



## Assessment of genetic divergence in pumpkin (*Cucurbita moschata*)

POOJA<sup>1\*</sup> and S K MAURYA<sup>2</sup>

G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145, India

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### ABSTRACT

Pumpkin (*Cucurbita moschata* L.) is one of the most important Cucurbitaceous crops having a huge potential of nutritional security and has vast diversity in Indian condition. Forty diverse genotypes of pumpkin were evaluated for phenotypical variations and assessment of genetic diversity, at G B Pant University of Agriculture and Technology Pantnagar during spring-summer of 2018 and 2019. The experiment was laid out in Randomized Block Design (RBD) with three replications. The data was subjected to Principal Component Analysis, where a total of 8 components were identified. First four components account for about 60.26% and 60.33% cumulative effects during first and second season, respectively. During first year the Eigen root of the first principal component caused 20.24% variation of total variation while, during second year the Eigen root of first principal component accounted 25.58% variation of total variation. A relative positive weight by each of the component to each single trait indicated that there was great scope for improvement in these traits through selection. Presence of sufficient phenotypic and genotypic diversity showed the scope in pumpkin crop for further improvement.

**Keywords:** Genetic diversity, Improvement, PCA, Phenotypic variations, Pumpkin

Pumpkin (*Cucurbita moschata* L.) is an annual, monoecious, climbing vine belonging to family Cucurbitaceae. It is a natural amphidiploid ( $2n=40$ ) and a cross pollinated species grown and consumed in many tropical and sub-tropical countries around the world (Juna *et al.* 2006) and is believed to have originated in Central America (Stuart 2004). As per National Horticultural Board, pumpkin occupies 78,000 ha area and 1714,000 MT production in India during 2017–18 (Anonymous 2017, 2018). A number of varieties and hybrids have been developed both by public and private sector, which becomes absolute and low productive in due course of time, therefore, evaluation of new germplasm/genotypes/lines has become a continuous process to overcome new environmental and biotic challenges. Neglected germplasm of the pumpkin possesses various agronomic and horticultural characteristics of interest such as high yield, good amount of carotene content, seed oil content, low male female sex ratio etc. and utilization of these germplasm resources in crop improvement may provide a scope to harness the potentiality of the crop. Diverse genotypes further can be utilized to create heterotic pool and for development of transgressive segregants (Maurya *et al.* 2009).

Genetic improvement of any crop is largely depending on the magnitude of several genetic parameters on which the breeding methods are formulated for its further improvement. Testing morphological diversity is the easiest and quickest way to check variability present between different genotypes for constitution of heterotic pool. Principal component analysis is one of the crucial and widely used methods of the true Eigen vector-based multivariate analysis for measuring genetic diversity in precise manner. The first principal component contributes to maximum possible variation in the data and each succeeding component accounts for as much of the remaining variability as possible (Singh and Narayanan 2013).

Pumpkin has huge potential and vast diversity in Indian condition, particularly in fruit shape, size and yield traits. Therefore, present experiment was conducted with objective to study the morphological diversity supported by principal component analysis to analyze genetic diversity among the 40 genotypes of pumpkin, and to screen out superior genotypes for further improvement.

### MATERIALS AND METHODS

The experiment was executed during spring-summer of 2018 and 2019 consecutively, at Vegetable Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. Forty diverse genotypes of pumpkin (including two checks) were collected from different parts of the tarai region. Two standard check varieties Pusa Biswas and Pusa Vikas were obtained from IARI, New Delhi. The experiment was laid out in Randomized Block

<sup>1</sup> Department of Animal Husbandry, Pashulok, Rishikesh, Dehradun, Uttarakhand; <sup>2</sup>G B Pant University of Agriculture and Technology Pantnagar, Uttarakhand.\*Corresponding author email: poojaarya53@gmail.com

Design (RBD) with three replications. The crop was raised adopting all standard agronomical practices. Each genotype had 5 plants to evaluate and spaced at 3 m distance between the channels/rows and 1 m spacing plant to plant was maintained by thinning. Observations were recorded timely and appropriately on 24 horticultural traits, viz. main vine length (m), diameter of main vine (cm), nodes to female flower, days to first female flower, male female flower ratio, days to first harvest, number of harvests, pedicle length, fruit set per cent, average fruit weight (kg), fruits per vine, seeds per fruit, circumference (cm), fruit diameter (cm), flesh thickness (cm), central cavity (cm), Test weight (g), Total soluble solids ( $^{\circ}$ brix), reducing sugars (g/100g), non-reducing sugars (g/100g), ascorbic acid (mg/100g), carotenoid content (mg/100g), carbohydrate content (g/100g) and yield per plant (kg). Statistical analysis of principal component was done using software of INDOSTAT.

### RESULTS AND DISCUSSION

Extended phenotypic diversity was observed among the pumpkin genotypes during the study, which is presented in Table 1 and Fig 1. The phenotypical variations were most apparent in plant and fruit characteristics, such as plant length, fruit shape, size, color etc. Few genotypes were small (<15 cm diameter) and medium fruited (15–30 cm) while some produced very large fruits (>30 cm). The diameter of fruit ranged from 12.22–31.31 cm and 11.47–28.39 cm during first and second season respectively. Category of fruit shape varied from round flat, spherical, oblong to even club shaped. Different colors of fruit surface at immature stage were reported as cream, light green, medium green to dark green fruits. Similarly, fruit flesh color at ripening was categorized as creamy white, yellowish orange, orange

and dark orange. Ridges/groves on fruit surface were either present or absent. The variations were also seen in least noticed traits, such as pedicle length and type of calyx. Medium (5–10 cm) to short (<5 cm) length of pedicle was noticed during the study ranging from 3.00–7.23 cm and 3.19–7.14 cm during first and second season respectively. It was observed that calyx of the female flower was broad and leafy in some genotypes while in other it was just a linear leaf or small leaf at only apex portion. Leaf silvering pattern also varied and all genotypes of pumpkin did not have silvered leaf. Ahmed *et al.* (2011) has also observed sufficient morphological diversity in pumpkin during their study. This vast range for different traits indicates presence of sufficient variability which provides opportunity for further genetic improvement of pumpkin crop.

Evaluation of principal components based on 24 quantitative and qualitative characters for first and second season, (Table 2) clearly explains the genetic diversity among 40 genotypes of pumpkin. The first principal component showed high positive weight to per cent fruit set per plant (0.324), circumference (0.323) and average fruit weight (0.295), while yield per plant (0.382), test weight (0.335), circumference (0.257) had the biggest contribution to the PC II. During first season as per the values, Eigen root was calculated as 4.85 for the first principal component followed by 3.80 for the second component, 3.38 for the third principal component, 2.41, 2.13, 1.32, 1.12, and 0.8 for the fourth, fifth, sixth, seventh and eight components respectively. In the eighth component, value of Eigen fell lower than one. The factors with Eigen values less than 1 were ignored as it is minor component and does not contribute much to the variation in the population. The factors with Eigen values less than 1 were ignored by



Fig 1 Variation in fruit shape (Round flat, Spherical, Heart shape, Oval, Elongated, Club shaped)

Table 1 Morphological characters of 40 pumpkin genotypes

Genotype	Fruit colour at green stage	Fruit flesh colour at ripening stage	Fruit shape	Ridges availability (Surface groves)	Pedicle length	Type of calyx	Leaf silvering pattern	Fruit size	Length of main vine
PPU-1	Medium green	Yellow Orange	Spherical	Present	Short	Linear	Present	Medium	Long
PPU-2	Medium green	Orange	Spherical	Present	Medium	Broad leafy	Absent	Medium	Medium
PPU-3	Dark green	Dark range	Heart shaped	Present	Medium	Broad leafy	Present	Medium	Long
PPU-4	Medium green	Orange	Spherical	Present	Medium	Linear	Present	Medium	Medium
PPU-5	Cream	Creamy White	Elongated	Present	Short	Leafy at tip	Present	Medium	Long
PPU-6	Medium green	Orange	Spherical	Present	Short	Broad leafy	Present	Medium	Medium
PPU-7	Light green	Yellow Orange	Spherical	A	Short	Leafy at tip	Absent	Medium	Medium
PPU-8	Medium green	Orange	Round Flat	Present	Short	Linear	Present	Medium	Medium
PPU-9	Medium green	Orange	Spherical	Present	Short	Linear	Absent	Medium	Long
PPU-10	Medium green	Orange	Spherical	Present	Short	Broad leafy	Present	Medium	Medium
PPU-11	Medium green	Dark orange	Club shaped	Present	Short	Linear	Present	Small	Medium
PPU-12	Dark green	Orange	Spherical	Present	Short	Linear	Present	Medium	Long
PPU-13	Dark green	Yellow Orange	Spherical	Present	Medium	Broad leafy	Present	Medium	Medium
PPU-14	Medium green	Dark orange	Round Flat	Present	Short	Broad leafy	Present	Medium	Long
PPU-15	Medium green	Yellow Orange	Spherical	Present	Short	Leafy at tip	Present	Medium	Long
PPU-16	Cream	Yellow Orange	Round flat	Present	Short	Broad leafy	Present	Medium	Long
PPU-17	Medium green	Yellow Orange	Oval	Present	Short	Leafy at tip	Absent	Small	Medium
PPU-18	Medium green	Yellow Orange	Spherical	Present	Short	Leafy at tip	Present	Medium	Small
PPU-19	Cream	Orange	Spherical	Present	Medium	Leafy at tip	Absent	Medium	Long
PPU-20	Cream	Orange	Spherical	Present	Short	Leafy at tip	Present	Small	Small
PPU-21	Cream	Yellow	Oval	Present	Short	Linear	Present	Small	Medium
PPU-22	Medium green	Orange	Spherical	Present	Short	Linear	Present	Medium	Long
PPU-23	Cream	Yellow Orange	Round Flat	Smooth	Medium	Linear	Present	Medium	Long
PPU-24	Medium green	Dark orange	Spherical	Present	Medium	Leafy at tip	Present	Medium	Long
PPU-25	Medium green	Creamy White	Round Flat	Present	Short	Leafy	Present	Large	Medium
PPU-26	Medium green	Orange	Spherical	Present	Short	Broad leafy	Present	Medium	Medium
PPU-27	Cream	Yellow Orange	Oval	Present	Medium	Leafy	Present	Large	Long

Contd.

Table 1. (Concluded)

Genotype	Fruit colour at green stage	Fruit flesh colour at ripening stage	Fruit shape	Ridges availability (Surface grooves)	Pedicle length	Type of calyx	Leaf silvering pattern	Fruit size	Length of main vine
PPU-28	Dark green	Yellow Orange	Spherical	Present	Short	Leafy	absent	Large	Long
PPU-29	Medium green	Yellow Orange	Spherical	Present	Short	Leafy at the tip	Present	Small	Small
PPU-30	Medium green	Orange	Spherical	Present	Medium	Broad leafy	Present	Small	Small
PPU-31	Dark green	Dark orange	Oval	Present	Short	Leafy	Present	Small	Medium
PPU-32	Medium green	Orange	Spherical	Present	Short	Leafy	Present	Large	Medium
PPU-33	Medium Green	Yellow Orange	Spherical	Present	Medium	Leafy at tip	Present	Small	Long
PPU-34	Medium green	Orange	Round Flat	Present	Short	Leafy	Present	Medium	Medium
PPU-35	Medium green	Yellow Orange	Spherical	Present	Medium	Leafy	Present	Small	Small
PPU-36	Medium green	Orange	Spherical	Present	Short	Broad leafy	Present	Small	Medium
PPU-37	Cream	Creamy White	Oval	Smooth	Short	Leafy	Present	Small	Medium
PPU-38	Medium green	Yellow Orange	Spherical	Present	Short	Leafy	Present	Small	Long
Pusa-Vikas	Medium green	Orange	Spherical	Present	Short	Leafy at tip	Present	Large	Medium
Pusa-Biswas	Light green	Yellow Orange	Oval	Present	Short	Leafy at tip	Present	Large	Small

following “Guttman's lower bound Principal” (Kaiser, 1958). The Eigen root of the first principal component indicate 20.24% variation of total variation, followed by 15.86% variation of second component. First four component account for about 60.26% cumulative effect.

Similarly, during second season the first principal component had high positive weight to central cavity (0.339), length of main vine (0.325), male female flower ratio (0.295) and the second principal component had high positive weight to reducing sugars (0.382), days to first female flower (0.341), test weight (0.310) and carbohydrates (0.308). As per the values, Eigen root calculated as 6.14 for the first principal component was followed by 4.04 for the second principal component, 2.35 for third principal component, 1.93 for fourth principal component and 1.78, 1.41, 1.10 and 0.92 for fifth, sixth, seventh and eighth principal components respectively. The Eigen root of first principal component observed approximately 25.58% variation of total variation, followed by 16.86% variation in second principal component and total variation. Value of Eigen was lower than one after the seventh component. The principal component analysis further revealed that first four components accounted for more than 60.33% cumulative effect of total variation present in the population. Similar work has been reported by Singh *et al.* (2008) in ridge gourd. Verma *et al.* (2017) had also observed approximately 83.23%

variation by the first five principal components suggesting a considerable diversity present among the characters and rest of the component were not considered due to low contribution to the variation in pointed gourd. Debata *et al.* (2017) observed similar findings as they reported Eigen root of first principal component accounted for approximately 22.80 % variation of total variation followed by 13.84% of second component. Kirmana and Isutsa (2017) reported in pumpkin that the first 3 principal components explained 50.5% variation, whereby the first principal components accounted for 27.7%, the second 14.4% and the third principal components accounted for 8.8%.

Considering the morphological and principal components analysis for 40 genotypes, it can be concluded that considerable diversity was present among pumpkin genotypes which were collected from different parts of tarai region of Uttarakhand. Though, India is not a primary center of origin for pumpkin still we observed a lot of variations in fruit morphology and yield characteristics. Different genotypes showed a wide variation in quantitative and qualitative traits. Possibility of this much diversity in India, particularly tarai condition might be due to dispersion and introduction of pumpkin seeds from one area to other area. Continuous collection, cultivation and storage of pumpkin seeds for several years by the local farmers have helped in mixing of genotypes and in creating a genetic

Table 2 Eigen vector, Eigen root and associated variation for principal based on economic traits (2018 and 2019)

Characters	PCA I		PCA II		PCA III		PCA IV		PCA V		PCAVI		PCAVII		PCAVIII	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Days to first female flower	0.227	-0.149	-0.078	0.341	-0.221	0.166	-0.113	0.117	-0.082	-0.178	0.179	-0.161	0.128	0.078	-0.265	-0.100
Nodes to first female flower	0.225	-0.134	0.150	0.065	-0.251	0.021	-0.008	-0.357	-0.126	-0.419	-0.195	0.161	0.252	0.249	0.000	0.245
Male female flower ratio	0.085	0.296	0.234	-0.013	-0.326	0.067	-0.239	0.125	0.063	-0.136	-0.006	0.280	0.136	-0.002	-0.334	-0.312
Days to first harvest	-0.010	-0.218	0.063	-0.171	-0.296	0.207	-0.168	0.221	0.180	0.015	0.260	-0.219	-0.298	0.124	0.413	0.323
Pedicle length (cm)	0.134	-0.021	0.152	0.126	-0.307	0.170	-0.082	-0.306	0.048	-0.195	-0.113	0.334	-0.498	-0.345	-0.100	-0.323
Average fruit weight (kg)	0.296	0.284	0.204	-0.051	-0.126	0.237	0.076	0.166	-0.209	-0.237	0.241	-0.175	0.302	-0.152	0.056	0.000
Circumference (cm)	0.323	0.197	0.258	0.192	0.126	-0.247	-0.014	0.359	-0.011	-0.218	0.132	-0.147	-0.164	-0.014	0.000	0.000
Fruit diameter (cm)	0.182	-0.231	-0.249	0.026	0.320	-0.345	-0.202	0.008	-0.171	0.084	0.170	0.044	-0.088	-0.440	0.000	-0.100
Flesh thickness (cm)	-0.131	-0.257	-0.312	0.120	-0.251	0.374	-0.003	-0.200	0.083	-0.009	-0.246	0.105	0.353	0.022	0.100	0.000
Central cavity (cm)	-0.108	0.339	-0.342	0.051	0.080	0.015	-0.178	0.075	0.120	0.140	0.158	0.146	0.161	-0.125	-0.100	0.100
Number of harvests	0.140	-0.167	-0.150	0.237	0.217	0.169	0.168	0.205	-0.161	0.217	-0.125	-0.242	-0.312	0.243	-0.418	-0.442
Fruit set per cent	0.325	0.255	-0.183	0.273	-0.040	-0.067	-0.046	-0.089	-0.122	0.016	-0.299	0.102	0.189	0.074	0.055	0.100
Diameter of main vine (cm)	0.280	0.232	0.103	0.172	0.210	-0.007	0.272	-0.274	0.069	0.212	-0.215	-0.227	-0.031	-0.084	0.000	0.100
Main vine length (m)	0.214	0.325	0.113	0.114	0.071	0.106	0.322	0.202	0.310	0.138	0.183	0.177	0.092	0.097	0.110	0.000
Fruits per vine	0.097	0.061	-0.163	0.163	-0.233	-0.115	-0.158	-0.190	0.371	0.476	-0.272	-0.041	-0.267	0.126	-0.100	-0.100
Yield per plant (kg)	-0.127	-0.109	0.382	0.195	0.153	-0.371	-0.284	0.207	-0.113	0.075	0.017	0.395	0.047	-0.007	0.000	0.000
Number of seeds per fruit	0.200	-0.210	-0.215	0.185	0.203	0.039	-0.382	0.190	-0.006	-0.140	0.192	-0.162	-0.009	-0.558	-0.100	0.100
Test weight (g)	-0.101	0.095	0.335	0.311	0.114	-0.084	-0.117	-0.001	0.269	-0.317	0.151	-0.143	0.212	0.175	-0.323	-0.234
Total soluble solids ( <sup>o</sup> brix)	0.283	0.019	-0.182	-0.124	-0.166	0.465	-0.121	0.141	-0.206	0.274	0.277	0.244	-0.069	-0.168	0.000	0.000
Reducing sugars (g/100g)	0.249	-0.008	-0.093	0.383	0.030	0.076	0.245	-0.236	0.368	0.107	-0.025	0.013	0.076	0.016	-0.100	0.234
Non-reducing sugars (g/100g)	0.208	0.162	-0.125	0.218	0.004	0.268	-0.204	0.132	0.393	-0.127	0.097	0.126	0.111	-0.036	0.100	0.236
Ascorbic acid (mg/100g)	0.219	0.257	0.119	-0.142	0.049	-0.095	-0.247	-0.309	-0.221	-0.093	-0.420	-0.267	0.024	-0.101	0.256	-0.100
Carotenoid content (mg/100g)	0.134	-0.058	-0.097	-0.288	-0.202	-0.100	0.373	0.101	-0.109	-0.161	0.238	0.284	-0.030	0.273	0.000	0.000
Carbohydrate content (g/100g)	-0.205	-0.231	-0.117	0.309	-0.308	-0.049	0.165	0.132	-0.293	0.067	0.144	0.197	-0.062	0.105	-0.100	-0.100
Eigen Value (Root)	4.859	6.141	3.809	4.048	3.386	2.354	2.410	1.938	2.131	1.783	1.321	1.416	1.126	1.109	0.800	0.900
% Var. Exp.	20.245	25.586	15.869	16.867	14.110	9.809	10.042	8.076	8.879	7.430	5.505	5.899	4.691	4.622	3.400	3.700
Cum. Var. Exp.	20.245	25.586	36.115	42.453	50.224	52.262	60.266	60.338	69.145	67.767	74.650	73.667	79.341	78.289	82.760	82.000

diversity pool in this region. Neglected germplasm of the pumpkin possessed various agronomic and horticultural characteristics of interest such as high yield, good amount of carotene content, seed oil content, low male female sex ratio etc., utilization of these germplasm resources in crop improvement may provide a scope to harness the potentiality of the crop. Diverse genotypes further can be utilized to create heterotic pool for development of desired cultivars.

#### REFERENCES

- Ahamed K U, Akhter B, Islam M R, Ara N and Humauan M R. 2011. An assessment of morphology and yield characteristics of pumpkin (*Cucurbita moschata*) genotypes in northern Bangladesh. *Tropical Agricultural Research and Extension* **14** (1): 7–11.
- Anonymous. 2017, 2018. Accessed from <http://www.nhb.gov.in>.
- Debata J, Maurya S K, Yadav H and Bhatt L. 2017. Study on genetic diversity of pointed gourd using morphological traits. *International Journal of Current Microbiology and Applied Sciences* **6**(12): 1511–19.
- Juna H I, Lee C H, Song G S and Kima Y S. 2006. Characterization of the pectic polysaccharides from pumpkin peel. *Lwt-Food Science and Technology* **39**: 554–61.
- Kaiser H F. 1958. The varimax criteria for analytic rotation in factor analysis. *Psychometrika*. **23**: 187–200.
- Kiramana J K and Isutsa D K. 2017. Morphological characterization of naturalized pumpkin [*Cucurbita moschata* (Lam.) Poir.] accessions in Kenya. *African Journal of Horticulture Sciences* **12**: 61–83.
- Maurya S K, Ram H H and Singh D K. 2009. Standard heterosis for fruit yield and its components in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *Annals of Horticulture* **2**(1): 72–76.
- Singh D K, Maurya S K, Jaiswal H R and Singh A. 2008. Studies on genetic variability and genetic divergence analysis in ridge gourd [*Luffa acutangula* (Roxb.) L.]. *Progressive Horticulture* **40**(2): 149–54.
- Singh P and Narayanan S S. 2015. *Biometrical Technique in Plant Breeding*, 5<sup>th</sup> revised edn, pp. 35–36. Kalyani publishers, New Delhi
- Stuart M E. 2004. *All about Pumpkins*. The University of Arizona cooperative extension in Yavapai country.
- Verma P, Maurya S K, Yadav H and Panchbhैया A. 2017. Determination of genetic divergence in pointed gourd by principal component and non-hierarchical Euclidean cluster analysis. *Journal of Applied and Natural Science* **9**(4): 2421–26.