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Genetics and heterosis of quality and yield of pumpkin

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ABSTRACT

Gene action, combining ability and heterosis for quality and yield attributes in pumpkin was studied involving 21 cross combinations obtained from seven diverse inbreds in half-diallel fashion for four characters. The analysis revealed that none of the parents was a good general combiner for all the characters consistently; however, the parent, pumpkin-172 was good combiner for flesh thickness, total carotenoids and yield. The parents, IVPK-226 and BP-18 appeared to be good general combiners for ascorbic acids content. The *gca* variances were higher than the *sca* variances for flesh thickness, total carotenoids and ascorbic acid, while yield per plant had *gca* variances lower than the *sca* variances indicating the pre-dominance of non-additive gene effects for yield and additive gene action for flesh thickness, total carotenoids and ascorbic acid. The cross Pumpkin-172 × Pumpkin-105 exhibited highest *sca* estimates for flesh thickness, total carotenoids and yield, while the combination, IVPK-226 × Pumpkin-172 exhibited significant *sca* estimate for ascorbic acid content. The maximum heterosis for yield and ascorbic acid was exhibited by BS-165 × VRPG-7, whereas, BP-18 × Pumpkin-105 showed the maximum heterosis for total carotenoids. The study revealed that for improvement of traits like flesh thickness, total carotenoids and ascorbic acid, selections could be made, while fruit yield may be improved through hybridization.

Key words: C*ucurbita moschata*, combining ability, total carotenoids, heterosis.

INTRODUCTION

Pumpkin (*Cucurbita moschata* Duch. ex Poir.) is a cucurbit vegetable grown throughout the tropical and sub-tropical countries, including India. It is a principal ingredient of several culinary vegetable utilized at immature and mature fruit stage. Pumpkin is a valuable source of carotenoid and ascorbic acid that have major role in nutrition in the form of provitamin A and vitamin C as antioxidant, when used at ripening stage or after the storage. In India, consumers prefer dark yellow colour, round fruits having thick and deep yellow flesh. Pumpkin shows a lot of variability in yield and yield contributing components. For developing a suitable and efficient breeding programme, information regarding the nature and magnitude of genetic variation that exists in the breeding population is necessary. Although, pumpkin is becoming a commercial crop but relatively less attention has been paid towards the improvement of existing germplasm available in different parts of the country. In case of pumpkin, there are reports of high heterosis to the extent of 180 and 97.52% for yield and 48.47% for flesh thickness (Bairagi *et al.*, 1; Pandey *et al.*, 11) and 113.28% for β-carotene (Pandey *et al.*, 2), but the benefit of hybrid breeding for quality traits (total carotenoids and ascorbic acid) has not been exploited. A knowledge of general combining ability (*gca*) and specific combining ability (*sca*) helps to make choice of the parents of for hybridization and to know the nature of gene action. The present investigation therefore was undertaken to identify potential parental combinations in order to develop superior hybrids.

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MATERIALS AND METHODS

Seven diverse pumpkin inbreds, *viz.***,** IVPK-226, NDPK-130, BP-18, Pumpkin-172, Pumpkin-105, BS-165 and VRPG-7 were selected from the germplasm pool of IIVR, Varanasi and crossed with all possible combinations (21 F_1) excluding reciprocals. The F_1 hybrids and their parents were evaluated in a complete randomized block design (CRBD) with 10 plants each in three replications. In each row, seeds were sown keeping row-to-row and plant-to-plant spacing 2 m × 70 cm, respectively and managed as reported previously (De *et al.*, 2). Observations were recorded from seven random but competitive plants of parent and their F_1 hybrid in each treatment and replication for flesh thickness (cm), total carotenoids (μg/100g), ascorbic acid (mg/100g) and yield per plant (kg). The ascorbic acid (mg/100g) content was estimated titrimatically using 2,6-dichlorophenol dye method of Ranganna (12), while total carotenoids were extracted and partitioned in acetone and petroleum ether, respectively and estimated using a spectrophotometer as per the method of Gross (4). Three pulp samples were taken from each fruits and all were mixed to make single sample for final reading. The combining ability variance and effects were worked out according to (Griffing, 3) and heterosis was estimated over better and mid-parents.

RESULTS AND DISCUSSION

The analysis of variance showed significant difference due to treatments for all the characters except yield for parents *vs* their F_1 hybrids (Table 1). The t^2 value was non-significant for all the characters except flesh thickness indicating the validity of hypothesis pertaining to diallel cross analysis. The estimate of H_1 and H_2 were significant and higher than that of D for all the characters (Sit and Sirohi, 14). The estimate of F, h_2 and Ě component was positive and non-significant indicating the excess of recessive gene. The $(H_1/D)^{0.5}$ showed over dominance for all characters (Sit and Sirohi, 14; Pandey and Rai, 10). The ratio $H_2/4H_1$ indicated asymmetrical distribution of positive and negative gene among the parents (Hayman, 5). The proportion of KD/KR was more than unity indicating excess of dominant gene except flesh thickness. The ratio of h_2/H_2 indicated that this character is controlled by one gene group and exhibits dominance gene action. The correlation was positive and non-significant for all the character under study (Table 2).

Highly significant variances were recorded for both general and specific combining ability for all the

Table 1. Analysis of variance for quality and yield in pumpkin.

Source of variation	df	Flesh thickness	Total carotenoids	Ascorbic acid	Yield
Replication	2	0.105	32223.68	0.021	0.86
Treatment	27	0.891**	930052.03**	20.01**	2.54**
Parent	6	0.16**	811014.44**	1.89**	1.59**
F_1s	20	1.15**	980176.65**	2.07**	2.90**
P vs F_1	1	0.21**	641785.00**	1.55**	0.86
Error	54	0.03	483.12	0.02	0.23

**Significant 1% level of probability.

Table 2. Genetic parameters and their related statistics for quality and yield.

Genetic parameters related statistics	Flesh thickness	Total carotenoids	Ascorbic acid	Yield
D	0.04 ± 0.19	270177.50** ±105057.19	0.63** ± 0.17	0.45 ± 0.52
F	0.01 ± 0.45	32.7500.17± 252030.03	0.43 ± 0.42	0.95 ± 1.24
Ĥ	1.23±0.46**	1276178.31± 252922.18**	2.16±0.42**	3.85±1.24**
H_2	1.09±0.40**	1015693.32± 222859.95**	1.68± 0.37**	2.89±1.10**
ĥ1	0.03+-0.27	119668.44± 149682.9	0.29±0.25	0.12±0.74
Ě	0.01 ± 0.07	161.06 ± 37143.33	0.01 ±0.06	0.08 ±0.18
$(H_1/D)^{0.5}$	5.31	2.17	1.86	2.91
$H_2/4H_1$	0.22	0.20	0.19	0.19
KD/KR	0.97	1.77	1.46	2.11
h^2/H_2	3.038	0.00002	13.664	4.292
r	0.0788	0.5048	0.5678	-0.0899
t^2	48.4025**	0.4763	0.6926	0.7285

**Significant at 1% level of probability.

characters, indicating that parents and crosses differ significantly with regard to their general and specific combining ability, respectively. The *gca* variance was higher than the *sca* variance for flesh thickness, total carotenoids and ascorbic acid. This indicated the limited scope of heterosis breeding for these characters due to additive gene action therefore, improvement through recurrent selection should be adopted for exploiting the genetic variations (Kushwaha and Ram, 7; Pandey *et al.*, 9) in these characters. The *gca* variances were lower than the *sca* variances (Table 3) indicating the predominance of non-additive gene effects for yield. Improvement in yield may be obtained in F_1 due to non-additive gene action. The information regarding *gca* effect of the parent is of prime importance since it helps in successful predication of genetic potentiality of the crosses. Estimates of *gca* effect showed that it is difficult to pickup good general combiner for all the characters (Pal *et al.*, 8). Together as the combining ability effect were not consistent for the yield. However, overall evaluation on the basis of *per se* performance and significant *gca* effects indicates that Pumpkin-105, BP-18, and NDPK-130 are the best general combiner for yield and quality traits (Table 4).

Similarly, on the basis of *per se* performance and significant *gca* effects, Pumpkin-105 and Pumpkin- 172 was recorded to be good general combiner for flesh thickness and yield. Pumpkin-172 and BS-165, IVPK-226 and BP-18 were best general combiner for total carotenoids and ascorbic acids, respectively (Yadav *et al.*, 15). Among the 21 crosses, the Pumpkin-172 × Pumpkin-105 and Pumpkin-105 × BS-165 were the best specific combiner for flesh thickness and total carotenoids, respectively. IVPK-226 × Pumpkin-172 was found good specific combiner for ascorbic acid, whereas, BS-165 × VRPG-7 and Pumpkin-172 × Pumpkin-105 were found good specific combiner for yield, on the basis of *per se* performance and positive *sca* effects (Table 5). Similar results were obtained by Pandey and associates (13). The range of heterosis over better parent varied between 36.36 to 60% for flesh thickness, 63.04 to 65.29% for total carotenoids, -39.97 to 33.65% for ascorbic acid and -68.20 to 68.20% for yield. The heterosis over mid-parent ranged between 28.13-60% for flesh thickness, 61.93-120.10% for total carotenoids, -42.86 to 49.94% for ascorbic acid and -58.16 to 95.64% for yield per plant (Table 6). For flesh thickness, the highest magnitude of heterosis over better parent was recorded in cross combination BP-18 × VRPG-7 (60%) followed by Pumpkin-172

Table 3. Analysis of variance for combining ability for quality and yield.

Source of variance	d.f.	Flesh thickness	Total carotenoids	Ascorbic acid	Yield
gca	6	0.305**	389439.15**	1.32**	0.726**
sca	21	0.295**	287325.41**	0.488**	0.880**
Error	54	0.009	161.06	0.005	0.077

**Significant at 1% level of probability.

Table 4. Estimate of general combining ability effect of parents for quality and yield.

Parent	Flash thickness	Total carotenoids	Ascorbic acid	Yield
IVPK-226	-0.01	87.15**	0.67**	-0.08
NDPK-130	-0.03	-163.99**	0.41**	-0.33**
BP-18	-0.20**	-63.39**	0.18**	-0.21**
Pumpkin-172	0.09**	359.70**	-0.03	0.06
Pumpkin-105	0.34**	185.86**	-0.41**	0.55**
BS-165	0.01**	151.47**	0.17**	0.10
VRPG-7	0.19**	-185.07**	-0.17**	-0.10
SE (G1)	0.03	3.92	0.02	0.08
SE (Gi-Gj)	0.04	5.98	0.03	0.13
Best parents based on *per se* performance and gca effects	Pumpkin-105 Pumpkin-172	Pumpkin-172 BS-165	IVPK-226 BP-18	Pumpkin-105 Pumpkin-172

**Significant at 1% level of probability.

Table 5. Ranking of three desirable specific combiner on the basis of *per se* performance and *sca* effect for quality and yield in pumpkin.

Character	Desirable parents as *per se* performance	Good specific combiners	Best parents based on *per se* performance and sca effects
Flash thickness	Pumpkin-172 × Pumpkin-105	Pumpkin-172 × Pumpkin-105	Pumpkin-172 × Pumpkin-105
	Pumpkin-105 × BS-165	Pumpkin-105 × BS-165	Pumpkin-105 × BS-165
	NDPK-130 × Pumpkin-105	BS-165 × VRPG-7	
Total Carotenoids	Pumpkin-105 × BS-165	Pumpkin-105 × BS-165	Pumpkin-105 × BS-165
	Pumpkin-172 × Pumpkin-105	BP-18 × Pumpkin-105	Pumpkin-172 × Pumpkin-105
	Pumpkin-172 × BS-165	Pumpkin-172 × Pumkin-105	
Ascorbic acid	IVPK-226 × BS-165	NDPK-130 × Pumpkin-105	IVPK-226 × Pumpkin-172
	IVPK-226 × Pumpkin-172	BP-18 × BS-165	
	IVPK-226 × BP-18	IVPK-226 × Pumpkin-172	
Yield	BS-165 × VRPG-7	BS-165 × VRPG-7	BS-165 × VRPG-7
	Pumpkin-172 × Pumpkin-105	Pumpkin-172 × Pumpkin-105	Pumpkin-172 × Pumpkin-105
	BP-18 × VRPG-7	BP-18 × Pumpkin-172	

× Pumpkin-105 (50.13%), and BP-18 × BS-165 (29.87%). Whereas, cross combination Pumpkin-172 × Pumpkin-105 (60%) was found better over mid-parent followed by Pumpkin-105 × BS-165 (57.92%) and BP-18 × VRPG-7 (29.87%). The maximum heterosis over better parent was found in cross combination BP-18 × Pumpkin-105 (65.29%) followed by NDPK-130 × BP-18 (37.62%) and Pumpkin-172 × Pumpkin-105 (28.26%) for total carotenoids, whereas cross BP-18 × Pumpkin-105 (120.10%) followed by Pumpkin-172 × Pumpkin-105 (89.65%) and pumpkin-105 × BS-165 (89.29%) was found over mid-parent. The maximum heterosis recorded for ascorbic acid in the cross combination BS-165 × VRPG-7 (33.65%) followed by NDPK-130 x Pumpkin-105 (33.33%) and NDPK-130 × BS-165 (33.33 %) over better parent and IVPK-226 × BS-165 (49.94%) followed by NDPK-130 × Pumpkin-105 (33.33%) and Pumpkin-105 × BS-165 (33.33%) for over mid-parent. For yield, the highest heterosis over better parent was recorded in BS-165 × VRPG-7 (65.44%) followed by BP-18 × VRPG-7 (51.96%) and Pumpkin-172 × Pumpkin-105 (28.85%) (Pal *et al*., 8; Rehana *et al*., 13). Whereas, over mid-parent cross combination BS-165 × VRPG-7 (95.64%), BP-18 x VRPG-7 (66.14%) and Pumpkin-172 × Pumpkin-105 (35.38%) exhibited the maximum heterosis. The results are in conformity with those obtained by Pandey *et al*. (11), and Hedau and Sirohi (6). The present study revealed that the inbreds Pumpkin-172, Pumpkin-105, BP-18, and VRPG-7 could be used as parental lines for development of hybrid for yield and quality traits. The F_1 hybrids from the crosses BP-18 × VRPG-7, and Pumpkin-172 × Pumpkin-105 were found promising and may be tested further for yield and quality traits under different agro-climatic conditions before commercialization. Due to non-additive gene action, carotene, ascorbic acid, and flesh thickness may be improved through hybridization followed by recurrent selection, while maximum yield may be obtained in F_1 hybrid.

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Table 6. Best three crosses selected on the basis of heterosis for quality and yield.

Character	Heterosis over BP		Heterosis over MP		Range over	
	Cross	% Heterosis	Cross	% Heterosis	BP	MP
Flesh thickness	BP-18 × VRPG-7	60**	Pumpkin-172 × Pumpkin-105	60**	36.36 - 60.00	28.13 - 60.00
	Pumpkin-172 × Pumpkin-105	50.13**	Pumpkin-105 × BS-165	57.92**		
	BP-18 × BS-165	29.87**	BP-18 × VRPG-7	29.87**		
Total carotenoids	BP-18 × Pumpkin-105	65.29**	BP-18 × Pumpkin-105	120.10**	-63.04 - 65.29	61.93 - 120.10
	NDPK-130 × BP-18	37.62**	Pumpkin-172 × Pumpkin-105	89.65**		
	Pumpkin-172 × Pumpkin-105	28.26**	Pumpkin-105 × BS-165	89.29**		
Ascorbic acid	BS-165 × VRPG-7	33.65**	IVPK-226 × BS-165	49.94**	-33.65 - 33.65	-42.86 - 49.34
	NDPK-130 × Pumpkin-105	33.33**	NDPK-130 × Pumpkin-105	33.33**		
	NDPK-130 × BS-165	33.33**	Pumpkin-105 × BS-165	33.33**		
Yield	BS-165 × VRPG-7	65.44**	BS-165 × VRPG-7	95.64**	-68.20 - 68.20	-58.16 - 95.64
	BP-18 × VRPG-7	51.96**	BP-18 × VRPG-7	66.14**		
	Pumpkin-172 × Pumpkin-105	28.85**	Pumpkin-172 × Pumpkin-105	35.38**		

**Significant at 1% level of probability, BP = Better parent, MP = Mid parent

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