Genetic Divergence of Germplasm Accessions in Potato (*Solanum tuberosum* subsp. *tuberosum*)

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One hundred ninety five accessions of tuberosum group of potato were evaluated for nine distinct characters during three consecutive autumn crop seasons to assess the genetic divergence based on Non-hierarchical Euclidean distances for the identification of genetically diverse and agronomically superior accessions which may generate putative transgressive segregates on hybridization. Based on first five principle components, namely plant height, number of tubers, tuber yield, and number of stems and germination, which accounted for 97.67% of the variation, 195 potato accessions were grouped into 8 well distinct clusters. Geographical diversity was not related to genetic diversity. Twenty genetically diverse and agronomically promising genotypes were identified, which may be used in crossing programme to obtain segregates with commercially desirable attributes for development of potato varieties for sub-tropical plains of India.

Key Words: Potato, Germplasm accessions, Genetic divergence, Cluster distance

Introduction

Potato is a highly heterozygous crop and increase in its heterozygosity results in hybrid vigour (Tarn and Tai, 1977). Crosses involving genetically diverse parents are likely to produce high heterotic effects (Gopal and Minocha 1997, Luthra *et al*., 2005). Analysis of genetic diversity in germplasm collection facilitates reliable classification of accessions and identification of core accession with possible utility for specific requirements (Mohammadi and Prasanna, 2003). Multivariate analysis based on Mahalanobis D^2 statistics has limitations for classifying huge germplasms for several characters (Arunachalam, 1981). The use of Non- hierarchical Euclidean cluster analysis to overcome these limitations has been suggested by Beale (1969). In potato, limited information on genetic divergence is available (Pandey and Gupta, 1995; Kumar and Kang, 2000; Sandhu *et al*., 2001; Singh, *et al*., 2004; Luthra *et al*., 2005) for subtropical plains which account nearly 85-90% of total production of the country. For meeting the varietal requirement of such vast area, genetically diverse parents with high tuber yield as well as desirable tuber attributes are required for making desirable cross combinations to obtain superior progenies from segregates. Hence, the present investigation was conducted to determine genetic divergence and identify the genetically diverse and agronomically superior germplasm accessions for use as parent in developing potato varieties.

Materials and Methods

The experimental material comprising 195 potato germplasm accessions (*Solanum tuberosum* subsp. *tuberosum*) was grown in RBD with three replications during autumn crop seasons of 1999-2000, 2000-2001 and 2001-2002 at CPRI Campus Modipuram, Meerut (29°N and 76°E; 222 msl). Fifteen tubers of each accession in single row of 3m planted at inter- and intra-row spacing of 60 cm and 20 cm respectively, represented each replication. Recommended cultural practices were followed. The trial was harvested at 90 days after planting and the observations were recorded on five randomly selected plants on nine characters (Table 3). Mean values were used for principal component analysis and the principal component scores were used for Non-hierarchical Euclidean cluster analysis (Beale, 1969; Spark, 1973). Statistical package SPARI was used for these computations. The appropriate number of clusters to group 195 accessions was determined following the 'Sequential F-ratio tests' (Rao, 1952).

Results and Discussion

Significant differences were found among the genotypes for all the characters studied indicating the availability of considerable diversity in the germplasm accessions. The principal component analysis yielded 9 Eigen vectors and roots. The per cent variation explained by nine roots; 1 to 9 was 40.29, 33.64, 10.72, 8.12, 4.90, 1.48, 0.56, 0.22 and 0.08 respectively). Further, highest maximum Eigen root value (3.626) was obtained by Eigen vector 1, followed

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by 3.027, 0.965, 0.731, 0.441, 0.133, 0.050, 0.020 and 0.007, respectively for the rest of the vectors. The first five principal components calculated by using standard variables, accounted for 97.67% of total variation. The first component was measure of plant height, second number of tubers, third of tuber yield, fourth of number of stems and fifth of germination (%), as the coefficients associated with these traits have the largest magnitude. These results confirmed the earlier findings on plant height (Sandhu *et al.*, 2001; Singh *et al.*, 2004), tuber number (Kumar and Kang 2000), tuber yield (Sandhu *et al.*, 2001) with the deviation of ranking of stem number and germination contributing toward genetic divergence which may be attributed to the material used and environmental conditions.

The 195 potato accessions were grouped into 8 groups (I-VIII) based on similarity in traits. The highest number of accessions (52) fell in cluster VI, while minimum number (12) were observed in cluster I and III (Table 1). Average distance of cluster-means from cluster centroids (intra-cluster distance; Table 2) ranged from 1.306 (cluster VII) to 2.349 (cluster VIII). The genotypes of the same cluster had little divergence from each other with respect to aggregate effect of 9 characters examined. In general, genotypes of same origin fell in different clusters indicating thereby that geographical diversity is not related to genetic diversity. Pandey and Gupta (1995) also found that 52 potato genotypes did not follow their geographical distribution and 11 resultant clusters were heterogeneous with respect to genotypes and their place of origin. Therefore, geographical diversity of the material alone would not help in selection of genetically divergent parents. In the present study four Indian potato

Table 1. Distribution of 195 potato germplasm accessions on the basis of Non-hierachical Euclidean cluster analysis for 9 characters

Cluster No	Number of accessions	Accessions (CP numbers)
I	12	CP1242*, 1361 (Albion), 1386 (Earlaine), 1409 (Fruhmolle), 1418 (Maritta), 1424 (Pionier), 1436 (Urgenta), 1440 (BD1456c(1)), 1443 (BD237/43), 1582 (Tawa), 1586 (PI197932), 1632 (XD2)
II	27	CP1057*, 1151*, 1163*, 1207*, 1329*, 1338*, 1358 (Idaho), 1367 (B922-6), 1399 (Ari), 1401 (Barima), 1414 (Irene), 1431 (Rival), 1442 (2613b(11)), 1456 (Febricia), 1462 (Spatz), 1507 (3305(9)), 1515 (3392(1)), 1516 (3392(4)), 1524 (Roslin Sasumua), 1538 (M124-2), 1555 (Pimpernel x 1006-212), 1596 (B4808-19), 1633*, Kufri Anand, Kufri Bahar, Kufri Pukhraj, Kufri Sutlej
III	12	CP658*, 721*, 1340*, 1343 (Kardinal), 1362 (Ag14(X37)), 1365 (AG54-55(self)), 1395 (B3627-12), 1417 (Luctor), 1427 (Profijt), 1527 (2403a(1)), 1529 (2305a(10)), 1545 (Saskia)
IV	13	CP1123*, 1172*, 1225*, 1243*, 1353 (Croissement), 1379 (96-56), 1390 (B3620-1), 1421 (Pandora), 1455 (Drossel), 1466 (Konsagris), 1473 (Ulanpur), 1482 (B3352-8), 1607 (B5088-26)
V	31	CP1187*, 1213*, 1325*, 1339*, 1364 (AG29), 1374 (B3781-3), 1378 (B595-76), 1380 (B3139-24), 1385 (B929-23), 1400 (Avenir), 1403 (Bevelander), 1404 (Burmania), 1408 (Froma), 1425 (Perfect), 1428 (Record), 1453 (Amsel), 1460 (Schwalbe), 1470 (Jiiueca), 1480 (B927-3), 1487 (B3960-1), 1497 (2814a(1)), 1503 (3069(d)), 1513 (3339d(13)), 1518*, 1523 (Roslin Riviera), 1530 (2591k(3)), 1576 (PI222945), 1595 (B4808-8), 1598 (B4845-4), 1604 (B5052-7), 1616 (835a(4))
VI	52	CP1180*, 1181*, 1205*, 1218*, 1232*, 1235*, 1237*, 1275*, 1304*, 1317*, 1346 (Krirrinee), 1350 (Monak), 1355 (Rhode Island), 1373 (B35-7), 1383 (B3404-1), 1391 (B3172-13), 1392 (B3603-28), 1402 (Bea), 1415 (Kwinta), 1420 (Meerster), 1433 (Sientje), 1441 (BD-1456c(1)), 1444 (5050/23/1), 1445 (Anita), 1451 (Lori), 1457 (Fink), 1465 (Electra), 1472 (Kpaxunuper), 1474 (Duquesa), 1483 (B3556-12), 1485 (B3604-19), 1491 (BD3053-18), 1519*, 1546 (Sirtema), 1547 (Pentland Envoy), 1548 (2787e(22)), 1564 (B4829-7), 1588*, 1589 (Datura), 1590*, 1591*, 1592 (B4744-23), 1594 (B4795-3), 1597 (B4830-19), 1619*, 1626 (2070(59)), Kufri Ashoka
VII	33	CP1302*, 1308*, 1342 (Jara), 1344 (Kotnov), 1345 (Krasava), 1348 (Adina), 1352 (Blank), 1363 (AG-16(X143)), 1366 (B721-35), 1368 (B3428-20), 1382 (B3401-15), 1388 (B3626-13), 1398 (Ambassadeur), 1407 (Dore), 1412 (Herkol), 1413 (Ijesselster), 1429 (Regina), 1432 (Rode Eersteling), 1435 (Tendira), 1439*, 1448 (Elenita), 1449 (Capella), 1476 (Olalla), 1492 (VD2-21), 1539 (M136-6), 1544 (Asoka), 1566 (B4986-15), 1574 (B5132-3), 1602 (B5030-10), 1612 (Vendal)
VIII	15	CP1086*, 1175*, 1215*, 1231*, 1233*, 1310*, 1314*, 1316*, 1330*, 1351 (Walanga), 1375*, 1463 (Spika), 1475 (Goya), 1479 (B-751-119), 1615 (Craigs Royal)

Name in parenthesis are the original donor name; * Original donor name not available

Table 2. Average inter- and intra-cluster (bold) distances in potato germplasm accessions

Cluster number	I	II	III	IV	V	VI	VII	VIII
I	**2.205**	6.240	4.093	4.334	3.490	4.658	2.625	7.187
II		**2.047**	5.999	4.145	2.941	2.647	4.301	4.894
III			**1.659**	4.166	4.835	3.390	2.507	3.983
IV				**2.259**	2.979	3.177	3.193	5.295
V					**1.527**	2.683	2.521	5.881
VI						**1.547**	2.159	3.245
VII							**1.306**	4.631
VIII								2.349

Table 3. Cluster means for 9 characters in potato germplasm accessions

Characters	Cluster							
	I	II	III	IV	V	VI	VII	VIII
Germination (%)	96.03	97.72	96.80	86.60	95.99	98.24	97.83	99.00
Plant height (cm)	45.70	58.56	44.78	49.17	51.99	52.22	49.94	56.54
Stems/plants	3.18	3.65	4.42	3.66	3.14	4.17	3.94	5.24
Tuber yield (g/plant)	172.30	369.63	266.37	295.99	268.38	329.10	253.93	391.60
Number of tubers/plant	6.52	7.76	12.54	8.48	6.47	9.09	8.62	13.16
Average tuber weight (g)	27.16	48.89	22.34	35.77	42.61	36.97	29.79	30.38
Marketable tuber yield (g/plant)	146.88	348.33	217.72	270.11	248.61	300.51	223.63	349.65
Number of marketable tubers/plant	4.10	5.72	6.55	5.77	4.77	6.34	5.43	8.29
Marketable average tuber weight (g).	35.86	61.39	32.73	47.67	52.26	47.55	41.41	41.80

varieties namely Kufri Anand, Kufri Bahar, Kufri Pukhraj and Kufri Sutlej were grouped together in cluster II, though they were bred from parent of wide genetic base. This is because these varieties were developed with the main aim of high yield under similar agro-climatic conditions of sub-topical plains.

The maximum inter-cluster distance (7.18) was found between clusters I and VIII followed by cluster I and II (6.24), cluster II and III (5.99), cluster V and VIII (5.88), cluster IV and VIII (5.29) and cluster II and VIII (4.89). The minimum inter-cluster distance (2.50) was observed between cluster III and VII (Table 2). Superior potato accessions with highest mean values for germination (99%), number of stems (5.24), tuber yield (391.60 g/plant), number of tubers (13.16 tubers/plant), marketable tuber yield (349.650 g/plant) and number of marketable tubers (8.29 tubers/plant) fell into cluster VIII, while highest plant height (58.56 cm), average tuber weight (48.89 g) and marketable average tuber weight (61.39 g) converged to cluster II (Table 3).

The data on inter-cluster distances and mean performance of potato accessions were used to select genetically diverse and agronomically superior genotypes from 195 potato germplasm accessions. Cluster II and VIII contained genotypes which were better in respect of one or more characters and comparable with control in respect to other characters. Superior genotypes were, however, also selected from other clusters, which were widely separated from cluster II and VIII but had desirable traits. In all, 12 promising accessions were selected from cluster II (CP1207, 1329, 1367, 1515, 1538, 1555, 1596, 1633, Kufri Anand, Kufri Bahar, Kufri Pukhraj and Kufri Sutlej), one accession each from cluster III (CP1362) and cluster VI (CP1181); and 8 accessions from cluster VIII (CP1215, 1310, 1316, 1330, 1351, 1475, 1479, 1615) (Table 4). Use of these genotypes in potato breeding programme as multiple crossing among them may result in segregates with commercially desirable attributes for development of potato varieties for subtropical plains of India.

Table 4. Diverse and superior potato germplasm accessions and their tuber attributes

Genotype	Tuber Yield/plant	Number of tubers/plant	Average tuber weight (g)	Tuber characters (Skin colour, tuber shape, eye depth, flesh colour)
CP 1181	402.10**	10.59*	38.43	Yellow, oval, deep, cream
CP 1207	369.28**	5.86	64.58**	Yellow, oval, shallow, white
CP 1215	360.11**	18.85**	20.42	Yellow, round, medium, cream
CP 1310	414.77**	13.05**	31.51	White, oval, medium, light yellow
CP 1316	540.71**	15.68**	32.26	Yellow, oval, medium, yellow
CP 1329	397.43**	8.48	47.07**	Yellow, oval, shallow, cream
CP 1330	442.27**	12.45**	35.52	White, round, medium, yellow
CP 1351	424.94**	12.92**	33.14	White, oval, medium, white
CP 1362	277.58	19.21**	14.38	White, oval, shallow, cream
CP 1367	390.25**	8.20	46.60**	White, oval, shallow, white
CP 1475	386.52**	14.39**	27.48	White, oval, medium, cream
CP 1479	366.68**	14.21**	25.72	Yellow, oval, shallow, white
CP 1515	456.48**	10.31*	49.98**	White, oval, shallow, white
CP 1538	476.49**	10.27*	49.01**	White, oval, shallow, white
CP 1555	372.35**	7.78	46.62**	Yellow, oval, shallow, white
CP 1596	402.41**	8.85	45.77*	Yellow, oval, medium, light yellow
CP 1615	414.37**	11.16**	36.41	Yellow, oval, medium, yellow
CP 1633	342.17	7.12	52.23**	White, oval, shallow, light yellow
Kufri Anand	431.11**	10.24*	42.09	White, long- oval flattened, fleet, white
Kufri Bahar	389.72**	8.08	51.88**	White, oval, medium, white
Kufri Pukhraj	448.92**	8.55	49.11**	Light yellow, oval, shallow, yellow
Kufri Sutlej	414.20**	7.38	56.38**	White, oval, fleet, white
Mean	300.96	8.74	36.17	
CD at 5%	41.78	1.45	7.41	
CD at %	54.92	1.90	9.73	

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