ± 0.67
CBZ51	10.66 ± 0.36	10.36 ± 0.12	10.51 ± 0.18	0.87 ± 0.20	1.43 ± 0.12	1.15 ± 0.28	29.33 ± 2.19	45.00 ± 0.58	37.33 ± 2.63	13.37 ± 1.07	19.41 ± 0.12	16.75 ± 1.04
CBZ52	12.00 ± 0.45	11.53 ± 0.06	11.81 ± 0.27	1.40 ± 0.06	2.00 ± 0.06	1.70 ± 0.13	27.33 ± 2.85	38.00 ± 0.58	30.83 ± 2.81	12.35 ± 1.08	18.29 ± 0.04	13.61 ± 1.49
CBZ53	11.96 ± 0.88	13.16 ± 0.08	12.51 ± 0.46	1.37 ± 0.07	1.33 ± 0.03	1.35 ± 0.05	30.00 ± 3.51	35.67 ± 0.33	33.50 ± 1.06	14.06 ± 0.28	11.30 ± 0.17	13.68 ± 0.80
CBZ54	10.63 ± 0.28	10.30 ± 0.10	10.53 ± 0.21	1.23 ± 0.09	1.47 ± 0.09	1.35 ± 0.06	24.00 ± 0.58	28.00 ± 0.58	25.17 ± 0.87	14.01 ± 0.62	16.39 ± 0.08	14.28 ± 0.71
CBZ55	12.03 ± 0.68	11.43 ± 0.08	11.81 ± 0.49	1.30 ± 0.06	1.50 ± 0.06	1.40 ± 0.06	34.00 ± 9.50	25.33 ± 0.67	27.50 ± 2.72	14.70 ± 0.59	12.64 ± 0.12	14.44 ± 0.54
CBZ56	13.13 ± 0.41	14.26 ± 0.03	13.55 ± 0.29	1.57 ± 0.03	1.23 ± 0.03	1.40 ± 0.08	48.00 ± 6.51	42.33 ± 0.67	49.00 ± 2.30	13.38 ± 0.04	15.37 ± 0.03	14.88 ± 0.78
CBZ57	12.36 ± 0.03	12.33 ± 0.03	12.50 ± 0.14	1.47 ± 0.19	1.67 ± 0.03	1.57 ± 0.06	29.33 ± 7.17	45.00 ± 0.58	37.50 ± 2.57	13.16 ± 0.32	18.39 ± 0.07	15.93 ± 1.10
CBZ58	13.03 ± 0.58	13.26 ± 0.06	13.06 ± 0.35	1.33 ± 0.09	1.27 ± 0.03	1.30 ± 0.07	25.67 ± 9.17	27.67 ± 0.33	23.00 ± 3.34	12.64 ± 0.46	18.43 ± 0.10	15.20 ± 1.31
CBZ59	14.16 ± 0.06	14.33 ± 0.14	14.18 ± 0.04	1.37 ± 0.09	1.50 ± 0.06	1.43 ± 0.03	38.33 ± 5.70	36.00 ± 0.58	41.00 ± 1.53	12.83 ± 0.41	17.35 ± 0.14	15.17 ± 0.84
CBZ60	13.56 ± 0.63	14.40 ± 0.15	13.98 ± 0.34	1.37 ± 0.07	1.40 ± 0.06	1.38 ± 0.05	28.33 ± 0.33	42.00 ± 0.58	32.83 ± 3.07	12.54 ± 0.25	16.48 ± 0.19	14.49 ± 1.03

CBZ61	12.03 ± 0.36	12.46 ± 0.08	12.50 ± 0.07	1.37 ± 0.09	1.37 ± 0.03	1.37 ± 0.06	33.33 ± 3.84	27.00 ± 0.58	27.83 ± 0.60	13.46 ± 0.08	17.33 ± 0.15	15.53 ± 0.98
CBZ62	11.06 ± 0.38	12.70 ± 0.05	11.63 ± 0.36	1.03 ± 0.12	1.20 ± 0.06	1.12 ± 0.07	32.67 ± 8.35	27.00 ± 1.16	38.00 ± 3.86	13.84 ± 0.34	18.40 ± 0.11	16.11 ± 1.20
CBZ63	11.03 ± 0.68	10.36 ± 0.06	10.75 ± 0.39	0.77 ± 0.09	0.77 ± 0.03	0.77 ± 0.03	22.67 ± 7.67	52.00 ± 0.58	29.67 ± 7.46	13.98 ± 0.26	19.64 ± 0.15	16.55 ± 1.09
CBZ64	11.70 ± 0.70	12.60 ± 0.05	12.10 ± 0.36	0.83 ± 0.20	0.77 ± 0.03	0.80 ± 0.10	41.00 ± 0.58	26.67 ± 1.45	37.17 ± 3.89	13.71 ± 0.41	16.69 ± 0.08	15.29 ± 0.90
CBZ65	11.30 ± 1.05	10.40 ± 0.05	10.86 ± 0.52	1.00 ± 0.21	1.30 ± 0.06	1.15 ± 0.07	39.00 ± 4.00	52.00 ± 0.58	47.33 ± 2.11	14.32 ± 0.07	18.46 ± 0.08	16.25 ± 0.85
CBZ66	12.26 ± 0.03	13.30 ± 0.15	12.80 ± 0.21	0.67 ± 0.09	1.70 ± 0.06	1.18 ± 0.22	28.33 ± 2.19	52.00 ± 0.58	40.50 ± 4.51	15.34 ± 0.99	17.40 ± 0.11	15.69 ± 0.64
CBZ67	12.53 ± 0.43	12.20 ± 0.10	12.51 ± 0.39	0.77 ± 0.22	1.23 ± 0.27	1.00 ± 0.15	25.00 ± 0.58	47.00 ± 0.58	34.50 ± 4.54	16.56 ± 0.68	16.29 ± 0.03	17.06 ± 0.26
CBZ68	12.83 ± 0.61	14.40 ± 0.05	13.43 ± 0.41	1.23 ± 0.03	1.07 ± 0.22	1.15 ± 0.09	27.33 ± 1.86	36.00 ± 0.58	29.17 ± 2.12	15.07 ± 0.38	17.78 ± 0.09	16.82 ± 0.71
CBZ69	11.80 ± 0.35	11.53 ± 0.03	11.66 ± 0.16	1.23 ± 0.03	1.30 ± 0.06	1.27 ± 0.02	34.67 ± 3.18	30.00 ± 0.58	30.17 ± 0.87	14.91 ± 0.61	19.59 ± 0.09	16.82 ± 1.13
CBZ70	11.63 ± 0.86	12.63 ± 0.08	12.13 ± 0.45	1.33 ± 0.03	1.40 ± 0.06	1.37 ± 0.06	36.67 ± 5.33	27.00 ± 0.58	35.67 ± 2.86	15.71 ± 0.57	18.55 ± 0.07	17.01 ± 0.48
CBZ71	9.83 ± 0.33	9.83 ± 0.06	9.90 ± 0.06	1.27 ± 0.09	1.63 ± 0.06	1.45 ± 0.12	29.00 ± 2.00	37.00 ± 1.53	32.50 ± 2.62	14.17 ± 0.36	16.48 ± 0.14	15.34 ± 0.42
CBZ72	10.10 ± 0.35	10.00 ± 0.11	9.96 ± 0.15	1.13 ± 0.12	1.73 ± 0.12	1.43 ± 0.10	34.33 ± 0.33	37.67 ± 0.33	36.17 ± 1.25	12.63 ± 0.76	15.71 ± 0.19	14.74 ± 0.59
CBZ73	11.23 ± 0.58	10.66 ± 0.03	10.98 ± 0.30	1.00 ± 0.15	1.37 ± 0.12	1.18 ± 0.13	30.67 ± 3.38	44.00 ± 1.53	39.33 ± 2.32	10.84 ± 0.71	16.67 ± 0.16	14.53 ± 1.46
CBZ74	11.60 ± 0.75	12.40 ± 0.05	11.98 ± 0.37	1.43 ± 0.12	1.40 ± 0.06	1.42 ± 0.06	25.33 ± 0.33	44.33 ± 1.20	34.67 ± 4.36	11.39 ± 1.94	19.46 ± 0.08	14.30 ± 2.17
CBZ75	9.76 ± 0.48	10.23 ± 0.08	10.11 ± 0.13	1.37 ± 0.03	1.47 ± 0.09	1.42 ± 0.06	31.33 ± 5.33	42.33 ± 0.33	33.33 ± 3.50	15.79 ± 0.38	18.44 ± 0.09	16.36 ± 0.67
CBZ76	9.16 ± 0.51	9.66 ± 0.08	9.30 ± 0.27	1.33 ± 0.09	1.47 ± 0.09	1.40 ± 0.04	42.67 ± 1.67	38.33 ± 0.33	40.17 ± 0.60	15.39 ± 0.93	15.28 ± 0.07	15.20 ± 0.80
CBZ77	10.26 ± 0.12	10.20 ± 0.00	10.23 ± 0.05	1.43 ± 0.09	1.40 ± 0.06	1.42 ± 0.05	42.00 ± 4.04	41.67 ± 0.88	43.50 ± 1.34	14.40 ± 0.96	11.54 ± 0.15	13.65 ± 0.99
CBZ78	10.13 ± 0.21	10.36 ± 0.06	10.26 ± 0.09	1.20 ± 0.06	1.47 ± 0.06	1.33 ± 0.07	31.67 ± 2.85	36.00 ± 1.16	33.33 ± 1.31	15.94 ± 0.35	18.43 ± 0.11	16.68 ± 0.68
CBZ79	9.93 ± 0.08	9.83 ± 0.03	9.86 ± 0.05	1.30 ± 0.12	1.27 ± 0.03	1.28 ± 0.06	32.33 ± 5.33	28.67 ± 0.88	30.83 ± 3.09	14.80 ± 0.64	14.21 ± 0.07	15.48 ± 0.60
CBZ80	11.26 ± 1.11	10.30 ± 0.15	10.80 ± 0.56	1.13 ± 0.03	1.20 ± 0.06	1.17 ± 0.14	37.67 ± 6.84	44.33 ± 1.20	41.17 ± 2.68	14.68 ± 1.29	18.53 ± 0.15	15.83 ± 1.09
CBZ81	12.43 ± 0.96	13.46 ± 0.06	12.88 ± 0.53	1.30 ± 0.10	2.00 ± 0.06	1.65 ± 0.17	26.67 ± 1.20	27.00 ± 0.58	27.00 ± 1.46	16.02 ± 1.30	17.52 ± 0.10	17.57 ± 0.16
CBZ82	11.06 ± 0.71	10.30 ± 0.05	10.71 ± 0.33	1.23 ± 0.27	1.73 ± 0.09	1.48 ± 0.17	32.33 ± 4.54	34.00 ± 0.58	31.67 ± 1.78	13.79 ± 0.37	18.35 ± 0.04	15.92 ± 1.12
CBZ83	11.96 ± 0.38	12.40 ± 0.05	12.26 ± 0.13	0.90 ± 0.30	0.73 ± 0.09	0.82 ± 0.15	39.33 ± 2.33	37.00 ± 0.58	39.33 ± 1.15	14.34 ± 0.09	18.44 ± 0.11	15.19 ± 1.14
CBZ84	11.00 ± 0.35	11.50 ± 0.05	11.21 ± 0.14	1.30 ± 0.21	1.57 ± 0.03	1.43 ± 0.07	35.67 ± 0.88	36.00 ± 1.16	35.67 ± 0.67	15.05 ± 0.60	11.46 ± 0.11	13.14 ± 0.61
CBZ85	10.46 ± 0.03	10.46 ± 0.03	10.46 ± 0.05	0.67 ± 0.19	1.87 ± 0.03	1.27 ± 0.20	34.33 ± 0.67	36.00 ± 1.16	36.67 ± 1.93	15.39 ± 0.93	12.66 ± 0.21	15.16 ± 0.72
CBZ86	11.36 ± 0.01	10.56 ± 0.08	10.95 ± 0.51	0.43 ± 0.07	1.37 ± 0.07	0.90 ± 0.24	33.67 ± 0.33	44.33 ± 1.20	39.33 ± 2.49	14.29 ± 0.87	16.55 ± 0.19	14.49 ± 0.69
CBZ87	12.60 ± 0.65	13.33 ± 0.08	13.00 ± 0.82	0.87 ± 0.27	1.57 ± 0.03	1.22 ± 0.22	36.33 ± 3.33	47.67 ± 0.33	39.67 ± 2.97	15.60 ± 0.68	13.61 ± 0.18	15.07 ± 0.51
CBZ88	11.00 ± 0.25	11.43 ± 0.08	11.20 ± 0.10	1.40 ± 0.06	1.43 ± 0.09	1.42 ± 0.05	37.67 ± 5.84	43.00 ± 0.58	40.50 ± 2.91	14.53 ± 0.17	14.59 ± 0.19	14.87 ± 0.32
CBZ89	11.40 ± 0.90	10.56 ± 0.08	10.98 ± 0.48	1.53 ± 0.03	1.53 ± 0.03	1.53 ± 0.03	29.33 ± 2.33	27.00 ± 0.58	27.67 ± 0.72	13.97 ± 0.28	16.47 ± 0.18	15.61 ± 0.60
CBZ90	12.33 ± 0.86	13.26 ± 0.08	12.80 ± 0.40	1.20 ± 0.35	1.53 ± 0.03	1.37 ± 0.02	38.67 ± 3.67	32.67 ± 0.88	34.67 ± 0.56	14.20 ± 0.66	17.73 ± 0.06	14.39 ± 1.19
CBZ91	10.93 ± 0.28	10.70 ± 0.05	10.83 ± 0.19	0.67 ± 0.07	1.57 ± 0.03	1.12 ± 0.25	41.67 ± 3.84	36.00 ± 0.58	41.00 ± 2.13	14.72 ± 0.76	10.48 ± 0.17	13.15 ± 1.05
CBZ92	11.13 ± 0.46	11.70 ± 0.05	11.55 ± 0.05	1.00 ± 0.15	1.83 ± 0.03	1.42 ± 0.21	31.33 ± 3.67	38.00 ± 0.58	36.83 ± 1.11	13.46 ± 0.02	11.56 ± 0.17	13.43 ± 0.80

CBZ93	11.23 ± 0.98	11.30 ± 0.05	11.10 ± 0.49	1.37 ± 0.09	1.33 ± 0.03	1.35 ± 0.06	23.33 ± 0.88	42.00 ± 0.58	30.33 ± 3.94	12.95 ± 0.47	17.33 ± 0.16	14.98 ± 0.81
CBZ94	12.20 ± 1.00	13.23 ± 0.06	12.71 ± 0.48	1.03 ± 0.47	1.53 ± 0.07	1.28 ± 0.08	25.33 ± 0.67	28.00 ± 0.58	27.33 ± 0.92	11.94 ± 0.36	14.52 ± 0.10	13.14 ± 0.49
CBZ95	11.20 ± 1.00	10.23 ± 0.06	10.73 ± 0.53	0.60 ± 0.35	1.20 ± 0.06	0.90 ± 0.24	25.00 ± 0.00	32.33 ± 0.88	29.17 ± 2.06	13.03 ± 1.55	13.30 ± 0.06	12.88 ± 0.84
CBZ96	12.76 ± 0.33	13.23 ± 0.08	12.96 ± 0.17	0.97 ± 0.23	1.30 ± 0.06	1.13 ± 0.05	26.00 ± 0.00	34.67 ± 0.33	30.50 ± 2.20	15.16 ± 1.06	16.29 ± 0.07	15.71 ± 1.45
CBZ97	12.66 ± 0.41	12.23 ± 0.08	12.43 ± 0.19	1.00 ± 0.25	1.67 ± 0.09	1.33 ± 0.23	26.00 ± 1.53	38.00 ± 0.58	33.00 ± 3.76	12.54 ± 0.66	13.51 ± 0.17	14.17 ± 0.76
CBZ98	12.66 ± 0.68	13.43 ± 0.03	13.06 ± 0.35	1.37 ± 0.12	1.37 ± 0.09	1.37 ± 0.07	30.00 ± 2.00	44.33 ± 1.20	34.33 ± 3.06	12.37 ± 1.08	18.46 ± 0.08	14.23 ± 0.76
CBZ99	10.93 ± 0.31	12.30 ± 0.05	11.46 ± 0.29	1.40 ± 0.06	1.60 ± 0.06	1.50 ± 0.05	35.33 ± 0.88	45.67 ± 2.40	39.83 ± 2.68	13.19 ± 1.17	17.46 ± 0.10	16.09 ± 1.61
CBZ100	11.36 ± 1.06	10.33 ± 0.06	10.78 ± 0.48	1.43 ± 0.12	1.40 ± 0.06	1.42 ± 0.06	34.67 ± 3.84	43.00 ± 1.53	37.50 ± 2.05	10.75 ± 0.24	18.52 ± 0.14	13.74 ± 1.24
WB22	12.43 ± 0.96	13.33 ± 0.06	12.95 ± 0.47	1.20 ± 0.21	1.57 ± 0.09	1.38 ± 0.08	34.33 ± 5.84	28.00 ± 0.58	28.50 ± 0.62	12.94 ± 1.64	13.34 ± 0.09	13.29 ± 1.38
WB54	11.36 ± 0.91	10.50 ± 0.05	11.00 ± 0.54	0.87 ± 0.32	1.63 ± 0.09	1.25 ± 0.21	42.67 ± 2.33	34.00 ± 1.53	39.33 ± 2.86	14.66 ± 1.62	19.46 ± 0.17	16.40 ± 0.18
WB83	13.50 ± 0.35	13.60 ± 0.05	13.48 ± 0.18	1.47 ± 0.09	1.60 ± 0.06	1.53 ± 0.06	38.00 ± 1.53	28.00 ± 0.58	35.33 ± 2.87	12.17 ± 0.69	10.54 ± 0.14	11.13 ± 0.37
WB102	12.56 ± 1.53	14.16 ± 0.06	13.38 ± 0.73	1.27 ± 0.29	1.60 ± 0.06	1.43 ± 0.13	39.67 ± 0.88	47.33 ± 0.88	44.33 ± 1.67	13.61 ± 0.21	11.44 ± 0.21	12.67 ± 0.32
WB112	9.73 ± 0.18	9.60 ± 0.05	9.71 ± 0.17	0.97 ± 0.17	0.80 ± 0.06	0.88 ± 0.12	40.00 ± 3.00	47.33 ± 0.67	41.33 ± 1.96	14.04 ± 0.35	12.65 ± 0.12	13.58 ± 0.13
WB115	10.96 ± 0.71	10.40 ± 0.11	10.61 ± 0.37	1.30 ± 0.10	1.33 ± 0.09	1.32 ± 0.05	42.67 ± 2.85	42.33 ± 0.33	45.00 ± 0.89	13.27 ± 0.12	13.63 ± 0.20	13.67 ± 0.37
WB185	12.30 ± 0.05	12.33 ± 0.08	12.33 ± 0.06	1.20 ± 0.06	1.30 ± 0.06	1.25 ± 0.04	30.33 ± 7.22	49.67 ± 0.88	39.83 ± 3.84	13.16 ± 0.13	14.44 ± 0.14	13.96 ± 0.62
WB195	12.30 ± 0.05	12.36 ± 0.12	12.33 ± 0.06	1.43 ± 0.12	1.30 ± 0.12	1.37 ± 0.08	19.00 ± 2.52	27.00 ± 0.58	24.33 ± 4.19	13.29 ± 0.13	15.23 ± 0.06	14.46 ± 0.77
WB206	12.43 ± 0.18	12.43 ± 0.08	12.41 ± 0.10	1.40 ± 0.06	1.50 ± 0.10	1.45 ± 0.06	28.33 ± 2.85	45.33 ± 1.76	36.00 ± 4.93	12.57 ± 0.79	16.60 ± 0.18	15.05 ± 1.46
WB216	12.66 ± 0.14	12.83 ± 0.06	12.75 ± 0.06	1.23 ± 0.09	1.47 ± 0.15	1.35 ± 0.08	34.67 ± 0.33	46.67 ± 0.88	39.00 ± 2.44	11.56 ± 0.23	17.36 ± 0.14	14.48 ± 1.29
WB222	13.30 ± 0.75	12.56 ± 0.03	12.93 ± 0.39	1.23 ± 0.03	1.27 ± 0.03	1.25 ± 0.06	39.33 ± 2.85	36.67 ± 0.88	35.50 ± 0.76	13.27 ± 0.98	18.43 ± 0.12	14.99 ± 0.38
WB257	13.00 ± 1.65	14.76 ± 0.08	13.86 ± 0.83	1.43 ± 0.07	1.43 ± 0.07	1.43 ± 0.08	43.00 ± 2.52	33.00 ± 0.58	39.67 ± 2.59	14.71 ± 0.59	16.29 ± 0.03	16.01 ± 0.97
WB335	10.03 ± 0.28	9.80 ± 0.05	9.95 ± 0.17	1.27 ± 0.09	1.53 ± 0.09	1.40 ± 0.04	38.00 ± 1.53	35.00 ± 0.58	35.67 ± 1.80	13.81 ± 0.63	17.42 ± 0.11	15.45 ± 0.82
WB341	11.46 ± 1.01	10.66 ± 0.08	11.06 ± 0.52	1.23 ± 0.03	1.40 ± 0.12	1.32 ± 0.05	31.00 ± 2.52	26.67 ± 0.88	30.50 ± 1.67	14.23 ± 0.12	18.39 ± 0.14	16.16 ± 0.82
WB352	12.26 ± 1.03	13.53 ± 0.08	12.93 ± 0.46	1.40 ± 0.06	1.43 ± 0.03	1.42 ± 0.04	33.67 ± 6.67	28.33 ± 0.67	26.17 ± 1.11	14.34 ± 0.09	16.50 ± 0.16	14.50 ± 0.70
WB371	11.03 ± 0.68	10.46 ± 0.08	10.73 ± 0.39	1.33 ± 0.09	1.47 ± 0.09	1.40 ± 0.09	39.33 ± 7.17	23.67 ± 1.45	36.83 ± 4.50	13.89 ± 0.25	11.54 ± 0.21	12.77 ± 0.71
WB379	13.03 ± 0.63	12.50 ± 0.11	12.76 ± 0.36	1.37 ± 0.09	1.67 ± 0.09	1.52 ± 0.05	26.00 ± 0.58	33.33 ± 1.20	30.67 ± 2.14	12.52 ± 0.71	10.54 ± 0.14	11.77 ± 0.31
WB435	13.70 ± 0.75	14.50 ± 0.05	14.08 ± 0.33	1.43 ± 0.09	1.40 ± 0.06	1.42 ± 0.12	25.67 ± 0.88	36.67 ± 0.88	33.00 ± 4.13	11.30 ± 0.02	9.67 ± 0.11	10.57 ± 0.29
WB482	12.73 ± 0.38	12.36 ± 0.03	12.53 ± 0.21	1.40 ± 0.10	0.63 ± 0.09	1.02 ± 0.19	27.00 ± 0.58	51.00 ± 0.58	38.67 ± 5.38	11.42 ± 0.06	10.39 ± 0.14	11.26 ± 0.59
WB489	14.00 ± 0.45	13.56 ± 0.03	13.78 ± 0.24	1.30 ± 0.06	1.50 ± 0.06	1.40 ± 0.08	30.00 ± 3.00	49.00 ± 0.58	38.50 ± 5.01	11.97 ± 0.54	12.61 ± 0.12	12.48 ± 0.53

WB634	14.06 ± 0.78	14.90 ± 0.05	14.48 ± 0.37	1.40 ± 0.06	1.17 ± 0.09	1.28 ± 0.05	31.67 ± 3.84	52.33 ± 0.88	44.50 ± 3.96	12.50 ± 0.54	15.49 ± 0.23	14.09 ± 0.71
WB651	12.93 ± 0.28	12.56 ± 0.08	12.75 ± 0.17	1.33 ± 0.09	1.50 ± 0.06	1.42 ± 0.06	25.00 ± 0.58	53.67 ± 0.33	39.33 ± 6.42	11.84 ± 0.60	14.59 ± 0.24	12.80 ± 0.72
WB832	13.43 ± 0.03	13.50 ± 0.05	13.48 ± 0.04	1.33 ± 0.09	1.27 ± 0.07	1.30 ± 0.10	32.67 ± 7.17	38.33 ± 0.25	28.33 ± 1.98	13.95 ± 0.66	13.44 ± 0.10	14.06 ± 0.57
WB864	11.56 ± 1.98	13.60 ± 0.05	12.58 ± 0.95	1.37 ± 0.03	1.70 ± 0.06	1.53 ± 0.06	46.33 ± 0.88	36.00 ± 1.16	42.00 ± 2.27	14.50 ± 0.75	17.46 ± 0.08	16.46 ± 1.34
WB877	8.73 ± 0.93	7.80 ± 0.05	8.26 ± 0.50	1.43 ± 0.12	1.60 ± 0.06	1.52 ± 0.06	38.00 ± 7.51	36.67 ± 1.45	39.50 ± 2.98	12.56 ± 0.67	18.55 ± 0.12	15.33 ± 1.11
WB923	10.56 ± 0.06	10.66 ± 0.08	10.60 ± 0.03	1.43 ± 0.09	1.37 ± 0.07	1.40 ± 0.06	27.00 ± 2.52	29.00 ± 0.58	28.00 ± 2.13	12.71 ± 0.77	17.54 ± 0.14	15.84 ± 1.72
WB952	11.46 ± 0.81	10.53 ± 0.06	11.00 ± 0.44	1.27 ± 0.19	1.50 ± 0.06	1.38 ± 0.07	31.00 ± 0.58	37.00 ± 0.58	33.67 ± 1.28	12.62 ± 1.31	19.65 ± 0.12	14.98 ± 0.49
WB956	13.36 ± 0.08	13.30 ± 0.05	13.35 ± 0.07	1.03 ± 0.29	1.23 ± 0.35	1.13 ± 0.23	31.00 ± 2.52	35.67 ± 1.20	35.33 ± 1.41	14.00 ± 1.29	16.57 ± 0.13	16.22 ± 1.48
WB966	13.10 ± 0.30	13.60 ± 0.05	13.36 ± 0.12	1.27 ± 0.19	1.90 ± 0.06	1.58 ± 0.16	27.33 ± 2.85	43.33 ± 1.45	34.33 ± 4.22	11.38 ± 0.14	18.53 ± 0.15	14.63 ± 0.83
WB1006	12.36 ± 0.06	12.53 ± 0.14	12.46 ± 0.09	0.70 ± 0.10	1.00 ± 0.06	0.85 ± 0.11	36.33 ± 2.85	42.00 ± 0.58	37.00 ± 1.77	14.08 ± 0.38	16.54 ± 0.21	14.63 ± 0.32
WB1129	12.06 ± 0.28	12.66 ± 0.14	12.33 ± 0.13	0.77 ± 0.22	1.53 ± 0.03	1.15 ± 0.27	47.67 ± 3.18	37.00 ± 1.53	42.50 ± 2.35	14.21 ± 1.06	14.54 ± 0.21	13.74 ± 0.49
WB1137	12.13 ± 0.68	11.56 ± 0.06	11.83 ± 0.35	1.20 ± 0.06	2.13 ± 0.09	1.67 ± 0.20	45.00 ± 10.02	53.33 ± 1.45	54.00 ± 0.78	15.33 ± 0.90	13.62 ± 0.19	15.29 ± 0.55
WB1187	12.60 ± 0.70	13.40 ± 0.11	13.06 ± 0.27	1.13 ± 0.03	1.60 ± 0.06	1.37 ± 0.10	27.00 ± 0.58	53.33 ± 1.20	40.00 ± 6.27	13.71 ± 0.36	15.55 ± 0.12	14.62 ± 0.61
WB1190	11.93 ± 0.73	11.53 ± 0.12	11.71 ± 0.42	0.97 ± 0.19	1.47 ± 0.09	1.22 ± 0.10	26.00 ± 1.16	52.67 ± 0.88	39.33 ± 5.41	14.04 ± 0.31	16.41 ± 0.17	15.67 ± 1.13
WB1282	13.56 ± 0.31	13.56 ± 0.18	13.51 ± 0.17	0.87 ± 0.32	1.63 ± 0.09	1.25 ± 0.23	29.33 ± 3.84	49.33 ± 0.33	37.67 ± 5.68	13.82 ± 0.35	17.64 ± 0.11	14.33 ± 1.13
WB1318	13.46 ± 0.53	14.10 ± 0.11	13.80 ± 0.24	1.57 ± 0.03	1.43 ± 0.09	1.50 ± 0.10	43.00 ± 5.51	53.00 ± 0.58	45.83 ± 3.83	13.98 ± 0.28	10.25 ± 0.10	13.18 ± 0.98
WB1319	11.60 ± 0.85	12.50 ± 0.05	12.03 ± 0.40	1.17 ± 0.29	2.07 ± 0.03	1.62 ± 0.12	53.33 ± 0.88	56.67 ± 0.33	54.50 ± 0.85	13.73 ± 0.14	15.76 ± 0.03	14.47 ± 0.44
WB1402	10.86 ± 1.16	9.80 ± 0.11	10.41 ± 0.67	0.83 ± 0.38	1.73 ± 0.09	1.28 ± 0.25	43.33 ± 9.17	52.67 ± 0.67	50.00 ± 2.84	13.28 ± 0.98	14.59 ± 0.19	14.63 ± 0.34
WB1436	11.86 ± 1.35	13.66 ± 0.08	12.71 ± 0.64	1.43 ± 0.32	1.50 ± 0.06	1.47 ± 0.06	34.33 ± 8.84	34.00 ± 1.16	28.33 ± 1.56	12.08 ± 0.68	16.45 ± 0.14	13.92 ± 1.14
WB1446	9.40 ± 0.40	9.16 ± 0.17	9.28 ± 0.24	1.00 ± 0.25	1.63 ± 0.17	1.32 ± 0.18	53.33 ± 0.67	28.00 ± 0.58	41.50 ± 5.12	12.51 ± 0.75	16.51 ± 0.16	15.05 ± 0.79
WB1492	11.36 ± 1.06	10.36 ± 0.06	10.86 ± 0.58	1.23 ± 0.18	1.53 ± 0.03	1.38 ± 0.08	43.00 ± 9.02	35.00 ± 0.58	44.17 ± 3.84	11.33 ± 0.05	17.29 ± 0.16	14.45 ± 1.45
WB1518	12.83 ± 0.66	13.63 ± 0.08	13.20 ± 0.32	0.87 ± 0.12	1.80 ± 0.06	1.33 ± 0.20	25.67 ± 1.67	36.67 ± 0.33	28.83 ± 2.47	12.11 ± 0.58	18.43 ± 0.11	13.98 ± 1.45
WB1634	12.20 ± 0.70	11.53 ± 0.06	11.86 ± 0.36	1.27 ± 0.12	0.73 ± 0.12	1.00 ± 0.10	35.33 ± 7.84	25.67 ± 0.88	27.17 ± 0.79	13.30 ± 0.13	12.32 ± 0.10	13.52 ± 0.69
WB1643	12.40 ± 1.15	13.60 ± 0.05	13.01 ± 0.54	1.10 ± 0.15	1.17 ± 0.09	1.13 ± 0.10	48.67 ± 1.45	28.00 ± 0.58	42.00 ± 4.65	13.17 ± 0.50	16.47 ± 0.18	14.50 ± 0.57
WB1664	10.63 ± 0.43	10.23 ± 0.06	10.41 ± 0.24	0.80 ± 0.06	1.77 ± 0.09	1.28 ± 0.22	45.33 ± 0.33	44.33 ± 1.20	46.17 ± 1.66	12.03 ± 0.43	13.60 ± 0.19	12.94 ± 0.28
WB1678	11.76 ± 0.27	11.56 ± 0.08	11.70 ± 0.18	0.93 ± 0.29	1.70 ± 0.06	1.32 ± 0.21	48.33 ± 2.85	52.00 ± 1.16	47.83 ± 1.11	11.27 ± 0.04	13.35 ± 0.11	12.46 ± 0.56
WB1679	11.66 ± 0.68	12.43 ± 0.08	12.03 ± 0.30	1.40 ± 0.06	1.70 ± 0.06	1.55 ± 0.08	45.67 ± 8.84	46.67 ± 0.88	47.17 ± 4.19	12.20 ± 0.67	14.38 ± 0.04	13.39 ± 0.97
WB1680	10.40 ± 0.00	10.43 ± 0.03	10.41 ± 0.04	1.40 ± 0.06	1.73 ± 0.09	1.57 ± 0.10	34.33 ± 8.84	26.67 ± 0.88	29.33 ± 3.17	13.28 ± 0.13	17.40 ± 0.11	14.74 ± 0.87
WB5176	11.03 ± 0.63	10.46 ± 0.08	11.10 ± 0.70	1.47 ± 0.09	1.70 ± 0.06	1.58 ± 0.09	49.33 ± 1.67	46.33 ± 0.88	49.83 ± 0.95	12.62 ± 0.65	13.41 ± 0.22	13.85 ± 0.53
WB21529	8.56 ± 3.88	14.40 ± 0.11	11.16 ± 2.03	1.53 ± 0.03	2.00 ± 0.06	1.77 ± 0.09	36.04 ± 9.97	52.67 ± 0.88	43.71 ± 5.51	7.52 ± 3.76	16.67 ± 0.13	11.24 ± 2.50

Supplementary Table S4. Table showing the Eigen values, variability and cumulative values

		PC1	*PC2*	*PC3*	*PC4*	*PC5*	*PC6*	*PC7*
Shuhama	Eigen value	2.142	1.908	1.107	1.028	0.8954	0.794	0.121
	Variability %	26.785	23.861	13.847	12.853	11.193	9.937	1.521
	Cumulative %	26.785	50.647	64.495	77.348	88.541	98.478	100.00
Wadoora	Eigen value	1.414	1.2077	1.126	0.964	0.888	0.748	0.650
	Variability %	20.204	17.253	16.089	13.773	12.698	10.686	9.292
	Cumulative %	20.204	37.458	53.547	67.321	80.020	90.707	100

Supplementary Table S5. Mean LnP (K) and Delta K values of assumed sub-population (K=2 to 10) during STRUCTURE analysis in 150 common bean genotypes

K	*Reps*	*Mean LnP(K)*	*St. Dev LnP(K)*	*Ln'(K)*	*|Ln''(K)|*	*Delta K*
1	3	-1080.1333	0.1528	-	-	-
2	3	-1093.8	22.4241	-13.6667	33.7	1.502848
3	3	-1073.7667	1.8448	20.03333	60.86667	32.99342
4	3	-1114.6	13.7851	-40.8333	58.76667	4.263046
5	3	-1214.2	126.9243	-99.6	38.23333	0.301229
6	3	-1275.5667	105.3144	-61.3667	142.7333	1.355307
7	3	-1194.2	93.7519	81.36667	172.5	1.839964
8	3	-1285.3333	98.4236	-91.1333	49.6	0.503944
9	3	-1326.8667	134.4703	-41.5333	146.9	1.092435
10	3	-1221.5	110.194	105.3667	-	-

Summary across replicates of K values using STRUCTURE Harvester. Using the Evanno method, K=3 is the optimal value (highlighted in above table).