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EVALUATION OF WINTER VEGETABLES FOR GENETIC DIVERGENCE AND CHARACTERIZATION OF GENOTYPES

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Abstract

Indigenous germplasm of winter vegetables (radish, turnip, coriander and fenugreek) were evaluated for genetic divergence and characterization under field conditions during 2003. High variance observed for most of the characters indicated the worth of local landraces. Medium to high genetic diversity was observed for radish, turnip and coriander, whereas in the case of fenugreek, the level of genetic diversity was low. Among all the vegetables desirable agronomic traits were identified which could be exploited for vegetable improvement. It was observed that areas with greater environmental stresses represented high biodiversity even in the same vicinity as the case of Attock and TT Singh (radish), Sahiwal (turnip) and DG Khan (coriander), whereas in some areas low diversity might be associated with vegetable growing culture in the area.

Introduction

Vegetables are grown on an areas of 340.4 thousand hectares with the production of 4826.6 thousand tons in Pakistan (Anon., 2003). Radish and turnip are important winter vegetables grown for their fleshy edible roots, which are eaten raw, salad, pickled, or cooked as vegetables. These are rich in minerals and vitamins A, B and C (Baloch, 1996).

Coriander belonging to the family *Umbelliferae* takes six months to produce seeds and is widely grown all over Pakistan. It is grown for green leaves which are used in curries and for seeds which have high medicinal value (Anon., 2003). Area under coriander production in Pakistan was reported to be 4.7 thousand hectares with the production of 2.2 thousand tones in 2002-03. Fenugreek belongs to the family *Leguminosae* and is used as green leaves that is rich in protein, minerals and vitamin C. The seeds and dried leaves are used for flavouring stews and curries.

Conservation of using agricultural genetic resources is vital to meet the needs of the world's food and feed demand. Crop improvement is primarily based on extensive evaluation of germplasm (Ghafoor *et al.*, 2001). Larger the genetic resources, the better are the chances of fishing out particular characters. In the wake of spread of high yielding varieties, this genetic variability comprising land races is gradually getting eroded resulting the large scale depletion of variability. This situation thus demands priority actions to conserve the eroding germplasm. Keeping in view the above facts, the indigenous winter vegetable germplasm was evaluated for genetic divergence and characterization of the genotypes conservation in the genebank for future utilization of genotypes.

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Materials and Methods

One hundred and eighteen accessions of four winter vegetables (radish, turnip, coriander and fenugreek) were collected from allover the country during 2002 and evaluated under field conditions during 2003. Table 1 presents the total number of accessions and traits for which germplasm was evaluated. Seeds were sown on raised beds of 5 meters length, whereas, inter and intra-row spacing were kept according to recommended practices. Data were recorded on 10 plants sampled randomly within each accession using IPGRI descriptors.

In case of radish and turnip days to maturity were recorded when crops reached marketable edible maturity (Anon., 2006). Plant weight, root weight, root diameter and root length were recorded on 10 plants sampled at random. Root volume was measured by dipping the root in a calibrated cylinder, filled with water, keeping the total volume at 2000 cc. Displacement was recorded after the root was taken out of the cylinder. Leaf number was recorded by counting all the leaves arising from top of the root. To measure the leaf length, the longest leaf was observed from the base of the root, whereas diameter of the same leaf was measured at the widest part of the leaf. For qualitative characters, root shape, color, texture and color of flesh were recorded visually.

In case of coriander and fenugreek data were taken for days to flowering, days to seed maturity, number of branches per plant and umbels/pods per plant. Seed weight was recorded by weighing 100 seeds taken from the bulk of each accession. Number of seed per umbel/pod was recorded by counting the seed taken from 10 umbels/pods from the plants, sampled randomly from each accession. The data thus recorded were analyzed for basic statistics i.e., mean, standard error, standard deviation, variance expressed as percent of mean for all the four vegetables with the help of computer software MS Excel. Genetic diversity was estimated with the help of computer software STATISTICA. Average of genetic diversity within each district was calculated to compare the diversity among the various districts.

Results

Results regarding various traits of all the vegetables are presented in Table 2. Bolting in radish started after one month and continued to the end of second month. Minimum days to bolting were recorded in the accession 4516-3 and maximum in 4470-9. Root diameter was maximum in 4458-12 and minimum in 4439-6. Qualitative characters i.e., root color, shape and texture also showed variation among the accessions. High variance was observed for all the traits except days to edible maturity and plant weight. High variance along with a wide range for most of the characters revealed the scope of improvement from this material.

Results obtained for turnip revealed that plant weight ranged from 0.75 to 2.15 kg, whereas root weight ranged from 79.1 to 225.4 g. High variance for days to flowering, root volume, root weight and root diameter, whereas, for other characters low variance was observed. Although high root weight and volume are not very much desirable traits in root vegetables, but desirable genotype could be isolated from this germplasm due to prevalence of high range and variance.

Table 1. The germplasm of four vegetable crops evaluated under field conditions.

Crop name	Accessions	Characters
Radish	41	16
Turnip	19	11
Coriander	29	5
Fenugreek	29	6
Total	**118**	

Table 2. Basic statistics for various quantitative characters in four winter vegetables evaluated under field conditions during 2003.

Traits	Mean ± SE	Standard deviation	σ^2 % of mean	Minimum	Maximum
Raphanus sativus					
Days to edible maturity	57 ± 0.3	1.68	4.96	56	60
Days to seed maturity	180 ± 4.79	28.76	459.73	169	189
Days to bolting	46 ± 2.17	8.15	144.60	33	56
Days to flowering	131 ± 3.96	22.77	396.06	81	154
Plant weight (kg)	2.50 ± 0.12	0.68	18.8	0.7	3.85
Root weight (gm)	331.73 ± 17.64	98.24	2909.62	147.6	538.2
Root diameter (mm)	46.8 ± 1.12	6.25	83.51	35.4	66.7
Root length (cm)	27.2 ± 1.03	5.74	121.17	14.0	36.3
Volume (cc)	316.2 ± 16.29	90.70	2601.93	148.7	556
Number of leaves	34 ± 6.16	34.34	3470	9	64
Leaf diameter (cm)	12.5 ± 0.45	2.54	51.63	8.7	19.5
Leaf length (cm)	33.4 ± 1.04	5.83	101.70	19.1	48.3
Brassica rapa					
Days to edible maturity	61± 0	0	0	61	61
Plant weight (kg)	1.47 ± 0.09	0.41	10.88	0.75	2.15
Days to flowering	120 ± 4.33	13.01	141.2	95	138
Days to seed maturity	173 ± 1.33	4	9.24	171	179
Volume (cc)	173.4 ± 11.57	50.43	1466.79	80	264
Root weight (gm)	174.9 ± 12.21	53.25	1621.18	79.1	255.4
Root diameter (mm)	67.2 ± 2.38	10.39	160.63	42.6	84.8
Number of leaves	17.7 ± 0.52	2.30	29.88	13	22.4
Coriandrum sativum					
Days to maturity	192 ± 0.31	1.66	1.42	190	194
Branches per plant.	8.9 ± 0.56	3.04	103.93	5	18
Umbel per plant	189 ± 7.76	41.79	921.62	121	336
Days to flowering	143 ± 2.47	13.28	123.29	96	152
100-seed wt (gm)	0.8 ± 0.03	0.14	2.5	0.60	1.16
Trigonella foenumgreacum					
Days to flowering	101 ± 5.53	29.82	880.75	67	134
Days to maturity	185 ± 0.40	2.20	2.61	182	188
Number of seeds per pod	14.3 ± 0.54	2.09	30.69	11.11	18.77
Seeds per umbel	76 ± 6.29	23.54	729.26	17	115
Pods or umbel per plant	390 ± 27.04	145.65	5430.02	199	924
100 –seed weight (gm)	0.59 ± 0.08	0.44	32.20	0.11	1.32

The results regarding coriander exhibited a narrow range for maturity. Number of branches per plant ranged from 5 to 18, whereas umbels per plant ranged from 121 to 336. A considerable variation was observed for 100-seed weight. Out of 5 agronomic traits, 3 (branches per plant, umbels per plant and days to flowering) exhibited high variance which indicated importance of the accession. Seed weight ranged from 0.6-1.16 per 100 grains that could be utilized to improve seed weight in coriander. Similarly the results regarding fenugreek revealed high variance for days to flowering, number of seed per raceme and number of pods/raceme plant, whereas, other characters revealed low to medium variance.

Genetic diversity: The phenogram of radish germplasm revealed 5 clusters at 50% dissimilarity (Fig. 1). The cluster 1 consisted of 8 accessions, cluster 2 eleven, cluster 3 four, cluster 4 two and cluster 5 consisted of 6 accessions. In cluster 1 bolting was observed in most of the accessions and all the accessions were seed types those exhibited a close resemblance for almost all the characters. Accessions in cluster 2 were all seed types and closely resembled for plant weight, days to edible maturity and days to flowering. In cluster 3, all the accessions bolted except 4456-4. Genetic diversity ranged from 0.45 (4465-6 vs 4462-6) to 9.40 (4467-23 vs 4544-3). On the basis of collection sites, maximum diversity was in the germplasm collected from Attock followed by the material collected from TT Singh and Lahore, respectively (Table 3).

Three clusters were observed for turnip germplasm based on 50% genetic dissimilarity (Fig. 2). Cluster 1 and 2 included four accessions each whereas, all others were grouped in cluster 3.Accessions in cluster 1 consisted of non-seed types except 4442-14. In this cluster the accessions exhibited <1 kg of plant weight and were similar for number of leaves per plant. Accessions in cluster 2 were seed types except 4467-18. Similarity was attributed towards leaf number, root diameter, root weight, root volume, days to seed maturity and plant weight. Genetic diversity ranged from 1.03 (4458-13 vs 4466-7) to 7.24(4551-10 vs 4442-14). Whereas, on the basis of district maximum diversity was observed in the germplasm collected from Sahiwal and minimum in the accessions collected from Multan.

At 50% dissimilarity two clusters were observed for coriander. Cluster 1 consisted of 7 accessions, whereas all others were in cluster 2 (Fig. 3). Days to seed maturity were same for all the accessions in cluster 1. The 100-seed weight and number of branches per plant were also in close proximity. In cluster two 100-seed weight was <1 g in all the accessions. Days to flowering and seed maturity also revealed close resemblance. Genetic diversity ranged from 0.50 (4441-1 vs 4464-16) to 7.00 (4520-1 vs 4464-16), whereas, on the basis of collection sites the maximum diversity was observed in the germplasm collected from DG Khan and minimum in the germplasm collected from Mansehra.

Fenugreek germplasm exhibited a low level of diversity and two clusters were observed even at 25% of dissimilarity (Fig. 4). Cluster 1 consisted of 13 accessions and all others were in cluster 2. All the accessions in cluster one produced umbels and close resemblance within the values of number of seeds per umbel was observed. Close proximity within values for 100-seed weight, days to maturity and days to flowering was also observed. Whereas in cluster two all the accessions produced pods except 4540-2, and very close resemblance within values for number of seeds per pod was noted. Genetic diversity ranged from 0.15 (4527-3 vs 4531-5) to 5.99 (4469-7 vs 4439-8) in fenugreek. On the basis of collection site maximum diversity was depicted by the collection of district Pak Pattan and minimum by Sialkot.

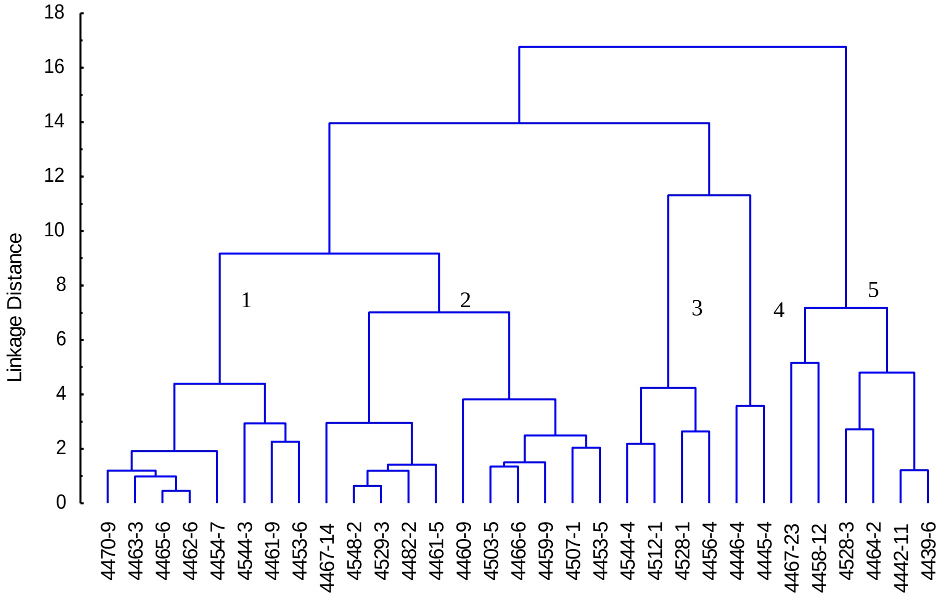

Fig. 1. Phenogram of radish based on 12 agronomic traits.

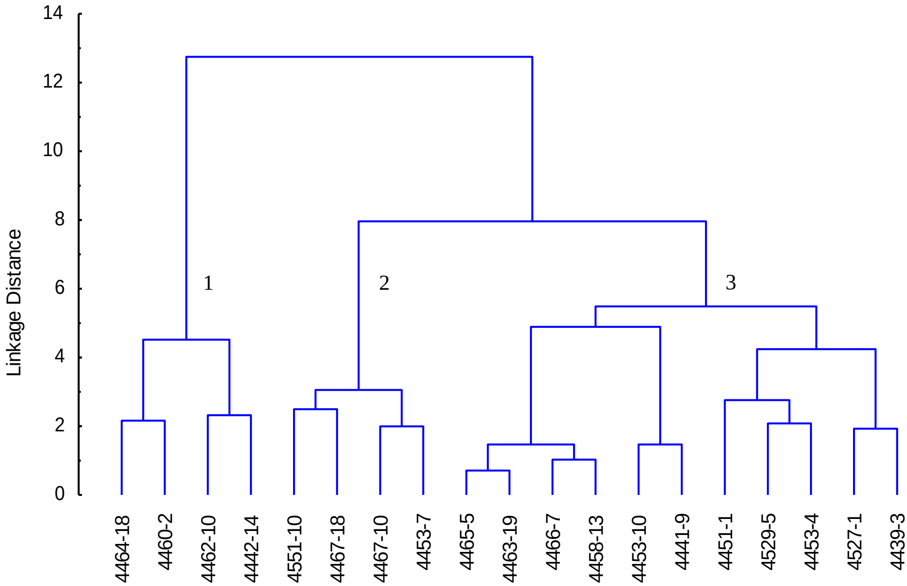

Fig. 2. Phenogram of turnip based on 8 agronomic traits.

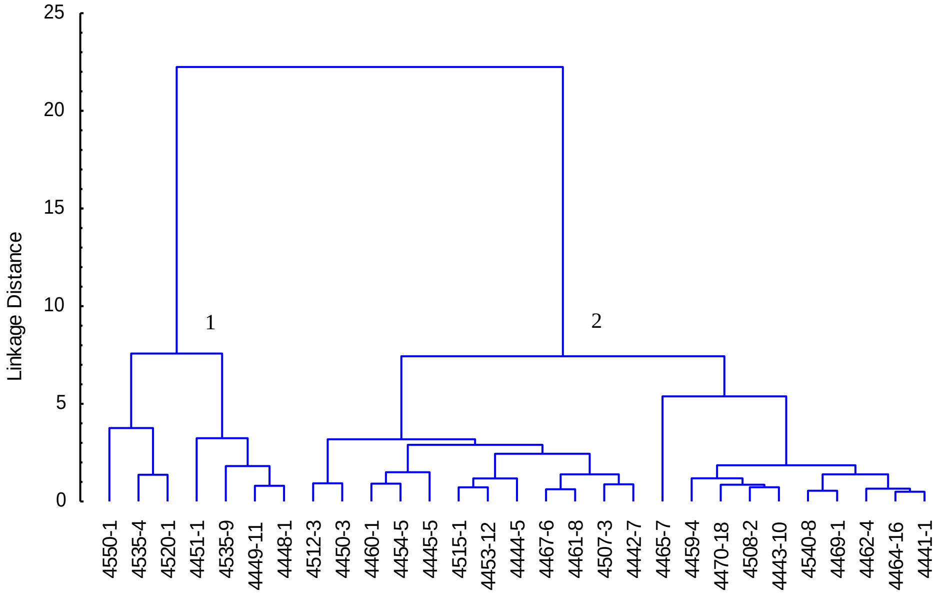

Fig. 3. Phenogram of coriander based on 5 agronomic traits.

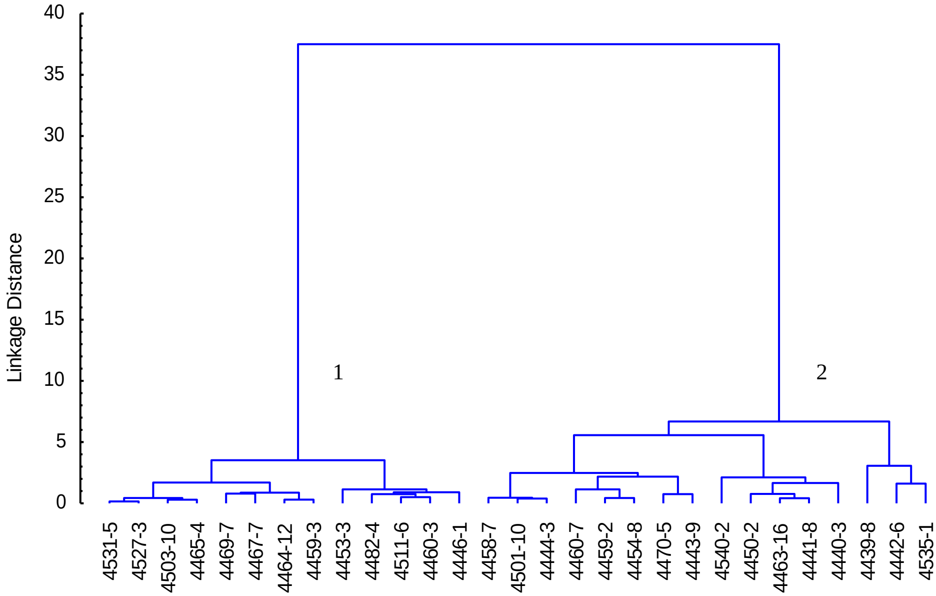

Fig. 4. Phenogram of fenugreek based on 6 agronomic traits.

Table 3. Genetic diversity in four winter vegetables based on agronomic traits presented on geographic pattern.

Districts	Radish	Turnip	Coriander	Fenugreek
Rawalpindi	4.85	3.35	-	3.43
Haripur	4.62	3.83	2.15	2.59
Atock	5.97	-	2.94	2.74
Chakwal	3.56	3.32	2.38	2.90
New Mirpur	3.68	-	-	-
Lahore	5.01	2.55	-	2.74
Sheikhupura	3.13	-	2.38	2.69
Farooqakbad	4.12	4.09	2.09	2.56
Gujranwala	3.47	-	2.12	2.67
Sahiwal	3.02	4.17	2.21	-
Multan	3.00	2.41	-	2.57
Khanewal	3.74	3.49	2.35	2.42
Bahawalpur	3.08	2.55	4.15	2.47
TT Singh	5.16	3.47	2.22	2.63
Muzaffarabad	3.05	-	2.17	2.47
Mansehra	3.00	-	2.02	2.62
Sialkot	3.20	-	-	2.40
Hafizabad	3.75	-	2.1	2.76
Mianwali	4.40	-	2.42	2.53
Vihari	4.46	3.12	-	2.45
Lodhran	3.07	3.21	-	-
Swat	5.00	-	-	-
Dir	2.91	-	-	-
Peshawar	-	3.90	-	-
Khushab	-	-	2.23	-
Jhang	-	-	2.42	-
D.G. Khan	-	-	5.16	-
Pak Pattan	-	-	3.71	3.56
Kohat	-	-	3.57	-
Total	**23**	**13**	**19**	**19**

Selection of superior accessions: Among all the 4 vegetables evaluated for various agronomic traits, desirable accessions were identified and are listed in the Table 4. Root weight and root volume were important yield contributing traits in radish and hence 11 accessions for root weight and 16 for volume were identified in the desirable range for both the traits. The most desirable ones could be selected from these accessions for further utilization. Similarly four accessions for turnip were identified for root volume.

In case of coriander 9 accessions were identified for branches, 10 for umbels per plant, 2 for early flowering and 4 for higher seed weight. Similarly 9 accessions of fenugreek were identified for early flowering and 9 for higher seed weight. Fenugreek is consumed as leafy vegetable, hence accessions selected for early flowering could be exploited for development of early cultivars due to high demand and prices of early vegetables.

Table 4. Selection of superior accessions of four winter vegetables.

Characters	Range	Numbers and dist. of collection
Raphanus sativus		
Root weight (g)	350-450	4453-5 (Chakwal), 4454-7 (Chakwal), 4456-4 (New mirpur), 4461-9 (Gujranwala), 4463-3 (Multan), 4465-6 (Bahawalpur), 4466-6 (Bahawalpur), 4470-9 (Muzaffarabad), 4503-5 (Sialkot), 4453-6 (Chakwal), 4512-1 (Mianwali)
Root volume (cc)	250-350	4446-4 (Attock), 4454-7 (Chakwal), 4456-4 (New mirpur), 4458-12 (Lahore), 4459-9 (Sheikhupura), 4460-9 (Farooqabad), 4461-5 (Gujranwala), 4461-9 (Gujranwala), 4462-6 (Sahiwal), 4463-3 (Multan), 4465-6 (Bahawalpur), 4482-2 (Mansehra), 4548-2 (Dir), 4529-3 (Lodhran), 4507-1 (Hafizabad), 4528-1 (Vihari)
Brassica rapa		
Root volume (cc)	100-150	4441-9 (Haripur), 4453-10 (Chakwal), 4460-2 (Farooqabad), 4464-18 (Khanewal)
Coriandrum sativum		
Number of branches per plant	>10	4448-1 (Attock), 4449-11 (Attock), 4450-3 (Attock), 4451-1 (Attock), 4469-1 (Hafizabad), 4512-3 (Mianwali), 4520-1 (D.G Khan), 4535-4 (Pakpattan), 4535-9 (Pakpattan)
Number of umbels per plant	>200	4443-10 (Haripur), 4448-1 (Attock), 4449-11 (Attock), 4454-5 (Chakwal), 4459-4 (Sheikhupura), 4460-1 (Farooqabad), 4464-16 (Khanewal), 4465-7 (Bahawalpur), 4470-18 (Muzaffarabad), 4508-2 (Khushab)
Days to flowering	90-110	4520-1 (D G Khan), 4535-4 (Pakpattan)
100-seed weight (gm)	>1	4520-1 (D G Khan), 4535-4 (Pakpattan), 4535-9 (Pakpattan), 4550-1 (Kohat)
Trigonella foenumgreacum		
Days to flowering	< 100	4535-1 (Pakpattan), 4439-8 (Rawalpindi), 4440-3 (Rawalpindi), 4441-8 (Haripur), 4444-3 (Attock), 4450-2 (Attock), 4454-8 (Chakwal), 4458-7 (Lahore), 4459-2 (Sheikhupura)
100-seed weight (gm)	>1	4535-1 (Pakpattan), 4441-8 (Haripur), 4444-3 (Attock), 4450-2 (Attock), 4454-8 (Chakwal), 4458-7 (Lahore), 4459-2 (Sheikhupura), 4463-16 (Multan), 4501-10 (Gujranwala)

Discussion

High variance for most of the characters revealed that improvement in radish could be achieved by exploiting local germplasm. Use of local germplasm for varietal development has been reported by various researchers in different crops (Ghafoor *et al*., 2003, Javaid *et al*., 2003; Lepse *et al*., 2002, Nisar *et al*., 2007, Yadav, 1999; Mukesh *et al*., 2003). Germplasm evaluated in this trial showed mixed response under the given climatic conditions. Some of the accessions performed very well, while others poorly. Major factor for poor performance may be the non – acclimatization of different genotypes. So there is a need of collaborative efforts to be made to evaluate the germplasm in favorable environments. It is also suggested to evaluate this germplasm for diseases, insect and pest susceptibility and fertilizer requirements. In this way we can evaluate the actual potential of the germplasm and provide exact information to the breeder to exploit the useful genetic potential for the evolution of new varieties.

One of the approaches for building gene pool is to collect material from diverse geographical origins from proposed centres of diversity in individual samples. Representative samples from the complete geographical range of the crop species can help to ensure conservation of co-adapted gene complexes (Ghafoor *et al*., 2003; Beuselinck & Steiner, 1992). Although vegetable are cultivated throughout the country but few collection missions have been conducted for germplasm collection and very little data is available on evaluation, especially indigenous landraces. One of the problem in vegetable crops is that in most of the cases these are harvested as green vegetables and few farmers grow vegetables for seed production. Further it is observed that seed of most of the vegetable crops is being imported from other countries and sometimes mixed by the enterprisers that cause genetic impurity that make biological tracking difficult. Further this situation leads a tremendous genetic erosion especially in vegetable crops. Although, germplasm collection from easily approachable areas is first priority due to threat of genetic erosion because advanced breeding material can adapt easily to the areas nearer to major towns (Bisht *et al*., 1999). But, to fetch maximum genetic diversity, it is important to make a comprehensive plan for expeditions to have maximum area explored, especially interior territories and valleys between high mountains where maximum genetic diversity exists.

Variances of heritable quantitative traits provide an estimate of genetic diversity within and between collecting sites that is expressed by phenotypic and genotypic diversity for various legumes including lentil (Erskine & Muehlbauer, 1991); soybean (Perry & Mcintosh, 1991), peas (Kumar & Raj, 1998; Amurrio, *et al*., 1993,1995), blackgram (Ghafoor *et al*., 2003) and cowpea (Coulibaly *et al*., 2002; Fall *et al*., 2003). The differences according to geographical regions shown by the analysis of quantitative traits is useful in substantiating the postulated regions of diversity or gene centres. Genetic diversity in the present study indicated the worth in examining the centre of genetic diversity in vegetable crops. Similarly it was observed that areas with greater environmental stresses represented high biodiversity even in the same vicinity as the case of Attock and TT Singh (radish), Sahiwal (turnip) and DG Khan (coriander), whereas in some areas low diversity might be associated with vegetable growing culture in this area.

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