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Devesh Tiwari
Ph.D., Scholar, Department of Vegetable Science, A.N.D. University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

GC Yadav
Associate Professor, Department of Vegetable Science, A.N.D. University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Corresponding Author
Devesh Tiwari
Ph.D., Scholar, Department of Vegetable Science, A.N.D. University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Character association among the horticultural, yield traits and quality traits in pumpkin

Devesh Tiwari and GC Yadav

Abstract
The present investigation was carried out with the aim to know the association among the quantitative and qualitative traits and effect and intensity of these traits on the fruit yield of the pumpkin. Present study was conducted during *Zaid,* 2020 (Y_1) and *Zaid,* 2021 (Y_2). The present investigated shows that the most important trait fruit yield per plant had exhibited significant and positive phenotypic correlation with number of fruits per plant, average fruit weight, node number to first female flower appearance, total soluble solids, β-carotene, node number to first male flower appearance, vine length, polar circumference of fruit and negative significant association with equatorial circumference of fruit, number of primary branches per plant, dry matter content and ascorbic acid content at phenotypic level during both seasons (Y_1, Y_2) and over seasons (pooled). Analysis for the fruit yield per plant with respect to path of coefficient were found positively significant i.e. affected by number of fruit per plant and followed by average fruit weight, non-reducing sugars, node number to first male flower appearance and β-carotene at phenotypic level. The present investigation concluded that the number of fruit per plant and followed by average fruit weight, non-reducing sugars, node number to first male flower appearance most important traits for improvement for fruit yield in pumpkin.

Keywords: Pumpkin, fruit yield, quality traits, correlation and path analysis

Introduction
Pumpkin (*Cucurbita moschata* Duch. ex. Poir) is one amongst foremost important vegetable crop of family (gourd) Cucurbitaceae. It's has been grown throughout the world due to having its good nutritional/medicinal value and also higher returns to the farmers. The centre of origin of pumpkin is believed to be central Mexico. Pumpkin is a sexually propagated, herbaceous annual vegetable allopolyploid having chromosome number 2n=2x=40.
Pumpkin is comparatively high in energy, carbohydrates and also a good source of vitamins, minerals and especially high carotenoid pigments. It may certainly contribute to improving nutritional status of the people, especially the vulnerable groups with respect to the requirement of vitamin A. In South Asian countries night-blindness is a very serious problem which can overcome the problem through taken the pumpkin.
Pumpkin showed more variability in their fruit size, colour, shape, fruit yield and also other agronomic attributes (Singh, 2005 and Singh *et al.*, 2005) [1, 2]. Like other gourds pumpkin is summer season crop and hence it may be cultivated throughout the year in central and southern states of the country. Whereas, in northern parts of the country which face cooler in winter months and it is generally cultivated during summer and rainy season, which is generally sowing from January to July. Producer in north India planted in July-August after onset of monsoon in the mounds or hills in the vicinity of house and the growing plants are trained on thatches, hutments and other abandoned spaces.
The procedure of path coefficient was developed by Wright (1921) [6] helps in estimating direct and indirect influence of various components in building up the total correlation towards fruit yield. On the basis of these studies the quantum significance of individual traits is marked to facilitate the selection programme for better gains.

Materials and Methods
The experimental materials for the present study comprised of nine promising and diverse inbreds and varieties of pumpkin selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) India. The selected parental lines *i.e.* Narendra Agrim (P_1), Narendra Amrit (P_2), Narendra Upkar (P_3), NDPK-7-24 (P_4),

NDPK-76-1 (P_5), NDPK-2-1 (P_6), NDPK-39-2 (P_7) NDPK-41-2 (P_8), and NDPK-43-3 (P_9) were raised and crossed in the all possible combinations, excluding reciprocals, during *Zaid*, 2019 to develop 36 F_1 hybrid seeds and evaluated during *Zaid*, 2020 and 2021 for the study of character association.

Observations were recorded on fourteen economic traits including biochemical analysis *viz.*, node number to first male flower, node number to first female flower, days to first male flower anthesis, days to first female flower anthesis, days to first fruit harvest, vine length (m), internodal length (cm), number of primary branches per plant, equatorial circumference of fruit (cm), polar circumference of fruit (cm), flesh thickness (cm), average fruit weight (kg), number of fruits per plant, fruit yield per plant (kg), ascorbic acid (mg/100g), total soluble solids (%), β – carotene, dry matter content (%), reducing sugars (%), non-reducing sugars (%) and total sugars (%).

Results and Discussion

A knowledge of the nature of association between yield and its components is of a great interest in plant breeding. The statistics which measures the relation and its extent, between two or more variables is known as correlation coefficient. Correlation tests show that choosing one character leads to progress for the other positively correlated characters. Many of the characters have a positive or negative correlation with other characters as a result of natural association. The indirect correlation becomes more difficult as more variables are included in correlation tables.

The phenotypic and genotypic correlation coefficient computed among the twenty one characters under study had been presented in Table 1 and 2 for Y_1, 3 and 4 for Y_2 and 5 and 6 for pooled.

The most important trait fruit yield per plant had exhibited significant and positive phenotypic correlation with number of fruits per plant, average fruit weight, node number to first female flower appearance, total soluble solids, β-carotene, node number to first male flower appearance, vine length, polar circumference of fruit and negative significant association with equatorial circumference of fruit, number of primary branches per plant, dry matter content and ascorbic acid content at phenotypic level during both seasons (Y_1, Y_2) and over seasons (pooled) except equatorial circumference of fruit in Y_1, number of primary branches per plant in Y_2 and ascorbic acid content in pooled. Many previous researchers, including Rana *et al.* (1985) [7]; Doijode and Sulladmath (1986) [10]; Amaral *et al.* (1994) [8]; Kumaran *et al.* (1998) [15]; Mohanty (2001) [16]; Pandey *et al.* (2002) [19]; Mohmmad *et al.* (2015); Ahmed *et al.* (2018) [9] and Singh *et al.* (2019) [3] had reported positive and significant correlations of most of the above traits with fruit yield per plant and thereby, they also supported present findings.

Looked at these associations from findings of present research it appears that for improvement of pumpkin, number of fruits per plant, average fruit weight, node number to first female flower appearance, total soluble solids, β-carotene, node number to first male flower appearance, vine length, polar circumference of fruit, equatorial circumference of fruit, number of primary branches per plant, dry matter content and ascorbic acid need to be given consideration.

Early flowering and flower appearance at lower nodes would be appropriate selection criteria to get early yield, based on a positive association between node number to first male and flower appearance, days to first female flower anthesis and with days to first fruit harvest. The presence of positive correlation of number of fruits per plant with vine length and primary branches per plant suggested that longer vine length can be preferred to harvesting more marketable fruits. The positive and significant association of dry matter content with average fruit weight revealed that the increase in dry matter content can increase the total yield.

Path coefficient is the simple standardized partial regression coefficient that divides the correlation coefficient into the measures of direct and indirect effects of a set independent variables on the dependent variable. It helps to find out the direct and indirect influences of yield parameters, which is crucial in the selection of superior genotypes. The correlation coefficient estimations simply show the character's interrelationships, not the cause and effect correlations. Wright, 1921 [6] provide the effective means for the determination of direct and indirect causes of association with respect to path of coefficient. It allows for a critical examination of specific forces acting producing a given correlation while also measuring the relative importance of each causal factor. Path coefficient analysis was firstly demonstrated in a breeding effort with crested wheat grass progenies by Dewey and Lu (1959) [11].

Due to the mutual association, the development of dependent variable is determined by the degree of direct effect of independent variables and indirect effects exerted via other characters, arising inevitably as an integral part of the growth pattern. In such complex scenarios, the total correlation is insufficient to convey the true relationship in order to manipulate the characters effectively and profitably.

The path coefficient analysis was carried out from phenotypic and genotypic correlation coefficients to determine the direct and indirect impact of different characters on fruit yield.

The direct and indirect effect of different characters on fruit yield at phenotypic level is presented in Table 4.4.1, 4.4.3 and 4.4.5.

The analysis of path coefficient found that the highest positive direct effect on fruit yield per plant, followed by number of fruit per plant, average fruit weight, non-reducing sugars, node number to first male flower appearance and β-carotene at phenotypic level.

Table 1: Estimates of correlation coefficient at phenotypic level for growth, yield and biochemical traits in pumpkin during 2020 (Y_1)

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.484**	-0.004	0.119	0.254**	0.131	-0.157	-0.366**	0.022	0.176*	-0.032	0.375**	0.359**	-0.011	0.089	-0.178*	-0.514**	-0.436**	-0.140	0.293**	0.252**
2		0.043	0.146	0.150	0.267**	-0.238**	-0.335**	-0.080	0.194*	-0.082	0.011	0.277**	0.048	-0.260**	-0.085	-0.144	-0.149	0.050	0.493**	0.432**
3			0.020	0.123	0.068	-0.086	0.091	-0.003	0.131	0.043	0.252**	0.168*	-0.049	0.037	0.124	-0.240**	-0.120	-0.122	0.120	-0.050
4				0.162	0.334**	0.097	0.052	-0.193*	0.146	-0.082	0.151	0.246**	0.215*	-0.211*	-0.210*	-0.141	-0.189*	0.003	0.054	0.003
5					0.214*	-0.099	-0.232**	-0.028	0.036	0.100	0.054	0.267**	0.090	-0.171*	-0.133	-0.246**	-0.231**	0.023	0.208*	0.138
6						0.223**	-0.200*	-0.084	0.064	-0.217*	-0.060	0.048	0.382**	-0.397**	-0.033	-0.143	-0.101	0.012	0.293**	0.250**
7							-0.114	0.155	-0.066	0.053	-0.044	-0.438**	0.411**	-0.033	0.188*	0.066	0.173*	-0.005	-0.245**	-0.091
8								-0.055	-0.064	-0.061	0.143	0.059	-0.183*	0.203*	0.176*	0.145	0.215*	-0.045	-0.316**	-0.361**
9									0.181*	0.320**	0.108	-0.008	0.044	-0.052	0.214*	0.024	0.173*	0.062	-0.109	-0.030
10										0.048	0.253**	0.272**	-0.005	-0.035	0.166	-0.236**	-0.083	-0.004	0.300**	0.244**
11											0.059	0.209*	-0.138	-0.096	0.079	0.135	0.147	0.336**	-0.148	0.030
12												0.382**	0.061	0.246**	0.053	-0.346**	-0.185*	-0.148	-0.211*	-0.167
13													0.032	-0.120	-0.104	-0.025	-0.120	0.306**	0.228**	0.292**
14														-0.255**	0.120	0.240**	0.216*	0.353**	-0.083	0.256**
15															0.158	-0.084	0.008	-0.199*	-0.280**	-0.311**
16																0.075	0.657**	0.106	-0.086	0.053
17																	0.634**	0.442**	-0.316**	0.035
18																		0.349**	-0.256**	0.059
19																			-0.005	0.425**
20																				0.745**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

1. Node number to first male flower appearance, 2. Node number to first female flower appearance, 3. Days to first male flower anthesis, 4. Days to first female flower anthesis, 5. Days to first fruit harvest, 6. Vine length (m) 7. Internodal length (cm), 8. Number of primary branches per plant, 9. Equatorial circumference of fruit (cm) 10. Polar circumference of fruit (cm), 11. Flesh thickness (cm), 12. Ascorbic acid content, 13. Total soluble solids, 14. β – Carotene 15. Dry matter content, 16. Reducing sugars, 17. Non-reducing sugars, 18. Total sugars, 19. Average fruit weight, 20. Number of fruits per plant, 21. Fruit yield per plant

Table 2: Estimates of correlation coefficient at genotypic level for growth, yield and biochemical traits in pumpkin during 2020 (Y_1)

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.561**	0.129	0.305**	0.581**	0.159	-0.179*	-0.411**	0.087	0.644**	-0.036	0.469**	0.428**	-0.024	0.160	-0.192*	-0.603**	-0.552**	-0.168*	0.361**	0.297**
2		0.162	0.255**	0.388**	0.454**	-0.252**	-0.419**	-0.012	0.495**	-0.081	-0.036	0.363**	0.030	-0.368**	-0.077	-0.214*	-0.203*	0.083	0.632**	0.556**
3			0.473**	0.655**	0.437**	-0.211*	0.198*	-0.497**	0.816**	-0.093	0.625**	0.493**	-0.064	-0.106	0.213*	-0.507**	-0.151	-0.345**	0.315**	-0.044
4				0.972**	0.718**	0.200*	0.016	-0.108	0.343**	-0.104	0.227**	0.472**	0.416**	-0.508**	-0.477**	-0.214*	-0.544**	-0.013	0.101	-0.013
5					0.635**	-0.265**	-0.610**	0.038	0.231**	0.239**	0.137	0.561**	0.161	-0.564**	-0.289**	-0.574**	-0.612**	0.050	0.439**	0.312**
6						0.288**	-0.296**	-0.214*	0.279**	-0.293**	-0.065	0.046	0.491**	-0.462**	-0.051	-0.178*	-0.168*	0.010	0.335**	0.287**
7							-0.202*	0.268**	-0.156	0.078	-0.066	-0.533**	0.518**	-0.045	0.256**	0.113	0.242**	0.034	-0.289**	-0.102
8								-0.123	-0.212*	-0.038	0.145	0.057	-0.286**	0.226**	0.192*	0.177*	0.266**	-0.043	-0.363**	-0.408**
9									0.487**	0.499**	0.081	-0.011	-0.029	-0.106	0.404**	-0.021	0.249**	0.120	-0.166	-0.022
10										0.067	0.396**	0.535**	-0.108	-0.328**	0.259**	-0.518**	-0.145	-0.021	0.734**	0.551**
11											0.052	0.253**	-0.104	-0.109	0.094	0.157	0.176*	0.379**	-0.172*	0.033
12												0.385**	0.004	0.325**	0.129	-0.441**	-0.208*	-0.194*	-0.253**	-0.202*
13													0.017	-0.184*	-0.122	-0.055	-0.107	0.362**	0.220**	0.316**
14														-0.345**	0.141	0.260**	0.285**	0.449**	-0.095	0.309**

15															0.182*	-0.113	0.089	-0.276**	-0.356**	-0.402**
16																0.107	0.810**	0.136	-0.078	0.088
17																	0.784**	0.512**	-0.356**	0.034
18																		0.447**	-0.311**	0.073
19																			-0.087	0.416**
20																				0.741**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

1. Node number to first male flower appearance, 2. Node number to first female flower appearance, 3. Days to first male flower anthesis, 4. Days to first female flower anthesis, 5. Days to first fruit harvest, 6. Vine length (m) 7. Internodal length (cm), 8. Number of primary branches per plant, 9. Equatorial circumference of fruit (cm) 10. Polar circumference of fruit (cm), 11. Flesh thickness (cm), 12. Ascorbic acid content, 13. Total soluble solids, 14. β – Carotene 15. Dry matter content, 16. Reducing sugars, 17. Non-reducing sugars, 18. Total sugars, 19. Average fruit weight, 20. Number of fruits per plant, 21. Fruit yield per plant.

Table 3: Estimates of correlation coefficient at phenotypic level for growth, yield and biochemical traits in pumpkin during 2021 (Y_2)

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.472**	-0.003	0.108	0.246**	0.146	-0.204*	-0.355**	0.047	0.168	-0.047	0.347**	0.344**	-0.007	0.086	-0.176*	-0.496**	-0.400**	-0.129	0.273**	0.252**
2		0.056	0.125	0.131	0.248**	-0.256**	-0.329**	-0.064	0.258**	-0.071	0.013	0.256**	0.060	-0.235**	-0.074	-0.140	-0.142	0.035	0.471**	0.429**
3			0.039	0.126	0.060	-0.075	0.084	-0.003	0.097	0.038	0.246**	0.184*	-0.037	0.060	0.112	-0.237**	-0.136	-0.100	0.118	-0.063
4				0.142	0.321**	0.078	0.079	-0.160	0.111	-0.105	0.173*	0.245**	0.246**	-0.186*	-0.168	-0.139	-0.150	0.031	0.017	-0.016
5					0.228**	-0.073	-0.229**	-0.033	0.017	0.109	0.025	0.265**	0.049	-0.153	-0.127	-0.239**	-0.219*	0.027	0.209*	0.139
6						0.194*	-0.189*	-0.085	-0.001	-0.192*	-0.062	0.053	0.346**	-0.380**	-0.032	-0.140	-0.069	0.012	0.284**	0.239**
7							-0.117	0.112	-0.019	0.055	-0.056	-0.418**	0.369**	-0.050	0.178*	0.051	0.145	0.017	-0.222**	-0.089
8								-0.049	-0.160	-0.080	0.129	0.064	-0.149	0.190*	0.174*	0.145	0.206*	-0.037	-0.307**	-0.353**
9									0.153	0.293**	0.140	-0.005	0.069	-0.054	0.197*	0.027	0.171*	0.052	-0.109	-0.032
10										0.074	0.229**	0.302**	-0.032	-0.080	0.148	-0.238**	-0.094	0.005	0.336**	0.288**
11											0.049	0.207*	-0.138	-0.105	0.096	0.132	0.154	0.308**	-0.148	0.023
12												0.362**	0.075	0.213*	0.049	-0.343**	-0.154	-0.133	-0.204*	-0.159
13													0.016	-0.100	-0.089	-0.021	-0.118	0.301**	0.226**	0.295**
14														-0.206*	0.113	0.226**	0.207*	0.322**	-0.092	0.234**
15															0.147	-0.074	-0.024	-0.172*	-0.270**	-0.294**
16																0.073	0.605**	0.075	-0.086	0.038
17																	0.615**	0.412**	-0.313**	0.034
18																		0.298**	-0.239**	0.055
19																			0.018	0.425**
20																				0.744**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

1. Node number to first male flower appearance, 2. Node number to first female flower appearance, 3. Days to first male flower anthesis, 4. Days to first female flower anthesis, 5. Days to first fruit harvest, 6. Vine length (m) 7. Internodal length (cm), 8. Number of primary branches per plant, 9. Equatorial circumference of fruit (cm) 10. Polar circumference of fruit (cm), 11. Flesh thickness (cm), 12. Ascorbic acid content, 13. Total soluble solids, 14. β – Carotene 15. Dry matter content, 16. Reducing sugars, 17. Non-reducing sugars, 18. Total sugars, 19. Average fruit weight, 20. Number of fruits per plant, 21. Fruit yield per plant

Table 4: Estimates of correlation coefficient at genotypic level for growth, yield and biochemical traits in pumpkin during 2021 (Y_2)

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.570**	0.147	0.318**	0.625**	0.153	-0.163	-0.419**	0.068	0.598**	-0.037	0.491**	0.434**	-0.026	0.166	-0.195*	-0.616**	-0.584**	-0.180*	0.376**	0.313**
2		0.162	0.240**	0.445**	0.482**	-0.249**	-0.432**	-0.033	0.403**	-0.090	-0.046	0.358**	0.023	-0.395**	-0.088	-0.216*	-0.213*	0.093	0.650**	0.580**
3			0.597**	0.717**	0.478**	-0.195*	0.207*	-0.548**	0.851**	-0.062	0.662**	0.529**	-0.087	-0.163	0.236**	-0.535**	-0.130	-0.389**	0.335**	-0.047
4				1.205**	0.792**	0.171*	0.048	-0.134	0.426**	-0.186*	0.281**	0.505**	0.434**	-0.522**	-0.494**	-0.241**	-0.599**	-0.054	0.066	-0.054
5					0.657**	-0.309**	-0.648**	0.060	0.291**	0.241**	0.189*	0.609**	0.229**	-0.634**	-0.318**	-0.612**	-0.670**	0.047	0.463**	0.324**
6						0.312**	-0.307**	-0.225**	0.340**	-0.305**	-0.066	0.043	0.522**	-0.484**	-0.056	-0.181*	-0.196*	0.007	0.348**	0.296**
7							-0.209*	0.320**	-0.237**	0.076	-0.050	-0.549**	0.555**	-0.037	0.267**	0.117	0.263**	0.027	-0.302**	-0.116
8								-0.137	-0.079	-0.018	0.154	0.067	-0.314**	0.234**	0.196*	0.179*	0.278**	-0.049	-0.369**	-0.407**
9									0.509**	0.552**	0.045	-0.015	-0.062	-0.109	0.442**	-0.025	0.259**	0.138	-0.172*	-0.017
10										0.036	0.374**	0.542**	-0.074	-0.301**	0.239**	-0.441**	-0.109	0.015	0.668**	0.516**
11											0.062	0.257**	-0.097	-0.105	0.088	0.161	0.176*	0.402**	-0.173*	0.031
12												0.385**	-0.007	0.357**	0.137	-0.449**	-0.234**	-0.213*	-0.257**	-0.212*
13													0.025	-0.205*	-0.120	-0.057	-0.097	0.366**	0.227**	0.321**
14														-0.384**	0.149	0.268**	0.296**	0.477**	-0.092	0.319**
15															0.195*	-0.124	0.119	-0.301**	-0.365**	-0.415**
16																0.110	0.855**	0.153	-0.081	0.090
17																	0.806**	0.533**	-0.357**	0.038
18																		0.487**	-0.324**	0.076
19																			-0.104	0.411**
20																				0.744**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

1. Node number to first male flower appearance, 2. Node number to first female flower appearance, 3. Days to first male flower anthesis, 4. Days to first female flower anthesis, 5. Days to first fruit harvest, 6. Vine length (m) 7. Internodal length (cm), 8. Number of primary branches per plant, 9. Equatorial circumference of fruit (cm) 10. Polar circumference of fruit (cm), 11. Flesh thickness (cm), 12. Ascorbic acid content, 13. Total soluble solids, 14. β – Carotene 15. Dry matter content, 16. Reducing sugars, 17. Non-reducing sugars, 18. Total sugars, 19. Average fruit weight, 20. Number of fruits per plant, 21. Fruit yield per plant

Table 5: Estimates of correlation coefficient at phenotypic level for growth, yield and biochemical traits in pumpkin over seasons (pooled)

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.469**	-0.027	0.121*	0.257**	0.146*	-0.152*	-0.386**	0.020	0.175**	-0.041	0.363**	0.345**	0.037	0.058	-0.177**	-0.503**	-0.416**	-0.117	0.280**	0.268**
2		0.046	0.128*	0.135*	0.257**	-0.231**	-0.334**	-0.076	0.222**	-0.077	0.006	0.254**	0.062	-0.261**	-0.075	-0.137*	-0.140*	0.049	0.484**	0.443**
3			0.021	0.118	0.058	-0.069	0.099	0.002	0.109	0.045	0.238**	0.161**	-0.047	0.051	0.127*	-0.230**	-0.117	-0.118	0.125*	-0.052
4				0.157**	0.332**	0.104	0.036	-0.183**	0.131*	-0.098	0.168**	0.248**	0.255**	-0.217**	-0.191**	-0.142*	-0.171**	0.033	0.029	-0.002
5					0.226**	-0.071	-0.252**	-0.036	0.026	0.100	0.045	0.268**	0.099	-0.180**	-0.134*	-0.245**	-0.229**	0.033	0.198**	0.140*
6						0.215**	-0.202**	-0.092	0.036	-0.206**	-0.056	0.055	0.366**	-0.394	-0.037	-0.144*	-0.089	0.025	0.287**	0.249**
7							-0.114	0.131*	-0.045	0.050	-0.034	-0.404**	0.378**	-0.024	0.168**	0.044	0.140**	-0.004	-0.250**	-0.114
8								-0.026	-0.110	-0.060	0.107	0.032	-0.208**	0.212**	0.194**	0.156**	0.229**	-0.053	-0.282**	-0.342**
9									0.169**	0.309	0.115	-0.017	0.036	-0.040	0.213**	0.031	0.180**	0.048	-0.099	-0.029
10										0.062	0.242**	0.291**	-0.014	-0.060	0.158**	-0.238**	-0.086	0.000	0.316**	0.267**
11											0.051	0.208**	-0.147*	-0.095	0.091	0.134*	0.152*	0.319**	-0.145*	0.026
12												0.372**	0.095	0.209**	0.047	-0.345**	-0.170**	-0.127*	-0.210**	-0.157**
13													0.059	-0.139*	-0.094	-0.018	-0.115	0.324**	0.228**	0.312**
14														-0.241**	0.087	0.208**	0.177**	0.347**	-0.108	0.230**
15															0.170**	-0.066	0.011	-0.190**	-0.260**	-0.292**

16																0.074	0.630**	0.080	-0.081	0.040
17																	0.623**	0.420**	-0.313**	0.029
18																		0.314**	-0.242**	0.051
19																			-0.003	0.420**
20																				0.743**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

1. Node number to first male flower appearance, 2. Node number to first female flower appearance, 3. Days to first male flower anthesis, 4. Days to first female flower anthesis, 5. Days to first fruit harvest, 6. Vine length (m) 7. Internodal length (cm), 8. Number of primary branches per plant, 9. Equatorial circumference of fruit (cm) 10. Polar circumference of fruit (cm), 11. Flesh thickness (cm), 12. Ascorbic acid content, 13. Total soluble solids, 14. β – Carotene 15. Dry matter content, 16. Reducing sugars, 17. Non-reducing sugars, 18. Total sugars, 19. Average fruit weight, 20. Number of fruits per plant, 21. Fruit yield per plant.

Table 6: Estimates of correlation coefficient at genotypic level for growth, yield and biochemical traits in pumpkin over seasons (pooled)

Traits	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.504**	0.538**	0.661**	0.821**	0.226**	-0.216**	-0.434**	-0.050	0.686**	-0.103	0.524**	0.424**	-0.161**	0.151*	-0.407**	-0.801**	-0.822**	-0.421**	0.465**	0.227**
2		0.567**	0.220**	0.484**	0.643**	-0.243**	-0.382**	-0.097	0.608**	-0.204**	-0.144*	0.184**	-0.215**	-0.383**	-0.302**	-0.374**	-0.438**	-0.189**	0.734**	0.445**
3			0.238**	0.589**	0.614**	-0.602**	0.069	-0.256**	1.198**	-0.467**	0.670**	0.634**	-0.212**	0.182**	0.149*	-0.477**	-0.235**	-0.314**	0.577**	0.241**
4				1.594**	0.756**	-0.190**	-0.038	0.439**	0.527	-0.239**	0.454**	1.157**	0.544**	-0.655**	-0.715**	-0.243**	-0.627**	0.210**	0.138*	0.226**
5					0.516**	-0.338**	-0.554**	0.384**	0.502**	0.088	0.223**	0.737**	0.028	-0.438**	-0.516**	-0.644**	-0.772**	-0.036	0.728**	0.655**
6						0.292**	-0.474**	0.238**	0.746**	-0.236**	0.070	0.007	0.507**	-0.531**	0.170**	-0.246**	-0.104	0.106	0.426**	0.545**
7							-0.425**	0.536**	-0.110	0.106	0.012	-0.585**	0.608**	-0.032	0.640**	0.191**	0.477**	0.212**	-0.327**	0.064
8								-0.187**	-0.247**	-0.144*	0.045	0.137*	-0.257**	0.195**	0.160**	0.365**	0.370**	0.062	-0.383**	-0.404**
9									0.386**	0.562**	-0.034	-0.190**	-0.026	-0.363**	0.448**	-0.029	0.189**	-0.107	-0.163**	-0.063
10										0.112	0.187**	0.262**	-0.249**	-0.298**	-0.059	-0.658**	-0.505**	-0.313**	0.669**	0.382**
11											-0.064	0.337**	-0.045	-0.137*	0.021	0.366**	0.277**	0.394**	-0.260**	0.148*
12												0.481**	0.168**	0.489**	0.092	-0.334**	-0.205**	-0.073	-0.364**	-0.206**
13													-0.049	-0.164**	-0.617**	-0.100	-0.382**	0.255**	0.007	0.083
14														-0.287**	0.257**	0.294**	0.371**	0.597**	-0.279**	0.331**
15															0.343**	-0.211**	0.054	-0.364**	-0.401**	-0.565**
16																0.239**	0.757**	0.122	-0.412**	-0.204**
17																	0.898**	0.626**	-0.586**	-0.106
18																		0.544**	-0.669**	-0.193**
19																			-0.324**	0.380**
20																				0.626**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

1. Node number to first male flower appearance, 2. Node number to first female flower appearance, 3. Days to first male flower anthesis, 4. Days to first female flower anthesis, 5. Days to first fruit harvest, 6. Vine length (m) 7. Internodal length (cm), 8. Number of primary branches per plant, 9. Equatorial circumference of fruit (cm) 10. Polar circumference of fruit (cm), 11. Flesh thickness (cm), 12. Ascorbic acid content, 13. Total soluble solids, 14. β – Carotene 15. Dry matter content, 16. Reducing sugars, 17. Non-reducing sugars, 18. Total sugars, 19. Average fruit weight, 20. Number of fruits per plant, 21. Fruit yield per plant.

At phenotypic level, node number to first female flower appearance via number of fruits per plant exhibited positive association with fruit yield per plant. Polar circumference of fruit had positive association with fruit yield per plant which was mainly due to indirect positive effect of number of fruits per plant. The numbers of fruits per plant with respect to vine length have been associated with the fruit yield per plant. The appearance of nodes number to first male flower from the number of fruits per plants showed positive association with respect to yield per plant. Total soluble solids had positive association with fruit yield per plant which was mainly due to indirect positive effect of number of fruits per plant. Fruit yield per plant with respect to days of first fruit harvest via number of fruits per plant have been positively associated. Number of primary branches per plant had significant negative association with fruit yield per plant. Break up this association found that the indirect effect via number of fruits per plant was mainly responsible for this association. Dry matter content via indirect effect of number of fruits per plant had negative significant association with fruit yield per plant and ascorbic acid content via number of fruits per plant had negative significant association with fruit yield per plant at phenotypic level. As a result, these traits should be prioritised during genotype selection in order to develop high-yielding genotypes in pumpkin. Positive direct effect of several characters on fruit yield has also been reported by earlier workers *viz.*, for average fruit weight (Gopalkrishnan *et al.*1980; Rana *et al.*1985; Mohanty 2001; Shivananda *et al.* 2013; Yadegari *et al.* 2012; Murlidharan *et al.* 2015; Naik *et al.* 2015; Chaudhari *et al.* 2017; Mohsin *et al.* 2017) [20, 7, 16, 5, 23, 17, 18, 12, 21] for number of fruits per plant (Kumaran *et al.* 1998; Mohanty 2001; Pandey *et al.* 2002; Rahman *et al.* 2002; Camacho *et al.* 2006; Shivananda *et al.* 2013; Grisales *et al.* 2013; Murlidharan *et al.* 2015; Naik *et al.* 2015; Sulatana *et al.* 2015; Chaudhari *et al.* 2017; Mohsin *et al.* 2017) [15, 16, 19, 13, 5, 17, 18, 4, 12, 21] for stem length (Gopalkrishnan *et al.*1980; Mohanty 2001; Murlidharan *et al.* 2015) [20, 16, 17] for flesh thickness (Rana *et al.* 1985; Yadav *et al.* 2006; Chaudhari *et al.* 2017) [7, 22, 12] for equatorial and polar circumference of fruit (Pandey *et al.* 2002; Yadav *et al.* 2006; Chaudhari *et al.* 2017) [16, 22, 12] for number of branches (Murlidharan *et al.* 2015) [17] which substantiate the present findings. The direct and indirect effects at genotypic level have been found to be variable while analyses the path coefficient because of the variable degree influence of environment on several traits studied. However, these were also observed in component variance analysis and correlation studies during both seasons and over environment. Finally the path coefficient analysis revealed that focusing node number to first male flower appearance, number of fruits per plant, non-reducing sugars, average fruit weight and β-carotene could improve breeding efficiency of pumpkin.

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