Research Article

Variability, Correlation and path Analysis Studies in Pumpkin (*Cucurbita Moschata* Duchesne ex Poir.)

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Abstract

The present investigation was carried out to estimate the extent genetic variability and character association for fruit yield per plant and different quantitative traits in 76 genotypes of pumpkin. The experimental results revealed significant differences among the genotypes for all the traits under study. On the basis of mean performance, the genotypes DPU-6, DPU-26 and DPU-51-3 were found most promising for fruit yield per plant and other traits. Further, high heritability estimates coupled with high genetic gain were observed for all the traits under study, which indicated that these traits are under additive gene effects and are more reliable for effective selection. The correlation coefficients (phenotypic and genotypic) among different quantitative traits along with fruit yield per plant depicts that fruit yield per plant had significantly positive association with mature fruit weight (0.880 and 0.912), harvest index (0.551 and 0.558) and flesh thickness (0.450 and 0.505). Path coefficient analysis at genotypic level revealed that mature fruit weight (0.929) had maximum positive direct effect on marketable fruit yield per plant, followed by number of mature fruits per plant (0.320) and harvest index (0.232). Besides this, maximum positive indirect effects of fruit diameter (0.747), cavity diameter (0.713), fruit length (0.616) and flesh thickness (0.555) via mature fruit weight was observed on fruit yield per plant.

Keywords: Correlation, *Cucurbita moschata*, Genetic gain, Heritability

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Introduction

Pumpkin (*Cucurbita moschata* Duch. ex Poir) is an important cucurbitaceous vegetable grown throughout India and other warmer region of the globe. This crop is native of Northern and Southern America. There are 27 species under the genus *Cucurbita*, five of which are in cultivation. These are *C. moschata, C. maxima*, *C. ficifolia, C. pepo* and *C. mixta*, commonly known as Pumpkin [1]. It is used at both mature and immature stages as a vegetable. It is also consumed after processing. Yellow or orange fleshed pumpkins are rich in carotene [2]. Its young leaves, tender stems and flowers are also cooked and consumed. Consumers prefer because of its high productivity potential, low cost of production, good storability, long period of availability, better transport qualities and excellent response to forcing and comparatively high content of carotene in fruits. These factors have enhanced the importance of this crop in recent years. Pumpkin is relatively high in energy and carbohydrates and a good source of vitamins, especially high carotenoid pigments and minerals [3]. It may contribute to improve the nutritional status of the people, particularly the vulnerable groups in respect of vitamin A requirement.

Efficient management and utilization of the germplasm requires detailed knowledge of the genetic diversity of economically important traits for proper characterization of populations to facilitate efficient generation of breeding populations that are designed to achieve specific objectives. Available information on the nature and magnitude of the genetic variation governing the inheritance of quantitative character like yield and its components is essential for effecting genetic improvement. A crop breeding programme, aimed at increasing plant productivity requires consideration not only of yield but also its components that have direct or indirect bearing on yield. Correlation coefficient empowers a breeder to know the degree of association between the independent and dependent variable traits. Path coefficient analysis measures direct influence of one variable upon another and permits separation of correlation coefficient in component direct and indirect effect, which can be used for crop improvement through

selection of component traits [4]. Therefore, the present study was undertaken to estimate the genetic variation, the correlation coefficients and path-coefficient and to screen out the suitable genotypes with better performances for future breeding program in the seventy-six genotypes of pumpkin.

Materials and Methods

The present investigation was carried out at the Research Farm and Laboratories of Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi during the spring-summer season of the year 2014. The experimental material for the present study consisted of seventy-six promising and diverse genotypes of pumpkin including four check varieties collected from different parts of the country. The seeds of seventy-six genotypes of pumpkin were sown in plug-trays and seedlings transplanted in the field during spring-summer season of 2014 for comparative evaluation on various quantitative traits. The experiment was laid out in a Randomized Complete Block Design with three replications of each genotype. Two to three seeds of each genotype were sown in the hills on the ridges at a spacing of 3.5 m × 60 cm. The standard cultural practices as mentioned in Package of Practices for Vegetable Crops by Thamburaj and Singh [5] were followed to raise the healthy crop stand.

Days to first mature fruit harvest was calculated from transplanting to first mature fruit harvest (at physiological maturity). Fruit length (Polar diameter of fruit) was recorded at mature fruit stage and measured in each fruit from fruit stalk end to stylar end. Fruit diameter (Equatorial diameter of fruit) was recorded at broadest point in each fruit. Mature fruit weight (at physiological maturity) from each plant in each treatment was recorded and their average weight was calculated. Number of mature fruits per plant was calculated by fruits harvested on observational plants and counted at each harvest. The total numbers of fruits from all pickings were counted. Total number of fully matured fruits harvested from each treatment was divided by the number of plants. Harvest index was calculated as the ratio between fruit yield per plant (economic yield) at physiological maturity and gross plant weight (biological yield) and expressed in terms of percentage. Flesh thickness was measured at maximum fruit diameter i.e. at the broadest point at physiological maturity stage with the help of vernier calliper. Cavity length and cavity diameter were measured in each fruit cut in longitudinal section along fruit stalk end to stylar end direction and along the broadest point, respectively. Yield per plant was calculated by total weight of fully matured fruits of all the harvests divided by the number of plants. The mean values of data recorded for different traits were subjected to analysis of variance Gomez and Gomez [6] for Randomized Complete Block Design using MS Excel-2007 worksheet. The Genotypic and Phenotypic Coefficients of variability were calculated as per formulae given by Burton and De-Vane, [7]. Heritability in broad sense and genetic advance were calculated by using the formulae by Allard [8]. Genetic gain expressed as per cent ratio of genetic advance and population mean was calculated by the method given by Johnson *et al.* [9]. The genotypic and phenotypic correlations were calculated as per Al-Jibouri *et al.* [10] by using SPAR 3.0 software Anonymous [11]. The direct and indirect paths were obtained by following Dewey and Lu [12].

Results and Discussion

Parameters of genetic variability

Mean performance

The analysis of variance indicated significant differences among the genotypes for all the studied traits. The genetic parameter of variability, heritability and expected genetic advance over mean for yield and different quantitative traits is shown in **Table 1**. Highly significant variations were observed among all the genotypes for number of days taken to first mature fruit harvest which ranged from 84.67 to 117.00 days and mean value recorded was 102.08 days. Fruit length and diameter are important parameters which directly contribute to the fruit weight, thereby affecting the total yield. Among different genotypes, fruit length and diameter values ranged from 8.01 to 30.33 cm and 11.50 to 31.27 cm, respectively. Fruit weight has direct effect on yield and is an appealing trait to the consumers. The mature fruit weight in different genotypes ranged from 0.71 to 7.91 kg with a population mean of 2.90 kg. Similar variations were also recorded by Mladenovic *et al.* [13] and Muralidhara *et al.* [14] for the traits under study. The perusal of data pertaining to harvest index revealed highly significant differences among all the genotypes studied and ranged from 27.00 to 68.33 per cent and population mean recorded was 52.45 per cent. Flesh thickness in different genotypes ranged from 2.12 to 4.87 cm, with a mean value of 3.02 cm. Statistical analysis for the fruit yield per plant showed highly significant differences among seventy-six genotypes investigated, which ranged from 1.07 to 9.88 kg and general mean observed was 4.83 kg. The main focus of cultivating a crop is to have the maximum yield per unit area

for better returns. Moreover, high fruit yield is the ultimate goal of any breeding program; hence, it requires the highest consideration. High variations for yield traits were also reported earlier Cyril *et al.* [15] in pumpkin.

Table 1 Estimates of phenotypic and genotypic coefficients of variability, heritability and genetic gain for yield and its attributing traits in pumpkin

Sr. No.	Traits	Range	Mean ± SE(d)	Coefficients of variability (%)		Heritability (%)	Genetic gain (%)
				Phenotypic	Genotypic		
1	Days to first mature fruit harvest	84.64-117.0	102.08±3.30	7.15	5.95	69.30	10.21
2	Fruit length (cm)	8.01-30.33	15.92±1.37	30.49	28.61	88.00	55.28
3	Fruit diameter (cm)	11.50-31.27	20.02±1.18	16.82	15.19	81.60	28.27
4	Number of mature fruits/plant	1.00-2.27	1.69±0.14	16.86	13.60	65.00	22.49
5	Mature fruit weight (kg)	0.71-7.91	2.90±0.2	37.28	36.39	94.80	72.72
6	Harvest index (%)	27.00-68.33	52.45±3.76	18.20	15.95	76.80	28.79
7	Flesh thickness (cm)	2.12-4.87	3.02±0.25	18.69	15.67	70.30	27.15
8	Cavity length (cm)	4.83-23.80	10.98±1.05	37.56	35.67	90.20	69.76
9	Cavity diameter (cm)	8.43-24.33	14.05±0.84	18.60	17.10	84.60	32.38
10	Fruit yield per plant (kg)	1.07-9.88	4.83±0.45	33.31	31.31	88.30	60.66

Coefficients of variability (%)

The estimate of phenotypic and genotypic coefficients of variability gives a clear picture of amount of variations present in the available germplasm. For all the traits studied, phenotypic coefficients of variability were higher in magnitude than genotypic coefficients of variability, though the difference was very less in majority of cases, thus showing that these traits are less influenced by environmental factors. Coefficients of variability varied in magnitude from trait to trait, either low or moderate or high. Therefore, it indicated the presence of high diversity. The phenotypic and genotypic coefficients of variability were found high for cavity length (37.56% and 35.67%), mature fruit weight (37.28% and 36.39%) and fruit yield/plant (33.31% and 31.31), respectively. Fruit length was found high for phenotypic coefficients of variability (30.49%) and moderate for genotypic coefficients of variability (28.61%).Whereas moderate values were recorded for flesh thickness (18.69% and 15.67%), cavity diameter (18.60% and 17.10%), harvest index (18.20% and 15.95%) and fruit diameter (16.82% and 15.19%). Number of mature fruits/plant was recorded moderate for phenotypic coefficients of variability (16.86%) and low for genotypic coefficients of variability (13.60%). Phenotypic and genotypic coefficients of variability were recorded low in magnitude for days to first mature fruit harvest (7.15% and 5.95%), respectively. The present findings pertaining to different estimates of phenotypic and genotypic coefficient of variation are in line with the results of earlier workers like Kumar *et al.* [16].

Heritability (%)

The estimates of heritability (broad sense) varied from 65.00-94.80 per cent for different traits under study (Table 1). It was found high for the traits *viz.,* mature fruit weight (94.80%), cavity length (90.20%), fruit yield per plant (88.30%), fruit length (88.00%), cavity diameter (84.60%), fruit diameter (81.60%), harvest index (76.80%), flesh thickness (70.30%), days to first mature fruit harvest (69.30%) and number of mature fruits/plant (65.00%). The genotypic coefficient of variation does not offer full scope to estimate the variations that are heritable and therefore, estimation of heritability becomes necessary. Burton and De-Vane [7] has suggested that genetic coefficient of

variability along with heritability estimates would give a reliable indication of expected amount of improvement through selection. Similar estimates of heritability for above studied traits were also reported earlier by Akter *et al.* [17] in pumpkin.

Genetic gain (%)

Genetic gain (expressed as per cent of population mean) was low to high in nature and ranged from 10.21-72.72 per cent for different traits under study (Table 1). It was found high for the traits *viz.*, mature fruit weight (72.72%), cavity length (69.76%), fruit yield per plant (60.66%) and fruit length (55.28%). Moderate genetic gain was observed for cavity diameter (32.38%), harvest index (28.79%), fruit diameter (28.27%) and flesh thickness (27.15%). Genetic gain was recorded low for days to first mature fruit harvest (10.21%) and number of mature fruits/plant (22.49%). The present results corroborate the earlier findings of Pandey *et al.* [2], for most of the above traits under study. High heritability estimates coupled with high genetic gain were observed for mature fruit weight, cavity length, fruit yield per plant and fruit length, which indicated that these traits are under additive gene effects and these traits are more reliable for effective selection Panse [18]. Similar results were also reported by Akter *et al.* [17] for these traits under study. High heritability coupled with moderate genetic gain observed for cavity diameter, harvest index, fruit diameter and flesh thickness, indicated that these traits are under non-additive gene effects and selection for these traits will be less effective. Such traits are more under the influence of environment and do not respond to selection. Similar results for some of these traits were also reported by Pandey *et al.* [2].

Correlation and Path Analysis

The phenotypic and genotypic correlation coefficients among the different quantitative traits along with fruit yield per plant are presented in **Tables 2** and **3**, respectively. In general, the genotypic correlation coefficients were higher in magnitude than phenotypic correlation coefficients. The phenotypic and genotypic correlation coefficients among different traits revealed that fruit yield per plant had significantly positive association with days to opening of first female flower (0.130 and 0.233), node number of first female flower (0.256 and 0.306), fruit length (0.589 and 0.651), fruit diameter (0.645 and 0.702), number of mature fruits per plant (0.155 and 0.164), mature fruit weight (0.880 and 0.912), harvest index (0.551 and 0.558) and flesh thickness (0.450 and 0.505), respectively. Similar correlations of yield with various quantitative traits have also been reported earlier by several workers viz. Akter *et al.* [17], Naik *et al.* [19]. Beside this, fruit length resulted in positive and significant association with fruit diameter (0.230 and 0.233), mature fruit weight (0.629 and 0.663), flesh thickness (0.179 and 0.167), cavity length (0.960 and 0.973) and cavity diameter (0.213 and 0.226), while significant negative association of this trait was found with number of mature fruits per plant (-0.142 and -0.151). Yadav *et al.* [20] had also reported similar results for the positive and significant correlation of fruit polar and equatorial diameter with fruit weight and flesh thickness, respectively. The present findings corroborate the results obtained by Muralidhara *et al.* [14], who had also reported negative and significant association of number of fruits per plant, making a clear indication that increase in number of fruits per vine would indirectly affect the total yield, which is more dependent on fruit weight.

Although correlation studies are helpful in determining the components of yield, but it does not provide a clear picture of nature and extent of contributions made by number of independent traits. Path coefficient analysis devised by Dewey and Lu [12], however, provides a realistic basis for allocation of appropriate weightage to various attributes, while designing a pragmatic programme for the improvement of yield. The data on path coefficient analysis at genotypic level showing the direct and indirect effects of significant traits over fruit yield per plant have been presented in **Table 4**. The data revealed that mature fruit weight (0.929) has maximum positive direct effect on marketable fruit yield per plant, followed by number of mature fruits per plant (0.320), harvest index (0.232), plant weight (0.197) and fruit length (0.184). While, negative direct effect of cavity length (-0.230), cavity diameter (-0.077), flesh thickness (-0.026), days to first mature harvest (-0.014), fruit diameter (-0.016) and days to opening of first female flower (-0.044) was observed on fruit yield per plant. Besides, maximum positive indirect effects of fruit diameter (0.747), cavity diameter (0.713), fruit length (0.616), cavity length (0.566) and flesh thickness (0.555) via mature fruit weight was observed on fruit yield per plant. Significant positive direct effect of different quantitative traits on fruit yield in pumpkin had also been reported earlier by Naik *et al.* [19]. Maximum negative indirect effects of number of mature fruits per plant (-0.302) via mature fruit weight, fruit length (-0.223) and mature fruit weight (-0.140) via cavity length and flesh thickness (-0.113) and fruit diameter (-0.108) via number of mature fruits per plant was recorded on fruit yield per plant. Similar results were also reported by Muralidhara *et al.* [14

Table 2 Phenotypic coefficients of correlation among different quantitative traits in pumpkin

Trait	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.339**	0.342**	0.138*	0.414**	0.044	0.175**	-0.014	0.153*	0.354**	-0.170*	0.122	0.022	0.186**	0.130*
2		1.00	0.426**	0.126	0.349**	0.117	0.255**	0.010	0.216**	0.343**	-0.031	0.255**	0.095	0.216**	0.256**
3			1.00	0.090	0.517**	0.184**	0.309**	0.038	0.336**	0.453**	-0.013	0.275**	0.157*	0.290**	0.373**
4				1.00	0.163*	-0.106	0.016	-0.093	-0.049	0.023	-0.106	0.062	-0.109	-0.018	-0.098
5					1.00	0.186**	0.240**	0.043	0.323**	0.511**	-0.081	0.304**	0.141*	0.175**	0.371**
6						1.00	0.230**	-0.142*	0.629**	0.246**	0.289**	0.179**	0.960**	0.213**	0.589**
7							1.00	-0.277**	0.763**	0.322**	0.303**	0.608**	0.186**	0.927**	0.645**
8								1.00	-0.275**	-0.076	0.276**	-0.238**	-0.046	-0.224**	0.155**
9									1.00	0.399**	0.416**	0.531**	0.589**	0.729**	0.880**
10										1.00	-0.496**	0.385**	0.190**	0.281**	0.381**
11											1.00	0.104	0.318**	0.300**	0.551**
12												1.00	0.133*	0.405**	0.450**
13													1.00	0.180**	0.565**
14														1.00	0.615**
15															1.00

***Significant at 5% level of significance; ****Significant at 1% level of significance**

1=days to opening of first female flower, 2=node number of first female flower, 3=vine length (m), 4=days to immature fruit at marketable maturity stage, 5=days to first mature fruit harvest, 6=fruit length (cm), 7= fruit diameter (cm), 8=number of mature fruits per plant, 9=mature fruit weight (kg), 10=plant weight (kg), 11=harvest index (%), 12=flesh thickness (cm), 13=cavity length (cm), 14=cavity diameter (cm) and 15= fruit yield per plant (kg)

Table 3 Genotypic coefficients of correlation among different quantitative traits in pumpkin

Trait	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00	0.440**	0.494**	0.078	0.536**	0.064	0.277**	0.009	0.243**	0.414**	-0.120	0.175**	0.043	0.285**	0.233**
2		1.00	0.529**	0.134*	0.400**	0.146*	0.318**	0.020	0.247**	0.396**	-0.039	0.312**	0.130*	0.247**	0.306**
3			1.00	0.150*	0.586**	0.253**	0.364**	-0.006	0.424**	0.556**	-0.013	0.391**	0.200**	0.330**	0.471**
4				1.00	0.303**	-0.199**	0.110	-0.177**	-0.037	0.100	-0.227**	0.196**	-0.194**	0.082	-0.109
5					1.00	0.245**	0.245**	-0.004	0.369**	0.553**	-0.056	0.313**	0.194**	0.167*	0.410**
6						1.00	0.233**	-0.151*	0.663**	0.291**	0.334**	0.167*	0.973**	0.226**	0.651**
7							1.00	-0.336**	0.804**	0.332**	0.384**	0.651**	0.164*	0.938**	0.702**
8								1.00	-0.325**	-0.048	0.161*	-0.354**	-0.027	-0.261**	0.164*
9									1.00	0.435**	0.454**	0.598**	0.609**	0.768**	0.912**
10										1.00	-0.439**	0.337**	0.237**	0.294**	0.450**
11											1.00	0.219**	0.354**	0.375**	0.558**
12												1.00	0.123	0.439**	0.505**
13													1.00	0.167*	0.618**
14														1.00	0.678**
15															1.00

***Significant at 5% level of significance**
****Significant at 1% level of significance**

1=days to opening of first female flower, 2=node number of first female flower, 3=vine length (m), 4=days to immature fruit at marketable maturity stage, 5=days to first mature fruit harvest, 6=fruit length (cm), 7= fruit diameter (cm), 8=number of mature fruits per plant, 9=mature fruit weight (kg), 10=plant weight (kg), 11=harvest index (%), 12=flesh thickness (cm), 13=cavity length (cm), 14=cavity diameter (cm) and 15= fruit yield per plant (kg)

Table 4 Estimates of direct and indirect effects of different quantitative traits on marketable mature fruit yield per plant in pumpkin

Trait	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**-0.044**	0.023	0.006	0.001	-0.007	0.012	-0.004	0.003	0.226	0.082	-0.028	0.004	0.010	0.022	0.044
2	-0.019	**0.052**	0.007	0.002	-0.005	0.027	-0.005	0.006	0.229	0.078	-0.009	0.008	0.030	0.019	0.019
3	-0.022	0.028	**0.012**	0.003	-0.008	0.046	-0.006	-0.002	0.393	0.110	-0.003	0.010	0.046	0.025	0.022
4	-0.003	0.007	0.002	**0.018**	-0.004	-0.036	-0.002	-0.057	-0.035	0.020	-0.053	-0.005	0.045	-0.006	-0.003
5	-0.023	0.021	0.007	0.006	**-0.014**	0.045	-0.004	-0.001	0.343	0.109	-0.013	0.008	-0.044	0.013	0.023
6	-0.003	0.008	0.003	-0.004	-0.003	**0.184**	-0.004	-0.035	0.616	0.057	0.078	-0.004	0.223	0.017	0.003
7	-0.012	0.017	0.004	0.002	-0.003	0.043	**-0.016**	-0.108	0.747	0.065	0.089	-0.017	-0.038	0.072	0.012
8	0.000	0.001	0.000	-0.003	0.000	-0.020	0.005	**0.320**	-0.302	-0.009	0.037	0.009	0.056	0.070	0.000
9	-0.011	0.013	0.005	-0.001	-0.005	0.122	-0.013	-0.104	**0.929**	0.086	0.105	-0.015	-0.140	0.059	0.011
10	-0.018	0.021	0.007	0.002	-0.008	0.053	-0.005	-0.015	0.404	**0.197**	-0.102	-0.009	-0.054	0.023	0.018
11	0.005	-0.002	0.000	-0.004	0.001	0.061	-0.006	0.052	0.422	-0.086	**0.232**	-0.006	-0.081	0.029	0.005
12	-0.008	0.016	0.005	0.004	-0.004	0.031	-0.010	-0.113	0.555	0.066	0.051	**-0.026**	-0.028	0.034	0.008
13	-0.002	0.007	0.002	-0.004	0.003	0.179	-0.003	-0.009	0.566	0.047	0.082	-0.003	**-0.230**	0.013	0.002
14	-0.012	0.013	0.004	0.002	-0.002	0.042	-0.015	-0.084	0.713	0.058	0.087	-0.011	-0.038	**-0.077**	0.012
15	-0.044	0.023	0.006	0.001	-0.007	0.012	-0.004	0.003	0.226	0.082	-0.028	0.004	0.010	0.022	0.044

1=days to opening of first female flower, 2=node number of first female flower, 3=vine length (m), 4=days to immature fruit at marketable maturity stage, 5=days to first mature fruit harvest, 6=fruit length (cm), 7=fruit diameter (cm), 8=number of mature fruits per plant, 9=mature fruit weight (kg), 10=plant weight (kg), 11=harvest index (%), 12=flesh thickness (cm), 13=cavity length (cm), 14=cavity diameter (cm) and 15= Genotypic correlation coefficient for fruit yield per plant (kg)
Residual effect: 0.00944
Diagonal figures represent the direct effect

Conclusion

In the present study, the genotypes DPU-6, DPU-26 and DPU-51-3 were found most promising for higher fruit yield and also performed better for different quantitative traits under study. Further, high heritability estimates coupled with high genetic gain were observed for all the traits under study, which indicated that these traits are more reliable for effective selection. The fruit yield per plant had significantly positive association with fruit length, fruit diameter, number of mature fruits per plant, mature fruit weight, harvest index and flesh thickness. Mature fruit weight, number of mature fruits per plant, harvest index, and fruit length have maximum positive direct effect on marketable fruit yield per plant.

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References

[1] Tindall H D. Vegetables in the Tropics. Macmillan Education, London. 1987, pp 166.
[2] Pandey S, Singh J, Upadhya AK, Ram D. Genetic variability for antioxidants and yield components in pumpkin (Cucurbita moschata Duch. ex Poir.). Veg Sci. 2002, (29):123-126.
[3] Bose T K, Som M G. Vegetable crops in India. Naya Prokash, Calcutta, India. 1998, pp 92-95.
[4] Sood S, Kumar N, Chandal K S, Sharma P. Determination of genetic variation for morphological and yield traits in bell pepper (Capsicum annum var. grossum). Indian Journal of Agricultural Sciences. 2011, (81):590–594.
[5] Thamburaj S, Singh N (Eds.) Vegetables, Tuber Crops and Spices. 2004, ICAR, New Delhi.
[6] Gomez K A, Gomez A A. Statistical Procedures for Agricultural Research. John Wiley and Sons Inc., New York. 1983, pp. 357-427.
[7] Burton G W, De Vane D H. Estimating heritability in tall fescue (Festuca arundinacea) from replicated clover materials. Agron J. 1953, (45):478-481.
[8] Allard R W. Principles of Plant Breeding. John Wiley & Sons, Inc., New York, USA. 1960, 485p.
[9] Johnson H W, Robinson H F, Comstock R E. Estimates of genetic and environmental variability in soybean. Agron. J. 1955, (47):314-318.
[10] Al-Jibouri H W, Miller P A, Robinson H F. Genotypic and environmental variances and co-variances in an upland cotton cross of interspecific origin. Agron J. 1958, (50):633-636.
[11] Anonymous ICAR-Indian Agricultural Statistics Research Institute. 2012, http://iasri.res.in/spar/
[12] Dewey D R, Lu K H. A correlation and path coefficient analysis of components in crested wheat grass and seed production. Agron. J. 1959, (51):515–518.
[13] Mladenovic E, Berenji J, Kraljevic-Balalic M, Cukanovic J, Blagojevic I. Multivariate analysis of species from Cucurbitaceae family. Genetika. 2012, (44):227–234.
[14] Muralidhara M S, Gowda N C N, Narayanaswamy P. Genetic variability studies in pumpkin (Cucurbita moschata Duch. ex Poir.). Indian Horticulture J. 2014, (4):105-107.
[15] Cyril N, Denton D A, Oyelana O. Genetic variability and heritability of vegetative, fruit and seed yield traits in fluted pumpkin (Telfairia occidentalis Hook F.). African Journal of Biotechnology. 2014, (13):3262-3270.
[16] Kumar J, Singh R K, Pal K. Variability and character association in pumpkin (Cucurbita moschata Duch. ex. Poir). Indian J. Agric. Res. 2011, (45):87–90.
[17] Akter S, Rasul M G, Islam AKMA, Hossain M M. Genetic variability, correlation and path coefficient analysis of yield and quality traits in pumpkin (Cucurbita moschata Duch. ex Poir.). Bangladesh J Pl Breed Genet. 2013, (26):25-33.
[18] Panse V G. Genetics of quantitative characters in relation plant breeding. Indian J Genet Pl Breed. 1957, (17):318-328.
[19] Naik M L, Prasad V M, Laxmi R P. A study on character association and path analysis in pumpkin (Cucurbita moschata Duch. ex Poir.). International J. Advanced Res. 2015, (3):1030-1034.
[20] Yadav R K, Sanwal S K, Yadav D S, Sarma P. Correlation and path analysis in pumpkin. Haryana Journal of Horticultural Sciences. 2006, (35):338-339.

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