



Genetic analysis of flowering times and physiological maturity traits by analyzing the generation mean analysis of four maize hybrids and calculating the hybrid vigor and the of hetrosis percentage (field traits)

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Received: November 11th 2023; Accepted: December 14th 2023; Published: December 30th 2023

Abstract

With the aim of determining the optimal way to develop yield characteristics by adopting statistical and genetic design as an electoral indicator to improve yield characteristics in new generations. A field experiment was carried out at the Field Crops Research Station, College of Agricultural Engineering Sciences - University of Baghdad - Al-Jadriyah to estimate the averages of the six generations, the hybrid vigor, and the hetrosis percentage that control the inheritance of the field traits of the selected inbred lines and their resulting hybrids using Generation Mean Analysis. Five were selected Pure inbred lines of maize (ZA17WR), Zi17WZ, ZM74, ZM19, ZM49W3E), from fifteen different strains with flowering and maturity times. In the spring season of 2019, it was multiplied according to the objective (early In the spring season (2020) to produce the six generations: P1, P2, F1, F2, BC1, and... The six generations (BC2), P1, P2, F1, F2, BC1, and (BC) of the four hybrids were evaluated in comparative experiments using a randomized complete block design (RCBD) with three replications. In the fall season of 2020, statistical analysis was carried out on the hybrid vigor, and the hetrosis percentage of hybrids was calculated for the characteristics of tasselling and Silking, plant height, comb height, number of leaves, and leaf area index. The results of the analysis showed that the fourth hybrid gave the first generation the lowest number of days of tasselling, amounting to 47.33 days, and the second backcrossed parent was 53.33 days later than the two parents. The same applies to the silking characteristic, as the average number of days for the first generation was 50.66 days, and for the second regressive father, 57.66 days. Negative hybrid vigor and a negative hybrid ratio indicate the presence of superior or partial dominance of the genes of the earlier father. The third hybrid excelled by giving it the highest plant height of 181.15 cm and a positive hybrid and hybrid strength of 10.71. While the second hybrid excelled in the upper plant height, reaching 108.34 cm, the second regressive parent 97.99 cm, with negative and positive hybrid vigor, and a hetrosis rate of 13%. The second hybrid also excelled in the number of leaves and leaf area index over the rest of the hybrids by 15.45 leaves (3.025 leaves, respectively). We conclude from the above that the superior or molecular dominance of the genetic action is the result of the superiority of the individuals of the first generation over the parents and their average in field traits. Therefore, we recommend using the method of reciprocal recurrent selection (RRS).

Keywords: Genetic analysis, Flowering times, Physiological maturity, Maize, Hetrosis.

*Research is part of PhD dissertation for first author

Introduction

The presence of genetic and morphological variation in the field traits of the maize crop is important in determining the optimal way to develop the yield trait by adopting statistical and genetic design as a selection indicator for improving yield in new generations. The genetic design determines the distance between the selected genotypes and

reflects the relative contribution of the specific traits toward the overall diversity (Hefny, 2010). (Comstock and Robinson, 1952) demonstrated methods for obtaining the components of genetic variance (dominance and additive variance) and the average degree of dominance for any number of loci, assuming that there is no overlap between these loci, and called it mating systems (Mating Design).

Estimating the effects of genetic action and genetic influences, the other helps the plant breeder choose the most appropriate breeding method to improve the trait of the crop under study (Gamble, 1962). The backcross method is one of the important techniques in creating hybrids that tested for selection of those superior in their characteristics suitable for environmental conditions through the information obtained about genetic variations and the effects of the general and specific union abilities of the parents and the hybrids. The process of hybrid development and new synthetic varieties of maize crops requires the Availability of sufficient information about the genotypes of the parental lines involved in the hybridization process. This is done by different mating designs, including backcrossing in transferring traits from the donor father to the recipient mother, Recurrent, to obtain promising genotypes in terms of flowering and grain yield (Schweitzer et al., 2002). The backcrossing method is one of the most important techniques in creating hybrids, that are tested to select those that excel in their characteristics appropriate to environmental conditions, through the information obtained about understanding the nature of genetic actions and identifying their interactions in transferring and inheriting the characteristics of maturity and flowering to different inbred lines with flowering and physiological maturity times and their resulting hybrids. Where individuals of the first generation (F1) are crossed with one of the parents (the first father, P1), not producing a father, it is called (BC1), and the procedure for crossing individuals of the first generation, F1, with the second father (P2), not producing a father, is called (BC2). Performing the backcrossing process for several generations until the target gene for the desired quantitative trait is stabilized in future generations (Schweitzer et al., 2002). The flowering and physiological maturity stages are characteristics compared with factors that influence the increase in yield and its components, as the two characteristics are complex quantitative characteristics that are controlled by a group of pairs of genes and are affected by the surrounding environmental factors during the growing season, as well as significant environmental genetic interference, leading to the emergence of new beneficial genetic mutations. By reducing the action of harmful genes, which leads to the emergence of individuals with new traits or harmful mutations that lead to the emergence of plants with undesirable traits (Ferrante and Mariani, 2017). (East ,1908) and (Shull ,1910) are the first to

discover this phenomenon, which is observed in Hybrids resulting from mating between two genetically distant breeds.

It is defined as an image of a state of genetic mixing that is the basis of the vitality and strength of crops. Moreover, the strength of the hybrid is more evident with the increase in genetic divergence between the genotypes (parental inbred lines) involved in the hybridization (Al-Aswady, 2002). The hybrid strength was a useful tool discovered by plant breeders. In the past centuries, has been one of the most important discoveries for maize breeders. Hybrid strength has received great interest, which means the superiority of the first-generation F1 individuals resulting from the mating of two genetically distant inbred lines, as well as from the best parents. The phenomenon of hybrid vigor has been known for more than a century, and plant breeders around the world are still working on it in several field crops, vegetables, and fruits. The expression Hybrid Vigor or heterosis is given to this phenomenon, which has had a significant impact on raising the yields of several crops in the world, including maize.

Hybrid vigor is achieved by crossbreeding between two genetically distant inbred lines, and we can only verify this through extensive testing in the fields after completing the backcrossing and obtaining the seeds of the first-generation F1. In general, if the two crossed inbred lines have widely varying genetic locations, the vigor of the hybrid appears in the first generation F1 and much of it disappears. In the second generation F2 and beyond, the second generation F2 is never planted for any crop for the reason mentioned above. The hybrid has a higher average compared to its parents for the desirable trait or lower than its parents for the undesirable trait. Therefore, the condition of two different and genetically distant inbred lines can be expressed, and after multiplying them and obtaining the hybrid, the state of the hybrid will be $1- > (1- \times 1+) > 1+$ and in a high morale way and then the symbol for the two inbred lines is + and – to highlight the state of genetic divergence for several genetic sites, on the average of the two parents, the mid parent, higher than the highest of its parents (1+) and lower than the lowest of its parents (1-) (El-sahookie and Dawood, 2021). The strength of the preferred hybrid is negative. tasselling and Silking characteristics and the physiological maturity times (the presence of a negative sign indicates the ability of these inbred lines to transfer the characteristic of early flowering and maturity to their resulting hybrids), while the presence of a positive sign indicates the ability of the

inbred lines to transfer the characteristic of delay in flowering and maturity to their resulting hybrids. It is positive for the characteristics of several cobs, grain weight, cob length, and number of grains in the row. They are preferred as the strains can increase the number of cob, grain weight, cob length, and number of grains in the row.

The basic idea of hybrid vigor is based on the accumulation of the largest number of desirable genes in a hybrid individual, through backcrossing between different, genetically distant inbred lines. Hybrid vigor increases with increasing genetic divergence between the parental inbred lines. The phenomenon of hybrid vigor is defined as the increase in growth or size or the result of the plants of the first generation being the highest of the parents, the average of the parents, or the highest of the parents. However, if the vigor of the hybrid is higher than the highest of the parents, then it is called Hybrid Vigor (based on the deviation of the first generation from the average of the parents for the studied traits). The vigor of the hybrid increases completely. The lower the degree of genetic distance between the parents involved in the hybrid. To calculate hybrid strength values based on the average of the two parents, the average hybrid strength differs from what it is for the highest parents. Hybrid vigor values may appear positive and negative when estimating hybrid vigor values based on the highest parents, while we find that its value is positive in the case of the average (Elsahookie et al., 1983). Hassan et al. (2019) during their study of five pure inbred lines and their hybrids of maize showed that there was a negative hybrid vigor for the tasselling and Silking characteristics of the individual hybrids, except for the hybrids (4×1) (2×1) (5×1) reaching 4.4% and 9.4%. 5.4%, respectively, for the Silking trait, while for the (3×1) (4×1) hybrids, it was positive, amounting to 1.6% and 6.2%, respectively, for the tasseling trait. (Karim and Abdullah, 2019) indicated when conducting their study on several hybrids of the maize crop, the presence of Negative and positive hybrid vigor for the Silking trait reached the lowest value of hybrid vigor at 4.26%, while for the male flowering trait, the lowest value was in the desired negative direction -4.08%. (Ramdan et al., 2020) found, when conducting partial cross-breeding between pure inbred lines of the maize crop to produce twelve hybrids for the leaf area trait, that there was a positive hybrid vigor for eleven hybrids, the highest of which was 9.06% for the hybrid (8×4) relative to the best parents, while only one hybrid gave a negative value. The hybrid vigor amounted to

-0.10%. (Hassan et al., 2019) found a positive hybrid vigor for the number of leaves, the highest was 36.8% for the 5×3 hybrid, and the lowest for the 2×1 hybrid reached 4.1%, while the leaf area gave a positive hybrid vigor that ranged between 4.1 %-36.8%. Hybrid strength can be calculated based on the increase in individuals of the first generation (the generation resulting from crossbreeding between the two parents involved in the hybridization process), such as the increase in yield or growth strength compared to the best or parents average (El-Sahookie et al., 1990). Because of the high presence of significant differences between the fourth hybrids and their six generations, they were included in the analysis of the generation's average and the scaling test according to the fourth model criteria and six-generation parameters according to the model (Mather and Jinks, 1982). The current study aims to determine the type and nature of genetic action, its interactions in the transmission and inheritance of the traits of flowering and physiological maturity times of the inbred lines, the performance of the resulting hybrids ((F1) differing in flowering and physiological maturity traits. Identifying the best-inbred lines that produced the best hybrids superior in field characteristics and genetic expression to be included in breeding and improvement programs to obtain promising genetic compositions.

Materials and Methods

This study was carried out in the fields of the University of Baghdad, College of Agricultural Engineering Sciences / Al-Jadriya, and in four consecutive spring and fall seasons for the years (2019 and 2020). The land used for agriculture was prepared by performing all agricultural operations on it, including plowing, smoothing, leveling, and dividing according to the requirements of the study and the seasons. The field was fertilized with fertilizer. Dab compound (NPK) at a rate of 240 kg ha⁻¹ when preparing the soil, and urea fertilizer 46% nitrogen, 360 kg N ha⁻¹, was added in two batches, the first at the elongation stage and the second at the beginning of the flowering stage (Saleh and Salman, 2005).

First Season (Spring 2019): The experimental land was prepared by plowing, leveling, leveling, and harrowing, and the seeds of the fifteen pure inbred lines mentioned above were planted on rows with a row length of 6 meters and a distance between them of 0.8 meters, by planting six lines for one inbred line and in a hollow with a distance of 0.25 meters

between one hole and another on 3/19/2019. To calculate the days of tasselling and Silking, physiological maturity, compatibility of the two flowerings, and for conducting crosses between inbred lines in the subsequent season. Developing inbred lines by self-pollinating them to increase genetic purity, as well as selecting inbred lines with good growth and yield characteristics to plant them in the subsequent season.

Second Season (Fall 2019): The seeds of the fifteen inbred lines were planted in the fall season on 7/16/2019, and the hybridization experiment was conducted. The field allocated for the experiment was divided into two parts. The first part was planted with half the grains of the fifteen inbred lines on rows, with the distance between one row and another being (0.8) m, and in a hole, one distance from another (0.25) m, at a rate of (6) rows, and a rate of 2 seeds per hole, thinned to One plant in the valley. A week after planting, the second part of the field was planted with the same grains to ensure compatibility of flowering between the strains and to obtain pollen grains with effective vitality throughout the hybridization period. When the plants reached the flowering stage, the female inflorescence was wrapped before the silk appeared with paper bags to obtain the required pollination and to avoid open pollination between inbred lines. The male inflorescence was wrapped in paper bags one day before the pollination process between the pure lines began. The next day, the pollen grains were collected and the female inflorescences that were ready to receive the pollen were pollinated with them. This process was continued until all the required crosses were performed between the pure inbred lines used in the study. The inbred lines were multiplied among themselves, and the number of days of tasseling and silking and physiological maturity for each inbred line was recorded to select the resulting hybrids according to the research objective. (Late x late), (late x early), (early x late), and (early x early). The process of self-pollination of the inbred lines were carried out to multiply their seeds, and the process continued until the required crosses were completed and an average of (8-10) ears per cross was obtained as a minimum to ensure obtaining sufficient numbers of seeds to try the following season. At the end of the spring season and upon full maturity, the hybrid shoots and the self-pollinated parents were harvested individually. Four hybrids were chosen that were characterized by the success of the required multiplication and obtaining the largest number of seeds sufficient for

planting. The hybrids were as follows: the first hybrid (late x late) for the two inbred lines (15 x 3), the second hybrid (early x late) for the two inbred lines (11 x 8), and the hybrid. The third (late x early) (7 x 11), and the fourth hybrid (early x early) for the two inbred lines (8 x 7).

Third Season (Spring 2020): Planting took place in this season on 3/17/2020. The four hybrids and their parents were planted at a rate of 10 sirens for each father, and each hybrid had a length of 4 m. The backcrossing of the first generation F1 was conducted with the first father, P1, and the second father, P2, to produce BC1 and BC2 seeds sequentially. The plants were also pollinated. The first generation, F1, produces seeds of the second generation, F2. The process of self-pollination was carried out for the parents to multiply their seeds and use them in the comparison experiment. According to the recommendations, the process continued until the required crosses were completed and (10-15) ear rates per cross and self-pollination were obtained as a minimum to ensure obtaining sufficient numbers of seeds from the six generations (P1) and P2 and F1, F2, BC1, and (BC2) for each of the four hybrids, and introduced into a comparative experiment in the subsequent season.

Fourth Season (Fall 2020): The comparison experiment was conducted during the fall season (2020), where the seeds of the six generations of each hybrid were planted, on 22 July, using a randomized complete block design (RCBD) with three replications. Each genotype was planted on four 5-meter-long beds, with an interval of 25 cm between one plant and another, that is, at a plant density. 50 thousand plants per hectare. Three seeds were placed in each hole, and they thinned out to one plant 15 days after emergence. All agricultural operations were carried out as in previous seasons. When the plants reached harvest maturity, 20 plants were selected from the guarded middle lines for each (P1, P2, F1), 40 plants for the second generation (F2), and 30 plants for each of (BC1, BC2), and the following characteristics were calculated for them.

The following characteristics of the four hybrids were studied:

- 1- Number of days from planting until 75% male flowering (day): It was calculated from the date of the first irrigation until the appearance of the male inflorescence in 75% of the plants for each experimental unit (Elsahookie and Dawood, 2021).
- 2- Number of days from planting until 75% female flowering (day): calculated until the female

inflorescence appears in 75% of the plants taken for each generation.

- 3- Plant height (cm): calculated from the area where the stem emerges from the soil surface until the end of the male inflorescence. (El-sahookie, 1990).
- 4- Height of the upper ear (cm): calculated from the soil surface to the phalangeal node bearing the upper stem (El-sahookie, 2009).
- 5- Number of plant leaves (plant leaf-1): The number of leaves was calculated for the plants taken for each generation and for each hybrid under study.
- 6- Leaf area index: by dividing the area of leaves by the area occupied by the plant.

Statistical analysis: Statistical analysis was carried out for each of the studied traits using a randomized complete block design (R.C.B.D.) with three replications for each hybrid individually. The data was placed in tables, and statistically analyzed according to the design used, and the arithmetic means were compared using the least significant difference (L.S.D.) at a significance level of 0.05 using Excel and Gestate 2018 programs.

I also calculated the percentage of hybridization and hybrid vigor% according to the following two equations:

$$H\% ((MP)^{\bar{}}) = ((F1)^{\bar{}} - (MP)^{\bar{}}) / (MP)^{\bar{}}$$

$$H.V\%((HP)^{\bar{}}) = ((F1)^{\bar{}} - (HP)^{\bar{}}) / (HP)^{\bar{}}$$

Results and Discussion

First hybrid (Late × Late) (Zi17WZ × ZA17WR)

Number of days from planting to 75% tasseling (day): Buckler (2009) defined the number of days until tasseling as the number of days from planting until 75% of the pollen grains appear in the male inflorescence. The appearance of the male inflorescence and the beginning of its release of pollen grains is essential for the process of pollination and fertilization, which must coincide with the appearance of the silk and its readiness to receive pollen grains (Al-Kaisali, 2016). The results of Table 1 indicate that there are significant differences between the genotypes of the six generations (P1, P2, F1, F2, BC1, and (BC2) for the number of days from planting to 75% tasseling for the hybrid Zi17WZ × ZA17WR) resulting from crossing mothers and fathers who are late in flowering and physiological maturity. The first generation, F1, reached male flowering superior to its fathers, and its backcrosses reached 56.33 days, a difference of 1.33 and 3.67 days from the first father, P1, and the second, P2. The second backcross, BC2, delayed its arrival to male flowering by 63 days compared to the rest of the remaining generations (Table 5). These

results are consistent with the findings of (Almulhmi, 2017) and (El-schneiter, 2018), as their results showed significant differences between the genotypes regarding the number of days from planting to 75% tasseling. The reason is due to the hybrids being superior to their parents in the rate of increase due to the speed of division cells and the increase in their number. The hybrid (Zi17WZ × ZA17WR) gave a negative hybrid vigor relative to the first parents amounting to (-2.87%) and relative to the two parents average -4.25%. These results agreed with what (Hassan et al., 2019) and (Karim and Abdullah, 2019) mentioned, that the hybrid vigor differs depending on the hybrids. Parents that gave negative values indicate that the trait (tasseling) is under the control of partial or partial dominance of the genetic action, as the first generation average is superior to the oldest and middle parents

Number of days from planting to 75% Silking (day):

The number of days until Silking defined as the number of days from planting until 50% of the silk appears in the female inflorescence. The appearance of the female inflorescence (the beginning of the appearance of the silk) and its readiness to receive pollen (Yan and Wallace, 1998) are among the environmental factors affecting and controlling the flowering of maize inbred lines and hybrids temperature and duration of radiation). It is noted from the results of the statistical analysis in Table (1) that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and (BC2) regarding the number of days from planting to 75% silking for the hybrid Zi17WZ × ZA17WR) resulting from crossbreeding with mothers and fathers who are late in flowering and physiological maturity. The first generation, F1, was superior in arriving at Silking earlier than its parents, and its backcrossing reached 60.33 days, a difference of 0.33 and 2.67 days from the first parent, P1, and the second, P2. The second backcross, BC2, was delayed in reaching Silking by 67 days, compared to the remaining generations (Table 5). These agree. The results are consistent with the findings of (Almulhmi, 2017) and (El-Schneiter, 2018), as they showed in their study that there are significant differences between the genotypes in the number of days from planting to 75% silking. The hybrid (Zi17WZ × ZA17WR) gave a negative hybrid vigor relative to the oldest parents amounting to (-0.55%) and relative to the average of the parents (-2.43%), and this indicates the presence of superior dominance of the genetic action or partial dominance of the superiority of the first generation

average over the oldest and average parents. These results were in agreement with what was reported in (Karmullah et al., 2011), (Saudi , 2013), and (Hassan et al., 2019).

Plant height (cm): The plant height characteristic is one of the characteristics that plant breeders work on in raising the maize crop in terms of obtaining plants with appropriate lengths and heights to ensure an optimal distribution of leaves on the plant, to protect the plant from falling. The height of the plants in the maize crop stops as soon as the male inflorescence appears which is affected. It's appearance is mainly due to environmental factors surrounding the growing season and the nature of the genetic structure and the interaction between them IGE (Al-Dulemie, 2004). The results of the analysis of variance table (1) indicate that there are significant differences between the six generations of genotypes (P1, P2, F1, F2, BC1, and BC2) for the plant height trait of the hybrid Zi17WZ × ZA17WR) resulting from, crossing mothers and fathers who are late in flowering and physiological maturity times. The first generation F1 excelled by giving the highest average for the trait. which amounted to 172.5 cm, with a difference of 7.3 and 22.8 cm from the first parent, P1, and the second, P2 (Table 5). The backcrossing differed from the parents as BC1 gave a lower average than its parents, 152.5 cm, and the second backcross, BC2, gave a higher average than the second father reaching 156.6 cm. The hybrid (Zi17WZ × ZA17WR) had a positive hybrid strength relative to the tallest of the two parents, amounting to 6.46%, and relative to the average of the two parents, 10.68%. This indicates the presence of extreme or partial dominance of the genetic action to outperform the average of the first generation over the highest and parent's average. These results agreed With (Saudi ,2013), (Hussein et al.,2017), and (El-Schneider , 2018).

Ear Upper height (cm): The female inflorescence is formed at the beginning of the life of the maize crop, reaching a length of 1 cm 30-40 days after planting (DAP), which later forms cobs, greatly influenced by the surrounding environmental conditions (Elsahookie, 1990). The results of the analysis of variance shown in Table (1) show that there are significant differences between the (genotypes) of the six generations (P1), P2, F1, F2, BC1, and BC2 (for the ear upper height of the hybrid Zi17WZ × ZA17WR) resulting from crossing mothers and fathers who are late in flowering and physiological maturity. The first generation, F1, gave the highest average for the trait, superior to its

parents and crossbreeding, reached 87.35 cm, a difference of 11.92 cm and 9.5 cm from the first parent, P1, and the second, P2, respectively (Table 5). While the second backcross, BC2, reached the lowest shoot height of 69.50 cm compared to the remaining generations (which is similar to the behavior of the plant height characteristic of this hybrid (Table 10). The hybrid Zi17WZ × ZA17WR) gave a positive hybrid vigor relative to the highest parents amounting to 12.20% and relative to the parent's average 13.97%. These results were similar to those reached by (Hussein et al., 2017; El-Schneider, 2018), as their results gave positive and significant values for the vigor of the hybrid for the plant height trait.

Number of leaves on the plant (leaf⁻¹): The number of leaves is one of the important quantitative characteristics that contribute directly to increasing yield productivity in the maize crop, as increasing the number of leaves is evidence of increases in the flow of dry matter and an increase in the capacity of the source, which reflects positively on the yield and its components. The function of the leaves and their distribution pattern affects the interception and deception of the amount of light entering the process of carbon metabolism and then increases the carbon metabolism, which reflects positively on providing the sink with dry matter at the end of the reproductive phase. Table (1) shows there is significant differences between the (genotypes) of the six generations (P1, P2, F1, F2, BC1, and BC2) regarding the number of leaves in the plant for the hybrid (Zi17WZ × ZA17WR) resulting from crossing mothers and fathers who are late in flowering and physiological maturity. the first generation F1 gave the highest The average number of leaves was superior to its parents and cross-breeding, reaching 12.59 leaves, a difference of 2.32 and 2.59 leaves from the first parent, P1, and the second, P2, respectively. The second generation, F2, gave the lowest average number of leaves, with 10.68 leaves, compared to the remaining generations (Table 5). The reason for the existence of significant differences is due to the influence of the genetic factor, which was mentioned in many previous studies and research, including (Abd ,2012) and (El-schneider ,(2018). The hybrid (Zi17WZ × ZA17WR) gave a positive hybrid vigor relative to the highest parents, amounting to 22.55%, and relative to the average of the parents, 24.18%. This indicates the presence of superior dominance of the genetic action, as the first-generation average of outperformed the highest and average parents. This

confirms the results of the findings of (Al-Obaidy , 2018); El-schneider,2018).

Leaves area index: The leaf area index is one of the influential characteristics related to the yield directly or indirectly, through its connection with other components of the yield, due to it being the main source of dry matter deposited in the grains through carbon assimilation. The results of Table (1) show that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) for the leaf area index trait of the hybrid Zi17WZ × ZA17WR), resulting from crossing mothers and fathers who are late in flowering and physiological maturity. The first generation, F1, excelled by giving the highest average for the trait compared to his fathers and crossbreeding, it reached 3.02, a difference of 0.26 and 0.68 from the first father, P1, and the second, P2, respectively. The second backcross, BC2, gave an average of 2.36 for the leaf area index, compared with the second step, which reached 2.34 (Table 5). The hybrid (Zi17WZ×ZA17WR)) gave a positive hybrid vigor relative to the highest parents, amounting to 9.39%, and relative to the parents average, 18.40%, indicating the presence of superior dominance of the genetic action, with the average of the first generation superior to the highest and average parents. These results are consistent with the findings of (El-Hosary et al.,1999),(Shibak et al. ,2011), and (Wuhaib et al. ,2016).

Second Hybrid (early x late) (ZM49W3E×ZM74)

Number of days from planting to 75% tasselling (day): It appears from Table (2) and Table (6) that there are significant differences between the six generations (P1), P2, F1, F2, BC1, and (BC2) regarding the number of days from planting to 75% tasselling for the hybrid (ZM49W3E × ZM74) resulting from crossing early mothers and late fathers with flowering and maturity. Physiologically, the first generation F1 took the least amount of time to reach tasselling than its fathers and crossbreeds, amounting to 49.00 days, a difference of 3.00 days and 10.00 days from the first father, P1, and the second, P2, respectively, while the second backcross, BC2, delayed its arrival to tasselling by 58.00 days from the remaining generations. The hybrid (ZM49W3E×ZM74)) gave a negative hybrid vigor relative to the earliest parents amounting to -5.77% and relative to the average of the parents amounting to -11.71%. This results from the asymmetry between the parents, which led to an increase in hybrid vigor, and the hetrosis percentage, as evidenced by F2, which was close to the first and

early parent. From the second father, the high values of BC1 and BC2 indicate the presence of genetic variation in the flowering trait. It indicates the presence of superior or partial dominance of the genetic action, as the first-generation average outperforms the firstborn of the two parents and their averages. This agreed with what (Hassan et al. ,2019) mentioned, and (Karim and Abdullah , 2019).

Number of days from planting to 75% Silking (day):

The results of the analysis in Table (2) and the results of Table (6) indicated that there were significant differences between the six generations (P1), P2, F1, F2, BC1, and (BC2) regarding the number of days from planting to 75% Silking for the hybrid (ZM49W3E × ZM74) resulting from crossing early mothers and fathers delayed in flowering and physiological maturity. The first generation, F1, was earlier in its Silking, taking 53.00 days less than the Silking than its fathers, and its backcrossing amounted to 3.66 days and 10.66 days more than the first father, P1, and the second, P2, respectively. The second backcross, BC2, was delayed, taking 62.00 days to reach Silking from the remaining generations. The hybrid (ZM49W3E × ZM74) gave negative hybrid vigor relative to the first parents, amounting to -6.47%, and relative to the two parents average was -11.91%. These results agreed with the findings of (Karmullah et al. , 2011) and (Saudi ,2013) (Hassan et al., 2019) indicated that the hybrid vigor values in combinations of maize were negative values for several traits, including female flowering, and this indicates early Silking lowering, and the presence of partial dominance of genetic action, as the first generation average outperforms the firstborn and middle parents.

Plant height (cm): It is clear from table (2) and table (6) that there are clear differences between the different generations in the plant height characteristic of the hybrid (ZM49W3E × ZM74) .Resulting from crossing early mothers and late fathers in terms of flowering and physiological maturity, as we notice the superiority of the first-generation F1 over the highest and average parents and this is clear from the hybrid vigor values are 6.13% and the hetrosis rate is 8.17%. This indicates the presence of high genetic variations. The higher F2, BC1, and BC2 values of the parents confirm the lack of uniformity of this trait in its parents. Pairs of genes that are super dominant or partial control plant height trait. These results confirm what (Almuhmi, 2017; El-Schneider, 2018).

Ear Upper height (cm)

The analysis of variance in Table (2) and the data in Table (6) shows that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) in the ear upper height of the hybrid (ZM49W3E × ZM74) resulting from crossing early mothers and late fathers in terms of flowering and physiological maturity. The first generation, F1, excelled by giving it the highest rate. For the trait, it reached 108.34 cm, different from its fathers and its retrograde crosses, with a difference of 7.9 cm and 17.21 cm from the first father, P1, and the second, P2, respectively. The second generation, F2, gave the lowest average for the cob height trait, which amounted to 97.99 cm, Table (14). The hybrid (ZM49W3E × ZM74) achieved positive hybrid vigor relative to the highest parents, amounting to 7.86%, and relative to the two parents' average of 13.00%. This confirms that the trait is subject to the control of dominance genes. Partial and superior genetic action to outperform the average of the first generation over the highest and average parents. These results were similar to the results of previous studies, including (Hussein et al., 2017; El-Schneiter, 2018).

Number of leaves in a plant (leaf-1 plant): According to the results of the analysis in Table (2), significant differences appear between the six generations (P1, P2, F1, F2, BC1, and BC2) for the number of leaves per plant for the hybrid (ZM49W3E × ZM74) resulting from crossing early mothers and late fathers in terms of flowering and physiological maturity. The first generation F1 excelled by giving the highest average. The number of leaves reached 15.45 leaves, differing from its fathers by a difference of 1.95 leaves and 1.85 leaves from the first parent, P1, and the second, P2, respectively (Table 6), while the second backcross, BC2, gave the lowest average number of leaves, amounting to 13.13. A leave on the remaining generations. The hybrid (ZM49W3E × ZM74) gave a positive hybrid vigor relative to the highest parents amounting to 13.65% and relative to the average of the two parents 14.06%. This result is consistent with what was mentioned by (Abed, 2012; El-Schneiter, 2018), whose study indicated the existence of superior or partial dominance of genetic action for the trait. The average number of leaves first generation exceeds the highest and average parents.

Leave area index: Table (2) indicates that there are significant differences between the six generations (P1), P2, F1, F2, BC1, and (BC2) for the leaf area index trait of the hybrid (ZM49W3E×ZM74) resulting

from crossing early mothers and late fathers in terms of flowering and physiological maturity. The first generation, F1, was distinguished by having the highest average for the trait, amounting to 3.025, superior to his fathers by a difference of 0.26 and 0.681 from the first father, P1, and the second, P2, respectively (Table 6). The lowest mean trait for the second parent, P2, was 2.34, as it was close to the second backcross, BC2, which gave an index of 2.36. The hybrid (ZM49W3E × ZM74) achieved positive hybrid vigor relative to the higher of the two parents, amounting to 9.39%, and relative to the average of the two parents, 18.40%, indicating the presence of dominance. The superior or partial gene action is superior to the first-generation average over the highest and average parents. This result is consistent with what was found by (El-hosary et al., 1999; Shibak et al., 2011; Wuhaib et al., 2016).

Third hybrid (late x early) (ZM19×74 ZM)

Number of days from planting to 75% tasselling (day): The results of the statistical analysis in Table (3) indicated that there were significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) regarding the number of days from planting to 75% tasselling for the hybrid (ZM74 × ZM19) resulting from crossing late mothers and early fathers in terms of flowering and physiological maturity. The first generation plants F1, needed the least number of days to reach 75% tasselling amounting to 52.00 days, and were significantly different from their fathers, with a difference of 7.00 days and 1.00 days from the first father. P1 and the second, P2, respectively (Table 7). As for the plants of the second BC2 backcross, it took a longer period to reach this stage, amounting to 59.00 days, later than the remaining generations. The first backcross, BC1, was also later than the second backcross, BC2, despite it being crossed with the early father. This is attributed to the genetic divergence between the two inbred lines of this cross, and this supports what he found (Almulhmi, 2017; El-schneiter, 2018). The hybrid (ZM74×ZM19) gave a negative hybrid vigor relative to the first parents amounting to -3.77% and relative to the average of the two parents -8.83%. The negative value of the hybrid vigor and the hetrosis percentage indicates superior dominance or partial dominance of the genes of the first parent in controlling the flowering trait. (Shenowa, 2018; Hadi and Wuhaib, 2016; Amanah and Hadi , 2021) indicated similar results and a significant difference in hybrid vigor from the best and parents average for the number of days from planting up to 75% tasselling .

Number of days from planting to 75% silking (day):

The results of the statistical analysis in Table (3) show that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) regarding the number of days from planting to 75% silking for the hybrid (ZM74×ZM19) resulting from crossing late mothers and early fathers with respect to flowering and physiological maturity. The first generation F1 took the shortest period for the female to reach flowering was 55.00 days, superior to its fathers by a difference of 8.66 days and 2.66 days from the first father, P1, and the second, P2, respectively (Table 7). While the second backcross, BC2, was 63 days later in reaching Silking compare with other generations. These results agreed with the findings of (Almulhmi, 2017) and (El-schneiter, 2018), as there are significant differences between the six generations in the number of days from planting to 75% silking. The hybrid (ZM74×ZM19) gave a negative hybrid vigor relative to the first-born parents amounting to -4.62% and a percentage of -9.34% to the parent's average. This confirms that this trait is under the control of superior genes or the partial dominance of the first-born father. These results agreed with the findings of (Karmullah et al., 2011) and (Saudi, 2013) and (Hassan et al., 2019), who indicated the presence of hybrid vigor values in combinations of maize that were negative values for the silking trait.

Plant height (cm): It is noted from the analysis of variance table in Table (3) that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) in the plant height trait of the hybrid (ZM74 × ZM19) resulting from multiplying late mothers and early fathers in terms of flowering and physiological maturity, as the first generation F1 excelled by giving it the highest average. The plant height exceeded that of its parents, reaching 181.15 cm, a difference of 10.27 cm and 24.8 cm from the first parent, P1, and the second parent, P2, respectively (Table 7). While the second backcross BC2 individuals gave the lowest average for the trait with a height of 154.83 cm, lower than the tallest parents. The hybrid (ZM74×ZM19) gave a positive hybrid vigor in proportion to the highest parents amounting to 6.01% and in proportion to the two parent's average 10.71%. This variation appeared clearly in the vigor of the hybrid. These results agreed with the findings of (Saudi, 2013), (Hussein et al., 2017) and (El-schneiter, 2018), as their results showed a significant difference in the hybrid performance of the first generation compared to the best and parents average.

Ear upper height (cm): Based on the analysis of the variance table in Table (3), significant differences were observed between the six generations (P1), P2, F1, F2, BC1, and BC2) in the upper stem height of the hybrid (ZM74×ZM19) resulting from crossing late mothers and early fathers in terms of flowering and physiological maturity, as the first generation outperformed F1 gave it the highest average for the trait, which amounted to 93.81 cm (Table 7), and it did not differ significantly from the first father, which indicates the complete dominance of the genes of the first father, while the second father recorded the lowest average for the ear upper height characteristic, which amounted to 77.44 cm. This confirms the genetic divergence between the two fathers. Between the two inbred lines, the cross-breeding values BC1 and BC2 were lower than the first parent and higher than the second parent. The hybrid (ZM74×ZM19) gave negative hybrid vigor relative to the best parents, amounting to -0.04% and 9.55% relative to the parent's average. The negative values of hybrid vigor relative to the best parents indicate superior dominance to reduce the height of the ear, and positive values of hybrid vigor relative to the two parents average indicate the control of partial dominance genes over this trait for this hybrid.

Number of leaves in a plant (plant leaf¹): The results of the statistical analysis in Table (3) showed that there were significant effects between the six generations (P1), P2, F1, F2, BC1, and BC2) regarding the number of leaves per plant for the hybrid. The first generation F1 excelled by achieving the highest average for the number of leaves trait, amounting to 14.78 leaves, differing from its parents and backcrosses by a difference of 1.97 a leaf and 3.12 leaves for the first parent P1 and the second P2 in succession (Table 7). The second backcross, BC2, gave the lowest average for the trait by 11.36 leaves for the remaining generations. The significant difference between the parents in the average number of leaves for the trait was reflected in the hybrid vigor values (Table, 18). The strength of the hybrid and the of heterosis percentage were positive, amounting to 15.4 and 20.81%, respectively. This suggests the dominance of the genes of the superior dominance genetic action of the first father, 12.81 leaves or act, for the two parent's average, which amounted to 12.23. This indicates the presence of superior dominance or partial dominance of the genetic action to outperform the average of the first generation over the highest. Their parents are average. These results are consistent with the results

of previous studies conducted by (Abd, 2012; El-schneiter, 2018).

Leave area index: It is clear from the statistical analysis data in Table (3) that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) for the leaf area index trait of the hybrid (ZM74×ZM19) resulting from crossing late mothers and early fathers in terms of flowering and physiological maturity, as the first generation F1 achieved the highest average for the trait. The leaf area index reached 3.35, superior to its parents by a difference of 0.02 and 0.7 compared to the first parent, P1, and the second, P2, respectively (Table 7). The second backcross BC2 decreased the leaf area index by giving it the lowest average for the trait. The hybrid (ZM74×ZM19) had a positive hybrid vigor relative to the highest parent, which amounted to 1.64% and a ratio to the two parent's average, 13.09%. This result was similar to what was found by (El-Hosary et al., 1999; Shibak et al., 2011; Wuhaib et al., 2016; Hassan et al., 2019). Therefore they obtain a positive hybrid vigor for the leaf area index trait.

Fourth Hybrid (early x early) (ZM19×ZM49W3E)

Number of days from planting to 75% tasselling (day): The results of the statistical analysis in Table (4) showed that there were significant differences between the six generations averages (P1), P2, F1, F2, BC1, and (BC2) regarding the number of days from planting to 75% tasselling for the hybrid (ZM19 × ZM49W3E) resulting from crossing mothers and fathers with early flowering and physiological maturity. The first generation, F1, was earlier in its tasselling, taking 47.33 days, differing from its fathers and cross-breeding, with a difference of 5.00 days and 4.00 days from the first father and the second father, respectively, Table (8). The second backcross, BC2, was 53.33 days later in reaching tasselling than the remaining generations. The difference between the second generation and the first and second backcross is due to the lack of uniformity between the two inbred lines, confirming the existence of genetic variations for this trait, and it was clear in the strength of the hybrid. The hybrid was given (ZM19 × ZM49W3E) Negative hybrid vigor relative to the first parents amounted to -7.84% and relative to the average of the two parents -8.74%, and this indicates superior or partial dominance of genes. These results agreed with (Hassan et al., 2019; Karim and Abdullah, 2019).

Number of days from planting to 75% silking (day): The results of the statistical analysis in Table (4) indicated that there were significant differences between the six generations (P1), P2, F1, F2, BC1,

and (BC2) regarding the number of days from planting to 75% silking for the hybrid (ZM19 × ZM49W3E) resulting from crossing mothers and fathers with earlier flowering and physiological maturity. The first generation, F1, took the shortest period of time to reach 75% silking, which amounted to 50.66 days, superior to its fathers and backcrosses, with a difference of 6.00 days and 5.34 days over the first father, P1, and the second, P2, respectively (Table 8).

The second backcross, BC2, delayed silking from its parents by taking a period of 57.66 days. These results agreed with the findings of (Al-Mulhmi, 2017; El-schneiter, 2018), as they showed that there are significant differences between the genotypes in the number of days from planting to 75%. Silking. The hybrid (ZM19× ZM49W3E) gave a negative hybrid vigor relative to the earliest parents amounting to -7.88% and relative to the average of the two parents -8.74%. This indicates the presence of superior or partial dominance of the genetic action in the superiority of the first generation average over the oldest and parent's average. Both reached (Karmullah et al.,2011), (Saudi , 2013; Hassan et al., 2019) obtained similar results, as their results showed a significant difference in hybrid vigor from the best parents for the trait of number of days from planting to 75% silking.

Plant height (cm): It is clear from the results of the analysis of variance table (4) that there are significant differences between the six generations (P1), P2, F1, F2, BC1, and (BC2) for the plant height trait of the hybrid (ZM19 17 cm, superior to its fathers by a difference of 11.29 cm and 9.8 cm from the first father P1, and the second P2, respectively (Table 8). While the first backcrossing BC1 plants gave the lowest average for the trait at 143.66 cm, lower than the remaining generations. The hybrid (ZM19 × ZM49W3E) gave a positive hybrid vigor relative to the highest parents, amounting to 6.47% and relative to the average of the parents, 6.98%. This indicates the presence of superior or partial dominance of the genetic action, with the average of the first generation superior to the highest or average parents. The results of the current study confirmed previous studies, including (Saudi, 2013), (Hussein et al., 2017; El-schneiter, 2018).

Ear upper height (cm): According to the results of the analysis of variance in Appendix (4), significant differences appeared between the six generations (P1), P2, F1, F2, BC1, and (BC2) in the ear upper height of the hybrid (ZM19 For the trait, he reached 84.91 cm, significantly different from his fathers,

with a difference of 8.33 cm and 6.05 cm from the first father, P1, and the second, P2, respectively (Table 22). While the first backcrossing BC1 individuals recorded the lowest average for the trait, amounting to 69.03 cm, compared to the remaining generations. The hybrid ZM19 × ZM49W3E (ZM19×ZM49W3E) had a positive hybrid vigor for the trait of ear upper height, relative to the highest of the parents, amounting to 7.65% and relative to the average of the parents, 9.24%. These results were consistent with the results of (Hussein et al., 2017; El-schneiter, 2018), as their results showed a significant difference in the performance of the first generation hybrids compared to the best and parents average, giving positive values for the percentage of hybrid vigor and the percentage of hybrids for the coronal height trait

Number of leaves in a plant leaf¹: The results of the analysis of variance in Table (4) indicate that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) in the number of leaves trait in the plant for the hybrid (ZM19 It reached 12.66 leaves-1 and differed significantly from its parents, with a difference of 1.32 leaves-1 and 0.76 leaves-1 from the first parent, P1, and the second, P2, respectively (Table 8). The second backcross, BC2, gave the lowest rate for the same trait, amounting to 10.23 leaves - 1, significantly different from the rest of the generations. The hybrid (ZM19 × ZM49W3E) gave a positive hybrid vigor relative to the highest parent amounting to 6.38% and relative to the parent average of 8.93%. The results of the study conducted by (Abed , 2012),(Hadi and Wuhaib , 2016) and (Hadi and Abedl Aamir , 2018) supported the current results, and this indicates the existence of super dominance or the partial dominance of the genetic action due to the superiority of the average of the first generation over the highest and average parents.

Leave area index: It is clear from the data in Table (4) that there are significant differences between the six generations (P1, P2, F1, F2, BC1, and BC2) in the leave area index character of the hybrid (ZM19×ZM49W3E) resulting from crossing mothers and fathers that are early in flowering and physiological maturity, as the trait average increased in the first generation F1 plants. The highest value reached 3.19, and he differed significantly from his father's by a difference of 0.58 and 0.43 from the first father, P1, and the second, P2, respectively (Table 8).The first backcross, BC1, gave the lowest average for the same trait, amounting to 2.35,

compared to the remaining generations. (Shibak et al., 2011; Wuhaib et al., 2016).

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Table (1): Analysis of the mean variance of the first hybrid, Late×Late (ZI17WZ×ZA17WR) under a significance level of 0.05.

SOURCECES OF VARIATION	DF	Tassling	silking	Plant height	Ear height	Leaves number	Leaf area index
Replication	2	5.16	2.167	34.51	0.883	0.269	0.031
Genotype	5	27.3*3	28.23*	145.23 *	111.466*	2.72*	0.204*
Error	10	1.900	1.100	27.34	3.391	0.250	0.032
Total	17						

Table (2): Analysis of the mean of variance for the second hybrid, late × early (ZM49W3E × ZM74) under the significance level of 0.05.

SOURCECES OF VARIATION	DF	Tassling	silking	Plant height	Ear height	Leaves number	Leaf area index
Replication	2	1.38	3.72	1.08	81.29	0.46	0.31
Genotype	5	51.02*	48.6*	316.33*	89.42*	2.07*	0.204*
Error	10	4.58	1.38	49.24	31.47	0.49	0.032
Total	17						

Table (3): Analysis of the mean of variance for the third hybrid, early × late (ZM74 × (ZM19) at a significance level of 0.05.

SOURCECES OF VARIATION	DF	Tassling	silkin g	Plant height	Ear height	Leaves number	Leaf area index
Replication	2	1.500	0.16	20.25	14.93	0.17	0.011
Genotype	5	21.2*	22.8*	114.34*	81.32*	2.88*	0.29*
Error	10	0.90	1.56	20.85	22.27	0.86	0.02
Total	17						

Table (4): Analysis of the mean of variance for the third hybrid fourth hybrid early×early (ZM49W3E×ZM19) under 0.05 significance level.

SOURCECES OF VARIATION	DF	Tassling	silking	Plant height	Ear height	Leaves number	Leaf area index
Replication	2	0.22	0.00	64.87	50.50	1.991	0.212
Genotype	5	40.58*	42.10*	301.64*	152.37*	4.597*	0.334*
Error	10	3.22	3.400	12.29	34.58	0.548	0.437
Total	17						

Table (5): Means of traits with their standard errors for the six generations of the first hybrid of maize (Zi17WZ×ZA17WR) (late × late), hybrid vigor, and the percentage of heterosis for the fall season 2020.

Traits	Generations						Hybrid vigor%	Heterosis%
	P1	P2	F1	F2	B1	B2		
Tassling	57.66±0.881	60.00±1.52	56.33±0.881	55.00±2.90	61.00±0.577	63.00±0.577	-2.31	-4.25
Silking	60.66±0.66	63.00±0.57	60.33±0.881	59.00±1.52	65.00±0.577	67.00±0.577	-0.55	-2.43
Plant height	165.02±2.572	149.7±3.15	172.5±2.04	159.5±6.25	152.5±2.19	156.6±2.96	6.46	10.68
Ear height	75.43±0.66	77.85±1.28	87.35±0.60	72.94±3.41	73.66±1.76	69.50±0.50	12.20	13.97
Leaves number	10.27±0.30	10.00±0.21	12.59±0.23	10.68±0.78	11.62±0.09	11.06±0.50	22.55	24.18
Leaf area index	2.76±0.104	2.34±0.112	3.02±0.044	2.77±0.137	2.67±0.111	2.36±0.089	9.39	18.40

Table (6): Means of traits with their standard errors for the six generations of the second hybrid of maize (ZM49W3E×ZM74)(early×late), hybrid vigor, and the percentage of heterosis for the 2020 fall season.

Traits	Generations						Hybrid vigor%	Heterosis %
	P1	P2	F1	F2	B1	B2		
Tassling	52.00±0.577	59.00±0.00	49.00±1.154	50.66±2.333	56.00±0.577	58.00±0.577	-5.77	-11.71
Silking	56.66±0.333	63.66±0.333	53.00±0.577	55.33±1.201	60.00±0.577	62.00±0.577	-6.47	-11.91
Plant height	181.99±1.362	175.12±1.217	193.15±1.512	183.42±2.245	176.06±0.566	162.41±2.062	6.13	8.17
Ear height	91.31±0.674	100.44±1.079	108.34±0.908	97.98±3.877	99.50±1.527	98.66±1.589	7.86	13.00
Leaves number	13.50±0.25	13.60±0.330	15.45±0.228	13.44±1.253	13.96±0.504	13.13±0.338	13.65	14.06
Leaf area index	2.765±0.052	2.344±0.081	3.025±0.044	2.7160±0.147	2.673±0.111	2.369±0.089	9.39	18.40

Table (7): Means of traits with their standard errors for the six generations of the third hybrid of maize (ZM74 × ZM19) (late × early), hybrid vigor, and the percentage of heterosis for the fall season 2020.

Traits	Generations						Hybrid vigor%	Hetrosis %
	P1	P2	F1	F2	B1	B2		
Tassling	59.00±0.57	53.00±0.57	50.66±0.88	52.00±1.00	57.66±0.88	59.00±0.57	-3.77	-8.93
Silking	63.66±0.33	57.66±0.33	55.00±0.57	56.00±1.00	61.66±0.88	63.00±0.57	-4.62	-9.34
Plant height	170.88±1.47	156.35±1.05	181.14±0.57	168.76±3.50	160.93±2.99	154.83±1.81	6.01	10.71
Ear height	93.84±1.52	77.42±1.41	93.81±0.88	81.40±5.23	82.90±2.95	80.16±1.16	-0.04	9.55
Leaves number	12.81±0.270	11.66±0.384	14.78±0.604	13.21±1.163	12.26±0.405	11.36±0.688	15.40	20.81
Leaf area index	3.33±0.096	2.65±0.080	3.35±0.151	3.00±0.184	2.91±0.173	2.58±0.071	1.64	13.09

Table (8): Means of traits with their standard errors for the six generations of the fourth hybrid of maize (ZM19×ZM49W3E) (early × early), hybrid vigor, and the percentage of heterosis for the fall season 2020.

Traits	Generations						Hybrid vigor%	Hetrosis %
	P1	P2	F1	F2	B1	B2		
Tassling	52.333±0.666	51.333±0.333	47.333±0.666	46.666±2.333	52.00±0.577	53.333±0.881	-7.84	-8.74
Silking	56.666±0.333	56.00±0.577	50.666±0.666	52.00±1.154	56.00±0.577	57.666±0.333	-7.88	-9.25
Plant height	150.883±2.789	152.316±2.212	162.176±2.964	148.480±4.206	143.633±3.587	149.166±2.127	6.47	6.98
Ear height	76.583±2.626	78.880±2.632	84.916±0.831	80.746±4.457	69.033±3.755	79.833±2.905	7.65	9.24
Leaves number	11.346±0.641	11.903±0.171	12.663±0.370	10.200±1.385	10.733±0.817	10.233±0.417	6.38	8.93
Leaf area index	2.617±0.046	2.767±0.053	3.199±0.086	2.781±0.164	2.358±0.036	2.547±0.060	15.58	18.81