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Mean Performance, Heterosis and Potence Ratio for Six Inbred Lines and Their Intraspecific Hybrids of Pumpkin(*Cucurbita moschata*)

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ABSTRACT: This study was carried out during six successive seasons of 2020 till 2022 to development and evaluation six inbred lines of pumpkin (*Cucurbita moschata*) and their hybrids. Selection with self-pollination for six different cultivars was carried out for four generations. An evaluation experiment was conducted for twenty one genotyps (six parental inbred lines, twelve of their F_1 hybrids, and three reciprocals hybrids). Mean performance, heterosis percentages and potence ratio were estimated for vegetative, flowering, yield components and fruit quality characters. The results showed wide range of variability among the different genotypes for all studied traits. The estimated heterosis effects relative to both mid - and better - parents indicated that there were positive and negative values with different degrees for all studid charactrs. The estimated values of potence ratio illustrated that the inheritance of the four characters main stem length, number of days to first female flower, number of nodes to first female flower and total yield/plant**,** involved partial-dominance to over-dominance for taller over short plant, high over low number of days to first female flower, low over high number of nodes to first female flower and higher over low productivity, respectively. On the other hand, the inheritance of the other eight charactrs involved non-additive gene effects from partial and over dominance to partial and under-recessiveness. The three inbred lines P_1, P_3 and P_5 reflected the best desirable values for most studied characters; therefore, could be selected to produce the best hybrids. Concerning the F_1 hybrids; the three hybrids $P_3 \times P_1$, $P_6 \times P_1$ and $P_6 \times P_4$ showed the best performance for the various studied traits, varying according to the hybrid. Therefore, these hybrids are considered the best and most important in this study and could be considered as promising hybrids with distinguished specifications.

Keywords: Pumpkin, (Cucurbita moschata, Intraspecific Hybridization, Inheritance, gene action, heterosis, potence ratio**.**

INTRODUCTION

Cucurbita is a genus of important Cucurbitaceous plants; all species of this genus are diploid and have 20 pairs of chromosomes (2n = 2x = 40). Cultivated species of this genus include five species; three of which lead agricultural production worldwide: *Cucurbita maxima*, *Cucurbita moschata*, and *Cucurbita pepo* (Hosen *et al*., 2021); and, pumpkin refers to the cultivars of any of these species.

Pumpkin can be used in both the mature and immature stages as a vegetable; also, it can be consumed after processing. Pumpkin is distinguished by its high value among cucurbits, due to its long availability, long shelf life, high nutritional value, medicinal and protective properties, and better transport qualities (Ravani and Joshi, 2014). Therefore, it has attracted increasing attention in recent years, and becoming an important food source for much of the world's population. Despite the great importance of this crop and its somewhat increasing popularity; only very limited attempts have been made to genetically improve this crop. Some local studies have proven that there is a great diversity in the size, shape, and color of the fruits available in the local cultivar in Egypt (Omar *et al*., 2022 and Gomaa *et al*., 2023).

Plant genetic diversity allows plant breeders to produce new and better cultivars with desirable characteristics, which is crucial before starting breeding programs (Govindaraj *et al*., 2015, Escribano *et al*., 1998). Therefore, the diversity of parents from different locations with high productivity and quality would pave the way for the production and development of distinct hybrid cultivars. Where the breeder selects the genotypes from the parents that will suit the hybridization plan (Sundharaiya *et al*., 2015); one of the results of which is achieving a significantly high heterosis when crossing genetically diverse strains (Sharma, 1994).

Estimation of genetic parameters is considered very important when improving plant characteristics through selection or other breeding programs. Heterosis is known as the superiority in performance of hybrid individuals compared with their parents; so, it could be a tool to achieve improvement in the quality, quantity, and productivity of pumpkins (Hallauer *et al*., 2010 and Tamilselvi *et al*., 2015). Diallel cross is a useful tool to produce promising hybrids and to study the heterotic effects of these hybrids over their respective parents (Hosen *et al*., 2021). Intraspecific hybridization is a cross between different genotypes or cultivars of the same species; to produce a new cultivar with desirable characteristics. There are many studies on pumpkin indicated high heterosis to the extent of 181.5% and 97.52 % for yield, 70% for a greater number of female flowers, 68.7% for fruit weight, and 150% for number of fruits per plant (Mohanty *et al*., 1999 and Pandey *et al*., 2002). For total yield/plant, the hybrids showed a range of heterosis percentages from -56.1 to 77.6% and from -66.8 to 54% over the mid and better parent, respectively (Wessel-Beaver *et al*., 2021). Jhansi *et al*., (2018) recorded that there was hybrid vigor over mid-parents and the highest parent for flowering traits, number and weight of yield, and average fruit weight in three hybrids of tropical pumpkin (*C. moschata*).

Potence ratio is one of the estimates that should also be focused on to show the nature of dominance and its direction and the effectiveness of the crop and its components to improve through hybridization. El-Tahawey *et al*., (2015) calculated the values of potence ratio for some important traits of pumpkin; and found that most of the studied hybrids recorded positive values for vine length, flesh thickness, and average fruit weight, which reflected different degrees of dominance, ranging from partial- to over-dominance of these traits. On the other hand, the estimated values of the potence ratio for most hybrids were negative for the characteristics of leaf area, number of nodes to first female flower, and number of days to first female flower, which indicate different degrees of recessiveness, i.e., partial- to under-recessiveness.

Until now there is no new improved cultivar of pumpkin with higher production and better quality has been released in Egypt; despite the genetic diversity, which is founding in a large degree of the local cultivar of pumpkin. Therefore, the breeder can easily conduct many breeding programs by improving both the local cultivar alone or using foreign cultivars to develop a hybrid cultivar characterized by high productivity and quality. Hence, the aim of the current study was: 1-Development and evaluation performance of selected six inbred lines of pumpkin, *Cucurbita moschata* species and the hybrids produced from them by intraspecific hybridization.2-Estimating the heterosis relative to both mid- parents and better parent, as well as estimating the potency ratio for the traits under study; to understand natural of gene action contributing to the genetic variability, and inheritance of the studied characters. 3- Proving the hypothesis from the research that it is possible to produce local hybrids that are distinguished in both yield and quality characteristics.

MATERIALS AND METHODS

This study was carried out at the Experimental Station Farm, Faculty of Agriculture, Alexandria University, at Abies, during six successive seasons of 2020 till 2022. This study began with six different cultivars of pumpkin that belong to the species *moschata*. Sources, botanical models and general characteristics for these cultivars are shown in Table 1.

Table 1. Characterization of parents used in hybridization.

Parent Name	Source	Botanical models	General Characteristics
P_1	Saudi Arabia genotype	Butternut	Early maturity, medium vegetative growth, high productivity and good quality of fruits.
P_2	Egypt 'Balady' cultivar	A lot of models	Medium early maturity, strength vegetative growth high productivity and good quality of fruits.
P_3	Chinese	Moscata di Provenza	Medium early maturity, strength vegetative growth, high productivity and high total soluble solid content.
P_4	Chinese	Moscata di Provenza	Medium early maturity, strength vegetative growth and good fruit quality
P_5	Chinese	Dickinson pumpkin	Medium early maturity, strength vegetative growth and high productivity
P_6	Chinese	Butternut	High productivity and high fruit quality

Experimental procedures

This study was conducted in three stages:

First stage: Selfing with Selection to Produce the Parental Inbred Lines

For the six cultivars under study, selection with self-pollination was carried out for four generations in order to reach an appropriate degree of homozygosity that allows the start of the hybridization season. By the end of this stage, six parental inbreds lines were reached.

Second stage: Intraspecific Hybridization and Development the New Hybrids

During the fifth season, all possible combination in the two ways among the six selected inbreds lines respected Cucurbita *moschata* sp. were reached. Twelve out of fifteen hybrids in the first way were successful. On the contrary, only three out of fifteen hybrids in the reciprocal way succeed. By the end of this season, six parental inbred lines of pumpkin (*Cucurbita moschata*), twelve of their F_1 hybrids and three reciprocals' hybrids were obtained.

Third stage Evaluation the produced hybrids and their parents

During the sixth season, an evaluation experiment was conducted and included the six parents and the fifteen new hybrids produced.

Experimental design

In May 2022, the seeds of the hybrids produced and their parents were evaluated in a field experiment. Seeds were planted directly in the soil, using a randomized complete block design with three replications. The experimental unit included two rows with an area of 20 m^2, a row length of 4 m, a width of 2.5 m, and a planting distance of 0.8 m. All agricultural practices were applied according to the recommendations of the Ministry of Agriculture in Alexandria, Egypt.

Data Recorded

Five plants were chosen at random from each plot for recording the quantitative and qualitative characters as follows:

-Vegetative growth and flowering characters:

Main stem length (m), number of branches/plant, number of days to first female flower, and number of nodes to first female flower were recorded.

-Yield and its compomants characters

Average fruit weight (kg), number of fruits/plant, and total yield/plant (kg)

-Fruits quality characters

Fruit length, fruit width, cavity length, cavity width, and flesh thickness were measured in centimeter using rural.

-Chemical constituents of fruits

Fruit dry matter percentage, total soluble solids (TSS%), total carotenoid content (mg/100 gm.fw), and total sugars content (%) were determined in usual manner.

Statistical Analysis:

The statistical analysis of the recorded data of all various cucurbits characters were carried out using the standard method of the analysis of variance of a randomized complete blocks design, as illustrated by Snedecor and Cochran (1980); using SAS9.3 software (SAS Institute, Inc.,2007), a computer program for statistics of the differences between means.

Genetic parameters Estimation:

Heterosis:

Heterosis percentages, relative to mid-and better-parents, for the different studied characters were calculated as reported by Bhatt (1971) as follows:

$$MBH = \frac{F1-MP}{MP} *100 \qquad BH = \frac{F1-BP}{BP} *100$$

where MBH = heterosis over mid parents, BH = heterosis over better parent, F_1 = mean value of the particular hybrid, M.P. = mean value of the two parents for that hybrid $(P_1 + P_2)/2$, and B.P. = better parent mean value for that hybrid.

Potence ratio:

Potence ratio was calculated according to Smith (1952) to determine the nature of dominance and its direction as follows:

Potence ratio = $\frac{F1-MP}{1/2(P2-P1)}$

where P = potence ratio, F_1 = first generation mean, P_1 = mean value of lower parent, P_2 = mean value of higher parent, and M.P. = mid-parents value $(P_1 + P_2)/2$.

RESULTS AND DISCUSSION

Analysis of variance

Analyses of variance for the data of all studied characters for 21 genetic populations of *Cucurbita moschata* listed in Tables 2 and 3. The result showed significant or highly significant variances for all studied characters, except total sugars character. Sgnificant variances were reprted for the four characters; number of branches/plant, average fruit weight (Table 2), dry matter percentage and carotene content (Table 3). However, highly sgnificant variances were reprted for other eleven characters. The significant variances for the studied characters attributable to differences in the means of the assessed genetic populations. Such a result means that differences due to genotypes were so pronounced, suggesting that the superior genotypes can be selected and recommended for growers.

Table 2. Analyses of variance of six parental inbred lines and their fifteen F_1 hybrids of pumpkin for vegetative growth, flowering and yield components characters.

Sources of variance	D.F	Mean squares (M.S.)						
		Main stem length (m)	No. of branches /plant	No. of nodes to first female flower	No. of days to first female flower	No. of fruits /plant	Average fruit weight (kg)	Total yield /plant (kg)
Blocks	2	0.33	0.007	1.54	1.34	0.25	1.00	3.17
Genotypes	20	3.43^{**}	0.35^{*}	4.51^{**}	35.93^{**}	0.52^{**}	2.18^{*}	9.96^{**}
Error	40	0.29	0.20	1.22	0.54	0.17	1.03	3.88

* Significant at 0.05 level of probability, ** Highly significant at 0.01 level of probability. $^{ns.}$ Not significant at 0.05 level

Table. 3. Analyses of variance of six parental inbred lines and their fifteen F_1 hybrids of pumpkin for fruit quality and chemical constituents' characters.

Sources of variance	D.F	Mean squares (M.S.)								
		Fruit length (cm)	Fruit diameter (cm)	Cavity length (cm)	Cavity diameter (cm)	Flesh thickness (cm)	Dry matter (%)	T.S.S (%)	Carotene content (mg/100 gm.fw)	Total sugars (%)
Blocks	2	45.86	3.56	14.29	0.58	1.18	0.65	0.19	0.37	0.07
Genotypes	20	340.40^{**}	33.02^{**}	86.05^{**}	16.08^{**}	1.28^{**}	9.05^{*}	4.86^{**}	3.66^{*}	0.94^{ns}
Error	40	14.66	4.21	8.18	2.50	0.22	4.40	1.26	2.06	0.86

* Significant at 0.05 level of probability, ** Highly significant at 0.01 level of probability. $^{ns.}$ Not significant at 0.05 level

Mean performances of the parental inbred lines and their F_1 and F_{1r} hybrids

The mean performances of parental inbred lines and their F_1 hybrids including reciprocals for all studied traits are presented in Tables 4, 5 and 6.

Vegetative growth and flowering characters

The results presented in Table 4 showed the behavior of parents, hybrids and reciprocals for the vegetative growth and flowering traits. The results illustrated that P_1 (Saudi Parent) recorded the lowest mean value (desirable) for main stem length, number of nodes to first female flower, and number of days to first female flower traits, which were (3.98 m), (11.22), and (3.00), respectively; noting that the mean value of number of days to first female flower was the least significant compared to the all evaluated parents. As for number of branches/plant, P_3 (Chinese parent) reflected the highest mean value (desirable, 3.11), as well as the highest mean value for stem length (undesirable, 6.66 m); but the same parent (P_3) reflected low values for the two flowering traits (desirable). Thus, the average values of the parents reflected that there was no single distinguished parent for the vegetative growth and flowering traits; but it can be considered that both the two parents P_1 and P_3 are the best for these traits.

Regarding the comparison of the resulting hybrids for the vegetative growth and flowering traits, the hybrid P_6 x P_4, P_2 x P_1 reflected the lowest values for main stem length trait, which were 4.32 m, 4.34 m, respectively, with insignificant difference. While, the hybrid P_6 x P_2 gave the highest value for number of branches/plant (3.33), followed by the two hybrids P_5 x P_4, and P_6 x P_5 without any significant difference between one another. As for the flowering trait, the hybrid P_2 x P_1 recorded the lowest significant value (desirable) for number of days to first female flower (33.66); while, the hybrid P_6 x P_5 recorded the lowest value (desirable) for number of nodes to first female flower (9.88), preceded by both the two hybrids P_3 x P_2 and P_2 x P_1, which recorded the same value (11.55) without any significant difference between the three hybrids.

Table. 4. Mean performance of the six parental inbred lines and their 15 F_1 hybrids of pumpkin for vegetative growth and flowering characters.

Genotypes	Vegetative growth characters		Flowering characters	
	Main stem length (m)	No. of branches /plant	No. of nodes to first female flower	No. of days to first female flower
Parents				
P_1	3.98 jk	2.55 b-e	11.22 fg	30.00 i
P_2	5.48 e-h	3.00 a-c	13.11a-e	36.00 fg
P_3	6.66 b-d	3.11 ab	12.22 c-f	35.00 g
P_4	4.44 i-k	2.44 b-e	14.66 a	35.88 fg
P_5	4.98 g-i	2.11 de	14.88 a	38.44 d
P_6	4.82 h-j	2.11 de	13.11a-e	43.00 ab
Hybrids				
P_2 x P_1	4.34 i-k	1.88 e	11.55 e-g	33.66 h
P_3 x P_1	5.42 e-h	2.33 c-e	12.00 c-f	40.00 c
P_4 x P_1	4.98 g-i	2.44 b-e	13.22 a-e	37.00 ef
P_5 x P_1	6.24 b-e	2.55 b-e	13.33 a-e	42.44 b
P_6 x P_1	6.95 ab	2.66 a-d	13.33 a-e	36.11fg
P_3 x P_2	6.75 a-c	2.66 a-d	11.55 e-g	37.77 de
P_5 x P_2	7.05 ab	2.44 b-e	11.77 d-f	42.55 b
P_6 x P_2	7.62 a	3.33 a	13.11a-e	35.55 g
P_5 x P_3	5.14 f-i	2.33 c-e	12.55 c-f	38.66 d
P_5 x P_4	5.88 c-f	3.00 a-c	13.66 a-c	40.00 c
P_6 x P_4	4.32 ijk	2.44 b-e	13.44 a-d	40.00 c
P_6 x P_5	5.80 d-g	2.77 a-d	9.88 g	38.66 d
Reciprocals				
P_2 x P_3	5.00 g-i	2.44 b-e	12.66 b-f	35.00 g
P_3 x P_5	5.58 e-h	2.55 b-e	14.44 ab	40.00 c
P_4 x P_6	3.87 k	2.66 a-d	11.66 d-g	44.11 a

Values followed by the same alphabetical letter in each column do not differ significantly from each other using revised LSD

As for the reciprocal hybrids; the results in Table 4 showed that the F_{1r} hybrid P_4 x P_6 was the best reciprocal hybrid for the three characters; main stem length, number of branches/plant, and number of nodes to first female flower, which did not differ significantly from the best F_1 hybrids for the same traits. While, the reciprocal hybrid P_2 x P_3 was the best for number of days to first female flower; but it differed significantly from the best F_1 hybrid for the same trait with the same parent (P_2). The results showed, also, that there was insignificant difference between hybrids and their reciprocals for number of branches/plant, as well as for main stem length and number of nodes to first female flower traits, except in the case of P_3 x P_2 and its reciprocal P_2 x P_3, and the hybrid P_5 x P_3 and its F_{1r} P_3 x P_5 for main stem length and number of nodes to first female flower, respectively. While, number of days to first female flower trait reflected a noticeable significant difference between F_1 and F_{1r} hybrids.

Comparing the hybrids with their parents, the recorded data reflected that the reciprocal hybrid P_4 x P_6 gave the lowest value among all the combinations, preceded by P_1 without any significant difference for the main stem length trait. As for the number of branches/plant, the hybrid P_6 x P_2 excelled with the highest average value, followed by P_3 without a significant difference. Likewise, the hybrid P_6 x P_5 recorded the lowest value for number of nodes to first female flower, preceded by P_1 without a significant difference. While, the same parent (P_1) recorded the lowest number of days to first female flower, preceded by the F_1 hybrid P_2 x P_1. Similar findings were recorded by **El-Tahawey *et al.*, 2015**, who stated that increasing in vegetative measurements considered a natural result of crossbreeding between parents which have genetic divergence.

Yield and its components characters

Yield and its components characters of the parents and their hybrids, as well as reciprocals and their mean values are presented in Table 5. The means of the six parental inbred lines showed that the Chinse parent (P_3) reflected the highest significant value (2.77) for number of fruits/plant trait, followed by P_1 (Saudi parent) with a value of 2.00; while, the values of the other four parents were very close. Also, the same parent (P_3) achieved the highest value for total yield/plant (11.86 kg), followed by P_1 (8.81 kg) without any significant difference; however, the six parents reflected a wide range among themselves, ranging from 11.86 kg for Chinese parent (P_3) to 5.21 kg for Chinese parent (P_4). As for average fruit weight trait, the parents did not differ significantly from each other; where, the Chinese parent (P_6) reflecting the highest value (5.50 kg) and the parent P_3 was the lowest (4.27 kg). As it became clear from studying the behavior of the parents in the vegetative growth and flowering traits, the two parents P_3 and P_1 are the best; also, the same parents reflected the best results for the three yield components traits.

With respect to the general performances of F_1 hybrids for yield and its components, the results in Table 5 indicated that the mean values of the F_1 hybrids for number of fruits/plant and average fruit weight were close, and thus insignificant differences were evident among the hybrids. This result can be attributed to the close range between the parents in both traits. As for the two hybrids P_6 x P_5 and P_4 x P_1; reflected the highest value for number of fruits/plant and average fruit weight, respectively; while, the two hybrids P_2 x P_1 and P_3 x P_2 had the lowest values for the same traits, respectively. Concerning, total yield/plant the results reflected wide range among the hybrids mean values, which ranged from 4.06 kg to 9.52 kg in the hybrids P_3 x P_2 and P_3 x P_1, respectively.

As for comparing the behavior of the reciprocal hybrids, the results in Table 5 illustrated that there were insignificant differences between the resulting hybrids when studying the three yield components traits. The F_{1r} hybrid P_3 x P_5 recorded the highest value for the trait of average fruit weight (5.38 kg) and total yield (7.72 kg); while, for the trait of number of fruits/plant, the hybrids P_2 x P_3 and P_3 x P_5 recorded the highest

Table. 5. Mean performance of the six parental inbred lines and their fifteen F_1 hybrids of pumpkin for yield components.

Genotypes	Yield components characters		
	No. of fruits/plant	Average fruit weight (kg)	Total yield/plant (kg)
Parents			
P_1	2.00 bc	4.66 b-e	8.81 a-c
P_2	1.77 b-d	4.77 c-e	8.20 b-d
P_3	2.77 a	4.27 de	11.86 a
P_4	1.00 e	5.21 b-d	5.21 d-f
P_5	1.44 c-e	5.20 b-d	7.17 b-f
P_6	1.11 de	5.50 a-d	5.82 c-f
Hybrids			
P_2 x P_1	1.11de	4.10 de	4.60 ef
P_3 x P_1	1.88 bc	5.89 a-c	9.52 ab
P_4 x P_1	1.33 c-e	6.97 a	8.87 a-c
P_5 x P_1	1.88 bc	4.44 c-e	7.61b-e
P_6 x P_1	1.77 b-d	4.60 b-e	8.36 b-d
P_3 x P_2	1.44 c-e	3.06 e	4.06 f
P_5 x P_2	2.00 bc	4.38 c-e	8.72 a-c
P_6 x P_2	1.77 b-d	4.13 de	7.37 b-e
P_5 x P_3	1.66 b-e	5.30 b-d	8.46 bc
P_5 x P_4	1.33 c-e	6.13 ab	6.98 b-f
P_6 x P_4	1.33 c-e	4.52 b-e	5.63 c-f
P_6 x P_5	2.22 ab	4.58 b-e	9.16 ab
Reciprocals			
P_2 x P_3	1.55 b-e	4.05 de	6.64 c-f
P_3 x P_5	1.55 b-e	5.38 a-d	7.72 b-e
P_4 x P_6	1.33 c-e	5.34 a-d	6.91b-f

Values followed by the same alphabetical letter in each column do not differ significantly from each other using revised LSD

mean values with the same mean (1.55 kg). Also, comparing the hybrids with their reciprocals did not reflect any significant differences in the mean values of the three yield components traits.

The results of comparing the behavior of the parents and their hybrids, as well as the reciprocals, in general, showed that all mean values were significantly close for the three productivity traits, number of fruits/plant, average fruit weight, and total yield/plant. The result illustrated, also, that the parent P_3 gave the highest value for the traits of number of fruits/plant and total yield/plant; but it did not differ significantly from the value recorded by the F_1 hybrid P_6 x P_5. As for the trait of average fruit weight, the F_1 hybrid P_4 x P_1 gave the highest value (6.97 kg), followed by the hybrid P_5 x P_4 with a value of 6.13 kg.

Fruits quality and chemicals constituents' characteristics

Fruits quality characters

Fruit quality characters; fruit length, fruit width, cavity length, cavity diameter, and flesh thicknesses; for the different genetic population are listed in Table 6. The comparisons among the means of six parents showed that wide range of differences was observed among parents for the three fruit characters; fruit length, fruit diameter, and cavity length as shown in Table 6; however, this range of differences was not evident for cavity diameter and flesh thickness as they did not reflect significant differences among parents' means. The range of means for both of fruit length was 34.83 cm – 10.20 cm, fruit diameter was 24.65 cm – 16.72 cm, cavity length was 26.91 cm – 6.67 cm; while, for cavity diameter and flesh thickness the ranges among parents means were 13.96 cm –10.01 cm and 3.98 cm – 3.00cm, respectively. The results showed, also, that the parent P_1 recorded the highest (desired) mean value for fruit length and fruit diameter, and the parent P_3 gave the lowest (desired) for cavity length and diameter; while, P_5 recorded the highest (desired) mean value for flesh thickness.

The data in Table 6, in general, indicated that all hybrids showed a clear degree of variation among themselves for all five fruit traits. The average mean values for fruit length ranged from 55.44 cm - 16.00 cm, fruit diameter from 25.23 cm - 13.47 cm, cavity length from 26.76 cm - 9.33 cm, cavity diameter from 18.13 cm - 9.94, and flesh thickness from 4.92 cm - 1.91 cm. Where, the hybrids P_6 x P_4, P_5 x P_2, P_3 x P_2, P_6 x P_1, P_3 x P_1 recorded the best average mean values for the traits of fruit length, fruit diameter, cavity length, cavity diameter, and flesh thickness, respectively. Insignificant differences were recorded between the reciprocals, except for the trait of flesh thickness, where the F_{1r} hybrid P_3 x P_5 gave the highest significant mean (4.75 cm) among the reciprocals.

As for the relationship of the behavior of the hybrids with their reciprocals, the hybrid P_3 x P_2 did not differ from its F_{1r} hybrid P_2 x P_3 for all characters, with the exception the trait of c cavity length; where the hybrid P_3 x P_2 reflected a desirable value for the trait with an average of 9.33 cm; while its reciprocal recorded an undesirable mean value for the same trait (14.60 cm). As for the hybrid P_5 x P_3, it did not differ significantly from the reciprocal P_3 x P_5 for all traits. As for the hybrid P_6 x P_4, it outperformed the reciprocal hybrid for the fruit length trait; the fruit length was doubled in the hybrid P_6 x P_4 compared to its F_{1r} hybrid.

The results in Table 6 showed, also, that the variation of parents in most of the studied fruit traits was reflected in a clear variation in the resulting hybrids; as some hybrids outperformed parents for the traits of fruit length and flesh thickness. The hybrid P_6 x P_4, followed by the hybrid P_6 x P_2, recorded the highest significant mean values compared to all genotypes, parents and hybrids, for the trait of fruit length. Also, the hybrid P_3 x P_1 recorded the highest mean value, followed by the F_{1r} hybrid P_3 x P_5 and the hybrid P_5 x P_3, which did not differ significantly for the trait of flesh thickness. Also, for the trait of fruit diameter, the hybrid P_5 x P_2 recorded the highest mean value; but it

Table. 6. Mean performance of the six parental inbred lines and their fifteen F_1 hybrids of pumpkin for fruit characteristics.

Genotypes	Fruit characters					Chemical constituents			
	Fruit length (cm)	Fruit diameter (cm)	Cavity length (cm)	Cavity diameter (cm)	Flesh thickness (cm)	Dry matter percentage (%)	Total soluble solid %	Carotene content (mg/100 gm.fw)	Total sugars content (%)
Parents									
P_1	34.83 cd	19.53 d-g	26.91a	13.72 d-g	3.24 d-h	10.63 ef	11.23 d-f	8.73 ab	8.20 a-d
P_2	31.35 de	21.48 b-e	23.02 ab	13.96 c-g	3.37 d-h	11.40 c-f	11.10 d-f	7.75 a-d	7.78 a-d
P_3	10.20 k	24.65 ab	6.67 k	10.01 h	3.44 d-h	14.20 a-d	13.40 a-c	8.87 ab	7.69 b-d
P_4	23.07 f-i	18.47 e-h	16.60 c-h	12.44 e-h	3.83 c-f	12.26 b-f	11.46 d-f	9.20 ab	9.12 a-c
P_5	26.88 e-g	19.02 e-h	20.73 bc	11.67 f-h	3.98 b-d	11.44 c-f	12.60 c-e	8.86 ab	8.63 a-d
P_6	31.15 de	16.72 h-j	22.73 ab	11.91 f-h	3.00 gh	12.04 b-f	12.23 c-f	8.73 ab	8.33 a-d
Hybrids									
P_2 x P_1	24.08 f-i	19.83 d-g	14.64 e-i	13.46 d-g	3.64 c-g	11.83 b-f	10.80 ef	8.17 ab	9.27 a
P_3 x P_1	23.65 f-i	23.77 a-c	15.67 d-h	15.27 cd	4.92 a	11.13 c-f	12.46 c-e	9.25 ab	8.61 a-d
P_4 x P_1	20.22 h-j	21.18 c-e	14.10 f-j	15.44 b-d	3.60 c-g	11.68 b-f	11.20 d-f	6.04 cd	8.51 a-d
P_5 x P_1	24.20 f-i	17.75 f-i	15.77 d-h	12.11 f-h	3.18 f-h	10.34 f	10.46 f	9.96 a	8.19 a-d
P_6 x P_1	38.72 c	15.85 h-j	26.76 a	9.94 h	3.54 c-g	15.03 ab	14.50 ab	9.05 ab	8.09 a-d
P_3 x P_2	16.00 jk	20.96 c-f	9.33 jk	13.71 d-g	3.82 c-f	10.73 ef	11.83 c-f	8.55 ab	8.53 a-d
P_5 x P_2	18.55 ij	25.16 a	13.41 g-j	18.13 a	3.74 c-g	10.93 d-f	11.20 d-f	8.63 ab	7.41 d
P_6 x P_2	45.22 b	14.77 ij	18.93 b-e	10.51 h	2.74 h	14.56 a-c	13.66 a-c	5.63 d	8.88 a-d
P_5 x P_3	20.60 g-j	25.23 a	12.95 h-j	16.41 a-c	4.28 a-c	12.86 b-f	11.53 d-f	8.10 a-c	8.95 a-c
P_5 x P_4	27.61 ef	21.61 b-e	17.94 c-g	14.47 c-f	3.92 c-e	12.15 b-f	11.53 d-f	9.66 ab	9.21 ab
P_6 x P_4	55.44 a	13.47 j	19.36 b-d	10.10 h	1.91 i	16.85 a	14.93 a	9.54 ab	9.14 a-c
P_6 x P_5	37.77 c	17.10 g-i	21.18 bc	11.73 gh	3.08 f-h	11.65 b-f	12.70 b-d	7.55 b-d	7.64 cd
Reciprocals									
P_2 x P_3	21.21 g-j	19.17 e-h	14.60 e-i	13.38 d-g	3.28 d-h	9.93 f	10.53 f	7.71 a-d	8.24 a-d
P_3 x P_5	15.33 jk	22.67 a-d	10.01 i-k	15.04 c-e	4.75 ab	11.93 b-f	12.66 b-d	9.49 ab	8.94 a-d
P_4 x P_6	25.11 e-h	20.68 c-f	18.77 b-f	14.75 c-e	3.56 c-g	13.88 a-e	13.60 a-c	8.79 ab	9.03 a-c

Values followed by the same alphabetical letter in each column do not differ significantly from each other using revised LSD

did not differ significantly from the parent P_3. As for the traits of cavity length and diameter, the two hybrids P_3 x P_2 and P_6 x P_1 reflected the lowest mean values among the hybrids, which did not differ significantly from the parent P_3 for both traits.

Chemicals constituents' characteristics

The results of mean performances for the six parental inbred lines and their 15 $F_{1,1r}$ hybrids for chemical constituents characters, dry mater%, carotien content, total sugars content%, and TSS%, are presented in Table 6. Generally, the results showed that there were insignificant differences between the parents for those characters. Concerning the parental inbred lines; the Chinese parent P_3 had the highest mean value for both dry matter% and TSS% traits. While, the Saudi parent P_1 and Local parent P_2 had the lowest mean values for the two characters, respectively. However, Chinese parent P_4 had the highest mean value for both carotene content and total sugars%.

The mean values of the resulting hybrids were close for the four chemical constituents traits under study and this can be attributed to the presence of degree of closeness among the mean values of parents. The data in Table 6 showed, also, that the F_1 hybrid P_6 x P_4, followed by the two hybrids P_6, x P_1 and P_6 x P_2 reflected relatively superior values compared to the rest of the hybrids for the dry matter% (16.85%) and TSS% (14.93%) traits, and it can be noted that all of these hybrids shared the negation of the father (P_6). As for the carotene and total sugars%, the mean values of the traits for the different hybrids were close and did not differ significantly; as the mean values ranged from 9.96 for the hybrid P_5 x P_1 to 5.63 for the hybrid P_6 x P_2 for the carotene content trait; while, ranged from 9.27% in the hybrid P_2 x P_1 to 7.41% in the hybrid P_5 x P_2 for total sugars% trait.

As for the behavior of the reciprocal hybrids shown in Table 6, the results showed that the F_{1r} hybrids did not show significant differences among themselves for all chemical constituents' traits, with the exception of dry matter%, in which the F_{1r} hybrid P_4 x P_6 recorded the highest value, which differed significantly from the hybrid P_2 x P_3. The results illustrated, also, there were insignificant differences between the means of the F_1 hybrids and their F_1 reciprocals hybrids for all traits.

As for comparing the behavior of the parents and the resulting hybrids, no clear significant differences appeared between the parents and the hybrids for the carotene content and total sugars% traits. As for dry matter% and TSS% traits, there was a relative convergence between the parents and their hybrids; however, the two F_1's P_4 x P_6 and P_6 x P_1 reflected values that were relatively higher than the mean values of the different genotypes, whether the parents or the hybrids.

Heterosis Percentages and Potence ratio Parameters:

Vegetative growth and flowering characters

Estimation of heterosis:

The data in Table 7 illustrated the estimated value of heterosis for vegetative growth and flowering traits for the $F_{1,1r}$ hybrids. The results showed that the hybrids and reciprocal hybrids reflected clear heterosis either on mid-parents or better parent for these traits; with the exception of four hybrids that did not reflect any heterosis. Where, the F_1 hybrid P_5 x P_1 and F_{1r} hybrid P_2 x P_3 did not reflect any heterosis when estimated on the basis of better parent for the traits of number of branches/plant and number of days to first female flower, respectively. Also, the hybrid P_6 x P_2 did not reflect any heterosis either on the basis of better parent or mid-parents for the trait of number of nodes to the first female flower. It is, also, clear from Table 7 that six of the hybrids were distinguished and recorded negative (desirable) values for heterosis on the basis of mid-parents and three relatives to better parent for the trait of main stem length. Also, for the two flowering traits, nine and five hybrids reflected negative (desirable) heterosis relative to mid-parents and better parent for number of nodes to first female flower; while, number of days to first female flower trait recorded a lower number of hybrids for the hybrid vigor, whether based on mid- parents (four hybrids) or better parent (one hybrid) with negative (desirable) values. As for the best values of heterosis for the four

Table. 7. Heterosis percentages relative to mid - and better - parents (MP and BP) and potence ratio of the fifteen pumpkin F_1 hybrids for vegetative growth and flowering characters.

Genotypes	Vegetative growth characters						Flowering characters					
	Main stem length (m)			No. of branches/plant			No. of nodes to first female flower			No. of days to first female flower		
	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %
	MP	BP		MP	BP		MP	BP		MP	BP	
Hybrids												
P_2 x P_1	-8.24	9.04	0.52	-32.25	-37.33	-3.97	-5.05	2.94	-0.68	2.00	12.2	0.22
P_3 x P_1	1.87	36.18	0.07	-17.66	-25.08	-1.78	2.38	6.95	0.56	23.07	33.33	3.00
P_4 x P_1	18.28	25.12	3.34	-2.20	-4.31	-0.55	2.16	17.82	0.16	12.32	23.33	1.40
P_5 x P_1	39.28	56.78	3.52	9.44	0.00	1.10	2.14	18.80	0.15	24.02	41.46	1.95
P_6 x P_1	57.95	74.62	6.07	14.16	4.31	0.20	9.57	18.80	1.29	-1.06	20.36	-0.06
P_3 x P_2	11.20	23.17	1.15	-12.92	-14.46	-7.18	-8.80	-5.48	-2.78	6.39	7.91	4.54
P_5 x P_2	34.79	41.56	7.28	-4.50	-18.66	-0.28	-15.89	-10.22	-2.47	14.32	18.19	4.44
P_6 x P_2	47.96	58.09	7.48	30.33	11.00	1.93	0.00	0.00	0.00	-10.00	-1.25	-1.12
P_5 x P_3	-11.68	3.21	-0.80	-10.72	-25.08	-0.56	-7.38	2.70	-0.76	5.28	10.45	1.14
P_5 x P_4	24.84	32.43	4.33	31.86	22.95	3.62	-7.51	-6.82	11.10	7.64	11.48	2.18
P_6 x P_4	-6.69	-2.70	-1.63	12.08	4.50	1.37	-3.20	2.51	-1.11	1.41	11.48	0.15
P_6 x P_5	18.36	20.33	11.25	31.27	31.27	0.00	-29.4	-24.63	-4.57	-5.05	0.57	-0.89
Reciprocals												
P_2 x P_3	-17.62	-8.75	-1.81	-20.13	-21.54	-11.18	-0.03	3.60	-0.01	-1.40	0.00	-1.00
P_3 x P_5	-4.12	12.04	-0.28	-2.29	-18.00	-0.12	6.56	18.16	0.68	8.93	14.28	1.92
P_4 x P_6	-16.41	-12.83	-4.00	16.92	9.01	1.92	-16.02	-11.06	-2.78	11.84	22.39	1.29

studied traits; the two F_{1r} hybrids P_2 x P_3 and P_4 x P_6 reflected the best heterosis values (negative) whether relative to better parent or mid-parents for the trait of main stem length; and the two F_1 hybrids P_6 x P_5 and P_5 x P_4 recorded the best hybrid vigor values (positive) relative to better-and mid- parents for the trait of number of branches/plant. As for the trait number of nodes to first female flower, the hybrid P_6 x P_5, preceded by the reciprocal hybrid P_4 x P_6 reflected the best heterosis values (negative) based on better parent or mid-parents; while, the hybrid P_6 x P_2 recorded the best heterosis values (negative) based on mid-parents and better parent for the trait of number of days to first female flower. These results agreed with that reported by **El-Tahawey *et al.*, (2015)**, **Davoodi *et al.*, (2016) and Jansi *et al.* (2018)**, who reported significant values of positive heterosis for stem length in most studied hybrids. However, these results not in agreement with that reported by **Nisha and Veeraragavathatham, 2014,** who reported that the majority of the hybrids displayed negative heterosis for stem length. The presence of negative heterosis over better parent was, also, reported by **Jahan *et al.* (2012)**, **Nisha and Veeraragavathatham (2014)** and **Hosen *et al.*, (2022)** for number of nodes to the first female flower character. Also, **Nisha and**

Veeraragavathatham (2014) and **Mohsin *et al*. (2017)** on pumpkin and by **Preethi *et al.*, (2019**) on cucumber reported that heterosis in negative direction is preferred for days to female flower anthesis and for days to first harvest because is a well-recognized and prime objective of any breeding program as it helps the grower to a good early market price. Through the results of heterosis for the four studied traits; main stem length, number of branches/plant, number of nodes to first female flower, and number of days to first female flower; the nature of inheritance of these traits can be deduced. Where, the inheritance of these characters involved partial-dominance to over-dominance for taller over short plant, high over low number of days to first female flower, low over high number of nodes to first female flower. While the inheritance of number of branches/plant character involved non-additive effects from partial and over dominance to partial and under-recessiveness.

Estimation of potence ratio:

The results in **Table 7** show the estimated values of potence ratio for main stem length, number of branches/plant, number of days to first female flower and number of nodes to first female flower. Potence ratio estimates for main stem length character were positive for ten hybrids (greater than one in eight and less than one in two hybrids) and were negative for five hybrids (greater than one in three and less than one in two hybrids. These results reflected a clear over-dominance to partial dominance with different degree for taller plant form over its shorter. Potence ratio estimates for number of branches/plant were positive for six hybrids, greater than one in five hybrids, and less than one in one hybrid; however, the values were negative for eight hybrids; greater than one in four and less than one in four hybrids; and it was equals zero for one hybrid, which recorded different degrees of dominance and recessiveness. So, these results reflected clearly the presence of non-additive effects from partial and over dominance to under-recessiveness. The estimated values of potence ratio for nodes number to first female flower were positive for six hybrids; greater than one in two and less than one in four hybrids; however, the values were negative for eight hybrids; greater than one in five and less than one in three hybrids; and it was equals zero for one hybrid. It is clear from the estimated values of potence ratio for nodes number to first female flower of the different hybrids that there are degrees of dominance between partial dominance and under recessiveness. Potence ratio estimates for number of days to first female flower was positive for eleven out of fifteen hybrids, and greater than one in nine hybrids and less than one in two hybrids; while, the values were negative for four hybrids; greater than one in two and less than one in two hybrids; moreover, one F_{1r} hybrid showed potence ratio value equal -1. Generally, these results indicated that there was complete to over dominance towered a greater number of days to the first female flower; which, agreed with the hybrid vigor tends toward a greater number of days. Similar results were also reported by **El-Tahawey *et al.*, (2015), Jansi *et al*., (2018) and Preethi *et al.*, (2019)**, who stated that positive heterosis and over-dominance were important in the inheritance of number of days to first female flower character. Generally, the results of potence ratio regarding the inheritance of these traits agreed with what was reflected by the values of the calculated heterosis..

Yield and its components characters:

Estimation of heterosis:

Yield and its components, as shown in Table 8, reflected heterosis either on the basis of mid-parents or better parent, except for the hybrid P_6 x P_2, which did not show hybrid vigor relative to better; but it reflected a hybrid vigor on the basis of mid-parents. Also, eight out of the fifteen hybrids recorded positive heterosis (desirable) on the basis of mid-parents for the traits of number of fruits per plant and total yield per plant; also, positive heterosis (desirable) was recorded relative to better parent for four hybrids for the same two traits. As for the trait of average fruit weight, four hybrids and one reciprocal hybrid reflected positive hybrid vigor values (desirable) either on the basis of mid-parents or better parent. For the trait of number of fruits/plant, the highest values of positive heterosis (desirable) appeared on the basis of mid-parents or better parent for the two hybrids P_6 x P_5 and P_6 x P_4 and the reciprocal hybrid P_4 x P_6. As for the trait of total yield/plant, the hybrid P_6 x P_5 and the F_{1r} hybrid P_4 x P_6 recorded the best heterosis on the basis of mid-parents and better parent. From the estimates of heterosis it can be concluded that the inheritance of average fruit weight character involved partial to under-recessiveness towards lighter parents. While the inheritance of number of fruits/plant and total yield/plant characters involved non-additive effects from partial and over dominance to partial and under-recessiveness. The present results agreed to a great extent with those reported by **Jahan *et al*., (2012**), **Mohsin*et al*., (2017), Hosen *et al*., (2022**) and **Shafin*et al*., (2022)**,.

Table. 8. Heterosis percentages relative to mid - and better parents (MP and BP) values and potence ratio of the fifteen pumpkin F_1 hybrids for yield and its components characters.

Genotypes	Yield components characters								
	Number of fruits/plant			Average fruit weight(kg)			Total yield/plant (kg)		
	Heterosis (%)		Potence ratio	Heterosis (%)		Potence ratio	Heterosis (%)		Potence ratio
	MP	BP		MP	BP		MP	BP	
Hybrids									
P_2 x P_1	-41.11	-44.50	-6.73	-12.39	-12.76	-29.00	-45.91	-47.78	-12.8
P_3 x P_1	-21.17	-32.13	-1.31	31.91	59.18	71.25	-7.88	-19.43	-0.53
P_4 x P_1	-11.33	-33.50	-0.34	41.23	33.78	7.40	26.53	0.68	1.03
P_5 x P_1	9.30	-6.00	0.57	-9.93	-14.61	-1.81	-4.75	-13.62	-0.45
P_6 x P_1	13.82	-11.50	0.48	-9.44	-16.36	-1.14	14.28	-5.10	0.69
P_3 x P_2	-36.56	-48.01	-1.66	-31.77	-34.89	-6.62	-59.52	-65.76	-3.26
P_5 x P_2	24.61	12.99	2.39	-11.51	-15.76	-2.28	13.46	6.34	2.00
P_6 x P_2	22.91	0.00	1.00	-19.01	-24.9	-2.42	5.13	-10.12	0.30
P_5 x P_3	-21.14	-40.07	-0.66	11.93	1.92	2.26	-11.08	-28.66	-0.44
P_5 x P_4	9.01	-7.63	0.50	17.77	17.88	185.00	12.76	-2.64	0.80
P_6 x P_4	26.06	19.81	5.00	-15.59	-17.81	-5.75	2.08	-3.26	0.37
P_6 x P_5	74.11	54.16	5.72	-14.39	-16.72	-5.13	41.03	27.75	3.94
Reciprocals									
P_2 x P_3	-31.71	-44.04	-1.44	-9.69	-13.82	2.02	-33.79	-44.01	-1.85
P_3 x P_5	-26.36	-44.04	-0.83	13.62	3.46	2.58	-18.86	-34.90	-0.76
P_4 x P_6	26.06	19.81	5.00	-0.28	-2.90	-0.10	25.29	18.72	4.57

Estimation of potence ratio:

The estimated values of potence ratio for yield and its component are presented in Table 8. The data of potance ratio for number of fruits/plant indicated that the over-dominance was observed in four F_1 hybrids (positive values and greater than one), partial dominance appeared in three F_1 hybrids (positive values and less than one) and complete dominance appeared in only one F_1 hybrid (value equal one). While under recessiveness effect were showed in four F_1 hybrids with differnet degrees (negative and more than one) and partial recessiveness effect appeared in three F_1 hybrids (negative and less than one). These results reflected clearly the presence of non-additive effects from partial and over dominance to partial and under-recessiveness. Such heterotic effects and potence ratio estimates for number of fruits/plant indicated that various degrees of over-dominance, partial-recessiveness and under-recessiveness; seemed to be involved on the inertance of this character. Concerning average fruit weight trait; the data of potence ratio indicated that the presence of over-dominance for six F_1 hybrids, while under-recessiveness was detected for eight F_1 hybrids in addition one hybrid ($P_4 \times P_6$) was reflected partial-recessiveness. The estimated potence ratio values for total yield/plant revealed that the presence of over-dominance in four hybrids; while, under-recessiveness was detected in three F_1 hybrids. Moreover, partial dominance was present in four F_1 hybrids; while, four hybrids showed partial recessiveness effect. These results reflected the importance of non-additive gene effects from partial and over dominance to partial and under-recessiveness in the inheritance of this trait. Such potence ratio estimates indicated that various degrees of over-dominance, partial- recessiveness and under-recessiveness; seemed to be involved on the inertance of average fruit weight character. These results were in accordance with those found by **El-Tahawey *et al*., (2015)**, **Davoodi *et al*., (2016)**, **Jansi *et al*., (2018), and Wessel-Beaver *et al*., (2021)**, who reported that the yield and its components controlled by dominance gene action and hybrid vigor appear in these attributes, especially when there is a difference between the genotypes used in the crossbreeding program.

Fruits quality and chemicals constituents' characteristics

Fruits quality characters

Estimation of heterosis:

Table 9 reflects the estimates of heterosis for fruits quality characters; fruit length, fruit diameter, cavity length, cavity diameter, and flesh thickness. The results showed that these traits are the most studied traits that reflected significant heterosis in the desired direction. By estimating hybrid vigor based on mid-parents, the results reflected that 14, 10, 9, 8, and 7 hybrids out of the 15 hybrids recorded better hybrid vigor than mid-parents for cavity length, flesh thickness, cavity diameter, fruit length, and fruit diameter; respectively. Also, 5, 6, 5, 6, and 5 hybrids reflected hybrid vigor

Table. 9. Heterosis percentages relative to mid and better parents (MP and BP) values and potence ratio of the fifteen pumpkin F_1 hybrids for fruit quality characters.

Genotypes	Fruit characters														
	Fruit length (cm)			Fruit diameter (cm)			Cavity length (cm)			Cavity diameter (cm)			Flesh thickness (cm)		
	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %
	MP	BP		MP	BP		MP	BP		MP	BP		MP	BP	
Hybrids															
P_2 x P_1	-27.22	-30.86	-5.17	-3.29	-7.68	-0.69	-41.35	-36.40	-5.30	-2.74	-1.89	-3.16	10.13	8.01	5.15
P_3 x P_1	5.04	-32.09	0.09	7.60	-3.56	0.65	-6.67	134.93	-0.11	-3.75	11.29	-0.27	47.30	43.02	15.80
P_4 x P_1	-30.15	-41.94	-1.48	11.47	8.44	4.11	-35.18	-15.06	-1.15	18.04	24.11	3.68	1.83	-6.00	0.22
P_5 x P_1	-21.56	-30.51	-1.67	-7.91	-9.11	-5.98	-33.79	-23.92	-2.60	-4.60	3.77	-0.57	-11.91	-20.10	-1.16
P_6 x P_1	17.36	11.16	3.11	-12.55	-18.84	-1.61	7.81	17.72	0.92	-22.43	-16.54	-3.17	13.46	9.25	3.50
P_3 x P_2	-22.98	-48.96	-0.45	-9.12	-14.96	-1.32	-37.15	39.88	-0.67	-14.23	-1.79	-1.12	12.18	11.04	11.85
P_5 x P_2	-36.28	-40.82	-4.72	24.24	17.13	3.99	-38.69	-35.31	-7.39	41.47	55.35	4.64	1.76	-6.03	0.21
P_6 x P_2	44.70	44.24	139.7	-22.67	-31.23	-1.81	-17.24	-16.71	-27.2	-18.74	-11.75	-2.36	-13.97	-18.69	-2.40
P_5 x P_3	11.11	-23.36	0.24	15.54	2.35	1.20	-5.47	94.15	-0.10	10.57	40.61	0.49	15.36	7.53	7.60
P_5 x P_4	10.55	2.71	1.38	15.28	13.61	10.41	-3.88	8.07	-0.35	20.03	23.99	6.27	0.38	-1.50	0.20
P_6 x P_4	104.5	77.97	7.01	-23.44	-27.07	-4.71	-1.55	16.62	-0.09	-17.04	-15.19	-7.83	-44.07	-50.13	-3.62
P_6 x P_5	30.17	21.25	4.1	-4.30	-10.09	-0.66	-2.53	2.17	-0.55	-0.50	0.51	-0.50	-11.74	-22.61	-0.83
Reciprocals															
P_2 x P_3	2.09	-32.34	0.04	-16.88	-22.23	-2.45	-1.65	118.89	-0.02	-16.29	-4.15	-1.28	-3.67	-4.65	-3.57
P_3 x P_5	-17.31	-42.96	-0.38	3.82	-8.03	0.29	-26.93	50.07	-0.52	1.34	28.87	0.06	28.03	19.34	3.85
P_4 x P_6	-7.37	-19.39	-0.49	17.53	11.96	3.52	-4.55	13.07	-0.29	21.14	23.84	9.71	4.24	-7.04	0.34

based on better parent for the traits fruit diameter, flesh thickness, fruit length, cavity diameter, and cavity length, respectively. As for the best hybrids that gave heterosis, whether relative to mid-parents or better parent, the two hybrids P_6 x P_4 and P_6 x P_2 were the best, as they reflected positive heterosis values (desired) for fruit length trait. As for fruit diameter trait, the hybrid P_5 x P_2 and the F_{1r} hybrid P_4 x P_6 recorded the best positive values (desired), and the hybrids P_2 x P_1 and P_5 x P_2 reflected the best negative values (desired) for the hybrid vigor for cavity length trait. As for the cavity diameter trait, the best hybrids that reflected negative values (desired) for heterosis were P_6 x P_1 and P_6 x P_4; also, the hybrids P_3 x P_1 and the reciprocal hybrid P_3 x P_5 reflected the best positive values (desired) for flesh thickness trait. These results indicated that the two characters fruit length and fruit diameter seemed to have non-additive effects from partial and over dominance to partial and under-recessiveness in their inheritance. For cavity length, cavity diameter, and flesh thiknesses characters their heterosis values indicated that the inheritance of these characters involved partial-recessiveness to under recessiveness for length and diameter of fruit cavity twoerds less values, and partial to over dominance for thick over thin flesh thikness. The presence of negative heterosis over better parent for both fruit length and fruit diameter was also reported by **Jansi *et al*., (2018)** and **Shafin *et al*.,(2022)**

Estimation of potence ratio:

The results of potance ratio estimates, Table 9, for the five fruits quality; fruit length, fruit diameter, cavity length, cavity diameter, and flesh thicknesses; illustrated that five F_1 hybrids showed a clear over-dominance and three F_1 hybrid showed a partial dominance for fruit length trait. On the contrary four F_1 hybrids showed under recessiveness effect and three F_1 hybrids showed a partial recessiveness effect. The data of potance ratio in the case of fruit diameter showed that over-dominance were appeared in five F_1 hybrids with different degrees. On the other hand six F_1 hybrids showed under recessiveness effect. While, two hybrid showed partial dominance**,** and the remaining two F_1 hybrids showed a partial recessiveness effects. This result indicated the importance of non-additive gene effects in inheritance of both fruit length and fruit diameter (from partial dominance to under recessiveness) as detected from estimated values of heterosis relative to mid-parents and better parents and, also, from potence ratio values which gave negative and positive values. The presence of negative heterosis over better parent for both fruit length and fruit diameter was also reported by **Jansi *et al*., (2018)** and **Shafin *et al*., (2022**). Potence ratio estimates for cavity length were negative for all F_1 hybrids; except one hybrid. The values were greater than one in five and less than one in 9 hybrids. These results revealed that five F_1 hybrid showed under recessiveness effect and the other nine F_1 hybrids showed partial recessiveness effect with differnet degrees. These results reflected clearly the presence of non-additive effects from partial to under recessiveness for the low values relative to high values in cavity length. The potence ratio calculation for cavity diameter revealed that six F_1 hybrids showing potence ratio with negative value and greater than 1; while, there was four F_1 hybrids gave values greater than 1 with positive sign. In addition, two F_1 hybrids exhibited positive values less than 1, whereas the other two F_1 hybrids displayed negative These results reflected clearly the presence of non-additive effects between partial- recessiveness and under-recessiveness in the inheritance of this character. The calculation of the potence ratio for flesh thicknesses indicated that over dominance showed in six F_1 hybrids, while partial dominance showed in four F_1 hybrids; four F_1 hybrids reflected under recessiveness effect and one hybrid showed a partial recessiveness effect. These results reflected clearly the presence of non-additive effects from partial dominance to over dominance for the high values relative to low values.

Chemicals constituents' characteristics

Estimation of heterosis

The results in Table 10 showed that all hybrids recorded clear heterosis, whether based on mid-parents or better parent, for the chemical fruit components traits; where it was most evident in total sugars% trait, where ten and nine hybrids out of fifteen hybrids achieved positive (desirable) heterosis based on mid-parents or better, respectively. Also, eight hybrids out of fifteen hybrids reflected positive (desirable) heterosis based on mid-parents for the traits of dry matter% and carotene content; while, heterosis based on better parent was recorded by five and six hybrids for the previous two traits, respectively. As for TSS% trait, positive (desirable) hybrid vigor was recorded for a

Table. 10. Heterosis percentages relative to mid and better parents (MP and BP) values and potence ratio of the fifteen pumpkin F_1hybrids for chemical constituents' characters.

Genotypes	Chemical constituents											
	Dry matter percentage (%)			Total soluble solid (T.S.S) %			Carotene content (mg/100gm.fw)			Total sugar content (%)		
	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %	Heterosis (%)		Potence ratio %
	MP	BP		MP	BP		MP	BP		MP	BP	
Hybrids												
P_2 x P_1	7.39	3.77	2.11	-3.26	-3.82	-5.61	-0.84	-6.41	-0.14	16.02	13.04	6.09
P_3 x P_1	-10.35	-21.61	-0.71	1.17	-7.01	0.13	5.11	4.28	6.42	8.37	5.00	2.60
P_4 x P_1	2.05	-4.73	0.28	-1.27	-2.26	-1.26	-32.62	-34.34	-12.44	-1.73	-6.68	-0.32
P_5 x P_1	-6.29	-9.61	-1.71	-12.21	-16.98	-2.12	13.24	14.08	17.92	-2.67	-0.12	-1.04
P_6 x P_1	32.59	24.83	5.24	23.61	18.56	5.54	3.66	3.66	0.00	-2.11	-2.88	-2.69
P_3 x P_2	-16.17	-24.43	-1.47	-3.42	-11.71	-0.36	2.88	-3.60	0.42	10.27	9.64	17.66
P_5 x P_2	-4.29	-4.45	-24.50	-5.48	-11.11	-0.86	3.913	-2.59	0.58	-9.68	-14.13	-1.87
P_6 x P_2	24.23	20.93	8.87	17.10	11.69	3.53	-31.67	-35.50	-5.32	10.24	6.60	3.00
P_5 x P_3	0.31	-9.43	0.02	-11.30	-13.95	-3.67	-8.62	-8.68	-153.00	9.68	3.70	1.68
P_5 x P_4	2.53	-0.89	0.73	-4.15	-8.49	-0.87	6.97	5.00	3.70	3.77	0.76	1.36
P_6 x P_4	38.68	37.43	42.72	26.04	22.07	8.01	6.41	3.69	2.44	4.75	0.21	1.05
P_6 x P_5	-0.76	-3.23	-0.30	2.29	0.79	1.54	-14.15	-14.78	-19.15	-9.90	-11.47	-5.6
Reciprocals												
P_2 x P_3	-22.42	-30.07	-2.05	-14.04	-21.41	-1.49	-7.22	-13.07	-1.07	6.52	5.91	11.22
P_3 x P_5	-6.94	-15.98	-0.64	-2.61	-5.52	-0.85	7.05	6.98	125.00	9.55	3.59	1.65
P_4 x P_6	14.23	13.21	15.72	14.81	11.20	4.55	-1.95	-4.45	-0.74	3.49	-0.98	0.77

smaller number of hybrids, whether on mid-parents or better parent, which were represented by six and five hybrids, respectively. It is clear from the estimation of heterosis that the reciprocal hybrids did not distinguish themselves in terms of hybrid vigor, whether on mid-parents or better parent, except for the total sugars% trait. The P_6 x P_4 hybrid showed the best positive heterosis value relative to either mid-parents or better parent for both dry matter% and TSS%. Generally, some hybrids reflected values higher than or very closer to their respective higher parent and the other hybrids reflected values lower than or very closer to their respective lower parent for the studied traits of fruit chemical constituents; indicated that these characters seemed to have non-additive effects from partial and over dominance to partial and under-recessiveness in the inheritance of dry mater%, TSS%, and carotene content; while, the inheritance of total sugar% trait was mostly in the direction of partial dominance to over dominance.

Estimation of potence ratio

Concerning the estimated values of potence ratio **for** chemical components of fruits as illustrated in Table 10; the results showed that the potence ratio values of dry matter% were positive for eight out fifteen hybrids, greater than one in five hybrids and less than one in three hybrids. However, the values were negative for seven hybrids; greater than one in four hybrids and less than one in three hybrids. These results indicated the importance of non-additive gene effects from partial dominance to under recessiveness in the inheritance of this trait. The present results agreed to a great extent with those reported by **Davoodi *et al.*, (2016), Hosen *et al*., (2022) and Shafin *et al*., (2022),** who recorded non- additive gen action in dry matter% trait. Data of potence ratio for TSS% trait indicated that the presence of over-dominance for five F_1 hybrids, also, under-recessiveness was detected for five F_1 hybrids. However, four F_1 hybrids reflected partial-recessiveness effect and only one hybrid reflected partial-dominance. Based on the above mentioned, it can be noted that the nature of inheritance of this trait lies between over dominance and under-recessiveness. Potence ratio estimates for carotene content were positive for seven hybrids; greater than one in four hybrids and less than one in three hybrids; also, the values were negative for seven hybrids; greater than one in five and less than one in two hybrids; and it was equal zero for one hybrid. These results agreed with that reported by **Jahan *et al*., (2012**), **Davoodi *et al.*, (2016), Hosen *et al*. (2022) and Shafin *et al*., (2022**), who illustrated the importance of non-additive gen action in the inheritance of carotene content character. Potence ratio estimates for total sugars% character was positive for ten hybrids: greater than one in nine and less than one in one hybrid. On the other hand, potence ratio estimates were negative for five hybrids; greater than one in four hybrids and less than one in one hybrid. It is noteworthy that the values of potence ratio for most hybrids reflect a degree of inheritance in the direction of increasing the percentage of total sugars, which reflects over dominance in the inheritance of this trait. Such potence ratio and heterosis estimates indicated that various degrees of partial-dominance, over-dominance, partial-recessiveness and under-recessiveness seemed to be involved on the inheritance of chemical constituents' characters.

CONCLOUSION:

This study concluded that the two inbred lines P_3 and P_1 reflected the best desirable values for number of nodes and number of days to first female flower, flesh thicknesses, total yield/plant, and carotene characters. In addition, the parent P_3 had the highest values for number of branches/plant, number of fruits/plant, fruit diameter, cavity length, cavity diameter, dry matter percentage and total soluble solid%. Moreover, the parent P_1 gave the best values, also, for main stem length, fruit length, flesh thicknesses, and total sugars%. Also, the parent P_5 was the best for average fruit weight, total yield/plant, cavity diameter, flesh thicknesses, TSS% and total sugars%. Therefore, the three parental inbred liens $P_{1,}$ P_3 and P_5 can be selected used to produce the best hybrids. Concerning the best hybrids, the results of studding the performances of produced hybrids concluded that the two F_1 hybrids P_6 x P_1 and $P_3 \times P_1$ had the best performances for eight and six characters, respectively, as well as, the F_1 hybrid P_6 x P_4 and its reciprocal P_4 x P_6, and the F_1 hybrid P_5 x P_3 and its reciprocal P_3 x P_5 recorded the best performances for five to six traits. Therefore, three F_1 hybrids $P_6 \times P_1$, $P_3 \times P_1$ and $P_6 \times P_4$ could be considered the most important ones and promising new produced pumpkin hybrids from this study.

The estimated heterosis effects relative to both mid and better parents indicated that there were positive and negative values with different degrees for all studid charactrs. The results of the means of the genetic populations and the estimations of heterosis and potence ratios illustrated that the inheritance of the four characters main stem length, number of days to first female flower, number of nodes to first female flower and total yield/plant**,** involved partial-dominance to over-dominance for taller over short plant, high over low number of days to first female flower, low over high number of nodes to first female flower and higher over low productivity, respectively. On the other hand, the inheritance of th other eight charactrs involved non-additive gene effects from partial and over dominance to partial and under-recessiveness.

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الملخص العربي

سلوك وقوه الهجين ودرجة السيادة لسته سلالات مرباه داخليا وهجينتها من القرع العسلي (*Cucurbita moschata*)

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اجريت هذه الدراسة خلال سته مواسم متتاليه بدأ من 2020 وحتى 2022م وذلك بهدف انتاج وتقييم سته سلالات مرباه داخليا من القرع العسلي (*Cucurbita moschata*) والهجن الناتجة بينهم. تم اجراء الانتخاب مع التلقيح الذاتي لمده اربعه اجيال متتاليه لعدد سته اصناف مختلفة من القرع العسلي. اجريت تجربه تقييم لإحدى وعشرين تركيب وراثي (سته سلالات مرباه داخليا و أثنى عشر هجين بينهم وثلاثة هجن عكسيه) وتم تقدير السلوك العام وقوه الهجين ودرجه السيادة لصفات النمو الخضري والزهري ومكونات المحصول وصفات جوده الثمار.

أوضحت النتائج وجود مدى واسع من الاختلافات الوراثية بين مختلف التراكيب الوراثية في كل الصفات موضع الدراسة. أوضحت تقديرات قوه الهجين ودرجه السيادة وجود قيم موجبه واخرى سالبه بدرجات مختلفة للصفات المدروسة. أظهرت النتائج ان طبيعة التوريث لصفات طول الساق الرئيسية وعدد الايام وعدد العقد حتى ظهور اول زهره مؤنثه بالإضافة الى صفه المحصول الكلي تتضمن سياده جزئه الى سياده فائقة لصفات الساق الأطول والعدد الاكبر للأيام حتى الول زهرة مؤنثة وعدد العقد الاقل حتى أول زهرة مؤنثة والإنتاجية المرتفعة. على الجانب الاخر فان طبيعة التوريث لباقي الصفات الاخرى تضمنت فعل جيني غير اضافي تراوح بين السيادة الجزئية والسيادة الفائقة مع اختلاف اتجاه السيادة داخل كل صفه. أفضل الاباء في معظم الصفات موضع الدراسة هي الاباء P_1 , P_3 , P_5.