The Pharma Innovation Journal 2021; 10(12): 1858-1861

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 1858-1861

www.thepharmajournal.com
Received: 10-10-2021
Accepted: 12-11-2021

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Assessment of genetic variability in F_4 generation of pumpkin (*Cucurbita moschata* Duch ex. Poir)

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Abstract
A field experiment was conducted at All India Co-ordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during the Summer season in the year 2019. The present investigation was undertaken with 5 progenies with their 20 plants of each progeny for a cross RHR PK-10-1-1 x RHR PK-19-2-1-3 (C:3x4) of pumpkin in F_4 generation for evaluating their genetic components such as variability, heritability, genetic advance, genetic advance as a per cent mean and correlation for growth, yield and yield attributes. Significant variations were found among the genotypes for most of the characters studied. The maximum phenotypic and genotypic coefficient of variation was observed for characters viz. number of primary branches per vine, number of fruits per vine, fruit yield per vine, fruit weight and fruit yield per hectare. high calculates of heritability were associated with high calculates of per cent mean of genetic advance were observed for the characters like per vine number of fruit, fruit length, fruit diameter, per vine fruit yield, per plot fruit yield, per hectare fruit yield, flesh thickness, number of ridges per fruit, seed cavity length, seed cavity width, number of seed, 100-seed weight and TSS. fruit yield per plant had highly significant positive association observed for final vine length, number of fruit per vine, weight of fruit and fruit flesh thickness.

Keywords: pumpkin, variability, heritability, genetic advance, correlation

Introduction
Pumpkin (*Cucurbita moschata* Duch. Ex Poir.) is a popular cucurbitaceous vegetable that can be grown in a lot of different climates around the world. The genotypic as well as phenotypic coefficient of variability are helpful in assessing the existence of variability in breeding populations, whereas heritability calculates provide a measure of character transmissibility. As a result, a suitable selection strategy for higher yield in pumpkin can be developed based on these parameters. Furthermore, genetic progress can be used to predict the effectiveness of selection. The correlation co-efficient study assesses the component features from which yield may be enhanced and investigates association between various plant characters. The present study was therefore undertaken to find out and establish suitable selection criteria for higher yield through study of variability and relationship between yield and yield components in pumpkin.

Materials and Method
The present investigation was carried out at All India Co-ordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) during the *summer* 2019. The seeds of cross RHR PK-10-1-1 x RHR PK-19-2-1-3 (C:3x4) along with their parents were obtained from Department of Horticulture, MPKV, Rahuri. F_3 progenies from the cross were selected on the basis of shape of fruit and flesh colour. Five progenies (20 plants/progeny) were sown along with parents in randomized block design with three replications. Seeds of these generations were sown at a spacing of 5m x 1m. Observations were recorded on various growth and yield parameters for F_4 generation. Estimation of variations and genetic advance was done following Johnson *et al*., (1955) [6], coefficient of variations following Burton and De Vane (1953) [2] and heritability following (Lush, 1949) [8]. The correlation coefficient was estimated as suggested by Snedecor and Cochran (1967) [13].

Results and Discussion

Genetic variability

Relatively high estimates of genotypic and phenotypic coefficient of variation were observed for the traits, such as the number of primary branches per vine, number of fruits per vine, fruit yield per vine, fruit weight and fruit yield per hectare in tonnes. Whereas, Moderate genotypic coefficients of variation were observed for node number at which the first female flower appeared, days until the first female flower appeared, fruit diameter and fruit length. For the remaining traits, such like vine length, days until the first fruit harvest and diameter of the fruit, the genotypic as well as phenotypic co-efficients of variation were found low in the F_4 generations. Characters with higher estimations of GCV and PCV could be fully exploited in a future selection programme due to the wider range of the variation within segregating populations, *i.e.*, potential for the enhancement by selection. Characters with lower GCV and PCV estimations might be used the least in future selection programmes because of the relatively small amount of the variation observed within segregating populations, indicating that there is no room for further research through choosing. These findings were consistent with Kanal *et al.* (2019), Mekala *et al.* (2017) [7, 9].

Heritability and genetic advance

The High calculates of heritability were associated with high calculates of per cent mean of genetic advance in characters like per vine number of fruit, fruit length, fruit diameter, fruit yield per vine, fruit yield per plot, fruit yield per hectare, flesh thickness, number of ridges per fruit, seed cavity length, seed cavity width, number of seed, 100-seed weight and TSS. Whereas, high calculates of heritability were observed with moderate calculates of genetic advance as a per centage of the mean for vine length, per vine number of primary branches, days until the first female flower appearance, node number at which first female flower appeared, fruit weight. The high calculates of heritability with lower calculates of genetic advance as per cent of mean was noted in sex ratio, days until the first fruit harvest. The high calculates of heritability and per cent mean of genetic advance might be due to the predominance of additive gene action. As a consequence, it appears that character selection for the characters listed in the preceding crossings, as well as their subsequent generations, is feasible. Chaudhari *et al.* (2017), Mohsin *et al.* (2017) [4, 10]. A non-additive gene effect is concluded by a higher calculates of heritability with low per cent mean of genetic advance expressed. As a result, it's possible that selecting for these characteristics will prove futile. The least phenotypic diversity in these variables may explain both its high heritability as well as the low genetic advance. Similar findings were shown to be in agreement with Pathak (2014), Torkadi and Musmade (2007) [11, 14].

Correlation studies

Correlation studies have been done at both genotypic and phenotypic level. The perusal of the data revealed that the correlation at the genotypic as well as phenotypic levels has the same trend for most of the traits studied. The magnitude of genotypic correlation coefficients was relatively higher than the corresponding phenotypic correlation coefficients in almost all the characters paired indicated the inherent association between various characters. Similar result was obtained by Chaudhari *et al* 2017 [4]. Lower phenotypic correlation coefficients than genotypic correlation coefficients indicate that both genotypic and environment correlation in those study act in same direction, and finally maximize their expression at phenotypic level. In present study fruit yield per plant had highly significant positive association with final vine length, number of fruit per vine, weight of fruit and fruit flesh thickness. While, negatively and significantly correlated with days to 1st female flower appearance, sex ratio, node at which first female flower appeared and days to first harvest. These findings in indicate that the ideal vine should have more final vine length, more number of fruits per vine, more weight of fruit, and maximum flesh thickness of fruit and less days required for first female flower appearance, lower node position at which first female flower appeared and less days required for first harvest of fruit. The selection of a higher yielder should include a focus on improvement in these components. Gopalakrishnan *et al.* (1980), Borthakur and Shadeque (1994), Akter *et al.* (2013), Singh *et al.* (2019) [5, 3, 1] in pumpkin reported similar trend of correlation coefficient.

Table 1: Mean, range, GCV, PCV, ECV, heritability, genetic advance and per cent mean of genetic advance of F_4 population of cross RHR PK-10-1-1 x RHR PK-19-2-1-3 (C:3x4).

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h^2 (bs) (%)	GA	GAM (%)
1.	Final vine length (cm)	482.67	445.33-522.67	5.15	5.15	0.43	99.77	51.13	10.59
2.	Number of primary branches per vine	3.48	3.10-4.23	11.16	11.32	3.33	97.12	0.79	22.65
3.	Days to 1st female flower appearance	53.63	51.21-59.43	6.36	6.45	1.93	97.02	6.92	12.91
4.	Sex ratio	18.67	17.72-19.92	3.99	4.36	3.04	83.82	1.40	7.52
5.	Node at which first female flower appeared	14.04	12.86-15.54	7.15	8.05	6.40	78.95	1.84	13.10
6.	Days to first harvest	100.53	97.13-105.28	3.08	3.12	0.88	97.34	6.30	6.26
7.	Number of fruits per vine	2.12	1.70-2.39	14.05	14.22	3.79	97.63	0.61	28.61
8.	Weight of fruit (kg)	5.09	4.48-5.51	7.24	7.84	5.20	85.32	0.70	13.78
9.	Length of fruit (cm)	23.33	18.28-28.22	17.42	17.66	5.03	97.29	8.26	35.40
10.	Diameter of fruit (cm)	18.00	14.16-21.37	13.91	14.17	4.70	96.33	5.06	28.11
11.	Yield per vine (kg)	10.76	7.58-13.51	20.25	20.65	7.05	96.12	4.40	40.89
12.	Yield per plot (kg)	53.32	34.55-67.55	21.95	22.41	7.87	95.89	23.61	44.28
13.	Yield per hectare (t)	21.52	16.25-27.02	20.25	20.66	7.08	96.09	8.80	40.90
14.	Fruit flesh thickness (cm)	3.13	2.45-3.93	15.82	16.15	5.66	95.91	1.00	31.91
15.	Number of ridges per fruit	14.53	10.28-19.02	22.48	22.78	6.40	97.37	6.64	45.69
16.	Seed cavity length (cm)	16.63	11.68-21.24	26.34	26.42	3.47	99.42	9.00	54.10
17.	Seed cavity width (cm)	15.20	11.77-18.18	14.58	15.63	9.76	87.00	4.26	28.02
18.	Number of seeds per fruit	157.52	123.55-194.12	18.37	18.38	0.88	99.92	59.59	37.83
19.	100 seed weight (g)	8.20	4.35-10.57	28.39	31.14	22.16	83.12	4.37	53.32
20.	TSS (^{0}Brix)	7.87	6.60-8.97	9.84	9.94	2.44	97.98	1.58	20.06

Table 2: Genotypic and Phenotypic Correlation coefficient for yield and yield-contributing characters in F_4 generation of Cross RHR PK-10-1-1 x RHR PK-19-2-1-3 (C:3x4)

Sr. No.	Characters		Final vine length (cm)	Number of primary branches per vine	Days to 1st female flower appearance	Sex ratio	Node at which first female flower appeared	Days to first harvest	Number of fruit per vine	Weight of fruit (Kg)	Length of fruit (cm)	Diameter of fruit (cm)	Fruit flesh thickness (cm)	Yield per plot (kg)
1	Final vine length (cm)	G P	1.000 1.000	0.638 0.627	-0.888** -0.871*	-0.942** -0.857*	-0.999** -0.883**	-0.958** -0.945**	0.966** 0.954**	1.017** 0.927**	0.288 0.282	0.679 0.670	1.017** 0.993**	0.994** 0.968**
2	Number of primary branches per vine	G P	-	1.000 1.000	-0.705 -0.675	-0.660 -0.553	-0.678 -0.551	-0.713 -0.708	0.812** 0.791*	0.680 0.633	-0.050 -0.033	0.195 0.175	0.701 0.673	0.741 0.736
3	Days to 1st female flower appearance	G P	-	-	1.000 1.000	0.880** 0.825**	1.045** 0.937**	1.012** 0.975**	-0.946** -0.933**	-1.070** -0.974**	-0.170 -0.152	-0.796* -0.758*	-0.905** -0.870**	-0.983** -0.950**
4	Sex ratio	G P	-	-	-	1.000 1.000	0.790 0.697	0.993 0.872	-0.945 -0.850	-1.107** -0.899**	-0.596 -0.518	-0.924** -0.859**	-0.960** -0.831**	-1.034** -0.884**
5	Node at which first female flower appeared	G P	-	-	-	-	1.000 1.000	1.124** 0.942**	-1.012** -0.895**	-1.160** -0.932**	0.024 0.040	-0.771 -0.679	-1.010 -0.895	-1.050** -0.903**
6	Days to first harvest	G P	-	-	-	-	-	1.000 1.000	-1.022** -0.982**	-1.090** -0.991**	-0.174 -0.170	-0.764* -0.738	-0.983** -0.951**	-1.025** -0.988**
7	Number of fruit per vine	G P	-	-	-	-	-	-	1.000 1.000	1.052** 0.957**	0.201 0.195	0.653 0.623	1.005** 0.969	1.016** 0.993**
8	Weight of fruit (Kg)	G P	-	-	-	-	-	-	-	1.000 1.000	0.256 0.238	0.924** 0.807*	1.016** 0.926**	1.021** 0.974**
9	Length of fruit (cm)	G P	-	-	-	-	-	-	-	-	1.000 1.000	0.410 0.399	0.209 0.208	0.262 0.264
10	Diameter of fruit (cm)	G	-	-	-	-	-	-	-	-	-	1.000 1.000	0.655 0.621	0.744 0.692
11	Fruit flesh thickness (cm)	G P	-	-	-	-	-	-	-	-	-	-	1.000 1.000	1.008** 0.970**
12	Yield per plot (kg)	G P	-	-	-	-	-	-	-	-	-	-	-	1.000 1.000

S: Symbol, G: Genotypic, P: Phenotypic *, **: Significance at 5% and 1%, respectively

Conclusion

The maximum phenotypic and genotypic coefficient of variation was observed for characters viz. number of primary branches per vine, number of fruits per vine, fruit yield per vine, fruit weight and fruit yield per hectare in tonnes in pumpkin and remaining character shows moderate and low PCV and GCV in the cross RHR PK-10-1-1 x RHR PK-19-2-1-3 (C:3x4) in F_4 generations. The characters showing wide range of variation provide ample scope for selecting the desirable plant types. High estimates of heritability for the characters indicating that they were least affected by environment and selection based on phenotypic performance would be reliable. The significant and positive correlation both at phenotypic and the genotypic level was observed between fruit yield per vine and yield contributing characters. Thus, association of characters should be considered for improvement.

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