International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 9 (2) : 102-108, December 2023

Cluster analysis and principal component analysis studies among different accessions of Grape accessions in Leh district of Ladakh UT

M K Sharma, Tsering Dolkar, Amit Kumar*, A S Sundouri and Tajamul Farooq Wani

Division of Fruit Science, Faculty of Horticulture,
Sher-e-Kashmir University of Agricultural Sciences and Technology-Kashmir,
Shalimar Campus, Srinagar (J&K)
**Email: khokherak@rediffmail.com*

Received : 16.03.2023 ; Revised : 16.06.2023 ; Accepted : 18.06.2023

DOI : 10.53552/ijmfmap.9.2.2023. 102-108

ABSTRACT

Evaluation of grape accessions was carried out from different villages of Leh district on the basis of several morphological characters. Observations were recorded on the basis of growth, foliage and yield of vine using cluster analysis and principle component analysis. The analysis of variance revealed significant differences among accessions for each character under study. Based on Mahalanobis D^2 values the accessions were grouped into five clusters. Cluster-II comprised of maximum of 27 accessions followed by cluster III and cluster V having eight accessions. Mean values of clusters for various growth and yield parameters revealed that cluster-I possessed maximum values for cane diameter (2.03 cm), yield (20.99 kg/vine), length (21.36 cm), breadth (11.12 cm), weight (150.42 g) of bunch, number of bunches/vine (148.75), number of berries/bunch (98.25), length (1.53 cm), breadth (1.33 cm) of berry, acidity (0.23 %) and juice content (89.99 %). Per cent variation (28.17) and eigen root (5.634) were registered maximum values for first component. Cluster I accessions and cluster IV accessions were observed more different from each other and provide better segregants through hybridization and can be taken as one of parent in future breeding programmes.

***Keywords*:** Accessions, cluster, evaluation, grape, PCA, selection, survey.

INTRODUCTION

Grape (*Vitis vinifera* L.) is now fully adapted in the subtropical and tropical climatic conditions of India however it is considered as temperate fruit crop. Grape species are highly heterozygous and offsprings produced through seedlings show wide genetic variability with respect to vine vigour and berry quality due to which seeds are not preferred for propagation. More than 9,600 grape cultivars are present across the world (Galet, 2000) and almost 16,000 prime names appear in the *Vitis* International Variety Catalogue (Maul and Eibach, 2003). For efficient utilization of germplasm, facts related to variability among plant species is of prime importance. Selection and multiplication of elite accessions of any fruit crop from existing heritable variability is important to increase its adoption and production for domestic consumption and from commercial point of view. Presence of genetic divergence in any population helps in the selection of desirable parents used in breeding programme which leads in the reduction of crosses made (Vanavermaete *et al.,* 2020). In any hybridization programme parents are selected on the basis of their earlier performance and the objectives of research programme. For purposeful hybridization in any heterosis breeding, degree and nature about the genetic divergence is important for the breeders in choosing the right parents (Farhad *et al.,* 2010, Khodadabi *et al*., 2011). To take advantages form the transgressive segregation, the information of genetic gap among parents is essential (Khodadadi *et al.,* 2011). The standardization of variables is also necessary towards defining the genetic distance so that all variables are of similar significance in defining the distance. Among various methods, Tocher's method is mostly used for the estimation of genetic diversity through cluster analysis. Euclidean distance can theoretically evaluate the genetic distance among parents to maximize the transgressive segregation (Hoque and Rahman, 2006). Identification of elite grapes accessions through survey, their adoption and multiplication, hence upsurge grapes productivity. Till date no recognized effort has been conducted and documented on this aspect in Ladakh region. Due to economic importance of grape and for the enhancement of its cultivation in Ladakh region, the present study was conducted in five villages of Leh district to produce vivacious figures on grape vine germplasm using cluster analysis and Principle Component Analysis.

MATERIALS AND METHODS

Area surveyed and experimental material details

After a systematic survey from five different villages (Achinathang, Warseedo, Dha, Hanuthang and Yokmathang) of Leh district in the UT of Ladakh region during 2014, fifty grape accessions were selected. The surveyed area lies between 34°80'N latitude and 77°34'E longitude at an altitude of 3414 m MSL however weather during the study period was mostly warmer with highest temperature upto 38°C in summers and lowest -37°C in winters. Considering vigour, health, bearing habit and desirable berry physio-chemical parameters of berries the vines were selected and marked which are of seedling origin having age between 20-60 years.

Observations recorded

Data was recorded on various growths and yield parameters viz. length (m) and diameter (cm) of cane, internodal length (cm), leaf area (cm^2), yield (kg/vine), yield efficiency (kg/cm^2) was calculated as per Westwood (1993). Ten bunches and ten berries were randomly taken for physical parameters and both bunch (length and breadth) and berry (length and breadth) were measured using vernier caliper and expressed in centimeter.Weight of bunch (g) and berry (g) were also taken using digital weighing balance from the randomly selected samples. Number of bunches/vine, berries/ bunches (randomly ten bunches/vine) and seeds/ berry were counted and expressed in numbers. Bio-chemical analysis of berries on various parameters *viz.* total soluble solids (°B), acidity (%), TSS/acid ratio, total sugars (%) and juice content (%) were recorded as per the standard procedure as given in AOAC (2000).

Data recorded on all the studied parameters were statistically analyzed using standard procedures (Panse and Sukhatme, 1995). Non- hierarchical Euclidean cluster method was used for the analysis of genetic divergence (Spark, 1973) among the accessions and for the classification of accessions into uniform groups.

RESULTS AND DISCUSSION

Significant differences were observed among the accessions for all the studied characters which depict large extent of genetic variability. The computation from covariance matrix gave non-hierarchical clustering based on Mahalanobis D^2 values among fifty accessions and grouped them into five clusters. The clusters occupied by fifty accessions of grape are presented in Table 1and Fig. 1 and elucidated that maximum number of accessions was registered in cluster II having 27 accessions followed by cluster III, cluster V, Cluster I and cluster IV having eight, eight, four and three accessions, respectively. The clustering pattern revealed that accessions from the same locations did not fall in the same cluster depicting that genetic diversity was not necessarily associated with graphical location. The configuration of grouping indicated that the geographical diversity was not the only criteria to group the accessions of a specific source or area which means that accessions originating from a single locality were grouped in different clusters which could be due to factors like, genetic architecture, heterogeneity, history of selection and mutation in the existing population (Martínez *et al.*, 2023). A similar trend of clustering patterns has been reported by Barua and Sharma (2003), Kaushal and Sharma (2005), Thakur *et al.* (2005),Sharma *et al.* (2014 and 2015) and Bhowmick *et al.* (2016) in different fruit crops *viz.* apple, almond, pecan, walnut and Burmese grape, respectively.

The mean value on various characters of cluster in grape accessions is presented in Table 2. Cluster I had the highest mean values for characters cane diameter (2.03cm), internodal length (29.17cm), leaf area (170.75cm^2), yield (20.99kg/vine), bunch length (21.36 cm), bunch breadth (11.12cm), bunch weight (150.42g), number of bunches/vine (148.75), number of berries/bunch (98.25), length of berry (1.53cm), breadth of berry (1.33cm), number of seeds/berry (1.75), acidity (0.23 %) and juice content (89.99 %) while cluster II exhibited the highest yield efficiency (0.09) and total sugar

Table 1: Clustering pattern of fifty grape accessions on the basis of genetic divergence

Cluster	Number of accessions	Accessions number
I	4	LG-1, LG-15, LG-29, LG-42
II	27	LG-2, LG-4, LG-5, LG-6, LG-7, LG-8, LG-9, LG-10, LG-11, LG-12, LG-18, LG-19, LG-20, LG-21, LG-22, LG-24, LG-25, LG-26, LG-27, LG-30, LG-31, LG-32, LG-33, LG-37, LG-38, LG-41, LG-45
III	8	LG-3, LG-16, LG-17, LG-34, LG-36, LG-43, LG-44, LG-46
IV	3	LG-13, LG-40, LG-47
V	8	LG-14, LG-23, LG-28, LG-35, LG-39, LG-48, LG-49, LG-50

Table 2: Cluster means for differentparameters of grape accessions in Leh district

Characters	Clusters				
	I	II	III	IV	V
Cane length (cm)	186.76	136.98	171.22	127.62	201.77
Cane diameter (cm)	2.03	1.54	1.71	2.02	1.72
Internodal length (cm)	29.17	23.13	24.58	23.13	22.54
Leaf area (cm^2)	170.75	141.44	150.37	164.78	154.16
Yield (kg/vine)	20.99	12.10	14.68	13.47	12.20
Yield efficiency (kg/cm^2)	0.08	0.09	0.03	0.07	0.05
Bunch length (cm)	21.36	17.13	20.25	19.26	18.36
Bunch breadth (cm)	11.12	9.21	10.55	9.95	9.59
Bunch weight (g)	150.42	90.19	113.22	100.65	90.28
No. of bunches/vine	148.75	135.29	129.12	102.96	94.82
No. of berries/bunch	98.25	62.77	76.50	66.66	56.37
Berry length (cm)	1.53	1.08	1.10	1.17	1.03
Berry breadth (cm)	1.33	1.02	1.04	1.05	1.03
Berry weight (g)	1.38	1.33	1.32	1.41	1.54
Number of seeds/berry	1.75	1.00	1.00	1.00	1.00
TSS (^oB)	19.10	20.18	20.53	20.66	20.08
Acidity (%)	0.23	0.21	0.20	0.15	0.22
Total sugars (%)	9.16	11.56	10.75	9.73	10.29
TSS/acid ratio	82.75	94.85	101.83	131.83	92.02
Juice content (%)	89.99	74.80	79.99	77.71	79.00

(11.56 %). Maximum mean values for TSS (20.66^{o}B) and TSS/acid ratio (131.83) was recorded in cluster IV whereas cane length (201.77 cm) and berry weight (1.54 g) was registered maximum in cluster V. Mean values of Cluster III and I were bestowed with desirable features which is required for desirable recombination's in segregating generations. Kanavi *et al.* (2020) reported that mean of clusters depicts the inner diversity in the material taken under investigation. Priority should be given to those clusters for further selection and choosing parents in hybridization programme, in which characters contribute more towards the D^2 values (Bose and Pradhan, 2005).

The principal component analysis revealed prominent differences among the accessions studied. Table 3 depicts that in principal component analysis, maximum contribution of diversity (28.17 %) and maximum eigen roots (5.634) values was observed in first component with major contributions from cane diameter, fruit yield, length, breadth and weight of bunch whereas minimum contribution towards diversity (0.04 %) and minimum eigen root value (0.007) was reported

Table 3: Eigen vectors, eigen roots and per cent variation elucidated by different characters of grape accessions

Characters	Eigen roots	Variation (%)	Eigen vectors																			
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	18	19	20
Cane length (cm)	5.634	28.17	0.228	0.201	0.167	0.198	0.349	-0.101	0.303	0.286	0.377	0.005	0.234	0.242	0.267	0.102	0.256	-0.005	0.075	-0.165	-0.063	0.308
Cane diameter (cm)	2.415	12.08	-0.021	0.041	-0.055	-0.015	0.007	0.087	-0.236	-0.206	-0.081	0.320	0.210	0.128	0.090	-0.336	0.046	-0.434	0.356	-0.094	-0.519	0.050
Internodal length (cm)	2.165	10.83	-0.296	-0.009	0.117	-0.015	0.250	0.447	0.111	0.055	0.135	0.304	0.402	-0.061	-0.097	-0.351	0.047	0.062	-0.266	0.228	0.242	-0.155
Leaf area (cm^2)	1.737	8.69	0.036	-0.398	0.094	-0.124	0.090	0.223	0.326	0.358	0.082	-0.153	0.003	-0.379	0.336	0.087	-0.097	-0.084	0.330	-0.031	-0.317	-0.043
Yield (kg/vine)	1.404	7.02	-0.080	-0.349	0.389	-0.181	-0.041	-0.026	-0.065	0.077	-0.089	0.106	-0.117	0.341	0.337	0.041	0.114	0.330	0.287	0.438	-0.076	-0.094
Yield efficiency (kg/cm^2)	1.181	5.91	0.080	0.183	0.419	0.400	0.125	-0.068	-0.076	-0.112	-0.023	0.429	-0.261	-0.219	-0.281	0.318	0.009	-0.161	-0.021	0.276	-0.050	0.014
Bunch length (cm)	1.108	5.54	-0.311	-0.219	0.071	0.132	-0.022	0.352	0.057	0.137	-0.029	0.132	-0.269	0.321	0.237	0.296	-0.248	-0.304	-0.217	-0.381	0.014	-0.059
Bunch breadth (cm)	0.881	4.41	0.012	-0.060	0.458	0.542	-0.278	-0.110	0.070	0.024	-0.160	-0.335	0.172	0.005	0.024	-0.373	-0.083	-0.003	0.003	-0.173	0.007	0.232
Bunch weight (g)	0.797	3.99	-0.441	0.120	-0.177	0.327	-0.092	0.265	-0.092	0.025	-0.114	-0.024	-0.116	-0.066	-0.113	0.064	0.459	0.366	0.317	-0.179	-0.006	0.201
No. of bunches/vine	0.702	3.51	0.304	0.063	-0.326	0.349	0.070	0.234	0.092	0.004	-0.051	0.166	-0.014	0.128	0.055	-0.071	-0.591	0.349	0.255	0.118	0.019	0.037
No. of berries/bunch	0.528	2.64	-0.399	0.401	0.068	-0.140	-0.180	-0.175	0.244	0.361	-0.227	-0.008	-0.073	-0.016	0.037	-0.162	-0.293	-0.128	0.012	0.248	-0.052	0.388
Berry length (cm)	0.468	2.34	0.023	0.119	-0.186	-0.043	-0.072	-0.329	0.234	0.353	-0.146	0.468	-0.084	0.011	-0.019	-0.074	0.161	0.114	0.039	-0.235	-0.015	-0.553
Berry breadth (cm)	0.321	1.61	0.099	-0.561	-0.312	0.300	-0.114	-0.187	0.141	0.093	-0.147	0.194	-0.037	-0.043	0.041	-0.179	0.225	-0.171	-0.231	0.201	0.085	0.366
Berry weight (g)	0.296	1.48	0.516	0.512	0.237	-0.250	-0.287	0.452	0.074	0.085	-0.323	0.134	-0.133	-0.023	0.002	-0.125	0.204	0.050	-0.110	-0.166	0.083	0.214
Number of seeds/berry	0.211	1.06	-0.117	-0.241	0.273	-0.180	0.122	-0.293	-0.066	-0.167	0.020	0.306	0.040	-0.047	-0.191	-0.142	-0.249	0.312	0.043	-0.479	0.127	0.357
TSS (°B)	0.074	0.37	0.068	-0.016	0.012	0.055	0.274	-0.001	-0.642	0.510	-0.082	-0.033	-0.055	-0.353	0.290	-0.106	-0.067	0.027	-0.071	-0.058	-0.025	-0.034
Acidity (%)	0.045	0.22	-0.082	0.014	0.022	-0.011	0.076	0.017	0.337	-0.357	-0.133	0.061	0.005	-0.567	0.624	0.072	-0.011	0.042	0.039	-0.058	-0.025	-0.034
Total sugars (%)	0.013	0.07	-0.014	0.004	0.005	0.024	-0.642	0.036	-0.129	0.090	0.609	0.208	0.087	-0.186	0.123	0.060	-0.075	0.151	-0.130	0.021	-0.196	0.044
TSS/acid ratio	0.010	0.05	0.001	-0.040	-0.011	0.012	-0.131	-0.037	-0.089	0.085	-0.414	0.066	0.690	0.016	-0.034	0.527	-0.053	0.087	-0.101	-0.004	-0.104	0.040
Juice content (%)	0.007	0.04	0.025	-0.028	0.010	-0.029	-0.202	-0.008	-0.064	0.066	0.097	0.088	0.148	-0.067	0.056	0.100	-0.017	-0.356	0.538	-0.005	0.689	-0.006

Percent variation explained by first 12 components = 95.1068

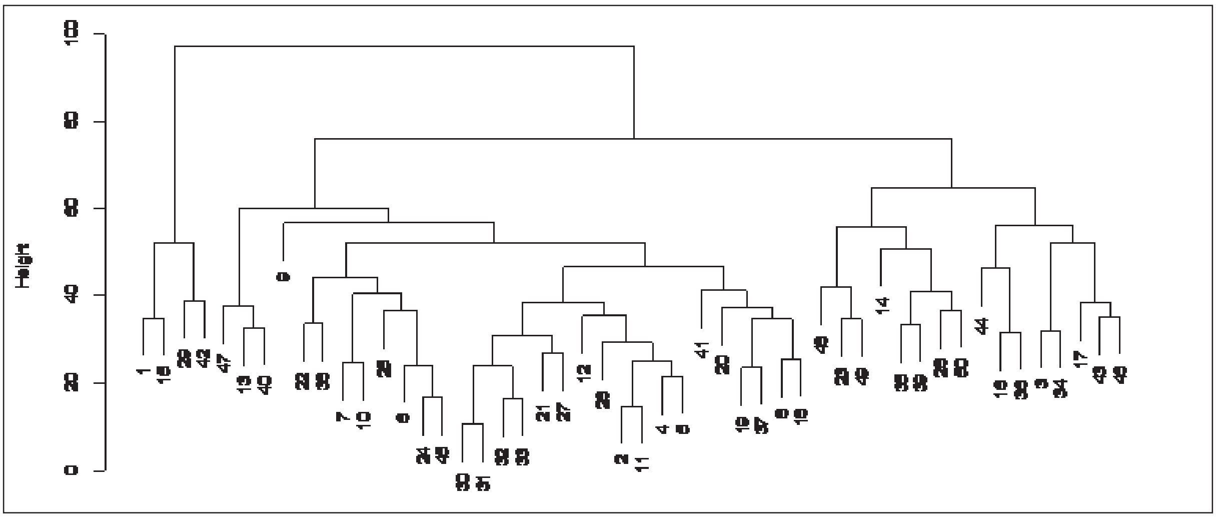

Fig. 1: Dendogram of cluster analysis of various grapes accessions of Leh district

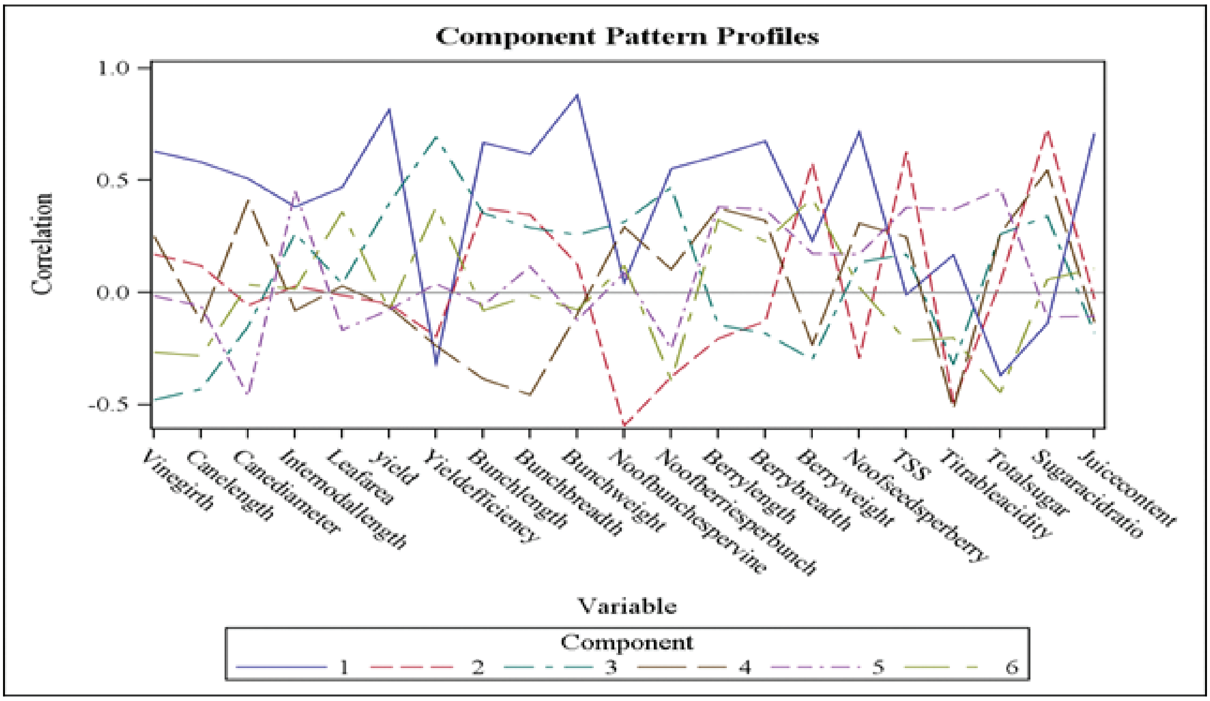

Fig. 2: Scatter plot of Principal component of various grape accessions ofLeh district

in last component with major role from number of berries/bunch, berry weight, acidity and TSS/acid ratio. Cane diameter which is second component exhibited the eigen root value and total variation of 2.415 and 12.08 per cent, respectivelywith mainly contribution of number of bunches/vine, number of berries/bunch and cane diameter. An eigen root value of 2.165 with total variation of 10.83 per cent was registered by the third component i.e. intermodal length and the major contribution for this component is of yield, yield efficiency, number of bunches/vine, number of berries/bunch and total sugars whereas 4th vector i.e. leaf area has the eigen root value and total variation of 1.737 and 8.69 per cent, respectively and the contribution was from length and breadth of bunch, breadth of berry and acidity. Yield was considered as fifth component with eigen root value of 1.404 and the total variation was 7.02 per cent with maximum and contributed mainly by internodal length, berry length, berry breadth, total soluble solids and total sugars, however, sixth component i.e. yield efficiency showed eigen root value and total variation of 1.181 and 5.91 per cent respectively and mainly contribution was of internodal length, leaf area, number of bunches/ vine, berry weight and total sugars. First twelve components registered 95.11 per cent of total variation.The scatter plot was generated for grape accessions selected from five different villages of Leh district for the first two principal components from a principal component analysis of twenty agro-morphological characters as depicted in Fig. 2. Such separation of genotypes may be due to distinct and diverse nature of the varieties for different agro-morphological traits (Kadu *et al*., 2007 and Viana *et al.,* 2011). Characters with largest absolute value closer to unity within the first principal component influenced the clustering more than those with lower absolute value closer to zero (Kumar *et al.,* 2015).

Rao *et al.* (2003) also reported that for any crop species there is direct correlation between geographical distribution and genetic diversity of that crop and also concluded that eco-geographically different cultivars/accessions also differ from each other genetically. A wide range of variation for almost all the economically important traits is present in this crop. This implies a great potential for breeding through hybridization programme.

From current investigations, with respect to genetic divergence and its component analysis of grape accessions this is inferred that hybridization among genetically different accessions will be helpful for obtaining desirable segregates.

REFERENCES :

AOAC. 2000. Official Methods of Analysis, 15th edition. Association of Official Analytical Chemists, Washington, DC, USA.

Barua, U. and Sharma, R.K. 2003.Estimation of genetic divergence in apple (*Malus x domestica* Borkh.). *Indian Journal of Plant Genetic Resources,* **16:** 4-6

Bhowmick, N., Pradhan, S. and Ghosh, A. 2016.Correlation study and cluster analysis in Burmese grape (*Baccaurea sapida* Muell. Arg.) under the sub-Himalayan Tarai region of West Bengal. *International Journal of Minor Fruits, Medicinal and Aromatic Plants,* **2**(1): 25-27

Bose, L.K. and Pradhan, S.K. 2005. Genetic divergence in Deep water rice genotypes. *Journal of Central European Agriculture,* **6**(4): 635-640

Farhad, M., Hasanuzzaman, M., Biswas, B.K., Arifuzzaman, M. and Islam, M.M. 2010.Genetic divergence in chilli. *Bangladesh Research Publication Journal,* **3**(3): 1045-1051.

Galet, P. 2000. Dictionnaireencyclopédique des cépages. Hachette, Paris.

Hoque, M. and Rahman, L. 2006. Estimation of Euclidian distance for different morpho-physiological characters in some wild and cultivated rice genotypes (*Oryza sativa* L.). *Pakistan Science,* **1:** 77-79.

Kadu, S.Y., Tambe, T.B. and Patil, S.P. 2007. Studies on leaf morphology and vine vigour of various grape wine varieties. *The Asian Journal Horticulture,* **2**(1): 131-134.

Kanavi, M.S.P., Koler, P., Somu, G. and Marappa, N. 2020.Genetic Diversity study through K-means clustering in germplasm accessions of Green gram (*Vigna radiata* L.) under drought condition. *International Journal of Bio-resource and Stress Management,* **11**(2): 138-147

Kaushal, R.K. and Sharma, S.D. 2005. Non-hierarchical Euclidean cluster analysis studies in seedling trees of pecan (*Carya illinoensis* (Wang) K. Koch.) growing in Himachal Pradesh. *Acta Horticulturae,* **696:** 97-101

Khodadabi, M., Fotokian, M.H. and Miransari, M. 2011. Genetic diversity of wheat genotypes based on cluster and principal component analyses for breeding strategies. *Australian Journal of Crop Science,* **5**(1): 17-24.

Kumar, A., Ahad, I. and Singh, P.K. 2015. Genetic diversity in Chilli genotypes based on cluster and principal component analyses. *Current Plant Science,* **1**(1): 14-22.

Martínez, O., Ojeda, A.C., Hayano-Kanashiro, C., Reyes-Valdés, M.H., Hernández, J.L.P. and Simpson, J. 2023. Criteria for prioritizing selection of Mexican maize landrace accessions for conservation *in-situ* or *ex-situ* based on phylogenetic analysis. *Frontiers in Ecology and Evolution* 11:1139377. doi: 10.3389/fevo.2023.1139377

Maul, E. and Eibach, R. 2003. *Vitis* international variety catalogue. http://www.genres.de/eccdb/vitis.

Murty, B.R. and Arunachalam, V. 1966.The nature of genetic and divergence in relation to breeding systems in crop plants. *Indian Journal of Genetics and Plant Breeding,* **26**: 188-198.

Panse, V.G. and Sukhatme, P.V. 1995. Statistical Methods for Agricultural Workers. ICAR Pub., New Delhi, p. 296.

Rao, E.S., Verma, V.K. and Munshi, A.D. 2003. Breeding potential of cucumber (*Cucumis sativus* L.) genotypes using D^2 analysis. *Indian Journal of Horticulture,* **60**(1): 53-58.

Sharma, S., Kumar, K. and Kumar, A. 2014. Genetic divergence studies in different growth and foliage characters of diverse walnut (*Juglans regia* L.) germplasm. *Advances in Horticultural Sciences,* **28(3)**: 123-128.

Sharma, S., Kumar, K. and Kumar, A. 2015. Genetic divergence studies in different nut and kernel characters of diverse walnut (*Juglansregia* L.) germplasm. *Journal of Applied Horticulture,* **17**(1): 66-69.

Spark, D.N. 1973. Euclidean cluster analysis algorithm AS. **58**. *Appl. Stat.*, 22: 126-130

Thakur, B.S., Sharma, O.C., Mehta, K., Sharma, D.P. and Rehalia, A.S. 2005.Genetic divergence in almond (*Prunus amygdalus* Batsch) growing in Kinnaur, Himachal Pradesh. *Acta Horticulturae,***696**: 69-74.

Vanavermaete, D., Fostier, J., Maenhout, S. and Baets, B.D. 2020. Preservation of Genetic variation in a breeding population for Long-Term genetic gain.*G3: Genes, Genomes, Genetics,* **10**(8): 2753–2762.

Viana, A.P., Riaz, S. and Walker, M.A. 2011. Evaluation of genetic dissimilarity in a segregating wine grape population.*Genetics and Molecular Research,* **10(4):** 3847-3855

Westwood, M.N. 1993. Temperate Zone Pomology. Timber press, Portland, Oregon, USA.