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RESEARCH ARTICLE

Genetic divergence studies in pumpkin (*Cucucrbita* spp.)

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SUMMARY

A study on genetic divergence was carried out on nineteen growth, earliness, yield and quality traits in fifty seven genotypes of pumpkin (*Cucurbita* spp.) These fifty seven genotypes were grouped into fifteen clusters. Yield per vine contributed maximum to total genetic diversity followed by leaf size, cavity size, carotene content, number of seeds per fruit and hundred seed weight. Intra-cluster distance was maximum among cluster XIV, I, XIII and XII. Maximum Inter-cluster divergence was observed between clusters X and XIV followed by cluster XI and XIV, cluster XIV and XV and cluster IV and XIV. Cluster XV recorded highest mean values for yield per vine, number of seeds per fruit, fruit length, average fruit weight and least mean value for days to first female flower, cluster XIV recorded highest mean value for leaf size, cluster XIII recorded highest mean values for fruit number, carotene content, TSS and least mean value for cavity size, cluster VIII recorded maximum mean values for hundred seed weight, flesh thickness and fruit circumference, cluster IV noticed least mean values for days to first harvest and nodes upto first female flower.

Key Words : Earliness, Genotypes, Genetic divergence, Carotene content, TSS, Flesh thickness

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Pumpkin (*Cucurbita* spp.) is an important cucurbitaceous vegetable, grown under wide range of agro- climatic conditions all over the world. High productivity, low cost of production, good storability, long period of availability, better transport qualities, excellent response to forcing and comparatively high content of carotene (a precursor of vitamin A) in fruits, have enhanced the importance of this crop. Genetic diversity has been considered as a pre-requisite for obtaining high yielding progenies through hybridisation. For getting high heterosis or for recovering transgressive segregants, parents chosen for hybridisation need to be genetically diverse or distant. The cultivars from widely separated localities have been usually included in the hybridisation programme, presuming the presence of genetic divergence and maximum likelihood of recovering promising segregants. As per expectations, in practice, this has not yielded very satisfactory and consistent results. Eco-geographical diversity has been regarded as a reasonable index of genetic diversity (Vavilov, 1926). However, it was reported later that, there does not exist any parallelism between geographic distribution and genetic diversity (Peter, 1975 in tomato). To arrange the diversity in the germplasm the D^2 statistics is the useful tool which measures the degree of diversification of genotypes and also determines the relative contribution of each component character to the total divergence. Hence, the available 57 pumpkin genotypes were subjected to D^2 to know the diversity in the germplasm for further use in breeding programme.

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MATERIALS AND METHODS

The present investigation comprised of fifty seven genotypes of pumpkin laid out in a randomised block design with two replications during the year 2009-10 with row to row distance of 2 m and plant to plant distance of 0.9 m. The

recommended agronomic and plant protection measures were adopted in raising good crop. Observations for nineteen growth, earliness, yield and quality parameters were recorded on three plants of each genotype in each replication. Mahalanobis (1936) D^2 statistics was used for assessing the genetic divergence between populations. The original correlated unstandardized character mean values were transformed into standardised uncorrelated values to simplify the computational procedure. The D^2 values were obtained as the sum of squares of the differences between the pairs of corresponding uncorrelated values of any two genotypes (Rao, 1952). Using all D^2 values, the genotypes were grouped into clusters using Tocher's method as described by Rao (1952). The intra- and inter-cluster distances were calculated by the formula given by Singh and Chaudhary (1979).

RESULTS AND DISCUSSION

D^2 analysis revealed the presence of considerable diversity among 57 genotypes of pumpkin, which ranged from 1237.60 to 21419.19. These 57 genotypes were grouped into 15 clusters based on similarity of D^2 values (Table 1). Cluster-I was the largest including 28 entries, of which 27 genotypes were developed in K.R.C. College of Horticulture, Arabhavi, one genotype was a local collection from Belgaum (Karnataka). Cluster XIV included 4 genotypes developed in K.R.C.College of Horticulture, Arabhavi. The remaining clusters were II (KP-4, KP-30), III (KP-44, KP-14), IV (KP-20, KP-37), V (KP-5, KP-18), VI (KP-31, KP-39), VII (KP-2, KP-13), VIII (KP-26, KP-19), IX (KP-41, KP-42), X (KP-43, KP-22), XI (KP-50, KP-6), XII (KP-1, KP-48), XIII (Arka Chandan and Arka Suryamukhi from IIHR, Bangalore) and XV (KP-32).

The clusters have been formed based on the contribution of different characters to the divergence. Among these characters yield per vine contributed maximum (27.07%) to total genetic diversity followed by leaf size (21.18%), fruit cavity size (13.66%), carotene content of fruit (11.03%), number of seeds per fruit (9.77%) and hundred seed weight (6.64%). However, days to first harvest (0.065%) and number of primary branches (0.188%) have meagerly contributed to the diversity. While, days to first male flower and number of leaves per vine had zero contribution to the total genetic diversity (Table 2).

Intra-cluster distances (Table 3) revealed, cluster XIV with four genotypes shared maximum intra-cluster distance (D^2=8728.562) followed by cluster I (D^2=4387.958) with 28 genotypes, cluster XIII (D^2=2478.250), cluster XII (D^2=2419.262), cluster XI (D^2=1976.517), cluster X (D^2=1750.989), cluster IX (D^2=1706.883), cluster VIII (D^2=1172.486), cluster VI (D^2=1063.399), cluster VI (D^2=900.857), cluster V (D^2=890.024), cluster IV (D^2=765.015), cluster III (D^2=718.083) and cluster II (D^2=654.418) with 2 genotypes each. However, present study showed that there is comparatively high intra-cluster distance among cluster XIV, I, XIII and XII indicating the presence of sufficient amount of diversity with genotypes of respective clusters. So there is scope for selection within the clusters.

Based on distance between clusters, *i.e.* inter-cluster distance (Table 3) the maximum divergence was observed between clusters X and XIV (D^2=21419.190) followed by cluster XI and XIV (D^2=20435.680), cluster XIV and XV (D^2=18427.63), cluster IV and XIV (D^2=16844.050), cluster XIII and XV (D^2=16754.88), cluster XIII and XIV (D^2=15317.150), cluster II and XIV (D^2=15070.770), cluster VIII and XIII (D^2=14666.66), cluster XI and XIII (D^2=12652.570), cluster XIV and I (D^2=12525.620), cluster XII and XIV (D^2= 12419.070), cluster IV and VIII (D^2=12244.060), cluster III and XV (D^2=12170.640), cluster VI and XIII (D^2=11722.770), cluster III and XI (D^2=11312.580),cluster III and X (D^2=10680.150), cluster X and XIII (D^2=10441.7), cluster IX and XIII (D^2= 104 10.010), cluster IV and VI (D^2=10264.930) and cluster IV and XV (D^2=10113.89). While, statistical distance was least between cluster VI and IX (D^2=1237.599). Hence, inclusion of genotypes from highly diverse clusters in hybridization programme could results into highly heterotic hybrids.

The mean values of 19 characters for 15 clusters are summarized in Table 4. For yield per vine, the highest cluster mean was observed in cluster XV followed by VIII, IX and VII. For leaf size, the higher cluster means recorded in cluster XIV followed by VI, VIII and V. For fruit cavity size, the least cluster mean was recorded in cluster XIII followed by IV and III. For carotene content of fruit, the highest cluster mean was observed in cluster XIII followed by XIV, XII, XV and IX. For number of seeds per fruits, the highest cluster means was observed in cluster XV followed by VII, IV, IX and X. For hundred seed weight, the highest cluster means was observed in cluster VIII followed by XV, IX, VI and V. For fruit flesh thickness, highest mean values was observed in cluster VIII followed by VII, IV and XI. For days to first female flower, the least cluster mean was obtained in cluster XV followed by XIII, VIII and V. For node of first female flower, least cluster mean was observed in cluster IV followed by IX, VIII, XV and I. For days to first harvest least cluster mean was observed in cluster IV followed by IX and XIII. For circumference of fruit, higher mean was observed in cluster VIII followed by XI, XV and XIV. For length of fruit cluster mean was highest in cluster XV, followed by VI and X. For average fruit weight, highest mean values was observed in cluster XV (6.03 kg) followed by VIII and XI. For number fruits per vine, highest mean values was observed in cluster XIII (3.247) followed by III and IX. For total soluble solids of fruit, highest mean value was observed in cluster XIII followed by VIII, XIV and XV. Hence, employment of hybridization programme between genotypes of respective clusters could be attempted for successful crop improvement.

Table 1: Clustering pattern of 57 genotypes of pumpkin (*Cucurbita* spp.) based on D^2 values

Cluster number	Number of genotypes	Genotypes included
I	28	KP-33, KP-8, KP-12, KP-35, KP-9, KP-7, KP-46, KP-36, KP-16, KP-45, KP-27, KP-53, KP-52, KP-11, KP-40, KP-34, KP-10, KP-17, KP-24, KP-54, KP-28, KP-23, KP-47, KP-21, KP-51, KP-49, KP-15, Belgaum Local.
II	2	KP-4, KP-30.
III	2	KP-44, KP-14.
IV	2	KP-20, KP-37.
V	2	KP-5, KP-18.
VI	2	KP-31, KP-39.
VII	2	KP-2, KP-13.
VIII	2	KP-26, KP-19.
IX	2	KP-41, KP-42.
X	2	KP-43, KP-22.
XI	2	KP-50, KP-6.
XII	2	KP-1, KP-48.
XIII	2	Arka Chandan, Arka Suryamukhi.
XIV	4	KP-3, KP-29, KP-25, KP-38.
XV	1	KP-32.

Table 2: Relative per cent contribution of different characters to the total divergence in pumpkin (*Cucurbita* spp.)

Sr. No.	Character	No. of times ranked first	Per cent contribution
1.	Vine length(m)	4	0.25
2.	Number of primary branches per vine	3	0.18
3.	Number of leaves per vine	0	0
4.	Leaf size (cm^2)	338	21.18
5.	Days to first male flowering	0	0
6.	Days to first female flowering	6	0.37
7.	Node of first female flowering	8	0.50
8.	Days to first harvest	1	0.063
9.	Circumference of fruit (cm)	14	0.88
10.	Length of fruit (cm)	36	2.25
11.	Average fruit weight(kg)	57	3.57
12.	Number of fruits per vine	19	1.19
13	Fruit flesh thickness(cm)	10	0.63
14.	Fruit cavity size(cm^2)	218	13.66
15.	Number of seeds per fruit	156	9.77
16.	Hundred seed weight(g)	106	6.64
17.	TSS (^{0}brix)	12	0.75
18.	β-Carotene content of fruit(µg/100g)	176	11.03
19.	Yield per vine(kg)	432	27.07
Total		1596	100

Table 3: Average intra- and inter-cluster D^2 values along with their 'D' values (in parenthesis) of 15 clusters for 19 characters formed by 57 genotypes of pumpkin (*Cucurbita* spp.)

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I	4387.958	3207.007	5019.617	4245.555	4888.883	5728.581	3611.542	7226.95	5315.11	5600.815	6694.41	3163.286	6616.251	12525.62	7675.024
	(66.242)	(56.63)	(70.849)	(65.158)	(69.921)	(75.687)	(60.096)	(85.011)	(72.905)	(74.839)	(81.819)	(56.243)	(81.34)	(111.918)	(87.607)
II		654.418	5084.894	1306.64	6024.993	7616.532	3657.057	9058.049	7031.423	2911.145	5209.09	1647.394	4149.272	15070.77	7264.252
		(25.582)	(71.308)	(36.147)	(77.621)	(87.273)	(60.474)	(95.174)	(83.854)	(53.955)	(72.174)	(40.588)	(64.415)	(122.763)	(85.231)
III			718.083	6628.337	1683.911	3668.903	2530.906	7481.719	3839.859	10680.15	11312.58	4247.023	5261.297	6142.294	12170.64
			(26.797)	(81.415)	(41.035)	(60.571)	(50.308)	(86.497)	(61.967)	(103.345)	(106.361)	(65.169)	(72.535)	(78.373)	(110.321)
IV				765.015	8019.705	10264.93	5138.807	12244.06	9062.644	4840.892	7825.178	2654.365	3583.901	16844.05	10113.89
				(27.659)	(89.553)	(101.316)	(71.685)	(110.653)	(95.198)	(69.577)	(88.46)	(51.521)	(59.866)	(129.785)	(100.568)
V					890.024	1927.333	2383.072	4285.584	1765.141	9919.071	9509.627	4767.602	7658.167	6056.479	9831.021
					(29.833)	(43.901)	(48.817)	(65.464)	(42.014)	(99.595)	(97.517)	(69.048)	(87.511)	(77.823)	(99.152)
VI						900.857	2324.253	1941.053	1237.599	9491.778	7844.405	5207.235	11722.77	6431.74	6664.629
						(30.014)	(48.211)	(44.057)	(35.180)	(97.426)	(88.569)	(72.161)	(108.272)	(80.198)	(81.637)
VII							1063.399	3680.694	2319.366	7153.198	7331.382	2775.078	6555.618	7009.233	7149.616
							(32.610)	(60.669)	(48.160)	(84.577)	(85.623)	(52.679)	(80.967)	(83.721)	(84.555)
VIII								1172.486	2199.625	9185.871	6027.123	6747.931	14666.66	9838.372	5330.632
								(34.242)	(46.900)	(95.843)	(77.635)	(82.146)	(121.106)	(99.189)	(73.011)
IX									1706.883	9083.029	7856.593	5326.334	10410.01	7056.277	6772.183
									(41.314)	(95.305)	(88.637)	(72.982)	(102.029)	(84.002)	(82.293)
X										1750.989	2579.402	3880.55	10441.7	21419.19	4456.858
										(41.845)	(50.788)	(62.294)	(102.185)	(146.353)	(66.76)
XI											1976.317	4698.617	12652.57	20435.68	4334.587
											(44.458)	(68.546)	(112.484)	(142.953)	(65.838)
XII												2419.262	4880.785	12419.07	6829.606
												(49.186)	(69.863)	(111.441)	(82.641)
XIII													2478.247	15317.15	16754.88
													(49.782)	(123.762)	(129.441)
XIV														8728.562	18427.6
														(93.427)	(135.748)
XV															0.000
															(0.000)

Bold diagonal indicates the intra cluster distance

Table 4: The mean values of 19 characters for 15 clusters formed by 57 genotypes in pumpkin (*Cucurbita* spp.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I	4.917	4.442	85.062	584.209	49.711	48.610	15.550	83.096	64.191	24.616	3.884	2.175	3.297	186.163	376.981	9.537	3.485	47.748	8.128
II	5.097	3.330	93.230	480.415	49.995	50.830	16.580	84.413	66.497	18.163	3.608	2.162	3.115	150.120	380.995	8.778	2.665	46.930	7.434
III	5.358	3.648	105.080	729.415	49.413	50.498	18.248	86.330	55.800	24.165	2.972	2.747	2.652	119.247	309.495	6.535	3.330	47.908	7.937
IV	4.262	4.580	81.330	455.495	47.748	47.995	13.663	79.247	68.413	18.830	3.497	1.413	3.813	118.665	454.663	8.157	3.162	47.305	4.939
V	4.975	3.412	94.327	756.747	50.163	47.748	16.245	83.083	57.748	25.665	2.995	2.162	3.207	184.663	277.997	10.500	3.497	46.583	6.364
VI	5.475	5.495	109.165	806.080	49.413	49.913	16.495	84.665	65.333	32.748	4.938	1.912	4.155	271.497	379.330	10.670	2.580	47.780	9.459
VII	5.778	5.162	93.577	718.747	50.080	49.913	17.830	85.583	69.497	19.748	4.517	2.247	3.670	200.497	474.497	9.753	3.415	49.862	10.103
VIII	6.082	5.330	110.163	798.412	49.580	47.748	15.330	82.495	72.580	26.330	5.235	1.997	4.305	393.165	433.580	11.885	4.077	49.522	10.347
IX	5.615	4.330	108.833	768.162	49.580	48.413	13.915	80.915	57.330	31.248	3.885	2.665	3.572	266.665	454.662	10.753	3.580	50.840	10.124
X	4.778	5.165	96.330	414.997	49.998	51.163	18.830	88.165	64.747	32.217	4.342	1.495	3.142	282.165	450.247	9.615	3.330	42.055	6.473
XI	4.677	4.830	92.580	534.995	48.330	47.995	17.413	84.413	72.415	31.663	5.037	1.247	3.810	419.745	385.665	9.105	2.580	43.855	6.198
XII	4.33	5.577	88.000	561.745	50.580	49.830	16.995	85.245	69.665	21.833	4.390	1.497	3.805	208.747	349.162	8.805	2.915	51.550	6.246
XIII	5.275	5.662	90.915	529.247	47.330	47.748	16.330	81.247	50.540	11.048	1.357	3.247	3.420	71.413	279.165	6.028	4.582	64.183	3.857
XIV	5.634	5.080	116.165	911.122	49.996	49.788	16.911	85.914	71.330	22.248	4.364	2.039	3.514	166.330	409.164	9.262	4.037	51.804	9.025
XV	7.175	7.665	177.995	496.665	49.165	46.660	15.495	82.830	71.995	34.160	6.030	2.495	3.765	361.665	517.160	10.975	4.000	51.350	15.022

1.Vine length (m), 2. Number of primary branches per vine, 3. Number of leaves per vine, 4. Leaf size (cm^2), 5. Days to first male flowering, 6. Days to first female flowering , 7. Nodes upto first female flowering, 8. Days to first harvest, 9. Circumference of fruit (cm), 10. Length of fruit (cm), 11. Average fruit weight (kg), 12. Number of fruits per vine, 13. Fruit flesh thickness (cm), 14. Fruit cavity size (cm^2), 15. Number of seeds per fruit 16. Hundred seed weight (g), 17. TSS (^{0}brix), 18. β-Carotene content of fruit (µg/100), 19. Yield per vine (kg)

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