



Production and Evaluation of Triple Hybrid Cucumber for Greenhouse Cultivation

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Abstract

The experiment was conducted over three seasons (autumn, spring, and autumn) starting September 15, 2023. Seeds from six of the nine cucumber varieties included in the study were sown, with three varieties (genetically distant) being excluded for use in the second season. A half-reciprocal cross was performed between these six varieties, resulting in fifteen single-cross hybrids from these crosses. In the second season (spring) beginning February 15, 2024, the seeds of the three inbred lines were planted with the fifteen individual hybrids. Crosses were done between them (line×tester) with the three inbred lines as fathers and the fifteen single hybrids as mothers to obtain 45 triple hybrids. For the third season (autumn) beginning September 15, 2024, the seeds of the three inbred lines (genetically distant), the fifteen single hybrids, and the 45 triple hybrids were planted, in addition to the comparison hybrid (Super Faris). The number of experimental units totaled 64 in one replicate. The experiment was based on a randomized complete block design (RCBD) with three replicates and was randomly distributed within two unheated plastic houses. Statistical analysis of the studied traits revealed clear genetic variability among the parents, as reflected in their growth and yield performance. Parent 2 was superior in plant height (250.33 cm) and total greenhouse yield (2.59 tons), while parent 1 excelled in the number of female flowers (57.33 flowers/plant). Among the maternal lines, 6×9 was outstanding in most yield traits, recording the highest plant height (285.00 cm), total greenhouse yield (3.63 tons), and experimental unit yield (30.28 kg). Likewise, the 3×5 mother was distinguished by plant height (284.67 cm) and internode length (9.62 cm). These differences were clearly reflected in the performance of the triple hybrids. With the single hybrid (3×5) showing the highest plant height (288.67 cm), surpassing the 280.33 cm for the Super Faris commercial check. In terms of yield traits, the triple hybrids 2(3×8) and 2(5×6) were the most outstanding, achieving the highest total greenhouse yields (4.38 and 4.36 tons, respectively) and experimental unit yields (36.54 and 36.30 kg), with highly positive heterosis values exceeding 60%. Other triple hybrids, such as 1(3×6) and 4(8×9), also showed superiority in fruit weight and fruit length. The results of the general compatibility of the parents showed that parent 2 (code C-H-1074) gave the highest compatibility compared to the others. Meanwhile, the highest general compatibility of the mothers (single hybrids) was for both 3×5 and 3×8, where one or both were repeated in several traits, including plant height (21.741 and 5.741), total number of female flowers (14.067 and 5.733), and total greenhouse yield (0.429 and 0.464). Regarding specific compatibility, the data indicated that the three hybrids 2(5×6) and 3(3×8) outperformed the others in several traits, including plant height (24.504 and 23.170), number of nodes (5.800 and 7.133), number of female flowers per node (53.459 and 40.625), number of fruits (9.778 and 8.000), and total greenhouse yield (1.067 and 0.819). For genetic characteristics, the average degree of dominance exceeded 1 for all the studied traits, while heritability in the broad sense was high for most of them. The non-additive action of the gene was more influential than the host action for most of the experimental traits, indicating that hybridization is the appropriate method for improving trait characteristics, while other traits can be improved by hybridization followed by selection to take advantage of superlocal isolations.

Keywords: Triple hybrids, Plant breeding, Cucumber, Line × tester, hybrids

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Introduction

Cucumber (*Cucumis sativus* L.) is one of the most important crops of the Cucurbitaceae family due to its economic and nutritional importance, as it contains several vitamins and minerals and has therapeutic properties for some stomach ailments and indigestion (3). According to (21), the use of triple hybrids may be preferred when the aim is to enhance yield and stability across different conditions compared to single hybrids, i.e., to achieve the best performance in a specific environment, or even for good, sustainable performance. (19) indicated that the triple hybridization process includes all possible triple hybrids resulting from crossing inbred lines and varieties. The results of the statistical analysis of this process can be clearly shown genetically and comprehensive information obtained from the existence of a broad genetic base.

This study aims to develop a triple cucumber hybrid suitable for protected cultivation conditions using a set of lines into a cross-breeding program, to achieve hybrid genetic combinations possessing superior productive performance.

Materials and Methods

The experiment was conducted in the unheated greenhouses of the Department of Horticulture and Landscape Engineering at the College of Agriculture, University of Anbar geographically located at 33.4263 north and 43.3332 on the eastern side of the city of Ramadi. All crop service operations were carried out, including pruning on one stem, weed removal, and others, as mentioned by (5). Fertilization was carried out according to (6). The hybridization program covered three seasons, during which nine locally developed lines were used. In the first season, six hybrid lines were planted on September 15, 2023 from the nine lines, and the remaining three were excluded for use in the second season to produce triple hybrids. Their seeds were sown with a spacing of 40 cm in 47-meter-long terraces set approximately 80 cm apart. Planting was carried out on one side of the terrace to facilitate the process of hybridization between the inbred lines (4).

Since the hybrid inbred lines were 100% female, six plants from each inbred lines were selected and sprayed with sex-modifying substances to obtain male flowers. Silver nitrate and sodium sulfate were used at a concentration of 1 g/L each (1). Hybridization between the inbred lines was carried out manually in the early

morning, and the flowers were packed the day before. As expected, it will open the next day, when the bag is lifted. The hybridization process was carried out by taking a male flower from the inbred lines (the parent) and wiping it with the stigma of the flower to be pollinated (the parent). It was then re-bagged to prevent contamination with foreign pollen. Each pollinated flower was labeled with all the information related to the hybridization, such as the father, the mother, and the date of the hybridization. The crosses were carried out in the early morning, and semi-reciprocal crosses were carried out between the six lines, where 15 single hybrids were obtained based on the second Griffin method (13). About 4-5 fruits were crossed per plant and allowed to grow.

When the pollinated fruits reached maturity, they were picked and placed in a bag with their own tags. The seeds were extracted manually and stored in a cool place for use in the second season. On February 15, 2024, seeds from the first season (15 single hybrids) considered as lines were sown, in addition to seeds from the remaining three inbred lines to produce 45 tri-crosses. These three inbred lines (testers) were genetically distant, and their separation was determined using polymerase chain reaction (PCR) technique with SSR. Five plants of the three lines were sprayed with sex-modifying agents to obtain male flowers, and each of the three homozygous lines was crossed with 15 single hybrids for the first season, resulting in 45 triple hybrids or about 4-5 fruits per hybrid. Each cross and fruit was marked with the parent plant and the date of hybridization. After 45 days when the fruit reached maturity, it was harvested with the marks and extracted as in the first season. In the third season (evaluation), which began on September 15, 2024, the seeds of the 15 single hybrids (mothers), the 45 triple hybrids and the three lines used (parents) in the previous season were planted in addition to the comparison hybrid (Super Faris).

The following measurements were made:

- Plant height (cm). Measured from the soil surface to the top of the growing tip at the end of the growth.
- Internode length (cm). Measured by dividing plant length by number of nodes.
- Fruit weight (gm). Measured by dividing the weight of the experimental unit yield by the number of fruits.

- Fruit length (cm). The average length of five marketable fruits per bunch for all bunches was taken as a measure using a Vernier.
- Number of female flowers. Calculated from the beginning of the growing season until the end of the crop.
- Total greenhouse yield (ton). Calculated by multiplying the yield per plant by 1200, which was the average number of plants in the greenhouse.
- Yield of experimental unit (kg). Calculated by multiplying the yield of one plant by 10, which is the number of plants in the experimental unit

Statistical analysis: The data were analyzed statistically with ANOVA using GenStat software and the arithmetic means were compared using the least significant difference (LSD) test at 0.05 significance level. Hybrid vigor was calculated for triple hybrids based on the deviation of the average of the first generation from the average of the best parents according to the equation: $H\% =$, except for the length of the internodes which were calculated on the basis of the lowest of the two parents.

Genetic analysis: Based on the statistically significant differences between the lines x testers overlap in the ANOVA table the union susceptibility was analyzed according to Singh and Chaudhary (2007). The mathematical model for general and special union susceptibility was as follows:

$$Y_{ij} = \mu + t_i + B_j + e_{ij}$$

where,

Y_{ij} - observation value for the genotype.

μ - overall mean for the trait.

t_i - effect of genotype.

B_j - effect of replicates

e_{ij} = experimental error value.

General combining ability for lines:

$$g_i = x_{i..} l \times t \times r - x... l \times t \times r$$

where,

g_i - the effect of combining ability for mother (lines)

i

$x_{i..}$ - the sum of the trait values for all hybrids resulting from mother (lines) i

l - number of lines

t - number of testers

r - number of replicates

$x...$ - total of all readings

General combining ability for testers:

$$g_i = x_{i..} l \times t \times r - x... l \times t \times r$$

where,

g_i - the effect of combining ability for tester (i)

$x_{i..}$ - the sum of the trait values for all hybrids resulting from tester i

The remaining symbols are as mentioned above.

Specific combining ability:

$$S_{ij} = - - -$$

where,

S_{ij} - effect of specific combining ability for hybrid resulting from (tester i x mother j)

X_{ij} - the sum of the trait values for the hybrid ($I \times j$)

The remaining symbols are as mentioned above.

Table 1. Line specifications

Line number	Line code	Specifications
1	C-H-1072	Female-type strain with good vegetative growth, elongated fruit, and good yield
2	C-H-1074	Female-type strain with strong vegetative growth, good yield, and tubular fruit
3	C-H-1076	Female variety with high vegetative growth, good yield, and dark green fruit
4	C-H-1078	Female variety exhibiting good vegetative growth and producing a good number of elongated fruits.
5	C-H-1080	Superior female variety with high vegetative growth, good yield, and tubular fruit
6	C-A-1082	Female variety with moderate vegetative growth, average yield, and tubular fruit with hairs
7	C-A-1085	Female variety with good vegetative growth, a high number of flower clusters, and elongated fruit
8	C-A-1086	Female variety with good vegetative growth, good flower clusters, good yield, and tubular fruit
9	C-A-1087	Female variety with moderate vegetative growth, good yield, and elongated fruit

The lines were locally developed and obtained from the supervisor

Table 2. Hybridization table for inbred lines, testers and triple hybrid

Tester Parents			
	1	2	4
3x5	1(3x5)	2(3x5)	4(3x5)
3x6	1(3x6)	2(3x6)	4(3x6)
3x7	1(3x7)	2(3x7)	4(3x7)
3x8	1(3x8)	2(3x8)	4(3x8)
3x9	1(3x9)	2(3x9)	4(3x9)
5x6	1(5x6)	2(5x6)	4(5x6)
5x7	1(5x7)	2(5x7)	4(5x7)
5x8	1(5x8)	2(5x8)	4(5x8)
5x9	1(5x9)	2(5x9)	4(5x9)
6x7	1(6x7)	2(6x7)	4(6x7)
6x8	1(6x8)	2(6x8)	4(6x8)
6x9	1(6x9)	2(6x9)	4(6x9)
7x8	1(7x8)	2(7x8)	4(7x8)
7x9	1(7x9)	2(7x9)	4(7x9)
8x9	1(8x9)	2(8x9)	4(8x9)

Results and Discussion

Plant height (cm)

The results in **Table 3** show that there were differences between the genotype of the arithmetic averages of the plant height trait, as father 2 outperformed the others, giving the highest average for the plant height trait at 250.33 cm. As for the mothers, both 6x9 and 3x5 excelled, giving the highest average for the trait, reaching 285.00 and 284.67 cm,

respectively, as well as outperforming the comparison hybrid (Super Faris) which averaged 280.33cm. The lowest average plant height was for the 5x7 mother at an average of 238.67 cm. The differences in the average plant height trait between the parents contributed to the emergence of differences between the resulting hybrids, as hybrid 1(3x5) outperformed the rest, reaching 288.67 cm, outperforming the comparison hybrid's 280.33 cm, while hybrid 4(5x7) gave the lowest average at 243.33 cm.

Table 3. Statistical analysis of the traits under study

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Greenhouse yield/ton	Yield of experimental unit
3x5	284.67	9.62	90.26	15.00	53.33	3.03	25.26
3x6	284.33	7.17	87.58	14.67	56.33	3.26	27.14
3x7	243.33	7.94	89.31	15.67	35.67	2.75	22.92
3x8	249.67	8.24	86.88	13.33	53.33	2.84	23.70
3x9	247.67	8.64	89.31	15.00	49.67	2.86	23.82
5x6	240.00	6.93	86.01	13.67	52.00	2.72	22.66
5x7	238.67	7.47	89.45	14.00	54.33	2.79	23.25
5x8	248.33	8.02	87.87	14.33	53.67	2.67	22.25
5x9	251.00	8.47	86.82	14.00	49.67	2.94	24.53
6x7	248.33	8.88	85.11	13.00	51.67	2.59	21.57
6x8	249.33	7.00	90.70	14.67	54.33	2.97	24.79
6x9	285.00	7.08	87.32	14.67	55.67	3.63	30.28
7x8	244.33	9.28	88.68	13.00	54.33	3.30	27.49
7x9	251.00	8.76	85.70	15.67	53.00	2.71	22.55
8x9	246.33	8.14	88.80	13.67	50.00	2.94	24.47
1(3x5)	288.67	7.10	88.81	14.67	79.67	3.91	32.56
1(3x6)	255.67	7.78	90.58	15.00	52.00	2.82	23.54
1(3x7)	247.00	8.15	87.47	13.67	73.00	2.66	22.16
1(3x8)	246.33	7.26	87.71	13.33	55.67	2.77	23.10
1(3x9)	258.33	9.45	88.82	14.33	59.00	2.88	23.98
1(5x6)	245.67	6.76	88.75	13.67	52.67	2.73	22.78
1(5x7)	257.67	8.50	89.16	14.67	54.33	2.75	22.88
1(5x8)	249.67	7.50	87.81	14.33	56.67	2.67	22.23
1(5x9)	248.33	7.12	89.71	13.67	62.33	2.98	24.84
1(6x7)	247.67	7.75	87.46	15.33	53.67	2.63	21.88
1(6x8)	245.67	7.03	89.16	14.33	53.33	2.78	23.19
1(6x9)	283.00	6.86	85.37	14.67	78.67	4.03	33.57
1(7x8)	256.00	8.46	89.07	14.33	52.33	2.78	23.16
1(7x9)	247.00	6.86	86.93	13.67	49.33	3.72	31.00
1(8x9)	246.33	7.63	88.03	13.00	48.00	3.00	24.97
2(3x5)	256.00	7.85	87.56	14.67	52.67	2.70	22.47
2(3x6)	253.00	8.25	87.43	13.33	54.33	2.69	22.42
2(3x7)	245.33	8.35	88.73	15.00	57.67	2.80	23.35
2(3x8)	283.33	6.64	86.29	14.67	75.00	4.38	36.54
2(3x9)	244.33	8.09	90.06	15.33	56.33	2.85	23.72
2(5x6)	284.00	6.99	89.24	15.33	81.33	4.36	36.30
2(5x7)	251.00	8.34	87.06	13.67	52.00	3.16	26.35
2(5x8)	254.00	8.14	86.23	15.00	56.33	2.66	22.13
2(5x9)	246.67	8.05	88.47	14.67	51.00	2.76	22.99

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Greenhouse yield/ton	Yield of experimental unit	
3x5	284.67	9.62	90.26	15.00	53.33	3.03	25.26	
2(6x7)	249.00	7.95	90.64	13.67	53.33	2.79	23.27	
2(6x8)	248.00	8.32	84.53	15.00	50.67	2.64	21.98	
2(6x9)	246.00	7.63	88.78	13.00	55.00	2.66	22.20	
2(7x8)	250.33	8.35	87.84	15.33	60.00	2.77	23.10	
2(7x9)	255.33	8.50	87.22	15.67	54.33	3.24	27.02	
2(8x9)	250.00	8.68	87.50	14.33	54.67	2.80	23.34	
4(3x5)	282.33	6.67	87.34	14.67	53.00	4.02	33.47	
4(3x6)	258.67	8.92	88.68	14.67	84.33	2.77	23.06	
4(3x7)	258.67	8.48	87.16	13.33	57.00	2.89	24.06	
4(3x8)	249.33	7.89	87.62	14.00	59.00	2.74	22.80	
4(3x9)	250.33	8.17	88.21	16.33	61.00	2.79	23.23	
4(5x6)	247.33	8.50	87.49	15.67	56.67	2.66	22.17	
4(5x7)	243.33	8.13	86.76	13.00	53.00	2.67	22.27	
4(5x8)	251.33	8.85	88.56	14.33	51.67	2.69	22.44	
4(5x9)	247.00	7.46	87.29	13.00	58.33	2.83	23.58	
4(6x7)	251.67	8.30	88.39	14.67	54.67	2.98	24.80	
4(6x8)	254.33	7.63	88.32	13.67	51.00	2.72	22.66	
4(6x9)	249.00	7.45	89.99	15.67	53.67	2.70	22.51	
4(7x8)	250.33	7.85	87.21	13.00	55.67	2.72	22.66	
4(7x9)	248.00	7.61	88.39	15.33	61.33	2.79	23.28	
4(8x9)	245.67	7.09	88.16	16.67	59.00	2.75	22.92	
Control (Super Faris)	280.33	7.31	90.06	16.67	55.33	3.60	30.01	
Testers	1	248.33	8.49	87.89	14.33	57.33	2.53	21.11
	2	250.33	8.46	88.77	12.67	53.00	2.59	21.62
	4	249.67	7.51	87.76	13.33	52.33	2.39	19.90
LSD	8.88	0.86	1.24	2.24	9.16	0.31	2.59	

Regarding hybrid vigor based on the best parents for this trait, the presence of a positive and significant hybrid vigor for about half of the number of hybrids, was for hybrids 2(5×6) and 2(3×8), with values of 13.449 and 13.182, respectively. It was also shown that there was a negative and significant hybrid vigor in the remaining hybrids, where the lowest value was for hybrid 2(6×9) at -13.684.

The results in **Table 5** regarding the effects of general combining ability (GCA) for parents and single hybrids (used as female) indicated that parent 1 exhibited the highest significant positive GCA effect, at 0.941. With respect to the single hybrids used as female parents, the

highest GCA effect was recorded for the single hybrid 3×5, which showed a value of 21.74. GCA reflects the magnitude of the contribution of a parent to the inheritance of the trait in the resulting progeny. In contrast, the lowest significant negative GCA effect was observed in two single hybrids, namely 4×9 and 8×9, both recording similar values at -6.593. For specific combining ability (SCA) effects, **Table 6** shows the triple hybrid 2(5×6) exhibiting the highest value, reaching 24.504, followed by the 2 (3×8) which recorded 23.170. The high variance in SCA indicates a strong genetic interaction among parental genotypes toward increasing plant height, whereas negative values reflect the opposite trend.

Table 4. Hybrid vigor for the traits under study

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Yield of experimental unit	Greenhouse yield/ton
1(3X5)	1.405	-16.321	-1.607	-2.222	38.953	40.440	28.900
1(3x6)	-10.082	8.501	3.057	0.000	-9.302	-2.424	-13.266
1(3x7)	-0.537	2.637	-2.057	-12.766	27.326	0.674	-3.300
1(3x8)	-1.335	-11.951	-0.201	-11.111	-2.907	3.081	-2.554
1(3x9)	4.027	11.362	-0.549	-4.444	2.907	6.754	0.680
1(5x6)	-1.074	-2.398	0.975	-8.889	-8.140	4.111	0.555
1(5x7)	3.758	13.800	-0.324	-2.222	-5.233	3.154	-1.593
1(5x8)	0.537	-6.413	-0.091	-4.444	-1.163	2.549	-0.079
1(5x9)	-1.062	-16.005	2.075	-8.889	8.721	8.862	1.279
1(6x7)	-0.268	-8.637	-0.493	2.222	-6.395	2.512	1.409
1(6x8)	-1.471	0.442	-1.694	-4.444	-6.977	1.035	-6.467
1(6x9)	-0.702	-3.129	-2.871	-2.222	37.209	30.652	10.865
1(7x8)	3.087	-0.377	0.444	-4.444	-8.721	-4.702	-15.766
1(7x9)	-1.594	-19.140	-1.088	-12.766	-13.953	43.351	37.486
1(8x9)	-0.805	-6.264	-0.867	-13.333	-16.279	3.042	2.017
2(3X5)	-10.070	-7.133	-2.991	-2.222	-1.250	-4.111	-11.031
2(3x6)	-11.020	15.081	-1.510	-9.091	-3.550	-8.017	-17.381
2(3x7)	-1.997	5.098	-0.646	-4.255	8.805	4.858	1.875
2(3x8)	13.182	-19.382	-2.786	4.762	40.625	61.250	54.155
2(3x9)	-2.397	-4.393	0.832	2.222	6.289	7.018	-0.417
2(5x6)	13.449	0.884	0.533	9.524	53.459	70.666	60.213
2(5x7)	0.266	11.730	-2.668	-2.381	-4.294	22.974	13.319
2(5x8)	1.465	1.474	-2.858	4.651	4.969	0.922	-0.517
2(5x9)	-1.726	-4.811	-0.330	4.762	-3.774	-0.353	-6.268
2(6x7)	-0.533	-5.952	2.107	-2.381	0.629	7.748	7.646
2(6x8)	-0.932	18.869	-6.799	2.273	-6.748	-5.278	-11.346
2(6x9)	-13.684	7.823	0.015	-11.364	-1.198	-14.460	-26.701
2(7x8)	0.000	-1.257	-1.040	9.524	10.429	-8.665	-15.969
2(7x9)	1.726	0.487	-1.746	0.000	2.516	36.904	19.807
2(8x9)	-0.133	6.671	-1.464	2.381	3.145	21.309	-4.624
4(3X5)	-0.820	-11.180	-3.235	-2.222	58.125	31.506	32.504
4(3x6)	-9.027	24.393	1.052	0.000	1.183	-0.138	-15.025
4(3x7)	3.605	12.834	-2.404	-14.894	12.739	3.096	4.989
4(3x8)	-0.134	5.047	-0.160	5.000	14.375	19.171	-3.817
4(3x9)	0.267	8.683	-1.235	8.889	8.280	6.270	-2.467
4(5x6)	-0.935	22.644	-0.311	14.634	1.274	6.136	-2.153
4(5x7)	-2.537	8.878	-3.011	-7.143	-4.908	4.814	-4.220
4(5x8)	0.668	17.711	0.785	0.000	8.696	-1.825	0.863
4(5x9)	-1.594	-0.759	-0.536	-7.143	4.459	6.161	-3.844

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Yield of experimental unit	Greenhouse yield/ton
4(6x7)	0.801	10.396	0.718	10.000	-2.548	5.268	14.953
4(6x8)	1.869	9.037	-2.617	-6.818	-1.227	1.388	-8.607
4(6x9)	-12.632	5.251	2.541	6.818	0.000	-10.312	-25.681
4(7x8)	0.267	4.427	-1.661	-2.500	12.883	-10.262	-17.568
4(7x9)	-1.195	1.292	0.722	-2.128	11.321	6.768	3.253
4(8x9)	-1.602	-5.640	-0.717	21.951	5.732	3.322	-6.322
SE	0.770	1.584	0.270	1.158	2.461	0.178	2.678

Table 5. General combining ability for the traits under study

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Total green house yield	Yield of experimental unit
1	0.941	-0.238	0.375	-0.393	0.556	0.037	0.308
2	0.496	0.157	-0.354	0.252	-0.511	0.141	1.174
4	-1.437	0.081	-0.021	0.141	-0.044	-0.178	-1.482
(3X5)	21.741	-0.641	-0.048	0.496	14.067	0.429	3.576
(3x6)	1.852	0.464	1.503	0.163	-3.711	-0.182	-1.517
(3x7)	-3.593	0.476	-0.161	-0.726	5.067	-0.257	-2.140
(3x8)	5.741	-0.587	-1.072	-1.170	5.733	0.464	3.869
(3x9)	-2.926	0.717	1.082	0.830	-0.822	-0.099	-0.826
(5x6)	5.074	-0.435	1.099	0.719	4.178	0.366	3.047
(5x7)	-3.259	0.471	0.157	-0.393	-5.489	-0.037	-0.309
(5x8)	-2.259	0.310	-1.191	0.830	-1.044	-0.358	-2.982
(5x9)	-6.593	-0.310	0.545	-0.170	-2.156	-0.104	-0.864
(6x7)	-4.481	0.150	1.325	0.163	-5.489	-0.281	-2.343
(6x8)	-4.593	-0.194	-0.610	-0.615	-5.600	-0.247	-2.061
(6x9)	5.407	-0.540	0.098	0.719	4.956	0.171	1.422
(7x8)	-1.704	0.366	-1.129	-0.504	-0.267	-0.286	-2.384
(7x9)	-3.815	-0.194	-1.211	-0.504	-3.933	0.407	3.394
(8x9)	-6.593	-0.053	-0.387	0.163	-5.489	0.014	0.119
SE	GCA-T	0.808	0.078	0.314	0.123	0.833	0.028
	GCA-L	1.806	0.175	0.702	0.275	1.863	0.063

Concerning genetic parameters, **Table 7** shows that broad-sense heritability was relatively high, reaching 0.944 which can be attributed to the greater contribution of genetic variance compared with environmental effects. However, narrow-sense heritability was low, at 0.143, indicating that most of the genetic variance was

due to non-additive gene action. Moreover, the degree of dominance was greater than unity, suggesting the presence of overdominance in the inheritance of this trait, implying that it can be more effectively improved through hybridization rather than selection. These results are consistent with (16, 9) in cucumbers.

Table 6. Specific combining ability for traits under study

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Total green house yield	Yield of experimental unit
1(3X5)	12.059	0.130	0.532	-0.163	6.889	0.481	4.009
1(3x6)	-1.052	-0.299	0.751	0.504	-3.000	0.010	0.081
1(3x7)	-4.274	0.064	-0.691	0.059	9.222	-0.081	-0.674
1(3x8)	-14.274	0.229	0.463	0.170	-8.778	-0.690	-5.750
1(3x9)	6.393	1.122	-0.581	-0.830	1.111	-0.020	-0.168
1(5x6)	-14.274	-0.416	-0.675	-0.719	-10.222	-0.629	-5.241
1(5x7)	6.059	0.412	0.681	2.393	1.111	-0.215	-1.789
1(5x8)	-2.941	-0.420	0.679	0.170	-1.000	0.029	0.238
1(5x9)	0.059	-0.186	0.846	-1.163	5.778	0.087	0.728
1(6x7)	-2.719	-0.009	-2.190	1.504	0.444	-0.091	-0.756
1(6x8)	-4.607	-0.392	1.447	-0.052	0.222	0.033	0.272
1(6x9)	22.726	-0.218	-3.054	0.281	15.000	0.861	7.173
1(7x8)	2.837	0.476	1.880	0.504	-6.111	0.068	0.567
1(7x9)	-4.052	-0.557	-0.178	-1.163	-5.444	0.351	2.922
1(8x9)	-1.941	0.066	0.091	-1.496	-5.222	-0.193	-1.612
2(3X5)	-20.163	0.486	0.011	0.193	-19.044	-0.833	-6.944
2(3x6)	-3.274	-0.222	-1.671	-1.141	0.400	-0.228	-1.901
2(3x7)	-5.496	-0.135	1.297	0.748	-5.044	-0.042	-0.354
2(3x8)	23.170	-0.778	-0.228	0.193	11.622	0.819	6.824
2(3x9)	-7.163	-0.640	1.381	-0.474	-0.489	-0.085	-0.704
2(5x6)	24.504	-0.584	0.547	0.637	19.511	1.067	8.889
2(5x7)	-0.163	-0.137	-0.687	-0.919	-0.156	0.246	2.052
2(5x8)	1.837	-0.183	-0.173	0.193	-0.267	-0.087	-0.726
2(5x9)	-1.163	0.351	0.335	0.526	-4.489	-0.239	-1.989
2(6x7)	-0.941	-0.205	1.718	-1.141	1.178	-0.028	-0.232
2(6x8)	-1.830	0.502	-2.454	0.637	-1.378	-0.216	-1.803
2(6x9)	-13.830	0.162	1.088	-0.363	-7.600	-0.608	-5.069
2(7x8)	-2.385	-0.024	-1.288	0.859	2.622	-0.124	-1.031
2(7x9)	4.726	0.683	0.834	0.193	0.622	0.119	0.995
2(8x9)	2.170	0.723	-0.711	-0.141	2.511	0.239	1.992
4(3X5)	8.104	-0.616	-0.543	-0.030	12.156	0.352	2.935
4(3x6)	4.326	0.521	0.920	0.637	2.600	0.218	1.820
4(3x7)	9.770	0.071	-0.606	-0.807	-4.178	0.123	1.028
4(3x8)	-8.896	0.549	-0.235	-0.363	-2.844	-0.129	-1.074
4(3x9)	0.770	-0.482	-0.799	1.304	-0.622	0.105	0.872
4(5x6)	-10.230	1.000	0.127	0.081	-9.289	-0.438	-3.648
4(5x7)	-5.896	-0.274	0.006	-1.474	-0.956	-0.032	-0.263
4(5x8)	1.104	0.603	-0.506	-0.363	1.267	0.059	0.488
4(5x9)	1.104	-0.165	-1.181	0.637	-1.289	0.151	1.261

Lines & Testers & Triploid	Plant height	Internode length	Fruit weight	Fruit length	Number of female flowers	Total green house yield	Yield of experimental unit
4(6x7)	3.659	0.214	0.472	-0.363	-1.622	0.119	0.988
4(6x8)	6.437	-0.110	1.006	-0.585	1.156	0.184	1.531
4(6x9)	-8.896	0.056	1.965	0.081	-7.400	-0.252	-2.104
4(7x8)	-0.452	-0.451	-0.591	-1.363	3.489	0.056	0.464
4(7x9)	-0.674	-0.127	-0.656	0.970	4.822	-0.470	-3.917
4(8x9)	-0.230	-0.789	0.620	1.637	2.711	-0.046	-0.381
SE	1.806	0.302	1.215	0.477	3.227	0.110	0.913

Internode lengths (cm)

The data for the internode length trait show significant differences between the genetic makeups of the parents, with parent 4 giving the lowest average internodes length (7.51 cm), while the highest was for parent 1 at 8.49 cm. As for the mothers, the lengths of the phalanges varied, with the shortest lengths for both the 5×6 and 6×8 mothers, averaging 6.93 and 7.00 cm, respectively, while the highest was for the 3×5 mother at 9.62 cm. The differences between the fathers and mothers were reflected in the resulting hybrids. The triple hybrids 2(3×8) and 4(3×5) gave the lowest average in internode lengths, at 6.64 and 6.67 cm respectively,

while the commercial hybrid (Super Faris) was 7.31 cm. The highest average of internodes length was for 1(3×9), which reached 9.45 cm.

Table 4 on hybrid strength shows a positive and negative hybrid vigor for the length of the internodes. The highest positive significant value for hybrid vigor was for the triple hybrid 4(3×6) at 24.39%, followed by the 4(5×6) at 22.64%, while the lowest negative value was for the 2(3×8), which recorded -19.38%. Internodal length is important as it contributes to higher production by increasing the number of nodes, which in turn leads to a greater number of leaves, which improves the accumulation of manufactured nutrients and an increase in the number of flowers, which ultimately lead to higher final yield.

Table 7. Genetic parameters for the traits under study

	$\bar{a}$	H^2_{ns}	H^2_{bs}	σ^2_E	σ^2_D	σ^2_A	σ^2_{SCA}	σ^2_{gca}
Plant height	36.301	0.143	0.944	29.356	120.108	0.729	120.108	0.182
Internode length	11.259	0.121	0.783	0.274	0.245	0.015	0.245	0.004
Fruit weight	9.940	0.591	0.297	4.432	0.460	0.037	0.460	0.009
Fruit length	33.313	0.152	0.847	0.682	0.942	0.007	0.942	0.002
Number of female flowers	26.622	0.250	0.889	31.240	62.836	0.709	62.836	0.177
Total greenhouse yield	22.376	0.381	0.957	0.036	0.204	0.003	0.204	0.001
Yield of experimental unit	22.376	0.381	95.782	2.503	14.156	0.226	14.156	0.057

Table 5 shows that parents 2 and 4 exhibited the highest GCA effects, with values of 0.081 and 0.157, respectively, an indication of their good combining ability. Regarding the single hybrids, several showed positive and significant GCA effects, with the single hybrid 3×9 registering the highest value of 0.717, followed by 3×7, which recorded 0.476. The SCA effects in **Table 6** show triple hybrids 1(3×9) and 4(5×6) having the highest positive and significant values, reaching 1.122 and 1.00, respectively.

Furthermore, the results of the genetic parameters in **Table 7** revealed that broad-sense heritability was high, at 0.783. This can be attributed to the greater influence of non-additive compared to additive gene action. In contrast, narrow-sense heritability was low, reaching 0.121, indicating the importance of additive gene action in the inheritance of internode lengths. Moreover, the degree of dominance was greater than unity, suggesting the presence of overdominance. Therefore, hybridization

followed by selection can be adopted as an effective breeding approach for improving the inheritance of this trait, as also noted by (10, 15, 14) in cucumbers.

Fruit weight (gm)

Table 3 shows significant differences between the parents in average fruit weight at the 5% probability, registering the highest for parent 2 at 88.77 grams. There were also significant differences between the mothers, with 6×8 having the highest average fruit weight at 90.70 grams, followed by 3×5 which registered 90.26 grams, while the lowest value was for 6×7 at 85.11 g. For the triple hybrids, the 2(6×7) had the highest average fruit weight of 90.64 g, followed by 1(3×6) at 90.58 g, while the lowest was for 2(6×8) at 84.53 g.

The results for hybrid vigor indicated positive and significant values for 13 triple hybrids with 1(3×6) and 2(6×7) being superior, giving values of 3.05 and 2.10% respectively, while the lowest negative value was for the 2(6×8) at -6.79%. The positive value in the hybrid vigor indicates that fruit weight is influenced by the superior dominance of the genes of the best parents while the negative value indicates the effect of the partial dominance of the lowest parents.

For GCA, **Table 5** shows parent 1 exhibiting the highest value, reaching 0.37. With respect to the estimation of GCA effects for single hybrids, the highest values were recorded for 3×6 and 6×7 at 1.503 and 51.32, respectively. Positive and significant GCA values of single hybrids indicate their potential to combine favorably with other parents toward the inheritance of this trait, whereas negative values indicate the opposite. Regarding SCA of the triple hybrids, positive and significant effects were observed in 24 hybrids, with the highest values recorded for 4(6×9) and 1(7×8), which recorded 51.96 and 1.880, respectively.

For genetic parameters, **Table 7** reveals low broad-sense heritability (0.297), which can be attributed to the predominance of non-additive gene action. In contrast, narrow-sense heritability was moderate, at 0.591, reflecting partial dominance, where both parents contribute to the expression of this trait. Consequently, additive gene action plays an important role, indicating that selection is an effective approach for improving average fruit weight, similar to the findings of (11, 8) in cucumbers.

Fruit length (cm)

The statistical analysis in **Table 3** shows no significant differences between the parents in fruit length trait, with father 1 having the highest average at 14.33 cm (within acceptable consumption limits), and father 4 the lowest at 13.33 cm. The mothers varied in this parameter with the highest average lengths for 7×9 and 3×7, reaching 15.67 cm and 15.00 cm, respectively. The variations between the parents for fruit lengths were also reflected in the triple hybrids. For the mothers, the highest average fruit lengths were for the triple hybrids of 4(8×9) and 4(3×9), at 16.67 and 16.33 cm, respectively, while the lowest was for the 1(8×9), at 13.00 cm.

The results in **Table 4** showed the presence of positive and significant hybrid vigor for many triple hybrids, with the 4(8×9) and 4(5×6) giving percentages of 21.95 and 14.63%, while the lowest was for the 4(3×7) which reached -14.89%. The positive values for fruit length indicate that this trait is affected by the superior dominance of the genes from the best parents, while the negative value points to the partial dominance of the genes of the lowest parents, which may be responsible for the short fruit lengths.

Based on the results in **Table 5**, parents 2 and 4 exhibited positive GCA values of 0.252 and 0.141, respectively. With regard to the single hybrids used as female parents, the highest GCA values were for the single hybrids (3×9) and (5×8), both of which showed the same value (0.83). Positive GCA values of the lines indicate their good combining ability with other lines toward enhancing this trait, whereas negative values reflect their weak contribution and tendency toward reducing fruit length. The results in **Table 6** for the three-way hybrids, show the 1(5×7) exhibiting the highest positive and significant SCA value for fruit length, reaching 32.39.

According to the results presented in **Table 7** for the genetic parameters, broad-sense heritability was high (0.847), which can be attributed to the high genetic variance and the low environmental variance. In contrast, narrow-sense heritability was low (0.152), due to the low additive genetic variance. Moreover, the degree of dominance was greater than unity, indicating the presence of overdominance. These results are consistent with those noted by (7) in cucumbers.

Number of female flowers

Table 3 shows significant differences in the trait of the total number of female flowers in the plants, where father 1 had the highest average number of flowers, reaching 57.33 flowers/plant, followed by father 2 at 53.00, while the lowest average was for father 4 at 52.33. The mothers varied among themselves, with 3×6 having the highest average of 56.33 flowers/plant followed by 6×9 at 55.67, while 3×7 gave the lowest average of 35.67. As for the triple hybrids, the 4(3×6) and 2(5×6) gave the highest average for total number of female flowers, at 84.33 and 81.33 flowers/plant. Many triple hybrids outperformed the comparison hybrid which had 72.67 flowers/plant.

Table 4 shows the positive and significant hybrid vigor, with hybrids 4(3×5) and 2(5×6) having rates of 58.12 and 53.45%, respectively, while the lowest negative value was for the 1(8×9) which reached -16.27%. Positive values indicate that the trait falls under the dominant control of the genes of the best parents, while the negative value represents the partial dominance control of the genes of the lowest parents on this row.

For GCA, as shown in **Table 5**, parent 1 exhibited the highest value, reaching 0.556. GCA effects reveal that the highest values were recorded for the single hybrids (3×5) and (3×8), with values of 14.067 and 5.733, respectively. Regarding SCA of the triple hybrids, positive and significant effects were observed in several hybrids (**Table 6**), with the highest values found in the 2(5×6) and 1(6×9), which recorded 19.51 and 15.00, respectively.

On genetic parameters (**Table 7**), the variance of SCA was higher than that of GCA, indicating a greater contribution of dominance variance compared with additive genetic variance. The degree of dominance was greater than unity, which is considered an indicator of the contribution of overdominance in the inheritance of this trait. Broad-sense heritability reached 0.889, reflecting the substantial contribution of genetic rather than environmental effects in the expression of the trait. In contrast, narrow-sense heritability was moderate (0.25), suggesting that the trait can be improved through hybridization followed by selection as an effective breeding strategy. These findings match those of (20, 18) in cucumbers.

Total greenhouse yield (ton)

The results of the statistical analysis in **Table 3** show that father 2 had the highest value for total greenhouse yield, which amounted to 2.59 tons, while father 4 gave the lowest at 2.39 tons. The same table also shows differences between the mothers, with 6×9 giving the highest average rate, at 3.63 tons, marginally outperforming the comparison hybrid (Super Faris), which registered 3.60 tons, followed by 7×8 at 3.30 tons. The lowest average value was for 6×7, at 2.59 tons. The differences between mothers and fathers contributed to the emergence of differences between the triple hybrids, with the highest average rate for this trait recorded by 2(3×8) at 4.38 tons, followed by 2(5×6), which produced 4.36 tons, while the lowest rate was for 1(6×7), at 2.63 tons. Six of the triple hybrids outperformed the comparison hybrid mentioned above.

Regarding hybrid vigor, **Table 4** shows the positive and significant, and negative values for this trait, Altogether 19 triple hybrids showed positive and significant values for this trait, while the others gave negative values. The highest positive values were for the triple hybrids 2(5×6) and 2(3×8), which reached 60.213% and 54.155%, respectively, while the lowest value was for 4(6×9) at -25.681%.

Table 5 on GCA indicates that parent 2 exhibited the highest value, reaching 0.141. Regarding the estimation of GCA effects for single hybrids, the highest values were recorded for the single hybrids 3×8 and 3×5, with values of 0.464 and 0.429, respectively, whereas the lowest negative GCA value was observed for the single hybrid 5×8, which recorded -0.358. Positive and significant GCA values of single hybrids indicate their potential to combine favorably with other parents toward the inheritance of this trait, whereas negative values reflect the opposite trend. With respect to SCA, positive and significant effects were observed in 22 triple hybrids, with the highest values recorded for 2(5×6) and 1(6 × 9), at 1.067 and 0.861, respectively, as seen in **Table 6**.

Based on the results on genetic parameters in **Table 7**, broad-sense heritability was high (0.957), indicating the importance of additive gene action in the inheritance of this trait. In contrast, narrow-sense heritability was moderate (0.381), suggesting a substantial contribution of non-additive gene action. Moreover, the degree of dominance was greater than unity, indicating the

presence of overdominance in the inheritance of this trait. These results agree with previous findings by (2, 12) for cucumbers.

Yield of experimental unit

The results of the statistical analysis in **Table 3** shows that fathers 2 and 4 had the same yield values of 21.62 kg, while father 1 gave a similar result of 21.11 kg. The table also shows differences between the mothers, with 6×9 averaging 30.28 kg, slightly outperforming the comparison hybrid (Super Faris), which stood at 30.01 kg, followed by 7×8 at 27.49 kg. The lowest value was for the 6×7 mother which averaged 21.57 kg. The differences between the parents contributed to the variances between the triple hybrids, with the highest average yield from the 2(3×8), which averaged 36.54 kg, followed by the 2(5×6) at 36.30 kg, while the lowest value of 21.88 kg was for the 1(6×7). Six of the three hybrids outperformed the above mentioned comparison hybrid.

Hybrid vigor showed positive and significant, as well as negative values for this trait (**Table 4**). The highest positive values were recorded for the triple hybrids 2(5×6) and 2(3×8), at 70.666% and 61.250%, respectively, and the lowest for 4(6×9) at -10.262%.

The results in **Table 5** indicate that parent 2 exhibited the highest GCA effect, with a value of 1.174, followed by parent 1 at 0.308. Regarding the estimation of GCA effects for single-cross hybrids, the highest values were observed in hybrids 3×8 and 3×5, which recorded 3.869 and 3.576, respectively. The positive and significant GCA effects of these single-cross hybrids indicate their good combining potential with other parents toward the inheritance of this trait, whereas negative values reflect the opposite trend. For SCA, positive and significant effects were detected in 22 hybrids, with the highest values recorded for the triple hybrids 2(5×6) and 1(6×9), at 8.889 and 7.173, respectively (**Table 6**).

Based on the genetic parameters of yield per experimental unit presented in **Table 7**, broad-sense heritability was high at 95.782, indicating the major contribution of non-additive gene action to the inheritance of this trait. In contrast, narrow-sense heritability was moderate (0.381), reflecting the limited contribution of additive gene action. Moreover, the degree of dominance exceeded unity, indicating the presence of overdominance. Accordingly, hybridization rather than selection may be a more effective approach for improving this trait, and these findings are consistent with a previous study by (17) in cucumbers.

Table 8. Analysis of variance table

Sov	Error	Line x Testers	Tester	Line	Crosses	P. vs. C	Parent	Tret	Rep
	124	28	2	14	44	1	17	62	2
Plant height	29.356	389	71.919	480.074	403.998	12.712	409756.371	467.800	96.254
Internode length	0.274	1.010	1.975	1.826	1.313	2.697	424.153	1.495	0.679
Number of female flowers	31.24	219.74	12.867	293.076	233.676	1366.375	17507.221	205.605	39.783
Fruit length	0.682	3.507	5.341	3.665	3.641	15.471	1274.149	3.971	0.069
Fruit weight	4.432	5.813	5.988	8.089	6.545	0.160	49232.092	6.609	0.893
Experimental unit yield	310	1259	165	749	2174	25.79	62421	2528	0.364
Total greenhouse yield	0.036	0.648	1.189	0.771	0.712	0.371	52.875	0.587	0.003

Conclusion

Based on the above findings, it is recommended that the special hybrids be planted in different locations with their parents and imported hybrids to ensure the stability of their genetic status, especially hybrids 2 (6×5) and 2 (3×8). It would also be useful to explore the possibility of utilizing genetic resources by re-deriving other strains from the nine strains and conducting crosses in different directions, which may help in obtaining other distinctive

hybrids. Also, the strength of the hybrids should be used to improve crops, including cucumbers, as the crosses produced in subsequent generations can be used to benefit from them. Finally, the production of triple crosses may be important in increasing yield and other traits because it increases genetic mixing and obtaining distinct genetic combinations.

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انتاج وتقييم هجن ثلاثية من الخيار الخاص للزراعة بالبيوت المحمية

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الخلاصة

أجريت التجربة على مدى ثلاثة مواسم (خريف - ربيع - خريف) ابتداءً من 15/9/2023 وهو موعد بدء الموسم الأول (الخريفي) حيث زرعت بذور ستة سلالات من سلالات الخيار التسعة الداخلة في الدراسة حيث تم استبعاد ثلاثة سلالات (المتباعدة وراثياً) من أجل استخدامها في الموسم الثاني وقد تم إجراء تضييب نصف تبادلي بين هذه السلالات الستة حيث تم الحصول على خمسة عشر هجين فردي من هذه التضييبات، وبعدها تم البدء بالموسم الثاني (الربيعي) بتاريخ 15/2/2024 حيث زرعت بذور السلالات الثلاثة مع الخمسة عشر هجين فردي حيث أجري بينها تضييب (سلالة X فاحص) بأختيار السلالات الثلاثة كأباء والهجن الفردية الخمسة عشر كأمهات وتم الحصول على 45 هجين ثلاثي، وفي الموسم الثالث (الخريفي) الذي تم إجرائه بتاريخ 15/9/2024 حيث تم زراعة بذور السلالات الثلاثة (المتباعدة وراثياً) والخمسة عشر هجين فردي والخمسة وأربعون هجين ثلاثي بالإضافة إلى هجين المقارنة (سوبر فارس) إذ بلغ عدد الوحدات التجريبية 64 وحدة تجريبية في المكرر الواحد وأجريت التجربة وفق تصميم القطاعات الكاملة العشوائية (RCBD) بثلاثة مكررات، ووزعت عشوائياً داخل بيتين بلاستيكيين غير مدفأين وأظهرت نتائج التحليل الإحصائي للصفات المدروسة وجود تباين وراثي واضح بين الآباء والأمهات انعكس على صفات النمو والإنتاجية. فقد تميز الأب 2 في صفة ارتفاع النبات (250.33 سم) وإنتاجية البيت البلاستيكي (2.59 طن)، بينما برز الأب 1 في عدد الأزهار المؤنثة (57.33 زهرة/نبات). أما من بين الأمهات، فقد تفوقت الأم (9×6) في معظم الصفات الإنتاجية إذ سجلت أعلى معدل لارتفاع النبات (285.00 سم) وإنتاجية البيت البلاستيكي (3.63 طن) وإنتاجية الوحدة التجريبية (30.28 كغم). كما تميزت الأم (5×3) بارتفاع النبات (284.67 سم) وطول السلاميات (9.62 سم انعكست هذه الفروقات على أداء الهجن الثلاثية، حيث تفوق الهجين الفردي (5×3) بارتفاع نبات بلغ 288.67 سم متقدماً على هجين المقارنة (سوبر فارس) وفي صفات النمو والإنتاجية كان الهجينين الثلاثيين 2(8×3) و2(5×6) الأفضل بينها، إذ سجلا أعلى إنتاجية للبيت البلاستيكي (4.38 و 4.36 طن على التوالي) وأعلى إنتاجية للوحدة التجريبية (36.54 و 36.30 كغم)، مع نسب قوة هجين موجبة وعالية تجاوزت 60%. كما أظهرت بعض الهجن الثلاثية الأخرى مثل 1(6×3) و4(9×8) تفوقاً في صفات وزن وطول الثمرة، بينت نتائج قابلية الائتلاف العامة للإباء أن الأب 2 ذو الرمز (C-H-) أعطى أعلى قابلية للائتلاف مقارنة ببقية الآباء الأخرى في حين كانت أعلى قابلية للائتلاف العامة للأمهات (الهجن الفردية) لكل من 5(3X5) و 8(3X8) حيث تكررت أحدها أو كلاهما في عدة صفات منها ارتفاع النبات، عدد الأزهار الانثوية الكلية، وحاصل البيت البلاستيكي وأعطيا قيم بلغت 21.741 و 5.741 و 14.067 و 5.733 و 0.429 و 0.464، فيما يخص قابلية الائتلاف الخاصة فقد أشارت البيانات أن الهجينين الثلاثيين 2(5×6) و 8(3×8) قد على بقية الهجن في العديد من الصفات منها ارتفاع النبات، عدد العقد، عدد الأزهار الانثوية في العقدة، عدد الثمار وحاصل البيت البلاستيكي حيث أعطيا قيم بلغت 24.504 و 23.170 و 5.800 و 7.133 و 53.459 و 40.625 و 9.778 و 8.000 و 1.067 و 0.819 بالتتابع، فيما بخصوص المعالم الوراثية فقد كانت معدل درجة السيادة أكثر من واحد لكل الصفات المدروسة وارتفاع نسبة التوريث بالمعنى الواسع لمعظم الصفات المدروسة وكان الفعل غير المضيف للجين أكثر تأثير من الفعل المضيف لأغلب صفات التجربة مما يشير إلى أن التهجين هو الطريقة المناسبة لتحسين خصائص الصفات فيما يمكن تحسين خصائص صفات أخرى بالتهجين متبوعاً بانتخاب للأستفادة من الانعزالات فائقة الحدود

الكلمات المفتاحية: هجن ثلاثية، تربية النباتات، خيار، سلالة x فاحص، هجن