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Research Article

PHENOTYPIC DIVERSITY OF NEPALESE FINGER MILLET (*ELEUSINE
CORACANA* (L.) GAERTN.) ACCESSIONS AT IAAS, RAMPUR, NEPAL

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Abstract

An experiment was conducted at Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal during July 2011 to September 2011 with an objective to determine phenotypic variability of Nepalese finger millet landraces using descriptive statistics, cluster analysis and principal component analysis. F- Value of REML procedure of mixed model analysis revealed that highly significant variation was observed in all studied 17 traits. Grain yield per plant was positive and highly significant correlated with grain yield per ear (0.769**) followed by plant height (0.529**), productive tillers number (0.473**), days to maturity (0.471**), days to heading (0.460**), days to flowering (0.457**), straw yield per plant (0.348**), finger number per ear (0.320**), thousand kernel weight (0.281**), flag leaf sheath width (0.230**) and finger length (0.211**). The ear shape ($H^2=3.42$) followed by grain color ($H^2=3.35$) showed high genetic diversity after estimated by using Shannon-Weaver index. 46% open type ear shape, 40% light brown grain color, 66% non-pigmentation, 70% absence of inflorescence branch and 54% absence of finger branch were found dominant to other on studied accessions. The distribution pattern was observed by using Ward's minimum-variance method into five clusters. The number of accessions in a cluster was ranged from 18 in cluster IV to 1 in cluster V. The cluster V (accession no. 10996) and III (accessions no. 431 and 11024) showed early phenological traits, lowest in finger length, finger width, finger number per ear, thousand kernel weight, grain yield per ear and grain yield per plant. The cluster II and IV showed late maturity type, long finger length and width, high in finger number per ear, grain yield per ear, grain yield per plant and plant height. The first five principal components accounted for 74.9% of total variance among 50 accessions. Most of variation was contributed from phenological characters, plant height, grain yield per ear, finger length, finger width, finger number per ear and productive tillers number. These traits were positively correlated with grain yield and can be used in selection for breeding programs.

Key words: Shannon-weaver index; Ward's minimum-variance; grain yield per plant; Finger millet

Introduction

Finger millet has displayed high variability and wide adaptability over short geographic distances in Nepal. Finger millet has been cultivated from low land terai region; Kachorwa village (85 masl) of Bara district (Amgain *et al.*, 2004) to high hill area: Borounse village (3130 masl) of Humla district (Baniya *et al.*, 1992) in Nepal. About 877 accessions have been maintained by National Plant Genetic Resource Centre (NPGRC), Khumaltar, Nepal but limited researches had been accomplished regarding with finger millet, although have immense opportunity to improvement of it.

Finger millet is considered as neglected, lost or orphan crops due to its negligible production and cultivated area. Though lower in production this crop can withstand stress condition and provides staple food to millions of people from marginal community and semi-arid regions of World and also to the population with subsistence farming system including that of Nepal. Finger millet grain has low

infestation of storage pest and can be stored for years due to its small grain size (Duke, 1978) so that also referred as "crop for poor" or a "famine food" (Vietmeyer, 1996). Therefore, it can supply food in famine prone areas (National Research Council, 1996). Grains are consumed by human while green straw which contains up to 61% total digestible nutrients (National Research Council, 1996) by animal consumption. Straw also used for livestock feeding, fuel, thatching and weaving e. g. basket. The grain consists up to 10 essential amino acids, proteins, carbohydrate and fats. Due to nutritious and slow digestion it is beneficial for hard working marginal farmers and metabolic disordered peoples too. Beside nutrition, plant parts have been used for folk medicine. Finger millet grains are mostly used in preparation of traditional products like *dhedo*, *roti*, *haluwa*, alcoholic beverages like *rakshi*, *chhyang*, *tumba*, *jandh* which have religious and cultural importance in different ethnic communities of Nepal. Although it has diverse importance, but in Nepal, finger millet is called "KUANNA" or unholy cereals that means is not used for worship.

Finger millet in Nepal is cultivated from terai to high hills and even in the mountains. The genotypes being cultivated in terai and in higher elevation vary in different agro morphological traits and their yielding ability. As there is variation in the microclimate and the elevation in short span in our country similar variation could be observed on the crops being cultivated in this region. This research was conducted to identify the level of genetic difference present in the finger millet genotypes being cultivated in Nepal.

Materials and Methods

The experiment was conducted using fifty finger millet landraces collected from National Agricultural Genetic Resource Centre (NAGRC), Khumaltar at IAAS, Rampur, Nepal during rainy season of 2011. The global positioning system (GPS) of the experimental site was 27.64728°N, 84.34775°E; 27.64715°N, 84.34779°E; 27.64697°N, 84.34718°E and 27.64717°N, 84.34713°E and at an altitude of 228 masl, respectively. The average maximum (33.01°C) and minimum (12.93°C) temperature was recorded in August and November during the experiment period, respectively. The field received average minimum rainfall (0.01 mm) and average maximum rainfall (24.7 mm) in October and July, respectively. The soil was sandy loam with acidic pH medium. The experiment design used was alpha lattice design with three replication and five blocks. Each accession had 3 rows per plot of 1.5m length and 0.25m apart. The plot area was 1.125 m² (0.25m X 3 rows X 1.5m) and distance between blocks 0.5m. The fertilizer rates used were 20:10:10 kg ha⁻¹ N:P₂O₅:K₂O as recommended by MoAC (2011). The observations were taken from randomly selected ten sampled plants from the three rows of a plot. Data on 5 qualitative (grain color, plant

pigmentation, inflorescence branch, finger branch, inflorescence shape) and 17 quantitative (days to heading, days to flowering, days to maturity, flag leaf sheath length, flag leaf sheath width, flag leaf blade length, flag leaf blade width, peduncle length, productive tillers number per plant, plant height, finger length, finger width, finger number per ear, thousand kernel weight, straw yield per plant, grain yield per ear, grain yield per plant) traits were recorded following finger millet descriptors (IBPGR, 1985).

The random model of Residual maximum likelihood analysis (REML) (Patterson and Thompson, 1971) in Crop Stat was used to analyze data of 17 quantitative traits. The simple correlation coefficient between yield and yield attributes was estimated by employing formulae of Snedecor and Cochran, (1981): $r_{xy} = \text{cov}_{xy} / \sqrt{v_x v_y}$ where, r_{xy} = correlation coefficient between character x and y; cov_{xy} = covariance between character x and y, v_x = variance for character x and v_y = variance for character y. Diversity analysis was estimated using Shannon-Weaver index (Shannon and Weaver, 1949) for 5 qualitative characters. Hierarchical clustering using Ward's minimum-variance method with squared euclidean distance and principal component analysis using correlation matrix for 17 quantitative characters was performed using MINITAB 14 software (MINITAB 2004).

Results

F-value of Residual maximum likelihood analysis of seventeen characters showed significant differences among accessions along with ranges, mean, standard deviation and coefficient of variation (CV) is presented in Table 1.

Table 1: Statistical parameters for quantitative characteristics of fifty accessions at Rampur, Chitwan (2011)

Traits	Range	Mean± SE	SD	CV	F-Value
Days to heading (DAS)	94.33-46.33	82.17±1.29	9.13	11.11%	81.73**
Days to flowering (DAS)	104.33-52.33	88.99±1.27	8.98	10.09%	75.04**
Flag Leaf sheath length (cm)	12.93-8.66	10.53±0.13	0.93	8.82%	3.388**
Flag Leaf sheath width (cm)	1.08-0.58	0.95±0.01	0.1	10.57%	4.767**
Flag leaf blade length (cm)	37.38-22.29	27.65±0.4	2.85	10.31%	5.82**
Flag leaf blade width (cm)	0.95-.73	0.85±0.007	0.05	6.13%	6.158**
Peduncle length (cm)	24.17-18.11	20.86±0.2	1.42	6.82%	3.242*
Plant height (cm)	118.63-46.9	96.34±1.82	12.84	13.33%	10.50**
Productive tillers number per plant	3.53-1.93	2.54±0.05	0.38	15.08%	2.572**
Finger length (cm)	12.88-4.62	6.66±0.32	2.29	34.36%	15.05**
Finger width (cm)	1.17-0.87	1.02±0.01	0.07	7.62%	1.772*
Number of finger per ear	9.19-4.26	7.35±0.15	1.08	14.73%	5.46**
Days to maturity (DAS)	128-74	117.36±1.44	10.18	8.68%	14.73**
Thousand kernel weight (gm)	3.04-1.33	2.29±0.05	0.35	15.63%	2.468**
Straw yield per plant (gm)	88.55-30.11	63.34±1.75	12.41	19.60%	2.644**
Grain yield per ear (gm)	5.33-0.96	3.98±0.12	0.90	22.73%	5.615**
Grain yield per plant (gm)	16.2-2.41	10.03±0.36	2.55	25.44%	3.497**

*= Significant at 0.05% level, **= Significant at 0.01% level

Table 2: Pearson's Correlation coefficient among seventeen traits of fifty accessions of finger millet landraces, at IAAS, Rampur, Chitwan (2011)

	flsl	flsw	flbl	flbw	pl	ph	pt	fl	fw	nfe	dtm	tkw	syp	gye	gpp
dtf	-.422**	.321**	-.508**	-.205*	-.178*	.648**	-.061	.291**	.090	.469**	.827**	.244**	.355**	.562**	.457**
flsl	1	-.114	.231**	.088	.067	-.247**	.062	.088	-.025	-.174*	-.369**	-.081	-.085	-.384**	-.320**
flsw		1	-.189*	.122	.146	.093	-.282**	.149	-.006	.306**	.202*	.040	.254**	.456**	.230**
flbl			1	.361**	.083	-.388**	.038	-.140	.002	-.219**	-.370**	-.135	-.080	-.254**	-.204*
flbw				1	.023	-.224**	-.069	-.287**	.038	.071	-.089	.018	-.129	.123	.047
pl					1	-.070	-.077	.000	.001	-.122	-.221**	-.032	.082	-.066	-.088
ph						1	.091	.376**	.078	.254**	.689**	.379**	.389**	.525**	.529**
pt							1	.121	.025	-.104	-.079	.029	.069	-.164*	.473**
fl								1	.345**	.051	.217**	.268**	.383**	.181*	.211**
fw									1	-.081	.086	.347**	.005	.131	.110
nfe										1	.402**	.040	.207*	.407**	.302**
dtm											1	.274**	.290**	.595**	.471**
tkw												1	.122	.315**	.281**
syp													1	.320**	.348**
gye														1	.769**

dtf = days to 50% flowering, flsl = flag leaf sheath length, flsw = flag leaf sheath width, flbl = flag leaf blade length, flbw = flag leaf blade width, pl = peduncle length, ph = plant height, pt = productive tillers no., fl = finger length, fw = finger width, nfe = no. of finger per ear, dtm = days to maturity, tkw = thousand kernel weight, syp = straw yield per plant, gye = grain yield per ear, gpp = grain yield per plant. * significant at 0.05% level, ** significant at 0.01% level

The phenotypic interrelation with grain yield per plant and its component is presented in Table 2. The estimates indicated that grain yield per plant had positive and highly significant ($p < 0.01$) correlation with grain yield per ear (0.769**) followed by plant height (0.529**), productive tillers number (0.473**), days to maturity (0.471**), days to flowering (0.460**), days to heading (0.457**), straw yield per plant (0.348**), finger number per ear (0.302**), thousand kernel weight (0.281**), flag leaf sheath width (0.230**) and finger length (0.211**). Negative but significant ($p < 0.01$) correlation of grain yield per plant was observed with flag leaf sheath length (-0.320**) and flag leaf blade length (-0.204*). Days to heading, flowering and maturity had statistically highly significant ($p < 0.01$) and positively correlated with each others.

Flag leaf blade length was highly significant and positively associated with flag leaf blade width and flag leaf sheath length. The non-significant and negative association with plant height was observed with peduncle length but positive association was found with productive tillers per plant. Highly significant and positive association was found between finger length and finger width but negative association was observed between finger length and flag leaf blade width.

Shannon-Weaver diversity index was found highest for ear shape ($H' = 3.42$) and grain color ($H' = 3.35$) among qualitative traits (Figure 1). The evenness was found for finger branch and richness for grain color. The dominant relation was found in light and purple brown for grain color, open type for ear shape, absence for plant pigmentation and inflorescence branch.

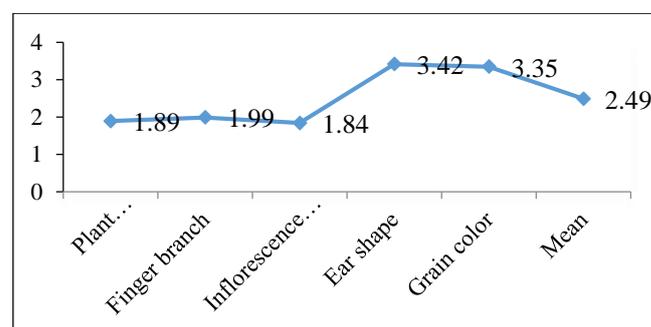


Fig. 1: Graphical representation of Shannon Weaver Index of qualitative characters

Cluster analysis grouped 50 accessions into five clusters using standardized mean of 17 quantitative traits as input (Figure 2 and Table 3). The number of accessions in a cluster ranged from 18 in cluster IV to 1 in cluster V. Among five clusters; cluster III contained two accessions

(accessions number 431 and 11024) and cluster V had one accession (accession number 10996). These accessions showed early phenological traits; lowest in finger length, finger width, finger number per ear, thousand kernel weight, grain yield per ear and grain yield per plant. But, cluster II and IV showed contrasting traits of clusters III and V. Likewise, cluster I had represented intermediate type traits.

The first five principle components and first two principle components revealed that 74.9% and 51.9% of variability

among 50 finger millet accessions respectively (Figure 3 and Table 4). Most of variation was contributed from phenological characters, plant height, grain yield per ear, finger length and grain yield per plant. These yield attributing traits were highly correlated and can be used in selection for breeding programs.

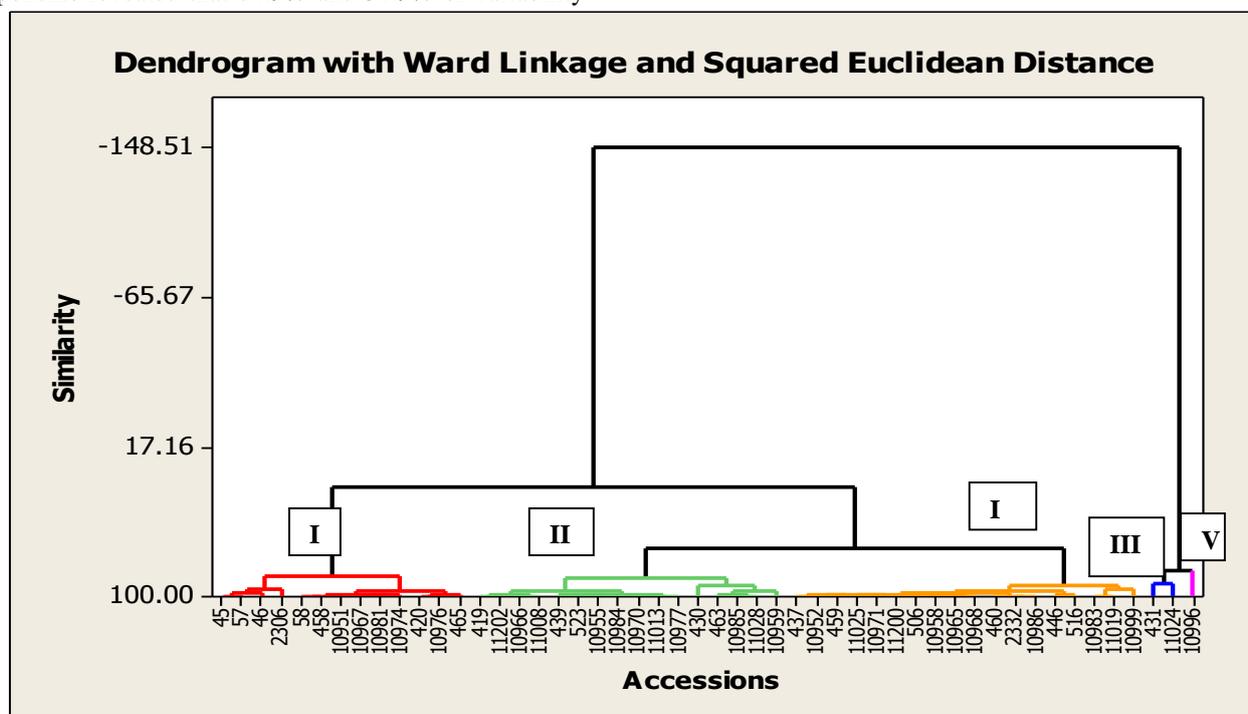


Fig. 2: Ward's linkage and Squared Euclidean distance analysis of 50 accessions of finger millet based on seventeen characters

Table 3: Mean value of Ward's linkage method clustering of Finger millet

S.N.	Variables	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
1	No of observations	13	16	2	18	1
2	Days to heading	80.641	85.417	53.50	85.556	46.333
3	Days to flowering	87.128	92.229	62.833	92.407	52.333
4	Flag leaf sheath length	10.431	10.656	12.868	10.132	12.66
5	Flag leaf sheath width	0.931	0.969	0.803	0.99	0.913
6	Flag leaf blade length	28.085	27.496	31.851	26.468	37.386
7	Flag leaf blade width	0.872	0.826	0.876	0.853	0.866
8	Peduncle length	20.892	20.994	21.18	20.57	23.346
9	Plant height	97.196	104.401	56.505	95.721	46.90
10	Productive tillers number	2.487	2.656	3.156	2.446	1.966
11	Finger length	5.446	8.394	5.011	6.296	4.90
12	Finger width	1.023	1.031	1.041	1.021	0.91
13	Finger number per ear	7.199	7.476	5.29	7.769	4.266
14	Days to maturity	116.949	121.25	86.333	120.056	74.00
15	Thousand kernel weight	2.278	2.399	1.897	2.306	1.337
16	Straw yield per plant	50.581	75.979	34.388	64.377	66.444
17	Grain yield per ear	3.927	4.130	1.211	4.332	1.265
18	Grain yield per plant	9.651	10.911	3.782	10.645	2.416

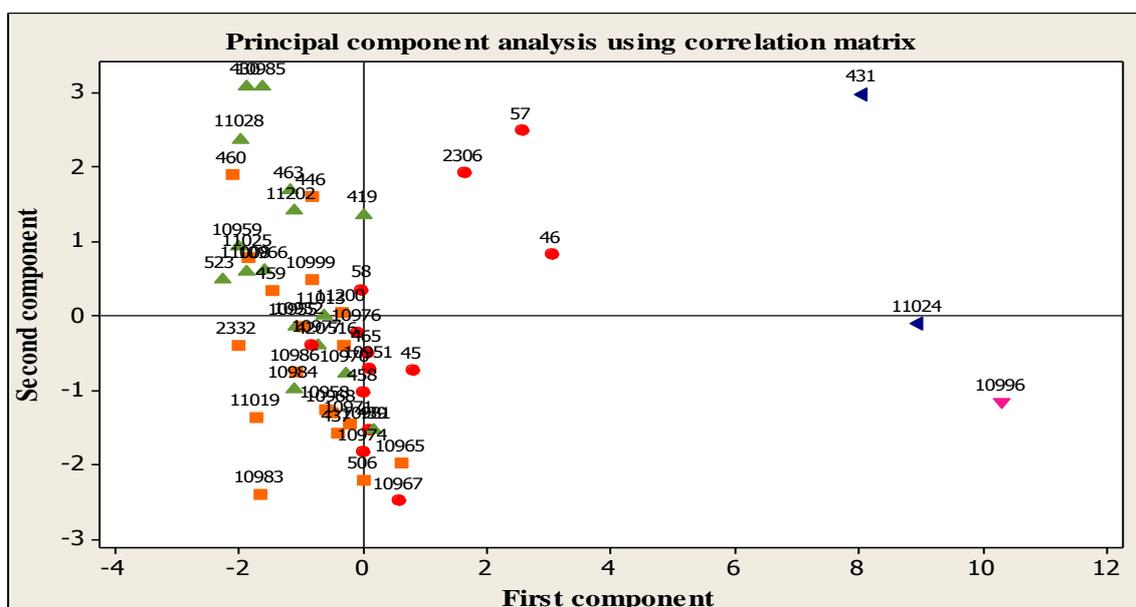


Fig. 3: Principal Component Analysis using correlation matrix

Table 4: Coefficient, eigen values and variances for 17 quantitative characters of finger millet accessions

Variable	PC1	PC2	PC3	PC4	PC5
Days to heading	-0.357	-0.084	0.081	-0.139	0.095
Days to flowering	-0.354	-0.045	0.098	-0.159	0.044
Flag leaf sheath length	0.241	0.146	0.188	0.079	0.213
Flag leaf sheath width	-0.170	-0.371	0.113	0.419	-0.113
Flag leaf blade length	0.231	-0.022	-0.266	0.173	0.382
Flag leaf blade width	0.087	-0.323	-0.529	0.156	0.182
Peduncle length	0.076	-0.110	0.208	0.622	-0.055
Plant height	-0.327	0.184	0.044	-0.043	0.006
Productive tillers number	0.038	0.435	-0.203	0.003	0.469
Finger length	-0.152	0.378	0.306	0.279	0.098
Finger width	-0.083	0.382	-0.270	0.189	-0.305
Finger number per ear	-0.228	-0.302	-0.011	-0.089	0.295
Days to maturity	-0.346	-0.005	-0.034	-0.222	0.105
Thousand kernel weight	-0.202	0.281	-0.264	0.130	-0.379
Straw yield per plant	-0.221	0.057	0.308	0.242	0.364
Grain yield/ ear	-0.327	-0.144	-0.242	0.202	-0.074
Grain yield per plant	-0.295	0.095	-0.327	0.209	0.217
Eigen value	6.6835	2.1466	1.5387	1.3202	1.0380
% of total variance	0.393	0.126	0.091	0.078	0.061
% of cumulative variance	39.3	51.9	61.0	68.8	74.9

Discussions

The significant differences between genotypes for all quantitative traits as observed from mixed model analysis revealed that the landraces possessed high variability inherited either from genotypes or genotype X environment interaction and thus, provides ample opportunity for plant breeder to select for further breeding activities. Similar results were reported in previous studies (John, 2006; Sonnad *et al.*, 2008).

The positive and significant correlation coefficient observed between grain yield per plant and finger length, finger number per ear, thousand kernel weight and productive tillers number per plant indicated that conventional methods and simulation selection method for

these traits will be more reliable to develop high yielding genotypes. The significant and positive association between grain yield and productive tillers might be due to influence of environments and magnitude and direction can be changes with alteration of environments.

The strong significant and positive correlation was found with grain yield per plant and between phenological characters (days to maturity and flowering) reported by John (2006) showed non additive gene action. Due to summer crop, the plant needs optimum temperature at maturity stage because till this period, chilling stress is not experienced as in higher elevated hills. So that high hill areas had low grain yield due to cold stress at grain filling

and maturity period. Therefore, increase in days to heading, flowering and maturity results increment in grain yield.

Similar results were reported previously by Duke (1978) in plant height; Priyadharsini *et al.* (2011) in finger length and finger number per ear.

The significant and negative association was observed for flag leaf blade length and flag leaf sheath length with grain yield per plant might be due to increase in length increases cell number but decrease in cell size cause low area for photosynthesis. The increment of flag leaf sheath/blade length with width produces higher in yield by increase in photosynthetic area and photosynthesis process. The grain yield decreases even increase in photosynthesis of early matured genotypes might be either reverse translocation of photoassimilates (from sink to storage organ i.e. peduncle) due to short grain filling period or translocation to biomass (straw).

Highest Shannon-Weaver diversity index usually found with the traits with richness in class. The ear shape has highest diversity followed by grain color might be due to oligogenic gene action and slight environmental interaction with genotypes.

Among 5 clusters, two clusters (Cluster III and V) consists early matured type accessions with high flag leaf blade length, flag leaf sheath length, peduncle length but low plant height and grain yield per plant. The accessions of these clusters can be used to develop of early mature lines for mountain regions where chilling stress occurs at maturity period. Similarly cluster II and IV can be used to develop high yielding late mature lines for mid hills and terai regions. The clustering of accessions based on trait value was confirmed by the principal component analysis.

Conclusion

The quantification and classification of Nepalese landraces based on phenotypic value is important for the utilization of breeding program. Since, complexity and tedious of creation of variation through hybridization by emasculation, chemical agents, hot water treatments in developing country like Nepal. The natural variation present within landraces is important for selection and development of varieties for the different agro-climatic regions of Nepal. This research will enhance the utilization of variation present within Nepalese landraces for designation and selection of materials of breeding programs.

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