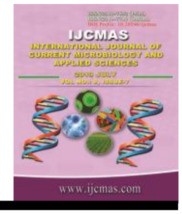
Int.J.Curr.Microbiol.App.Sci (2019) *8*(7): 1001-1010

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 07 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.807.120

Estimation of Heterosis for Growth, Yield and Quality Traits in Pumpkin (*Cucurbita moschata* Duch. ex. Poir)

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ABSTRACT

Keywords

Pumpkin (*Cucurbita moschata* Duch. ex. Poir), Heterosis for growth, Yield and quality traits

Article Info

Accepted:
10 June 2019
Available Online:
10 July 2019

The present investigation was carried out with aims to assess the heterosis involving 7 parents namely, Narendra Agrim (P_1), Narendra Amrit (P_2), Narendra Upkar (P_3), NDPK-76-1 (P_4), NDPK-724 (P_5) and NDPK-39-2 (P_6) and NDPK-12-10 (P_7) of pumpkin and their 21 F_1 hybrids produced in diallel mating design excluding reciprocals at MES, Vegetable Science, NDUA.&T, Kumarganj, Faizabad (U.P.) India in *Zaid*, 2016. The experiments were laid out in RBD with three replications having each experimental unit of single row with spacing of 3.0 m (R×R) × 0.5 m (P×P). The observations were recorded on parents and F_1's for twenty quantitative traits including six quality traits *viz*., node number to first male flower appearance, node number to first female flower appearance, 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, fruit weight (kg), number of fruits per plant, equatorial circumference of fruit (cm), polar circumference of fruit (cm), flesh thickness (cm), fruit yield per plant (kg), and six quality/biochemical traits namely ascorbic acid, reducing sugars (%) non-reducing sugars (%), total sugars (%), dry matter content and total soluble solids. Significant better as well as standard heterosis was estimated for all the traits. Out of twenty one crosses, nine crosses over better parent and nineteen crosses over standard parents showed significant heterosis for fruit yield. The extent of standard heterosis of six best crosses (20.87 to 133.04 %) for fruit yield per plant revealed that there was a great scope of realizing higher yield in pumpkin through heterosis breeding.

Introduction

Pumpkin (*Cucurbita moschata* Duch. ex. Poir) is one of the most important vegetable crop of family Cucurbitaceae. It is grown throughout the world due to its good nutritional value and also higher returns to the farmers. The centre of orgin of pumpkin is central Mexico. Pumpkin is a herbaceous annual, sexually propagated vegetable allopolyploid having chromosome number 2n=2x=40. Stem is angular, five ridged without hairs, trailing and branched. Trailing vine strikes roots at nods. Leaves are deeply or shallowly lobed not pinnatifid. Fruits have diuretic and vermetic action. Seeds are non bitter, tasty and nutritious. The flowers are large and yellow coloured with showy companulate corolla. Ovary is inferior and tricarpellary. Corolla is companulate, gamopetalous, lobed. Plants are monoecious, highly cross pollinated, entamophilous with three anthers. The word pumpkin was derived from the Greek word *pepon*, which means “large melon", something round and large.

Based on commercial significance the cultivated *Cucurbita* species rank among the 10 leading vegetable crops worldwide. China and India lead the world production and other major producers are U.S., Egypt, Mexico, Ukraine, Cuba, Italy, Iran and Turkey (Ferriol and Pico, 2008). The total area of pumpkin in India is 19,760 hectares whereas, the total production is 0.42 million tonne with productivity 21.25 mt/ha (Annonymous, 2015). Robinson and Decker-Walters (1999) concluded that in genus *Cucurbita*, there are 5 cultivated and 10 wild species. Seshadri and More (2009) also stated that the recent recognition of synonyms and taxonomic changes have reduced the number of *Cucurbita* species to 15 or even less. The five cultivated species are *C. argyrosperma* (earlier *C. mixta*), *C. pepo, C. maxima, C. moschata* and *C. ficifolia*. In India, pumpkin and squashes were introduced from South America by foreign navigators and emissaries. *Cucurbita moschata* is more widely cultivated than other four cultivated species in our country. Since *Cucurbita moschata* is amenable to hot climate more than other cultivated species, it is also the most widely grown vegetable throughout the tropics of both hemispheres. Pumpkins, like other squash, are thought to have originated in North America. The oldest evidence, pumpkin-related seeds dating between 7000 and 5500 BC, were found in Mexico.

The crop improvement can be brought about in pumpkin by assessing the genetical variability and exploitation of heterosis. Because of the monoecious nature of the crop, large flower size, ease of pollination, high proportion of fruit set of pollinated female flowers, large number of seeds per fruit and low seed rate required per unit area, pumpkin is highly amenable for heterosis breeding. During last three decades much works have been done on the study of hybrid vigour in pumpkin and high amount of heterosis has been reported by many research workers (Pandey *et al.*, 2010; Nisha and Veeraragavathatham, 2014 and Tamilselvi *et al.*, 2015). Several hybrids have been released by public as well as private sectors for its commercial cultivation. The area under F_1 hybrids is growing fast, which has helped to enhance the productivity and production of this crop.

Materials and Methods

The experimental materials for the present study comprised of six 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, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) India. The selected parental lines *i.e*. Narendra Agrim (P_1), Narendra Amrit (P_2), Narendra Upkar (P_3), NDPK-76-1 (P_4), NDPK-724 (P_5), NDPK-39-2 (P_6) and NDPK-12-10 (P_7) were raised and crossed in the all possible combinations, excluding reciprocals, during summer, 2016 to develop 21 F_1 hybrids. The experiments were conducted in Randomized Block Design (RBD) with three replications to assess the performance of 21 F_1 hybrids and 7 parents. The treatments were planted in row to row at 3.0 m apart with a plant to plant spacing of 0.50 m. The seeds were sown on 9^{th} March, 2017. All the recommended agronomic package of practices and plant protection measures were followed to raise good crop. 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 marketable fruit harvest, number of primary branches per plant, equatorial circumference of fruit (cm), polar circumference of fruit (cm), flesh thickness (cm), internodal length (cm), vine length (m), average fruit weight (kg), number of fruits per plant, fruit yield per plant (kg), ascorbic acid (mg/100g), reducing sugars (%), non-reducing sugars (%), total sugars (%), dry matter content (%) and total soluble solids (%).

The analysis of variance was carried out as suggested by Panse and Sukhatme (1967).

Results and Discussion

The exploitation of heterosis requires an intensive evaluation of germplasm to find out diverse donors with high nicking of genes and further identification of heterotic crosses. In the present study the estimates of heterosis over better parent (BP) and standard variety (SV) Narendra Agrim were calculated for twenty one F_1's.

Perusal of data given in Table 1 revealed that nature and magnitude of heterosis differed for different traits in various hybrid combinations. A wide range of variations in positive and negative direction of heterosis were also recorded for remaining traits.

A perusal of Table 1 revealed that crosses exhibiting significant and positive estimates of heterosis for one or both types of heterosis for fruit yield also exhibited significant heterosis for some other important yield, yield attributing traits and biochemical traits. In contrast none of the crosses showed significant and desirable heterosis for all traits.

For earliness negative heterosis is desirable. Since hybrids with heterosis for earliness produce first fruit earlier as compared to parents, thereby increasing production and productivity per per unit area and fetches good prices in the market by early supply of produce.

A close examination of heterosis values for five maturity traits i.e. node number to first male and female flower appearance, days to first male and female flower anthesis, and days to first fruit harvest, revealed that six and five hybrids for days to first male flower anthesis, four and five hybrids for days to first female flower anthesis, ten and fifteen hybrids for node number to first male flower appearance, ten and fourteen hybrids for node number to first female flower appearance, three and three hybrids for days to first fruit harvest exhibited significant and desirable heterosis in respect to better and standard parent respectively. However, top ranked crosses for fruit yield were almost at par for earliness and thereby showing good scope for early hybrids.

Our study further revealed that atleast one parent (P_1, P_2, P_4 and P_6) with early maturity was invariably involved in the top three F_1 hybrids ($P_1 \times P_2$, $P_1 \times P_5$ and $P_4 \times P_6$) for fruit yield over better parent and standard parent. Further the earliness of parents as well as crosses were directly associated with the high magnitude of heterosis.

Therefore, it can safely be concluded that either of parents, P_1, P_2, P_4 and P_6 or any two of them may be a better choice in any heterosis breeding programme intended to breed high yielding hybrids with earliness trait.

The present observations are in agreement with the findings of Singh (2008) and Maurya (2010) in case of bottle gourd.

Table.1 Estimates of heterosis (%) over better parent (BP) and standard variety (SV) Narendra Agrim in Pumpkin

Trait / Crosses	Node number to first male flower		Node number to first female flower		Days to first male flower anthesis		Days to first female flower anthesis	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_1 \times P_2$	10.34	10.34	-8.92	3.56	-6.91	6.08	-7.35	4.17
$P_1 \times P_3$	-8.20	15.86**	-14.26*	51.51**	-8.22	-8.22	-0.22	-0.22
$P_1 \times P_4$	-13.10*	-13.10*	4.94	10.68	-17.71**	-14.30*	-8.58	-2.73
$P_1 \times P_5$	4.83	4.83	15.80	34.52**	-22.31**	-20.86**	-10.53*	-8.34
$P_1 \times P_6$	3.45	3.45	1.16	43.84**	-22.20**	-21.82**	-13.70**	-11.21*
$P_1 \times P_7$	9.29**	70.34**	-23.83**	20.00	-7.41	8.77	-6.84	7.69
$P_2 \times P_3$	-13.11**	9.66	-13.95*	52.05**	-13.82**	-1.80	-5.05	6.76
$P_2 \times P_4$	-7.14	-19.31**	10.36	25.48*	-5.33	7.87	-1.41	10.86*
$P_2 \times P_5$	-8.73	-20.69**	3.54	20.27	-5.03	8.22	2.56	15.31**
$P_2 \times P_6$	25.53**	22.07**	-9.06	29.32**	-4.85	8.43	-1.41	10.86*
$P_2 \times P_7$	9.29	70.34**	-31.48**	7.95	-7.41	8.77	-6.09	8.55
$P_3 \times P_4$	-15.30**	6.90	-17.98**	44.93**	-5.64	-1.73	-5.61	0.43
$P_3 \times P_5$	-26.23**	-6.90	-38.29**	9.04	-11.19*	-9.53	-4.84	-2.52
$P_3 \times P_6$	14.75**	44.83**	-13.95*	52.05**	-4.67	-4.21	-3.77	-1.01
$P_3 \times P_7$	15.04**	79.31**	-18.29**	44.38**	-7.17	9.05	-4.66	10.21
$P_4 \times P_5$	8.55	-12.41*	9.91	27.67*	1.13	5.32	-11.01*	-5.32
$P_4 \times P_6$	-8.51	-11.03*	12.14	59.45**	-3.71	0.28	-3.99	2.16
$P_4 \times P_7$	-5.75	46.90**	-34.61**	3.01	-8.70	7.25	-3.42	11.65*
$P_5 \times P_6$	-13.48*	-15.86**	-10.21	27.67*	-11.05*	-9.39	1.89	4.82
$P_5 \times P_7$	-3.10	51.03**	24.87**	96.71**	-4.47	12.22*	-14.86**	-1.58
$P_6 \times P_7$	15.49**	80.00**	10.43	73.97**	-4.17	12.57*	-4.60	10.28
No. of crosses with significant (+) heterosis	**5**	**9**	**1**	**14**	**0**	**2**	**0**	**4**
No. of crosses with significant (-) ‘heterosis	**5**	**6**	**9**	**0**	**6**	**3**	**4**	**1**
Range of heterosis	**-26.23 to 25.53**	**-20.69 to 80.00**	**-38.29 to 24.87**	**3.01 to 96.71**	**-22.31 to 1.13**	**-21.82 to 12.57**	**-14.86 to 2.56**	**-11.21 to 15.31**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively
(P_1- Narendra Agrim, P_2- Narendra Amrit, P_3- Narendra Upkar, P_4- NDPK-76-1, P_5- NDPK-724, P_6- NDPK-39-2, P_7- NDPK-12-10)

Table.1 Contd…

Trait / Crosses	Days to first marketable fruit harvest		Number of primary branches per plant		Equotorial circumference of fruit (cm)		Polar circumference of fruit (cm)	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_1 \times P_2$	-6.09	-1.66	12.61*	12.61*	-13.32**	13.87*	6.87	21.85**
$P_1 \times P_3$	-14.86**	-14.86**	19.13**	19.13**	10.40	30.65**	3.68	21.30**
$P_1 \times P_4$	-1.36	-1.36	0.00	13.48*	6.00	14.37*	11.15	16.29*
$P_1 \times P_5$	0.40	0.40	0.43	0.43	-6.79	25.96**	8.13	20.83**
$P_1 \times P_6$	-18.70**	-16.21**	22.17**	22.17**	8.13	21.05**	20.99**	29.99**
$P_1 \times P_7$	-2.31	-2.31	20.43**	20.43**	1.56	1.56	10.88	10.88
$P_2 \times P_3$	-10.12*	-5.87	16.84*	-0.43	4.28	36.98**	7.63	25.92**
$P_2 \times P_4$	-6.14	-1.71	7.28	21.74**	-16.57**	9.60	6.87	21.85**
$P_2 \times P_5$	0.34	5.07	9.13	-1.30	6.79	44.31**	2.75	17.15**
$P_2 \times P_6$	-6.23	-1.81	19.39**	1.74	-3.14	27.24**	7.01	22.00**
$P_2 \times P_7$	-6.23	-1.81	13.30*	7.39	-8.61	20.06**	-6.94	6.11
$P_3 \times P_4$	-3.38	-6.63	-10.73*	1.30	5.53	24.89**	6.49	24.59**
$P_3 \times P_5$	-3.94	-5.72	4.81	-5.22	-3.05	31.01**	-1.41	15.35*
$P_3 \times P_6$	-6.19	-3.31	46.24**	10.00	1.98	20.70**	2.61	20.05**
$P_3 \times P_7$	-4.26	-12.10*	13.30*	7.39	6.73	26.32**	-9.44	5.95
$P_4 \times P_5$	-4.55	-6.33	8.81	23.48**	-7.74	24.68**	13.10*	26.39**
$P_4 \times P_6$	-2.97	0.00	3.45	17.39**	6.67	19.42**	3.86	11.59
$P_4 \times P_7$	0.21	-3.16	2.68	16.52**	7.71	16.22**	-4.79	-0.39
$P_5 \times P_6$	-1.36	1.66	14.42*	3.48	-6.26	26.67**	2.80	14.88*
$P_5 \times P_7$	-5.93	-7.68	6.88	1.30	-8.11	24.18**	-4.41	6.81
$P_6 \times P_7$	-6.48	-3.61	12.39	6.52	8.13	21.05**	8.02	16.05*
No. of crosses with significant (+) heterosis	**0**	**0**	**10**	**9**	**0**	**19**	**2**	**15**
No. of crosses with significant (-) 'heterosis	**3**	**3**	**1**	**0**	**2**	**0**	**0**	**0**
Range of heterosis	**-18.70 to 0.40**	**-16.21 to 5.07**	**-10.73 to 46.24**	**-5.22 to 23.48**	**-16.57 to 10.40**	**1.56 to 44.31**	**-9.44 to 20.99**	**-.39 to 29.99**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.
(P_1**-** Narendra Agrim, P_2**-** Narendra Amrit, P_3**-** Narendra Upkar, P_4**-** NDPK-76-1, P_5**-** NDPK-724, P_6**-** NDPK-39-2, P_7**-** NDPK-12-10**)**

Table.1 Contd…

Trait / Crosses	Flesh thickness (cm)		Internodal length (cm)		Vine length (m)		Average fruit weight (kg)	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_1 \times P_2$	3.48	63.01**	12.79*	12.79*	-39.37**	-39.37**	-19.35*	-19.35*
$P_1 \times P_3$	10.98	24.66**	-10.08	-10.08	10.16*	11.02*	-2.94	6.45
$P_1 \times P_4$	3.53	20.55*	-4.36	10.47	-42.52**	-42.52**	-3.23	-3.23
$P_1 \times P_5$	10.23	32.88**	6.62	18.60**	-47.24**	-47.24**	-12.90	-12.90
$P_1 \times P_6$	11.84	16.44	-6.98	-6.98	-10.24*	-10.24*	3.17	4.84
$P_1 \times P_7$	6.59	32.88**	12.01*	22.87**	-43.04**	-29.13**	4.84	4.84
$P_2 \times P_3$	2.61	61.64**	6.38	-3.10	-46.88**	-46.46**	-5.88	3.23
$P_2 \times P_4$	-5.22	49.32**	-15.77**	-2.71	-32.71**	-43.31**	5.17	-1.61
$P_2 \times P_5$	3.48	63.01**	-11.85*	-1.94	-16.82**	-29.92**	-5.17	-11.29
$P_2 \times P_6$	0.00	57.53**	8.51	-1.16	-23.77**	-26.77**	-9.52	-8.06
$P_2 \times P_7$	-6.96	46.58**	-6.01	3.10	-46.84**	-33.86**	4.92	3.23
$P_3 \times P_4$	10.59	28.77**	-14.09**	-0.78	-17.97**	-17.32**	-4.41	4.84
$P_3 \times P_5$	15.91*	39.73**	7.32	19.38**	-38.28**	-37.80**	-10.29	-1.61
$P_3 \times P_6$	17.07*	31.51**	8.51	-1.16	31.25**	32.28**	-5.88	3.23
$P_3 \times P_7$	16.48*	45.21**	-12.72*	-4.26	-33.54**	-17.32**	-10.29	-1.61
$P_4 \times P_5$	6.82	28.77**	8.05	24.81**	36.71**	-14.96**	0.00	-9.68
$P_4 \times P_6$	21.18**	41.10**	-17.11**	-4.26	-4.10	-7.87	-4.76	-3.23
$P_4 \times P_7$	8.79	35.62**	-8.05	6.20	-39.87**	-25.20**	0.00	-1.61
$P_5 \times P_6$	6.82	28.77**	-8.36	1.94	-40.98**	-43.31**	-4.76	-3.23
$P_5 \times P_7$	8.79	35.62**	2.79	14.34*	-41.77**	-27.56**	-9.84	-11.29
$P_6 \times P_7$	7.69	34.25**	1.41	11.24	-52.53**	-40.94**	-4.76	-3.23
No. of crosses with significant (+) heterosis	**04**	**20**	**02**	**06**	**03**	**02**	**0**	**0**
No. of crosses with significant (-) 'heterosis	**0**	**0**	**05**	**0**	**17**	**18**	**01**	**01**
Range of heterosis	**-6.96 to 21.18**	**16.44 to 63.01**	**-17.11 to 12.79**	**-10.08 to 24.81**	**-52.53 to 36.71**	**-47.24 to 32.28**	**-19.35 to 5.17**	**-19.35 to 6.45**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.
(P_1- Narendra Agrim, P_2- Narendra Amrit, P_3- Narendra Upkar, P_4- NDPK-76-1, P_5- NDPK-724, P_6- NDPK-39-2, P_7- NDPK-12-10)

Table.1 Contd…

Trait / Crosses	No. of fruits per plant		Fruit yield per plant (kg)		Ascorbic acid (mg/100)		Reducing sugars (%)	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_1 \times P_2$	10.34	14.29	30.43*	30.43*	32.73**	32.73**	35.14**	35.14**
$P_1 \times P_3$	10.67	48.21**	11.38	61.74**	-16.67**	-6.06	3.66	14.86*
$P_1 \times P_4$	29.85**	55.36**	28.70*	28.70*	-5.03	3.03	2.27	21.62**
$P_1 \times P_5$	30.36*	30.36*	30.58*	37.39**	21.93**	38.18**	18.39**	39.19**
$P_1 \times P_6$	1.10	64.29**	-10.88	49.57**	15.76**	15.76**	40.54**	40.54**
$P_1 \times P_7$	0.00	51.79**	4.19	73.04**	22.75**	40.61**	-12.09*	8.11
$P_2 \times P_3$	9.33	46.43**	8.38	57.39**	-5.38	6.67	-9.76	0.00
$P_2 \times P_4$	31.34**	57.14**	30.97*	28.70*	22.35**	32.73**	19.32**	41.89**
$P_2 \times P_5$	12.07	16.07	29.75*	36.52**	-16.58**	-5.45	-31.03**	-18.92**
$P_2 \times P_6$	-6.59	51.79**	-10.88	49.57**	66.23**	55.15**	21.13**	16.22**
$P_2 \times P_7$	1.18	53.57**	3.14	71.30**	-6.88	6.67	-31.87**	-16.22**
$P_3 \times P_4$	21.33*	62.50**	16.17	68.70**	26.34**	42.42**	-17.05**	-1.35
$P_3 \times P_5$	1.33	35.71**	44.91**	110.43**	30.48**	47.88**	-1.15	16.22**
$P_3 \times P_6$	9.89	78.57**	6.22	78.26**	6.99	20.61**	-9.76	0.00
$P_3 \times P_7$	8.24	64.29**	40.31**	133.04**	-10.58**	2.42	-17.58**	1.35
$P_4 \times P_5$	35.82**	62.50**	56.20**	64.35**	-9.09*	3.03	14.77**	36.49**
$P_4 \times P_6$	5.49	71.43**	33.16**	123.48**	6.70	15.76**	15.91**	37.84**
$P_4 \times P_7$	11.76	69.64**	-2.09	62.61**	-8.99*	4.24	-18.68**	0.00
$P_5 \times P_6$	1.10	64.29**	-18.65**	36.52**	5.88	20.00**	19.54**	40.54**
$P_5 \times P_7$	-3.53	46.43**	-25.13**	24.35	30.16**	49.09**	10.99*	36.49**
$P_6 \times P_7$	27.47**	107.14**	-27.98**	20.87	4.23	19.39**	-19.78**	-1.35
No. of crosses with significant (+) heterosis	**06**	**19**	**09**	**19**	**09**	**13**	**09**	**12**
No. of crosses with significant (-) ‘heterosis	**0**	**0**	**03**	**0**	**05**	**0**	**07**	**02**
Range of heterosis	**-6.59 to 35.82**	**14.29 to 107.14**	**-27.98 to 56.20**	**20.87 to 133.04**	**-16.67 to 66.23**	**-6.06 to 55.15**	**-31.87 to 40.54**	**-18.92 to 41.89**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.
(P_1- Narendra Agrim, **P_2-** Narendra Amrit, **P_3-** Narendra Upkar, **P_4-** NDPK-76-1, **P_5-** NDPK-724, **P_6-** NDPK-39-2, **P_7-** NDPK-12-10**)**

Table.1 Contd…

Trait / Crosses	Non-reducing sugars (%)		Total Sugars (%)		Dry matter Content (%)		Total soluble solids (%)	
	BP	**SV**	**BP**	**SV**	**BP**	**SV**	**BP**	**SV**
$P_1 \times P_2$	-29.63**	-29.63**	1.55	1.55	6.22	6.22	16.97**	33.10**
$P_1 \times P_3$	7.41*	7.41*	11.26*	11.26*	1.78	1.78	4.44	29.66**
$P_1 \times P_4$	3.70	3.70	12.62*	12.62*	20.00**	20.00**	22.84**	37.24**
$P_1 \times P_5$	-3.70	-3.70	17.09**	17.09**	-1.57	11.56**	35.17**	35.17**
$P_1 \times P_6$	-29.63**	-29.63**	4.27	4.27	1.33	1.33	41.36**	57.93**
$P_1 \times P_7$	-32.10**	-32.10**	-18.63**	-12.62*	0.44	0.44	18.90**	34.48**
$P_2 \times P_3$	-27.03**	-33.33**	-11.78*	-17.09**	30.22**	5.33	10.00**	36.55**
$P_2 \times P_4$	-29.73**	-35.80**	8.06	1.55	14.92**	-7.56*	9.70*	24.83**
$P_2 \times P_5$	-27.03**	-33.33**	-21.49	-26.21**	-13.33**	-1.78	19.39**	35.86**
$P_2 \times P_6$	-14.86**	-22.22**	2.69	-3.50	5.64	-8.44*	27.27	44.83**
$P_2 \times P_7$	-36.00**	-40.74**	-33.63**	-28.74**	22.92**	4.89	20.00**	36.55**
$P_3 \times P_4$	3.45	-25.93**	-6.34	-13.98**	14.29**	-7.56*	2.78	27.59**
$P_3 \times P_5$	3.45	-25.93**	4.51	-5.44	-13.33**	-1.78	9.44*	35.86**
$P_3 \times P_6$	30.00**	-3.70	1.86	-7.83	21.54**	5.33	13.33**	40.69**
$P_3 \times P_7$	-17.33**	-23.46**	-17.36**	-11.26*	5.73	-9.78**	12.22**	39.31**
$P_4 \times P_5$	12.96*	-24.69**	14.16**	4.85	-7.45*	4.89	22.22**	36.55**
$P_4 \times P_6$	0.00	-25.93**	13.95*	4.66	22.05**	5.78	30.25**	45.52**
$P_4 \times P_7$	-17.33**	-23.46**	-17.72**	-11.65*	2.60	-12.44**	10.98**	25.52**
$P_5 \times P_6$	-1.67	-27.16**	20.44**	5.24	-3.14	9.78**	20.99**	35.17**
$P_5 \times P_7$	-45.33**	-49.38**	-14.29**	-7.96	-5.10	7.56*	20.12**	35.86**
$P_6 \times P_7$	-40.00**	-44.44**	-28.93**	-23.69**	10.26**	-4.44	24.39**	40.69**
No. of crosses with significant (+) heterosis	**03**	**01**	**06**	**03**	**08**	**04**	**18**	**21**
No. of crosses with significant (-) 'heterosis	**12**	**17**	**07**	**08**	**03**	**05**	**00**	**00**
Range of heterosis	**-45.33 to 30.00**	**-49.38 to 7.41**	**-33.63 to 20.44**	**-28.74 to 17.09**	**-13.33 to 22.92**	**-12.44 to 20.00**	**2.78 to 41.36**	**24.83 to 57.93**

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.
(P_1- Narendra Agrim, **P_2-** Narendra Amrit, **P_3-** Narendra Upkar, **P_4-** NDPK-76-1, **P_5-** NDPK-724, **P_6-** NDPK-39-2, **P_7-** NDPK-12-10

Among significant crosses for fruit yield, few crosses showed positive and significant heterobeltiosis for quality traits *viz*., dry matter, T.S.S., total sugars, reducing and non-reducing sugar and ascorbic acid. For instance, out of nine crosses which exhibited significant heterobeltiosis for fruit yield, only one cross for dry matter, all crosses for total soluble solids, two crosses for total sugars, three crosses for reducing sugars, four crosses for ascorbic acid content showed significant and desirable heterosis. The number of crosses which showed significant standard heterosis for quality traits along with fruit yield were generally more in number than the crosses for significant better parent heterosis.

This showed negative association for heterosis between fruit yield and quality traits. Five crosses over better parent and six crosses over standard parents showed significant heterosis for fruit yield (Table 1). Increased yield in crosses of pumpkin observed in present investigation is in conformity with the findings of (Pandey *et al.,* 2010 and Tamilesvi *et al.,* 2015). The improvement in heterosis for yield component may not necessarily in increased yield. The increased fruit yield will definitely be cause of increase in one or more component traits. In the present study, the best performing heterobeltiotic F_1 (P_1 x P_2) for yield common showed significant and top ranked heterobeltiosis for number of fruits per plant over seasons. This hybrid also showed significant and desirable heterosis for number of primary branches per plant, equatorial circumference of fruit, polar circumference of fruit, and flesh thickness. Out of six crosses found significant heterotic over standard parent all crosses showed significant standard heterosis for number of fruits per plant. Among top heterotic crosses some of the parents were more frequently involved. The above findings indicated that some inbreds had more heterotic capability compared to other. The performance of hybrids depends upon the heterotic capability of parents involved, from economic point of view it will be useful to select and utilize the parental inbreds with strong heterotic capability for important economic traits associated with yield in order to achieve higher gains in F_1 hybrids through exploitation of heterosis.

A perusal of data given in Table 1 which showed best five crosses on the basis of desirable and significant heterobeltiosis, *per se* performance and common crosses among them for twenty traits revealed that $P_1 \times P_2$, $P_4 \times P_6$, $P_2 \times P_6$, $P_1 \times P_6$ and $P_3 \times P_6$ were the common crosses on the basis of *per se* performance and out of these common crosses for fruit yield per plant crosses $P_1 \times P_2$ and $P_1 \times P_5$ were also found common in respect to *per se* performance and better parent heterosis for fruit yield as well as some other traits studied. Standard heterosis of five best cross combinations along with *per se* performance and common crosses among them for different characters had been presented in Table 1. The extent of heterosis of best five crosses (20.87 to 133.04 %) for fruit yield per plant revealed that there was a great scope of realizing higher yield in pumpkin through heterosis breeding.

Since, earliness, desirable fruit shape, size, colour, number of fruits and fruit yield are important consideration for choice of elite high yielding F_1 hybrids. The decision for final selection of a hybrid(s) for commercial cultivation should also take into account the earlier mentioned features. Out of five top performing hybrids based on fruit yield over seasons, the three best common hybrids were $P_1 \times P_5$, $P_4 \times P_6$ and $P_1 \times P_2$ which exhibited high standard heterosis of 67.27 per cent, 55.78 per cent and 47.86 per cent respectively (Table 1). These three top hybrids were also at par for earliness and produced first fruit within 70.96 days ($P_1 \times P_5$), 75.00 days ($P_4 \times P_6$) and 77.10 days ($P_1 \times P_2$).

Acknowledgment

The work on pumpkin reported in this paper has been supported by research and teaching faculties of Department of Vegetable Science, N.D.U.A.T and We would also like to thank Mr. Murli Mohan Khetan for statistical analysis.

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How to cite this article:

Singh, M.K., V.B. Singh, G.C. Yadav and Pushpendra Kumar. 2019. Estimation of Heterosis for Growth, Yield and Quality Traits in Pumpkin (*Cucurbita moschata* Duch. ex. Poir). *Int.J.Curr.Microbiol.App.Sci.* 8(07): 1001-1010.
doi: https://doi.org/10.20546/ijcmas.2019.807.120