

Relationship between Selfing Generations and Hybrid Vigor in Maize (*Zea mays* L.)

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ABSTRACT

Self-pollination even for a few generations can result in a considerable alteration in the genetic recital of plant population. In general, hybrid vigor tends to be more positive with higher values along with selfing generations. At the same time, there was a clear effect of self-pollination in the performance deterioration of the most parents, which contributed to the emergence of F_1 progeny with a relatively high hybrid vigor. Thus, breeders should pay attention to the propagation method of the inbred lines, because continues practicing of selfing may result in a significant depression in the performance of such lines.

INTRODUCTION

It may not come as a surprise when we say maize (*Zea mays* L.) represents an important crop in terms both, use and trade. This irrefutable fact is based on the crop represents one of the key tools in food security strategies to diminish the gap between global production and consumption of food. Moreover, maize importance has increased due to the great variety of its uses. The crop is supplying raw materials for many industries such as plastic, anti-freezing and as bioreactors in producing bio-pharmaceuticals and as biofuel (Ganapathy, 2016; Hubbs, 2017).

Inbreeding leads to sharp decline in the fitness of most naturally outbreeding species. Although, it has been a long time since the first observation of this harmful aspect however, the molecular mechanism behind it is not clearly understood (Paige, 2010). Plant performance is affecting by the high frequency of allele homozygosity, consequently, plant productivity and vigor will decrease due to inbreeding depression (Mulalem and Abate, 2016).

Inbreeding which means the mating between closed related individuals who have identical genetic architecture and descended from a common ancestor, will cause a sharp decline in the general fitness due to decreasing of useful heterozygosity at specific loci and accumulation of recessive deleterious alleles (Pemberton *et al.*, 2017). The phenomenon which is contradicting the phenomenon of heterosis became a corner stone in the breeding programs of cross-pollinated species (Paige, 2010). To develop hybrids and synthetics maize, creating of parental inbred lines is fundamental. Therefore, genetic diversity and high level of homozygosity are the two main pillars for developing new maize hybrids (Pabendon *et al.*, 2008).

Conventionally, inbreeding depression is one of the early studied biological phenomena in an extensive way. Unfortunately, it has not received the same attention at the molecular level, hence still poorly understood (Kardos *et al.*, 2016). Perfect parental inbred pairs which expected to expose higher hybrid vigor is not necessary to be with the maximum level of genetic distance, nevertheless, it may be derived from parental inbred pairs with a low value of genetic distance, hence this could be easily detected among individuals belong to the same population (Pabendon *et al.*, 2010). In many occasions, genetic purity and the level of homozygosity of an inbred line could be detected through the uniformity of its phenotypic traits (Kawamura *et al.*, 2016). However, selection of genetic diversity and homozygosity level based on yield and other morphological traits will be less accurate. Therefore, the more precise evaluation could be obtained via molecular markers in general and epigenetic markers in particular (Sorkheh *et al.*, 2017).

Accordingly, this study have been projected to investigate the potential role of selfing in the depression of maize inbreds performance and its relationship with the hybrid vigor of the first filial generation in half diallel of maize.

MATERIALS AND METHODS

Spring Season 2016

The seeds of twenty maize inbred lines with their self-pollinated matches were planted in 15th of March 2016 at the Field Trails Station in the Department of Field Crop Science / College of Agriculture / University of Anbar in the alternative site (Abo Ghraib- Baghdad, Iraq) for two growing seasons, spring and fall of 2016. All the necessary processes for land preparation were established. Holes were overplanted then thinned to one seedling per hole. The field was kept free of weeds with aid of Atrazine herbicide (4.5 l ha⁻¹). Corn borer (*Sesamia cretica*) was controlled in both seasons at seedling stage of 6 leaves by using liquid diazenon (1.4 ml l⁻¹). Before silk protrudes, emerged ears were covered by paper bags, to ensure guided pollination. As tassels started shedding pollens, they were covered with bigger paper bags. In the early morning of the next day, the pollens were collected to do the necessary half diallel crosses within both, base and self-pollinated populations. All inbred populations were propagated by sibbing. Crossed ears were re-covered till its maturity, then they were harvested and left to dry then detached individually. The best five inbred lines were selected the end of the growing season.

Fall Season 2016

Comparison trial was conducted in this season, where, the thirty genotypes (5 original and their matches and their both single crosses) were planted in 29th July in ridges (0.25 x 0.75m), four ridges for each genotype with 4 m long.

Holes were overplanted and thinned later to one seedling per hole. Treatments were distributed randomly according to randomized complete block design (RCBD) with three replications. Land preparation and crop management were performed as previously stated in the previous growing season. Ten plants from each genotype were chosen randomly, to record the data for the necessary traits of each genotype. The phenotypic traits, anthesis date (day), silking date (day), plant height (cm), ear height (cm), leaves number, ear leaf area, tassel length (cm) and tassel branches number have been studied.

Data were analysed using Genstat Softwar, and hybrid vigor for each cross was estimated as the percentage of F_1 over the best parent.

$$\text{Heterobeltiosis (H\%)} = \frac{(F_1 - BP)}{BP} \times 100.$$

Where:

F_1 = the mean performance of the hybrid
BP = the mean performance of best parent.

RESULTS AND DISCUSSION

Anthesis days (day)

The analysis of variance revealed significant differences within both populations (original and self-pollinated) for anthesis trait. The earlier inbred from the original population (Table 1) was line 1 as it spent 53.67 days to anthesis. By contrast, 57 days was hardly enough for line 5 to anthesis, so it was the latest. However, this duration was not enough for the same inbred lines to shed their pollens after two rounds of selfing (Table 2), where, the latest inbred (line 3) required 59.33 day. Although, inbred 1 maintained its early flowering, it was slightly retreated compared with its ancestor (original inbred 1) as it spent 56.33 days. In essence, these results assured the negative effect of self-pollination in the earliness of anthesis which may be attributed to inbreeding depression.

The original inbreds have successfully passed down the variation in the anthesis time to their hybrids as the latest differed significantly too (Table 1). Quite remarkably, the original hybrids 1x2 and 1x3 gave the lowest mean for this trait (51.67 day), whereas the highest which was 56.67 day was showed by the hybrid 4x5. Seven out of the ten generated original hybrids exposed significant negative hybrid vigor against their earliest parent with the maximum percentage of -4.85% for 2x4 (Table 1). These negative values reflected the over dominance type of gene action of the earliest parent expressed in such crosses.

The grand mean of self-pollinated hybrids (Table 2) which was 52.93 day in contrary with the grand mean of their parents (57.93 day) showed the improved performance regarding anthesis time after two generations of selfing. However, the superiority of F1 hybrids over their best parent was additional evidence for the self-pollination effect. It can be observed that 1x5 and 2x5 hybrids were the earliest with 51.33 day until anthesis (Table 2). While the latest was the hybrid 4x5, even so, it required a shorter duration (55 days) than its original inbred.

Table 1. Means of anthesis (day) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	53.67	51.67	51.67	53.00	54.00
2	-3.73	55.00	53.67	52.33	53.00
3	-3.73	-2.42	56.67	55.33	56.33
4	-1.25	-4.85	-2.36	56.67	56.67
5	0.61	-3.64	-0.59	-0.01	57.00
Grand Mean of Parents	55.80	Grand Mean of Hybrids			53.77
LSD 5%	1.40	SE	0.88		

Table 2. Means of anthesis (day) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	56.33	54.33	52.67	52.33	51.33
2	-3.54	57.33	52.67	54.00	51.33
3	-6.50	-8.13	59.33	54.00	51.67
4	-7.10	-5.81	-7.42	58.33	55.00
5	-8.87	-10.46	-11.42	-5.71	58.33
Grand Mean of Parents	57.93	Grand Mean of Hybrids			52.93
LSD 5%	2.17	SE	0.87		

The inheritance of anthesis time strictly regulated by over dominance genes of the early parent after two generations of selfing (Table 2) since all the self-

pollinated hybrids marked with negative hybrid vigor and 3x5 hybrid was in the forefront (-11.42%). The significance of positive and negative hybrid vigor has been identified in previous studies (Al-Falahy, 2015 and Abdul-Hamed *et al.* 2017) that have agreed to some extent with what was reached in the present study.

Silking days (day)

The results of statistical analysis pointed to significant differences within the original and the self-pollinated genotypes (inbred lines and their half diallels) for silking time.

The first original inbred line (1) was the earliest parental line scoring 54 days till silking (Table 3). On the other side, inbreds 4 and 5 were the latest with 59.67 day to silking. Most of the inbred lines showed a rate of inbreeding depression (Table 4), however, line 1 showed high genetic conservative attitude after two generations of selfing and still ranks first (56.67 days). Inbred 3 acts in a different way as it silks took longer to stick out (61.67 days).

These variations were transmitted at a different rate to the F₁ hybrids in both, original and self-pollinated populations. The grand mean of original hybrids (Table 3) which was less than their parents (55.67 and 57.87 days, respectively) indicated the earliness of these hybrids for silking. The minimum days (53 days) was sufficient for both 1x2 and 1x3 original hybrids to silk, while 4x5 hybrid was not to silk in a period less than 60 days. The results showed significant hybrid vigor values for silking time (Table 3). The genes expressed overdominance effect of the best parent in six original hybrids exposed negative hybrid vigor percentages reached -2.95 % for 2x4 and 2x5 hybrids. The hybrid 1x4 was unique in showing a complete dominance of its earliest parent genes (inbred 1) with zero hybrid vigor.

Table 3. Means of silking (day) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	54.00	53.00	53.00	54.00	54.33
2	-1.85	56.67	55.67	55.00	55.00
3	-1.85	-1.77	59.33	57.67	59.00
4	0.00	-2.95	-2.80	59.67	60.00
5	0.62	-2.95	-0.56	0.56	59.67
Grand Mean of Parents	57.87	Grand Mean of Hybrids			55.67
LSD 5%	2.21	SE	1.17		

Table 4. Means of silking (day) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	56.67	55.33	54.33	54.00	52.67
2	-2.36	59.67	55.67	57.33	54.00
3	-4.12	-6.71	61.67	56.33	54.00
4	-4.71	-3.92	-7.15	60.67	56.67
5	-7.06	-9.50	-11.48	-6.59	61.00
Grand Mean of Parents	59.93	Grand Mean of Hybrids			55.03
LSD 5%	2.37	SE	0.84		

The variations among self-pollinated inbred lines reflected on their crosses (Table 4). Generally, the hybrids have a tendency to silk early based on their grand mean which (55.03 days) compared with their parents (59.93 days). The earliest self-pollinated hybrid (1x5) spent 52.67 days to silk, while the hybrid 2x4 required 57.33 days. The inheritance of this trait in all self-pollinated hybrids was tightly under the overdominance genes of their earliest parent due to the

negative hybrid vigor revealed by such crosses. The maximum value was -11.48% for hybrid 3x5, while the minimum value was -2.36 % for hybrid 1x2, Abdul-Hamed *et al.* (2017) and Adebayo *et al.*, 2017 stated similar findings.

Plant height (cm)

According to the analysis of variance, all studied genotypes (original and self-pollinated) have differed significantly in plant height. The trait means (Table 5) ranged between 144.23 cm and 166.02 cm for original inbred 5 and 2, respectively.

Selfing has a major effect on maize population as plant height has a sharp decline in the self-pollinated population with a range of 146.95 cm for inbred 4 to 117.26 cm for inbred 1 (Table 6). The grand mean of self-pollinated population (130.71 cm) approved a sort of dwarfness exposed by these inbreds compared with the same mean in their ancestors, the original inbreds (150.55 cm). Compared with their parental inbreds, the original diallel hybrids showed a wider range of plant height (145.20 cm to 175.67 cm for hybrids 4x5 and 1x4, respectively), (Table 5).

Half of the original hybrids revealed positive hybrid vigor (Table 5), and 3x4 hybrid achieved its highest percentage (18.18 %). The other half diallels showed a negative percentage, but only two of these were significant and 1x2 hybrid gained the lowest (-5.74 %). The positive and the negative hybrid vigor pointed to over and partial dominance role of highest parent genes, respectively in controlling trait inheritance.

By the same token, the self-pollinated hybrids showed obvious superiority against their best parent (Table 6). In the view of significant positive hybrid vigor showed by the majority of diallel hybrids, the trait was completely controlled by the genes with overdominance effect, and the diallel hybrid 1x3 scored the maximum value of such effect (35.24 %). These results agreed with those documented by Ali *et al.* (2017).

Table 5. Means of plant height (cm) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	149.95	156.48	166.55	175.67	168.88
2	-5.74	166.02	163.68	162.30	158.07
3	11.07	-1.41	145.32	174.02	166.00
4	17.15	-2.24	18.18	147.25	145.20
5	12.63	-4.79	14.23	-1.39	144.23
Grand Mean of Parents	150.55	Grand Mean of Hybrids 163.69			
LSD 5%	14.54	SE	3.06		

Table 6. Means of plant height (cm) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	117.26	171.20	178.03	173.03	149.77
2	29.08	132.63	161.20	177.83	156.18
3	35.24	21.54	131.65	157.05	161.50
4	17.75	21.02	6.87	146.95	149.62
5	19.75	17.76	22.68	1.81	125.07
Grand Mean of Parents	130.71	Grand Mean of Hybrids 163.54			
LSD 5%	22.66	SE	3.04		

Ear height (cm)

Significant variations have been detected within both studied populations for ear height trait. As expected, the performance of some genotypes (inbred 2,

4 and the hybrid 1x4) in this trait was highly affected by plant height trait due to the positive correlation between plant and ear height. Among original inbreds (Table 7), line 2 was holding the highest ear height (79.08 cm), while the lowest ear height (62.17 cm) was attained by line 3, even after two selfing generations (Table 8), but this time hardly reached 48.89 cm.

Of course, the highest value of ear height in self-pollinated population (68.83 cm) that acquired by line 4 was less than the highest value of the original population, in a clear reference to the role of inbreeding depression.

This assumption was supported by the grand mean which reached 72.06 cm in the original population, whereas it declined sharply to reach 57.60 cm in self-pollinated population. Like their ancestors, the original hybrids have a considerable portion of variations. The trait means of these hybrids were ranged from 70.78 cm for hybrid 2x4 to 92.72 cm for hybrid 1x4.

The results showed significant hybrid vigor (Table 7) ranged between positive and negative values for ear height trait. However, the inheritance of the trait in five original hybrids was under the effect of over dominance of genes. As, 1x4 being one of the previously mentioned hybrids, it shows the largest magnitude of positive vigor (22.83%). The negative hybrid vigor was the minimal level of -10.50 % for hybrid 2x4, indicating the partial dominance of its best parental genes.

In turn, self-pollinated hybrids clearly varied after two generations of selfing scoring a grand mean of 81.21, which was larger than its original match (79.43), (Table 8), hence their maximum and minimum limits were at a wider range (68.12 cm to 93.10 cm for 4x5 and 1x4 hybrids, respectively). In view of significant positive hybrid vigor (Table 8), which was revealed by almost self-pollinated hybrids (nine hybrids), the inheritance of ear height was guided by overdominance effect of highest parent genes. The hybrid 1x3 achieved its maximum percentage (60.87 %).

Table 7. Means of ear height (cm) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	75.48	71.23	84.20	92.72	90.97
2	-9.93	79.08	80.13	70.78	72.93
3	11.55	1.33	62.17	83.06	75.82
4	22.83	-10.50	15.92	71.66	72.50
5	20.51	-7.78	5.40	0.79	71.93
Grand Mean of Parents	72.06	Grand Mean of Hybrids 79.43			
LSD 5%	9.69	SE	3.91		

Table 8. Means of ear height (cm) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	55.33	87.45	89.02	93.10	77.00
2	47.74	59.19	84.75	88.45	70.02
3	60.87	43.17	48.89	71.23	82.93
4	35.25	28.50	3.49	68.83	68.12
5	38.16	18.28	48.80	-1.04	55.73
Grand Mean of Parents	57.60	Grand Mean of Hybrids 81.21			
LSD 5%	15.23	SE	6.36		

Finally, it can be noted that self-pollination has increased ear height of hybrids in disagreement with their parents. These outputs were partially agreed with

previous results (Matin *et al.*, 2017) in view of significant differences and hybrid vigor at both directions in the original hybrids, whereas the self-pollinated hybrids had completely positive values for hybrid vigor.

Ear leaf area (cm²)

Via analysis of variance no statistical differences have been detected within original genotypes (Table 9), even so, it was not obstacle against the inheriting of the desirable trait for the superior inbred 2 to its offspring over the subsequent generations. After two rounds of selfing, parental lines have a propensity to increase the range of difference in the trait means (Table 10) to exceed the significance threshold (451.54 cm² to 363.38 cm² for inbreds 5 and 3, respectively). This is not inconsistent with the fact that the self-pollinated parents bring to the light modest performance, which in turn praised the negative response of inbreds to self-pollination in leaf area. These variations did not restrict on inbreds, but it also included their single hybrids. Thus, self-pollinated inbreds inherited their variations in leaf area to their hybrids (Table 10), and the grand mean of diallel hybrids (483.36 cm²) which was larger than of their parents (408.50 cm²) indicated the superiority of F₁ hybrids over their best parents, The trait means in hybrids ranged between 408.24 cm² and 592.26 cm² for 1x3 and 1x2 hybrids, respectively. The maximum and the minimum values of hybrids point to that some hybrids responded positively to self-pollination in disagreement with the others. Overdominant genes was controlling the trait in all of the self-pollinated hybrids exposed positive hybrid vigor, which its top reached 39.32% for hybrid 1x2 (Table 10), whereas, 2x5 hybrid showed partial dominant genes of its earliest parent when it showed the minimum significant negative hybrid vigor (-5.64 %). Basically, Al-Falahy (2015) stated similar findings but with higher values.

Table 9. Means of ear leaf area (cm²) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	437.73	519.07	530.95	549.18	529.44
2		522.15	552.35	493.75	498.39
3			407.67	505.56	484.53
4				454.94	522.20
5					456.61
Grand Mean of Parents	455.82	Grand Mean of Hybrids			518.54
LSD 5%	ns				

Table 10. Means of ear leaf area (cm²) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	397.80	592.26	408.24	507.49	483.83
2	39.32	425.12	497.30	466.43	426.08
3	2.62	16.98	363.38	520.26	496.60
4	25.41	9.72	28.56	404.68	435.15
5	7.15	-5.64	9.98	-3.63	451.54
Grand Mean of Parents	408.50	Grand Mean of Hybrids			483.36
LSD 5%	61.25	SE			4.58

Leaves number per plant :

Based on the analysis of variance results, differences were beyond the significance level among genotypes within both, original and self-pollinated populations. Line 2 from the original population gained the maximum leaves number (14.77), while the

minimum (12.20) was the share of line 3 (Table 11). After two generations, the inbred 2 still sustaining the highest leaves number (12.46), while the inbred 1 was acquired the lowest mean (11.06). The grand means of original (13.52) and self-pollinated populations (11.95). This progressed performance assured the negative effect of inbreeding on the inbreds performance into desirable direct which was known as inbreeding depression.

The original hybrids simulated their parents with the significant range of leaves number (13.3 to 15.1 for 2x5 and 1x4 hybrids, respectively), (Table 11). The two generations of selfing didn't affect the general order of the hybrids when the hybrid 1x4 still in the lead of the hybrids for leaf number with a slight increment (0.1) compared with its original counterpart (Table 12). This is somewhat similar to the case of 2x5 hybrid, but on the opposite direction as it achieved the minimal leaves number (12.67).

The original hybrids directed into significant hybrid vigor for this trait ranged between positive and negative values (Table 11). According to the positive hybrid vigor revealed by half of the original hybrids, the transmission of this trait was under the effect of overdominant genes of the best parent. The hybrid 3x5 showed the maximum effect with 11.87% hybrid vigor. This type of gene action has entirely controlled the inheritance of leaf number after two generations of selfing (Table 12), as all of the self-pollinated hybrids showed positive hybrid vigor and 1x4 hybrid was in the lead by exposing the highest percentage (23.24%). The other half of original hybrids exposed negative hybrid vigor and the 2x5 hybrid gained the minimum value (-11.06%). These results were accordance with the recent findings stated by Abdul-Hamed *et al.* (2017) and Li *et al.* (2017).

Table 11. Means of leaves number (leaves plant⁻¹) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	14.23	13.30	13.87	15.10	15.00
2	-9.93	14.77	14.00	13.77	13.13
3	-2.58	-5.19	12.20	14.30	14.13
4	6.09	-6.77	3.67	13.79	14.47
5	5.39	-11.06	11.87	4.91	12.63
Grand Mean of Parents	13.52	Grand Mean of Hybrids			14.11
LSD 5%	0.72	SE			2.46

Table 12. Means of leaves number (leaves plant⁻¹) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	11.06	14.10	14.03	15.20	14.07
2	13.16	12.46	13.60	14.63	12.67
3	20.94	9.15	11.60	12.90	13.47
4	23.24	17.44	4.59	12.33	13.53
5	14.36	1.66	9.49	9.73	12.30
Grand Mean of Parents	11.95	Grand Mean of Hybrids			13.82
LSD 5%	0.65	SE			2.17

Tassel length (cm)

Inbred lines have different ability to produce viable pollens adequate for full seed set formation, which in turn will affect their role as possible pollinators. Hence, tassel length can be a determining factor in the real evaluation of any inbred. The analysis of variance revealed significant differences among genotypes within both populations for tassel length.

Among the original inbreds, inbred 2 showed the tallest tassel with the length of 37.83 cm, while the shortest tassel (30.58 cm) was gained by inbred 1 (Table 13).

Inbreeding depression has shortened the tassels in the parental lines after two generations of selfing. The tassel length in the self-pollinated inbreds (Table 14) was ranged from 35.71 cm for line 3 to 28.27 cm for line 5. This reduction in the tassels length could be easily distinguished via the total means for original (33.57 cm) and self-pollinated lines (32.01 cm).

Although the superiority of original lines over their self-pollinated counter parts, however, they were inferior in comparison with their offspring which revealed total mean of 36.28 cm.

From the original hybrids, 4x5 gained the highest mean for the trait (40.20 cm) in opposite to hybrid 1x4 that revealed the lowest mean (32.98 cm). The trait means retreated at the next generations (Table 14) as the tallest tassel record only 37.93 cm for hybrid 2x5, while the shortest was 32.28 cm for hybrid 1x2. At this point, the practicing of self-pollination has decreased the tassel length in the F₁ hybrids. This assumption was supported by the grand mean of the trait for the original hybrids (36.28 cm) compared with the self-pollinated hybrids (35.47 cm).

The original hybrids revealed significant hybrid vigor (Table 13) ranged between positive and negative estimates (3:2). The highest positive percentage showed by the hybrid 4x5 (25.17%), indicated the overdominance of his best parent genes (inbred 5) in the controlling of the trait inheritance. Whereas, partial dominant genes were the key players in the inheritance of the trait in the other hybrids due to their exposing to the negative hybrid vigor, which its lowest percentage reached -3.59% for hybrid 3x4.

The number of hybrids which showed significant overdominance effect of best parental genes increased to five hybrids at the next selfed generations (Table 14). At the same time, the maximal range of positive and negative hybrid vigor (19.96 % for 4x5 and -7.48 % for 1x2) pointed to a clear depression in the performance of the self-pollinated hybrids in context of tassel length, which may attributed to the distinguishable alteration in the genetic and epigenetic performance.

Table 13. Means of tassel length (cm) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	30.58	36.83	35.72	32.98	33.90
2	-2.64	37.83	38.23	36.82	36.50
3	-1.24	1.06	36.17	34.87	36.75
4	5.82	-2.69	-3.59	31.17	40.20
5	5.55	-3.52	1.61	25.17	32.12
Grand Mean of Parents	33.57	Grand Mean of Hybrids			36.28
LSD 5%	2.10	SE	2.74		

Table 14. Means of tassel length (cm) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	31.35	32.28	34.52	33.48	36.95
2	-7.48	34.89	36.73	33.90	37.93
3	-3.35	2.85	35.71	37.10	36.00
4	6.80	-2.85	3.88	29.82	35.77
5	17.86	8.71	0.80	19.96	28.27
Grand Mean of Parents	32.01	Grand Mean of Hybrids			35.47
LSD 5%	2.47	SE	2.82		

Tassel branches number (branches tassel⁻¹)

Significant deviation has been detected in the performance of both, original and self-pollinated populations. Inbreds still showed a marked decline in the grand performance in response to selfing process. That what the grand mean indicated as it reached 14.81 for original population against 11.53 for self-pollinated one. From original parents (Table 15), inbred 1 has a tassel with 17.87 branches, while inbred 5 has only 12.47 branches in its tassel. Some of the inbreds responded negatively to the self-pollination in disagreement with the others (Table 16). Inbred 1 was greatly retreated to give only 8.2 branches, while inbred 5 which had the largest leaf area gave 15.2 branches to become in the lead of inbreds. The inbreds transmitted the genetic variation to their diallel hybrids in a different norm. The original hybrid 1x4 gave the highest mean (19.8) of the trait (Table 15), while the hybrid 2x5 gave the lowest (12.27).

The grand mean of the original hybrids (16.35) proved the superiority of F₁ hybrids over their original parents for this trait, but it was slightly inferior compared with its descended self-pollinated hybrids (16.48). After all, the self-pollinated hybrids exposed wider range between 13.07 and 22.57 for 4x5 and 2x3 hybrids, respectively (Table 16).

The overdominant genes indicated their control in the inheritance of this trait in the original hybrids based on the positive hybrid vigor, which reached the maximum percentage (28.99%) in the hybrid 4x5. On the other side, the negative hybrid vigor assured the partial dominance of gene effect and its highest percentage was -29.50% in hybrid 2x5. After two generations of selfing (Table 16), the range has widened considerably to be 92.33% in its highest positive limit for hybrid 2x3. For sure, hybrids number which revealed negative hybrid vigor has been dropped to only two self-pollinated hybrids. The hybrid 4x5 revealed the highest partial dominance effect of his best parent genes (-14.04%).

Table 15. Means of tassel branches number (branches tassel⁻¹) for original inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values), in maize.

Parents	1	2	3	4	5
1	17.87	17.60	17.13	19.80	18.80
2	-1.49	17.40	14.87	16.47	12.27
3	-4.10	-14.56	12.53	13.87	14.93
4	10.82	-5.36	0.48	13.80	17.80
5	5.22	-29.50	19.15	28.99	12.47
Grand Mean of Parents	14.81	Grand Mean of Hybrids			16.35
LSD 5%	3.33	SE	5.24		

Table 16. Means of tassel branches number (branches tassel⁻¹) for self-pollinated inbred lines (diagonal values) and their half diallel hybrids (above diagonal values), and hybrid vigor (below diagonal values) in maize.

Parents	1	2	3	4	5
1	8.20	17.87	14.13	17.13	15.40
2	52.27	11.73	22.57	16.87	14.00
3	42.28	92.33	9.93	16.27	17.47
4	35.98	33.86	29.10	12.60	13.07
5	1.32	-7.89	14.91	-14.04	15.20
Grand Mean of Parents	11.53	Grand Mean of Hybrids			16.48
LSD 5%	3.00	SE	9.98		

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العلاقة بين جيل التلقيح الذاتي وقوة الهجين في الذرة الصفراء (*Zea mays* L.)

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يمكن أن يؤدي التلقيح الذاتي ولو لعدة أجيال إلى تغيير كبير في التوصيف الوراثي للمجتمع النباتي. عموماً، اتجهت قوة الهجين لتكون أكثر إيجابية وقيم أعلى مع التقدم في أجيال التلقيح الذاتي. وفي ذات الوقت، كان هناك تأثير واضح للتلقيح الذاتي في تدهور أداء معظم الأباء، مما ساهم في ظهور جيل أول F1 بقوة هجين عالية نسبياً. وبالتالي، ينبغي أن يولي مربي النباتات اهتماماً بطريقة تكاثر السلالات النقية، لأن الاستمرار في ممارسة التلقيح الذاتي قد يؤدي إلى انحدار وتدهور كبير في أداء هذه السلالات.