cultivars/lines namely BG 369, BGM 481, GL 88341 and GMS 815 have been reported to possess resistance against *M. javanica* (Ali, 1997). These sources of resistance could be utilized in breeding programme for developing commercial varieties possessing resistance against root-knot nematode.

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Genetic Divergence for Physico-Chemical Characteristics of Lemon Fruits Grown in Himachal Pradesh

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Lemon (*Citrus limon* Burm.) is one of the important fruits of citrus family. In India, it is cultivated in Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Assam, West Bengal, Bihar, Rajathan, Orissa, Punjab and Himachal Pradesh (Singh, 1995; Mankand, 1994). Lemon trees are prolific bearers and have very high productivity as compared to other citrus fruits (Sharma *et al.*, 2001). One of the important characteristics of this fruit crop is that its fruits are available during December-February when the Kagzi lime is either not available or is rather scarce (Singh, 1995). Very little attention has been given to improve this fruit crop though it is almost at par with lime. A wide range of diversity in lemon germplasm exists in India which can form a basis for any crop improvement programme. Therefore, an attempt was made to evaluate the genetic diversity among 52 accessions collected from various lemon growing regions of Himachal Pradesh.

The experimental material consisted of 52 accessions of lemon collected from various lemon growing regions of HP such as Nurpur, Kangra, Una and Hamirpur. All the 52 accessions are planted in the experimental Orchard of Regional Horticultural Research Station, Jachh, (Nurpur) Distt. Kangra (HP) except one *i.e.* IL-1 (Italian lemon) which was procured from Kangra. All the accessions were evaluated for various physico-chemical characteristics of fruits harvested at their optimum maturity. The fruit length, diameter and flavedo thickness were measured using digital vernier calliper. Total soluble solids (TSS) were recorded by using hand refractometer and acidity of juice by the method detailed by Ranganna (1997). The juice was extracted through screw type juice extractor. The data on various physical and chemical fruit characteristics were analysed using Non-hierarchical Euclidean Cluster Analysis method (Beale, 1969; Spark, 1973).

Data presented in Table 1 show that the fruit weight of lemon ranged between 125-525 g with a mean weight of 332.71 g. The size parameters viz., fruit length varied between 9.00-13.50 cm (mean 11.27 cm) and fruit diameter varied between 5.27-9.68 cm (Mean 8.14 cm). The average flavedo thickness was observed to be 3.17 mm. The juice yield ranged between 16.0-51.2

Table 1. Mean, range, standard deviation and coefficient of variation for physico-chemical characteristics of lemon

Parameter	Mean	Range	Standard deviation	Coefficient of variation
Fruit weight (g)	332.71	125-525	88.10	26.48
Fruit length (cm)	11.27	9-13.5	1.36	12.07
Fruit dia (cm)	8.14	5.27-9.68	0.95	11.67
Total peel (%)	19.88	8.3.-42.8	6.91	34.76
Flavedo thickness (mm)	3.17	1.58-5.33	0.79	24.92
Juice (%)	31.29	16.0-51.2	7.64	24.42
Residue/Pomace(%)	48.95	25.0-64.9	9.51	19.43
No. of segments	9.92	8-12	1.22	12.30
No. of seeds	23.12	0-40	9.38	40.57
TSS of juices	8.10	7.1-9.5	0.65	8.02
Acidity of juice	5.43	4.9-5.9	0.33	6.08

* Total peel includes flavedo and albedo

Table 2. Distribution of 52 accessions and average inter- and intra- cluster distance in lemon on the basis of physico-chemical characteristics of fruits

Cluster	Distribution of 52 accessions		Average inter and intra cluster distance									
Number	No. of trees	Tree numbers	I	II	III	IV	V	VI	VII	VIII	IX	X
I	3	J-6/2, J-3/2, IL-I	2.101									
II	2	J-16/6. J-8/6	4.625	1.392								
III	4	J-15/4, J-7/6, J-9/3, J 10/3	2.963	6.122	1.392							
IV	6	J-8/2, J-8/1, J-15/6, J-11/1, J-4/4, J-15/1	3.865	4.824	4.376	2.148						
V	6	J-7/5, J-9/6, J-18/3, J-9/5, J-4/12, J-5/3	3.649	4.281	4.265	5.048	1.960					
VI	3	J-19/5, J-5/8, J-16/5	5.895	5.034	6.497	3.924	4.693	1.341				
VII	10	J-19/6, J-10/5, J-19/2, J-21/2, J-10/2, J-10/1, J-17/6, J-10/6,8/5,9/7	3.697	5.322	3.254	3.279	2.805	3.724	1.746			
VIII	10	J-3/5, J-12/7, J-2/1, J-17/8, J-2/6, J-19/4, J-7/6, J-3/2, J-20/2, J-13/5	4.512	5.636	4.357	2.385	4.404	3.676	2.361	1.746		
IX	3	J-8/3, J-4/6, J-20/6	4.305	4.027	5.395	5.728	2.275	5.608	4.337	5.269	0.978	
X	5	J-19/1, J-10/1, J-20/4, J-20/1, J-10/4	4.868	3.543	5.888	3.591	3.544	2.583	3.453	3.563	3.664	1.579

* Diagonal elements represent intra-cluster distances

Table 3. Cluster mean, standard deviation and coefficient of variability of 10 clusters in different characters and per cent contribution of different fruit characteristics towards diversity in lemon

Characters		Cluster number										% contribution towards
		I	II	III	IV	V	VI	VII	VIII	IX	X	diversity in lemon
Fruit weight (g)	Mean	225.33	360.00	181.25	334.17	275.00	450.00	312.50	405.00	300.00	420.00	
	SD	65.58	14.14	51.54	57.92	54.77	66.14	39.53	53.75	43.30	44.72	31.66
	CV	29.10	3.93	28.44	17.33	19.92	14.70	12.65	13.23	14.43	10.65	
Fruit length (cm)	Mean	10.30	10.50	8.88	11.92	10.67	13.33	10.74	12.30	10.67	12.10	
	SD	0.26	1.41	1.11	0.92	0.8	0.76	0.97	0.75	0.58	0.89	28.07
	CV	2.52	13.43	12.50	7.72	8.25	5.70	9.03	6.10	5.44	7.35	
Fruit diameter (cm)	Mean	6.62	8.49	6.49	8.59	7.74	9.13	8.10	8.65	7.61	8.91	
	SD	1.13	0.81	0.87	0.83	0.81	0.07	0.41	0.51	0.24	0.24	13.45
	CV	17.07	9.54	13.40	9.66	10.46	0.77	5.06	5.89	3.15	2.69	
Total peel (%)*	Mean	24.47	38.30	20.73	27.18	16.35	22.50	15.70	17.33	13.60	20.18	
	SD	5.93	6.36	5.90	7.72	4.91	3.12	4.76	1.72	3.12	1.71	8.32
	CV	24.23	16.60	28.46	28.40	30.03	13.87	30.32	9.92	22.94	8.47	
Flavedo thickness (mm)	Mean	2.96	3.24	2.35	4.01	2.47	3.99	3.12	2.95	2.64	4.14	
	SD	0.49	0.23	0.60	0.73	0.40	0.26	0.67	0.52	0.26	0.69	5.70
	CV	16.55	7.10	25.53	18.23	16.19	6.52	21.47	18.63	9.85	16.67	
Juice (%)	Mean	33.77	40.50	25.08	24.52	39.09	30.20	29.21	25.33	46.83	36.08	
	SD	6.50	0.71	2.15	4.97	3.50	0.53	4.58	4.04	4.09	3.88	4.42
	CV	18.17	1.75	8.57	20.30	8.95	1.75	15.68	15.95	8.73	10.75	
Residence/pomace (%)	Mean	34.67	31.75	54.00	48.13	44.40	47.07	55.89	57.08	39.40	43.52	
	SD	9.24	9.55	5.30	7.51	6.51	3.72	7.31	4.41	1.82	4.35	3.70
	CV	26.65	30.08	9.81	15.60	14.66	7.90	13.08	7.72	4.62	9.99	
Number of segments	Mean	10.33	11.00	10.25	11.17	8.67	8.33	8.90	10.60	10.67	10.20	
	SD	0.58	1.41	0.96	0.75	0.52	1.53	0.88	0.84	0.58	0.45	2.44
	CV	5.61	12.82	9.36	6.71	5.99	18.37	9.88	7.92	5.43	4.41	
Number of seeds	Mean	13.33	26.00	20.00	23.67	18.83	39.67	22.90	22.90	20.00	27.60	
	SD	13.50	2.83	14.58	6.89	9.79	3.06	6.52	8.29	3.61	8.73	1.09
	CV	101.27	10.88	72.9	29.11	51.99	7.71	28.47	36.20	18.05	31.63	
TSS of juice (°Brix)	Mean	7.67	9.15	7.57	7.57	8.77	8.20	7.87	7.64	9.43	8.68	
	SD	0.51	0.07	0.17	0.20	0.43	0.20	0.23	0.25	0.12	0.34	0.67
	CV	6.65	0.76	2.25	2.64	4.90	2.44	2.92	3.27	1.57	3.92	
Acidity of juice (%)	Mean	5.20	5.85	5.17	5.05	5.83	5.57	5.40	5.18	5.87	5.78	
	SD	0.20	0.07	0.10	0.14	0.16	0.06	0.19	0.23	0.06	0.11	0.48
	CV	3.85	1.96	1.97	2.77	2.74	1.08	3.52	4.44	1.02	1.90	

* Total peel includes flavedo and albedo

per cent of fruit weight. Total peel (%) (flavedo + albedo) and residue/pomace (%) varied between 8.3-42.8 per cent and 25.0 to 64.9 per cent, respectively. The number of segments and seeds ranged between 8–12 and 0-40, respectively. However, the juice characteristics viz., total soluble solids and titratable acidity varied between 7.1-9.5 °Brix and 4.9 to 5.9 per cent, respectively in all the 52 accessions of lemon studied.

The 52 accessions were grouped into 10 clusters (Table 2). The cluster VII and VIII had maximum number of 10 accessions in each and cluster II had minimum of 2 accessions. The intra and inter-cluster variations among different accessions under study was of varying magnitude (Table 2). The maximum intra-cluster distance was observed in cluster IV (D = 2.148), followed by I (D = 2.101), V (D = 1.960), VII and VIII (D = 1.746). These clusters consisted of 6, 3, 6, 10 and 10 accessions, respectively. The above grouping indicates existence of wide genetic divergence among constituent accessions. The minimum intra-cluster value (D = 0.978) exhibited by cluster IX containing 3 accessions indicated limited genetic diversity among the constituents. The inter-cluster distance indicated greater cluster divergence between clusters II and VI, followed by clusters II and III, I and VI, III and X. Thus, a due emphasis in the breeding programme should be given to four accessions of cluster II, three accessions each of clusters I and IV, two accessions of cluster II and five accessions of cluster X. The selection of divergent genotypes from above clusters would produce a broad spectrum of variability for various physical and chemical characteristics of lemon fruits and its juice. The hybrids developed from the selected accessions within the limits of compatibility of these clusters may produce high magnitude of heterosis or desirable transgressive segregants which would be rewarding in varietal improvement programme. There was a wide range of variation in the cluster mean values for all the characters under study (Table 3). The contribution of different attributes towards genetic divergence revealed that fruit weight contributed maximum divergence, followed by fruit length, fruit diameter, peal (%), flavedo thickness, juice (%), residue/ pomace (%), number of segregants, number fo seeds, TSS of the juice and acid content. Data presented in Table 3 revealed that cluster VI recorded maximum fruit weight, fruit size and number of seeds, which consisted of 3 genotypes viz. J-19/15, J-5/8, J-16/5. Similarly the accessions present in cluster IX (J-8/3, J-4/6, J-20/6) showed highest yield, TSS and acidity of juice. The possible promising donors may be picked out of these clusters for further improvement in lemon.

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