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Study of Segregation Pattern in F_3 generation of Pumpkin (*Cucurbita moschata* Duch ex. poir)

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Abstract
Ten F_3 non-reciprocal hybrids and five parents viz., CM-45, CM- 14, CM-12, TPT-Local and CM-64 were evaluated for yield and its components to assess the genetic variation, heritability, genetic advance and segregation pattern. Moderate GCV and PCV were recorded for number of seed for fruit, number of fruits per vine, number of branches per vine, vine length and fruit weight while low GCV and PCV volumes observed for days to first male and female flower opening. Among the traits, fruit weight, yield per vine, vine length, number of fruits per vine recorded high heritability coupled with moderate genetic advance as per cent of mean indicated that the additive genes govern these characters and selection will be effective for improvement of such traits. The cross CM – 45 X CM - 12 depicted more percentage of total transgressive segregants (TTS) and specific transgressive segregants (STS) for fruit weight and yield per vine. Based on segregation pattern it can be deduced that the crosses CM – 14 X CM - 12 in respect of fruits per vine and CM – 45 X CM - 12 in respect of yield per vine are highly desirable and can be utilized to obtain high yielding genotypes in future generations.

Keywords: Genetic studies, segregation pattern, pumpkin, correlation.

Introduction
Pumpkin being a monoecious and cross-pollinated crop, offers a wide range of variability for both qualitative and quantitative characters. Pumpkin (*Cucurbita moschata* Duch ex. poir) is one of the popular cucurbitaceous vegetable widely grown in our country due to its high nutritive value. Pumpkin belongs to the family Cucurbitaceae. 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. Pumpkin is highly cross-pollinated crop having chromosome number 2n=40. Cucurbita moschata is probably the most widely grown species of Cucurbita and this species is cross compatible with C. maxima, C. pepo and C. mixta. It is insectpollinated and 1000 m isolation distance is necessary to maintain purity of cultivars plants and vine crop. It is an annual crop having a climbing or trailing habit (Katyal SL and ML Chadha, 2000). Pumpkin is relatively high in energy and carbohydrates and a good source of vitamins, especially high carotenoid pigments and minerals (Bose TK and MG Som, 1998) [1]. The delicate shoots and leaves are used as delicious vegetables. The fleshy large fruits can be consumed at mature and immature stages. It is one of the main vegetable in a wedding party or on other occasional party in northern India (Chauhan DVS, 1995) [3]. A thorough knowledge on genetic parameter viz., variability, heritability and genetic advance will provide information for formulation of systematic breeding strategy to improve any crop. The segregation pattern of crosses throws light on genetic width of the crosses which helps breeder to identify the superior individual plants. Such information pertaining to pumpkin is lacking. Therefore, the present investigation was carried out with a set of partial diallel crosses to find out the variability, heritability, genetic advance and segregation pattern in yield and its components of pumpkin.

Materials and Methods
The experimental material consisting of 10 F_3 and five parents *viz*., CM-45, CM- 14, CM-12, TPT-Local and CM-64 were grown in a randomized block design with three replications. Twenty-four plants for each cross and twelve plants for each parent were raised in each replication. Two healthy vigorous seedlings were maintained per pit with a spacing of 2m X 2 m respectively.

Data was collected on all plants in each replication for fifteen characters *viz*., vine length, branches per vine, node at first male flower appearance node at first female flower appearance, days to first male flower opening days to first female flower opening, sex ratio, number of fruits per vine, fruit weight, fruit length, fruit girth, fruit flesh thickness, yield per vine, number of seeds per fruit and hundred seed weight. The phenotypic and genotypic coefficients of variation were calculated as per Burton (1952) [2]. Heritability and expected genetic advance as per cent of mean were estimated according to Lush (1940) [7].

Results and Discussion

The analysis of variance revealed highly significant differences among the entries for all characters except sex ratio which indicated the presence of considerable amount of diversity in the material selected. The magnitude of variation was maximum for yield per vine and sex ratio (Table 1). Higher estimates of these components indicated wider diversity for the traits. Further, narrow difference between PCV and GCV was observed for the traits as it implied that they were less influenced by the environment. Similar results were reported by Sendur kumaran *et al*. (1977). Mohanty (2000) [8] and Lakshmi *et al*. (2002) [7] in pumpkin. Moderate GCV and PCV values were recorded for number of seeds per fruit, number of fruits per vine, vine length, number of branches per vine and fruit weight. While low GCV and PCV values were recorded for days to first male and female flowers opening which indicated less variation in the material and less scope for improvement of this trait. The PCV value was higher with the corresponding GCV for all the traits due to partly interaction of genotypes with the environment or other environmental factors influencing the expression of these characters (Choudhury *et al*. 1991). Narrow differences between PCV and GCV for all the characters except in case of sex ratio indicated that they were comparatively stable to environmental variations.

However, the coefficient of variation indicated only the extent of variability existed for different characters and did not indicate heritable portion of the character. The relative amount of heritable portion of variation is assessed with the help of heritability estimates and genetic advance expressed as percentage of mean. Johnson *et al*. (1955) [6] reported that heritability and genetic advance as percent mean together were more useful for predicting the resultant effect of selected genotypes than heritability or genetic advance as percent of mean alone. Among the traits, fruit weight, yield per vine, vine length, number of seed per fruit, number of branches and number of fruits per vine recorded high heritability coupled with high genetic advance as per percent of mean. While the traits, fruit girth, fruit fresh thickness, fruit length, node at which first male flower appeared and hundred seed weight showed high heritability coupled with moderate genetic advance as percent of mean. This indicated that the additive genes govern these characters and selection will be effective for improvement of such traits. High heritability with low genetic advance was recorded for node at first female appeared, days to first male and female flower opening. This may be due to non-additive gene effect and simple selection will not be effective to improve these characters. Those results are inconformity with Gopalakrishnan *et al*. (1980) [5] and Sendur Kumaran *et al*. (1997) in pumpkin.

Among 10 F_3 crosses, two F_3 (CM – 14 X CM - 12 and CM-12 X CM-64) exceeded the overall general mean number of fruits per vine (1.77). The crosses CM – 14 X CM - 12 recorded the highest mean number of fruits per vine (2.4 Kg) with parental means of 1.97 and 2.33 Kg respectively (Table 1). Five out of 10 F_3 crosses exceeded the general mean fruit weight (3.41 Kg) (Table-3). The highest mean fruit weight was recorded by CM-14 X CM - 12 (4.03 kg) with parental means of 3.61 and 3.58 kgs respectively. Among the F3 crosses, five F3 crosses exceeded the overall general mean yield per vine (8.96 kg). The cross CM – 15 X CM - 12 recorded the highest mean yield per vine of 12.62 kg with parental means of 5.60 and 10.66 kg respectively.

The crosses CM-14 X CM - 12 showed better segregation pattern for highest number fruits and fruit weight per vine, while the cross CM – 45 X CM - 12 recorded the better segregation pattern and highest mean yield per vine. (Table - 2, 3, &4). The total transgressive segregants (TTS) of for number of fruits per vine ranged from 38.16 to 49.32 per cent while significantly transgressive segregants (STS) ranged from 39.34 to 50.37 per cent. The cross CM - 14CM - 12 showed more percentage of TTS and STS with respect to fruit weight (Table 5). The TTS and STS in fruit weight was ranged from 38.13 to 50.33 and 36.69 to 49.92 respectively. While TTS and STS for yield per vine ranged from 39.98 to 49.67 and 33.14 to 48.13 respectively. The cross CM-45 x CM-12 depicted more percentage of TTS and STS for both fruit weight and yield per vine (Table 5).Based on segregation pattern it can be deduced that the crosses CM – 14 X CM - 12 in respect of fruits per vine and CM – 45 X CM - 12 in respect of yield per vine are highly desirable and can be utilized to obtain high yielding genotypes in future generations.

Table 1: Mean, Variance, Co-efficients of variation, heritability (Broad sense) and Genetic advance and Genetic advance as per cent of mean for 15 characters in F3 generation of 5 x 5 partial diallel of pumpkin

S. No	Character	General Mean	Variance		Co-efficient of variation		Heritability broad sense (%)	Genetic advance	Genetic advance as percent of mean (%)
			Genotypic (r_g)	Phenotypic (r_p)	Genotypic (r_g)	Phenotypic (r_p)			
1	Vine length (m)	7.895	1 283	1.338	14.35	14.65	95.9	2.29	29.005
2	Branches per vine	9.504	1.466	1.683	12.74	13.65	87.1	2.33	24.515
3	Node at which first male flower appeared	5.509	0.225	0.247	8.61	9.02	91.0	0.93	16.881
4	Node at which first female flower appeared	18.36	0.374	0.523	3.33	3.94	71.6	1.07	5.82
5	Days to first male flower opening	56.389	1.71 1	1.909	2.32	2.45	89.5	2.55	4.52
6	Days to first female flower opening	63.184	0.886	1.209	1.49	1.74	5.4	1.57	2.64
7	Sex ratio	0.138	0.001	0.0185	23	98.82	74.3	0.02	14.49

8	Fruits per vine	1.778	0.662	0.089	14.47	16.78	97.2	0.46	25.87
9	Fruit weight (Kg)	3.4093	0.132	0.135	10.64	10.79	91.4	0.74	21.70
10	Fruit length (cm)	24.5051	4.483	4.897	8.64	9.03	94.4	4.17	17.02
11	Fruit girth (cm)	24.276	4.05	4.288	8.29	8.53	91.8	4.03	16.601
12	Fruit flesh thickness(cm)	3.519	0.063	0.069	7.15	7.46	96.6	0.5	14.209
13	Yield per vine (kg)	8.967	3.71	3.839	21.48	21.85	93.2	3.9	43.493
14	Number of seeds per fruit	553.673	11289.030	12115.45	19.19	19.88	75.0	21 1.38	38.169
15	Hundred seed weight(g)	20.493	2.471	3.29	7.67	8.85		2.8	13.663

Table 2: Segregation pattern in F_3 generation for number of fruits per vine in pumpkin

S. No	Crosses	Percent population in different class intervals						Mean		
		0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	P_1	P_2	P_3
1	CM-45 X CM-14	0	38.39	30.47	21.34	7.9	1.90	1.40	1.97	1.66
2	CM-45 X CM-12	3.12	39.45	29.34	22.45	6.1	0	1.40	2.33	1.67
3	CM-45 XTPT- Local	0	40.21	27.51	23.4	8.7	0	1.40	1.73	1.70
4	CM-45 X CM-64	0	39.75	30.34	20.01	9.9	0	1.40	1.7	1.67
5	CM-14 X CM-12	0	28.33	41.59	21.22	6.84	2.02	1.97	2.33	2.40
6	CM-14 XTPT- Local	0	42.54	32.54	20.5	4.42	0	1.97	1.73	1.53
7	CM-14 X CM-64	0	41.59	29.52	19.54	7.7	0	1.97	1.70	1.73
8	CM-12 XTPT- Local	2.34	41.66	28.01	21.59	6.4	1.65	2.33	1.73	1.57
9	CM-12 X CM-64	0	39.45	31.01	22.5	7.04	0	2.33	1.70	1.77
10	TPT- Local X CM-64	0	38.77	33.22	21.51	6.5	0	1.73	1.70	1.80

Table 3: Segregation pattern in F_3 generation for fruits weight in pumpkin

S. No	Crosses	Percent population in different class intervals						Mean		
		0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	P_1	P_2	P_3
1	CM-45 X CM-14	0	15	28.30	54.45	2.25	0	2.54	3.16	3.30
2	CM-45 X CM-12	0	18.21	24.03	52.67	5.09	0	2.54	3.58	3.40
3	CM-45 XTPT- Local	0	14.34	39.34	44.66	1.66	0	5.54	3.18	3.73
4	CM-45 X CM-64	2.0	14.32	32.44	46.78	2.36	2.1	2.54	3.23	3.79
5	CM-14 X CM-12	0	6.12	21.62	29.33	36.43	6.5	3.16	3.58	4.03
6	CM-14 XTPT- Local	0	7.24	25.35	48.49	17.02	1.9	3.16	3.18	3.38
7	CM-14 X CM-64	2.04	6.2	23.14	50.3	17.02	1.6	3.16	3.23	3.76
8	CM-12 XTPT- Local	0	7.10	24.12	52.11	16.52	0	3.58	3.18	3.28
9	CM-12 X CM-64	1.6	6.72	17.30	52.6	20.1	1.6	3.58	3.23	3.89
10	TPT- Local X CM-64	0	9.75	20.9	49.35	18.51	1.4	3.18	3.23	3.35

Table 4: Segregation pattern in F_3 generation for yield per vine in pumpkin

S. No	Crosses	Percent population in different class intervals						Mean		
		0-3	3.1-6	6.1-9	9.1-12	12.1-15	15.1-18	P_1	P_2	P_3
1	CM-45 X CM-14	0	5.5	34.83	52.67	4.3	2.7	5.6	6.67	9.97
2	CM-45 X CM-12	0	2.1	12.17	37.39	43.24	5.1	5.6	10.66	12.62
3	CM-45 XTPT- Local	2.1	8.1	66.58	15.21	6.3	1.8	5.6	6.59	8.34
4	CM-45 X CM-64	0	5.01	60.16	25.3	7.51	2.02	5.6	9.4	10.96
5	CM-14 X CM-12	2.14	6.02	55.32	30.41	6.11	0	6.67	10.66	8.53
6	CM-14 XTPT- Local	1.99	8.07	51.67	25.45	10.81	2.01	6.67	9.4	8.73
7	CM-14 X CM-64	10.99	7.06	48.83	30.47	8.45	1.6	6.67	6.59	7.26
8	CM-12 XTPT- Local	2.01	10.8	54.66	23.33	7.1	2.10	10.66	6.59	9.00
9	CM-12 X CM-64	2.23	4.79	6.03	54.59	30.3	2.08	10.66	9.4	11.26
10	TPT- Local X CM-64	2.03	6.03	40.03	48.6	3.04	0	6.59	9.4	8.91

Table 5: Percentage of total transgressive segregants (TTS) and significantly transgressive segregants (STS) in F_3 generation for yield per vine in pumpkin

S. No	Crosses	Fruits per vine		Fruit weight		Fruit yield per vine	
		TTS	STS	TTS	STS	TTS	STS
1	CM-45 X CM-14	40.12	42.34	42.34	40.71	39.23	43.84
2	CM-45 X CM-12	39.16	44.13	44.13	37.22	50.33	49.92
3	CM-45 XTPT- Local	43.13	41.14	41.14	36.24	41.29	36.39
4	CM-45 X CM-64	40.22	41.14	41.14	33.14	47.84	43.82
5	CM-14 X CM-12	49.32	50.37	50.37	48.13	46.33	39.92
6	CM-14 XTPT- Local	42.66	42.34	42.34	41.14	42.83	45.44
7	CM-14 X CM-64	38.16	43.29	43.29	43.34	43.10	39.23
8	CM-12 XTPT- Local	40.09	45.67	45.67	39.38	38.13	44.12
9	CM-12 X CM-64	42.38	44.13	44.13	41.69	46.34	41.33
10	TPT- Local X CM-64	39.82	45,14	45,14	39.23	43.98	46.38

Conclusion

The crosses CM-14 X CM - 12 showed better segregation pattern for highest number fruits and fruit weight per vine, while the cross CM – 45 X CM - 12 recorded the better segregation pattern and highest mean yield per vine. (Table - 2, 3, &4) .The total transgressive segregants (TTS) of for number of fruits per vine ranged from 38.16 to 49.32 per cent while significantly transgressive segregants (STS) ranged from 39.34 to 50.37 per cent. The cross CM - 14CM - 12 showed more percentage of TTS and STS with respect to fruit weight (Table 5). The TTS and STS in fruit weight were ranged from 38.13 to 50.33 and 36.69 to 49.92 respectively. While TTS and STS for yield per vine ranged from 39.98 to 49.67 and 33.14 to 48.13 respectively. The cross CM-45 x CM-12 depicted more percentage of TTS and STS for both fruit weight and yield per vine (Table 5).Based on segregation pattern it can be deduced that the crosses CM – 14 X CM - 12 in respect of fruits per vine and CM – 45 X CM - 12 in respect of yield per vine are highly desirable and can be utilized to obtain high yielding genotypes in future generations.

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