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EVALUATION OF THE PERFORMANCE OF TRIPLE, SINGLE CROSSES AND THEIR INBRED IN BRED LINES OF MAIZE UNDER TWO PLANT POPULATION

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Abstract

In order to evaluate the performance of triple, single hybrids and their inbred in bred lines of maize and compared with the synthetic cultivar Ibaa 5018 under two plant populations, field experiment was carried out in the research station of the College of Agricultural Engineering Sciences/University of Baghdad in Jadriya, where the cultivation was conducted in the fall season 2018. The study included a comparison of five inbred inbred lines ZM43WIZE, ZM60, ZM49W3E, ZM19 and CDCN5 (symbolizes as 1, 2, 3, 4 and 5) respectively and 10 single hybrids resulting from cross of two inbred in bred lines together and 11 triple hybrids resulting from crossing hybrid with inbred line). As well as, the comparison cultivar Ibaa 5018, with two plant populations 60.000 plantha^{-1} and 80.000 plantha^{-1}. Furthermore, the experiment was performed according to split plot arrangement using Randomized Complete Block Design (RCBD) with four replicates, the main plots included the two levels of plant populations and the subplots included the genotypes (27 genotypes). The results showed that the lower plant populations (60 thousand plant ha^{-1}) was exceeded in the Mean number of sulking and sulking days of) 55.17 and 58.80 days respectively). Moreover, the number of rows per Ear was (15.59 rows), the number of grains per row (40.24 grain/row) and the number of grains per ear (623.8 grain/ear), while the high populations (80 thousand plant/ha) was exceeded for each of the plant height (197.29 cm) and the grain yield per unit area (11.73ton ha^{-1}). The results also showed that there were significant difference between the genotypes of all the studied traits, as the inbred in bred line 4 exceeded with the highest yield for unit area of 9.36 ton/ha and the inbred in bred line 5 was also exceeded in most traits by giving the highest Mean of plant height (213.55 cm). As, well as, the number of rows per Ear was (16.92 rows) and the number of grains per Ear) (552 grains) and as a result it has also given a highest yield of unit area by (8.91 ton ha^{-1}). The inbred in bred line 3 did not differ significantly in its unit area of (8.60 ton ha^{-1}), where single hybrids (3 × 2), (3 × 1) and (5 × 4) was exceeded on their parents and the comparison cultivarby the highest yield for unit area of (11.43, 11.31 and 11.03 ton ha^{-1}), respectively, for their superiority in several traits. Thus, it gave the highest number of grains per ear (631, 650 and 607grains), respectively. The majority of triple hybrids was exceeded over the single hybrids and in bred lines and the comparison cultivar, where the triple hybrid (2×5) ×1 was superior on its parents and the comparison cultivar. It gave the highest yield of unit area of 12.75 ton/ha due to having the highest Mean of number of rows per earof)15.68 rows) and the highest number of grains per row (637 grain/ear).Additionally, Hybrids (4×1)× 2, (3×1)×5 and (4×3)×2 was also superior over their parents and the comparison cultivar with a grain yield per unit area of (12.45, 12.01 and 11.91 ton ha^{-1}), respectively, for their superiority in most traits. Finally, the interaction between the two plant populations and the genotypes was significant for most studied traits except the number of rows per ear, as its interaction was not significant. It can be conclude from the above results that the crosses obtained are appropriate for the fall season and that the single hybrids was superior over their parents (inbred in bred lines) and the best one was hybrid (3×2), which gave the highest yield of 11.43 ton ha^{-1}. As well as, the triple hybrid (2×1)×5 was superior with the highest yield reached 12.75 ton/ha. It can be suggest that should be continue cultivated these superior) single and triple) hybrids in the fall season and tested under higher populations and other abiotic stresses such as drought.

Key words: Triple, Single Crosses, Maize.

Introduction

In order to achieve a significant increase in the quantity and quality the grain yields of maize crop, it is necessary to pay attention to the breeding and improvement programs. The production of single, triple hybrids and other hybrids is achieved by identifying the best-inbred inbred lines and the best hybrids that result from mating those inbred in bred lines. Single hybrid result from mating between two genetic diversity inbred in bred lines to obtain a hybrid that contains new genotypes. Plant breeders identify the best parents to produce local genotypes with good production specifications adapted to achieve the highest yield. Cockerham (1961) showed that the benefit of crossing is to obtain genetic variations between second-generation individuals and these individuals are characterized by giving a higher yield than the highest parents involved in their production. Griffing (1956) suggested the dialed cross, which is an important system for identifying the inheriting mechanism of different traits. While Rawlings and Cockerham (1962) proposed the triple cross system that gives broader information about the nature of gene action. Furthermore, the production of hybrids requires a great deal of effort and continuous scientific research to select the best parents as primary genetic material and determine the good combination between parents to produce single, triple and other double crosses Al-Zuhery and Al-Zubaidy, (2017), because it is a cross-pollinated and its tasseling separated from sulking and clear. Pollen can be easily transported from tasseling to sulking (AL-Rawi, 2012), which means that single crosses can be easily produced, but before the cross, it is necessary to evaluate the inbred in bred lines to determine the heterosis of the first-generation to see if the hybrid is suitable for commercial use. In order to determine the best combining parents and the best hybrid production, it is necessary to estimate some of the genetic features of them and the triple hybrids are an intermediate case between single and double hybrids. This means that it is across between inbred line and single hybrid and the two inbred in bred lines of single hybrid are ancestors, while the inbred line is considered a parent and the cost of producing triple hybrids is lower than the single and double, where it reduces time in inbred in bred lines selection and this type of crossing gives accurate information. Hybrids are characterized by the rapid division of their cells when compared to the division of parents' cells and the non-additive genes are control this trait (Theurer and Doney, 1997). The productivity of the improved cultivar is linked to genes responsible for inheriting phenotypic genetic traits such as, the number of ears, the number of grains per ear and the grain weight, which is related to the physiological genetic components. For example, the Crop Growth rate (CGR), harvesting index (HI), the total dry matter (TDM) and number of days to maturity (DTM) Wallace and Yan, (1998). It is necessary to know the nature of the combining ability for parents to determine the behavior of the crosses, select the best and identify promising hybrids (Bello and Olaoye, 2009). A study of triple hybrids showed that all the variance sources were significant and this is evidence that there are indications of additional and non-additional effects of the crop and its components and the inbred in bred lines were different in their ability to combining (Dawad and Ahmad, 2004). Anis, (2010) adopted single and triple crossing between maize inbred in bred lines, all the variation sources in the triple crossing analysis were significant and this is indicative of the significant genetic, additional, sovereign and interventional effects in controlling grain yield and its components. To promote the horizontal expansion of maize, modern cultivation methods should be adopt, where the most important of which is the use of high-yield hybrids, with the use of appropriate plant populations to ensures a significant increase in production. As the most of the increases in maize crop was caused by the improvement of cultivation process and the use of high populations Bender *et al.,* (2013). Furthermore, the genetic improvement of the grain yield is due to increase the tolerance of biotic and abiotic stresses, including plant populations (one of abiotic stresses) and that the potential yield in maize is estimated at three times the actual yield. In order to reduce the difference between the potential yield and actual yield, it is necessary to understand the interaction between the genetic factor of genotypes and the environmental factor of the plant populations and the genotypes must be tested under increasing populations (Duvick *et al*., 2004). The maize crop is a crop that responds well to plant populations according to the prevailing environmental conditions in the agricultural area. As its leaves take a certain position on the stem by increasing the populations to ensure that light arrives appropriately, this makes them withstand high populations, this means increasing productivity with increasing number of plants per unit area, Al-Dawdi and Al-Jobouri, (2015). Plant populations causes two types of competition, competition between parts of one plant for water absorption and soil elements, interception of light and competition between plant and another, especially in the sulking stage, competition is low in the early stages of growth and increase when increasing the plant size Hassan (2012). The effect of plant populations is reflected on vegetative growth and hence this is reflected in production and grain yields per unit area Rafai and Nomer, (2017). The aim of this research was to evaluate the genotypes performance of maize single and triple hybrids resulting from cross the genetic diversity inbred in bred lines and with high productivity and tested under two plant populations and compared with a locally synthetic cultivar.

Materials and methods

The study was carried out in the fall season 2018 in the research fields of the College of Agricultural

Engineering Sciences Field Crops Department / University of Baghdad Jadiriya) to evaluate the performance of triple and single crosses and their inbred in bred lines and compared with the synthetic cultivar Ibaa 5018 and estimate the heterosis and its some genetic features. The study was based on five pure inbred in bred lines of maize (ZM43WIZE, ZM60, ZM49W3E, ZM19, CDCN5) and the origin of the first four inbred in bred lines was Yugoslavia and the fifth inbred line was Italy. Their single hybrids 10 which obtained from the half daillel crosses during the spring season 2016 and 11 of their superior triple hybrids obtained from the crosses of single hybrids with their inbred in bred lines during the fall season 2016 and compared with the synthetic cultivar 5018. Moreover, the seeds were planted on 27/7/2018 using Randomized complete Block Design (RCBD) with four replicates in split plot arrangement, where the plant populations of 60 and 80 thousand plantha^{-1} as the main plots while genotypes represented the subplots. The seeds of the genotypes were planted in panels of 2m length and 3m width and the distance from one inbred line to another was 70cm, while the distance between the plants according to plant populations was (23.8 and 17.8 cm) for populations 60 and 80 respectively. Soil practices was carried out which included till aging, softening and dividing as recommended. As well as, Urea fertilizer (350 kg N h^{-1}) was added in two batches, the first two weeks after planting and the second at sulking. Then, a protective dose of granulated diazinon was added at a concentration of (10%) at a rate of 4 kg h^{-1} was placed in the of the plant for the protection from corn stem borer *Sesamia cretica* the crop practices as irrigation and weeding was carried out whenever needed. Five guarded median plants were taken from each experimental unit and the traits data were recorded, number of days to 50% sulking, number of days to 50% Sulking, plant height (cm), number of rows per ear, number of grains per row, number of grains per ear and grain yield per unit area (ton/ha). Statistical analysis of each trait was carried out according to the variance analysis ANOVA in split plot arrangement and the significance was tested by F test at the level of 5% significance and the treatment means were compared with the Least Significant Difference (LSD) with 5% level for all traits using GenStat 2014 program.

Results and discussion

Duration from planting to 50% Sulking

The Means table 1 shows that there were high significant differences between plant populations and genotypes and interaction between them. The two plant populations differed significantly and the low population's plants reached sulking early in 55.17 days, with a difference of three days ear inbred lines for low populations. The reason for this ear inbred lines was the availability and readiness of the growth factors such as sunlight, water and minerals for each plant and this was certainly reflected on the amount of materials manufactured in the source. This was consistent with Sharifi, Namvar, (2016), Ali *et al.,* (2017) and Taha *et al*., (2019) findings, that the difference in plant populations has effected on the number of days to reach the Sulking,

Table 1: Mean number of days from planting to 50% Sulking for maize genotypes) inbred in bred lines, single, triple hybrids and comparison cultivar) under two plant populations for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	80	
1	1inbred line	54.00	60.75	57.38
2	2inbred line	54.50	60.25	57.38
3	3inbred line	48.50	56.75	52.62
4	4inbred line	55.00	60.25	57.62
5	5inbred line	56.50	58.25	57.38
6	(1×2)	61.00	56.50	58.75
7	(1×3)	61.50	56.75	59.12
8	(1×4)	57.50	55.75	56.62
9	(1×5)	55.75	55.50	55.62
10	(2×3)	61.50	63.50	62.50
11	(2×4)	59.50	58.75	59.12
12	(2×5)	62.00	61.00	61.50
13	(3×4)	59.00	61.25	60.12
14	(3×5)	55.50	60.75	58.12
15	(4×5)	53.50	54.75	54.12
16	(2×3) ×1	49.00	57.25	53.12
17	(2×5) ×1	52.50	58.50	55.50
18	(3×5) ×1	50.50	53.75	52.12
19	(4×5) ×1	52.50	56.00	54.25
20	(1×3) ×1	51.00	57.75	54.38
21	(1×4) ×2	54.00	53.50	53.75
22	(3×4) ×2	52.00	63.25	57.62
23	(3×5) ×2	50.00	57.75	53.88
24	(4×5) ×2	54.00	51.75	52.88
25	(1×2) ×5	54.00	54.25	54.12
26	(1×3) ×5	52.00	58.00	55.00
27	Comparison cultivar	62.50	65.50	64.12
	L.S.D 0.05	2.43		1.7
	Mean	55.17	58.07	
	L.S.D 0.05	0.49		
	Inbred inbred lines Mean	56.48		
	Single hybrids Mean	58.56		
	Triple hybrids Mean	54.24		
	General Mean	56.62		

where the low populations plants was early to reach sulking due to the availability of sufficient growth requirements of water, nutrients and sunlight. The table also shows a significant difference between the genotypes in the days to tasting, the parent 3 was earliest and took 52.62 days to reach 50% sulking and it was significantly different from the other parents, which did not differ significantly among them. Furthermore, the parent 4 was the most delayed to reach sulking and took 57.62 days to reach the sulking the parents' Mean was close to the general Mean but lower. The single hybrids were delayed than their parents and the hybrid (5×4) was earliest and took 54.12 days and did not differ significantly from the hybrid (5×1), which took 55.62 days to reach sulking, these two hybrids have reached the sulking for less period than the general Mean, the parents Mean and single hybrids. While the hybrid (3×2) took the longest time to reach sulking amounted 62.5 days delayed than the earliest hybrids by more than 8 days. The triple hybrids differed significantly between them and the Mean of these hybrids differed from the parent's Mean, the single hybrids and the general Mean. The earliest triple hybrids was the (5×3)×3 hybrid, where it took 52.12 days to reach 50% sulking and did not differ significantly from the hybrids (3×2)×1, (4×1)×2 and (5×4)×2, which they took 53.12, 53.75 and 52.88 days respectively. These hybrids was superior over the other triple hybrids and their parents, the single hybrids and the comparison cultivar as well as the general mean. The triple hybrids delayed in sulking was the (4×3)×2 hybrid which took 57.62 days to reach the sulking. All genotypes from parents, single and triple hybrids were significantly superior over the comparison cultivar, which took 64.12 days to reach sulking except the single hybrid (3×2) which was not significantly different from it. The comparison cultivar was delayed to reach the sulking by 12 days from the earliest genotypes triple hybrid (5×3)×1, in general, 13 genotypes exceeded over the trait general Mean, while 25 genotypes was significantly superior over the comparison cultivar. The number of sulking days varies depending on the genotype, this is because of the genetic combination, the number of dominant genes pairs and the type of genetic action of each genotype, thesis consistent with Tollenaar *et al.*, (2006) results. The interaction was significant and the sulking trait responded depending on plant populations and genotypes and the response was towards increase the number of sulking days by increasing plant populations and 19 genotypes increased the number of sulking days by increasing plant populations. Finally, maximum increase in number of days with the populations increased was 11.25 days for the genotype (4×3)× 2 followed by inbred inbred line 3 and the triple hybrid (3×2)×1 with an increase reached 8.25 days for both. As well as, the lowest response for the triple hybrid (2×1)×5 was 0.25 days and this increase was not significant, as well as the hybrids (3×2), (4×3) and (5×4) their increases was not significant.

Duration from planting to 50% sulking

The results of table 2 showed that there were significant differences in the Mean duration from planting to 50% Sulking, for different plant population's levels and genotypes and their interaction. The low populations plants (60 thousand plant/ha) reached 50% Sulking earlier with a mean of 58.80 days, while the high populations plants) 80 thousand plant/ha) needed an Mean number of days of 61.97 days with a difference between the two populations amounted to 3.17 days. The reason for delays the high population's plants is the limited materials processed by the carbon metabolism process because of increased shading of leaves, this led to the continuation of vegetative growth and then delayed the sulking emergence. This was consistent with Mandic, (2011) Ahmad and Fathi, (2018) results, the variation in plant populations effected on duration required of the Sulking appearance. Table 2 data indicates that there were significant differences between genotypes, where the inbred line 3 exceeded by recorded the minimum number of days to reach 50% Sulking of 55.75 days. While the inbred line 4 was delayed as, the longest time needed to reach 50% Sulking of 62.38 days and did not differ significantly from the two inbred in bred lines 1 and 5. Therefore, they reached to the sulking by 61.00 and 61.62 days respectively and it was observed that the Mean of two inbred in bred lines 2 and 3 is lower than the general Mean where reached 60.38 days. As for single hybrids, the hybrid (5×4) was the earliest sulking by giving the lowest Mean number of sulking days was 58.62 days and it did not differ significantly from the hybrid (4×1). Then, the hybrid (3×2) was the last single hybrids to reach the sulking which needed 65.62 days and it did not significantly different from the hybrid (5×2) which needed 64.62 days to reach 50% Sulking, the Mean number of single hybrids was 62.62 days, which was higher than the general Mean and the inbred in bred lines Mean. The triple hybrid (5×4)×2 is one of the earliest hybrids as it needed the minimum number of days of Sulking amounted to 55.50 days and did not differ significantly from the hybrid (3×2)×1 and (4×1)×2 and (2×1)×5 This hybrids was significantly superior over the other triple, single hybrids and their parents except the parent 3 and also superior over the comparison cultivar. While the triple hybrid (4×3)×2 was the last hybrids to reach the sulking as it took 60.50 days and did not differ significantly from the triple hybrid (5×2)×1, The triple hybrids Mean was

Table 2: Mean number of days from planting to 50% Silking for maize genotypes (inbred inbred lines, single, triple hybrids and comparison cultivar) under two plant populations for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	80	
1	1inbred line	58.00	64.00	61.00
2	2inbred line	57.50	63.00	60.25
3	3inbred line	52.50	59.00	55.75
4	4inbred line	59.25	65.50	62.38
5	5inbred line	60.00	63.25	61.62
6	(1×2)	64.50	62.25	63.38
7	(1×3)	66.75	60.25	63.50
8	(1×4)	61.00	59.25	60.12
9	(1×5)	62.50	60.25	61.38
10	(2×3)	64.50	66.75	65.62
11	(2×4)	66.00	61.75	63.88
12	(2×5)	64.50	64.75	64.62
13	(3×4)	63.00	62.25	62.62
14	(3×5)	58.50	66.50	62.50
15	(4×5)	58.50	58.75	58.62
16	(2×3) ×1	52.50	61.00	56.75
17	(2×5) ×1	55.25	63.00	59.12
18	(3×5) ×1	54.50	60.25	57.38
19	(4×5) ×1	57.50	60.00	58.75
20	(1×3) ×1	54.25	61.25	57.75
21	(1×4) ×2	55.50	57.75	56.62
22	(3×4) ×2	55.25	65.75	60.50
23	(3×5) ×2	52.50	62.00	57.25
24	(4×5) ×2	55.50	55.50	55.50
25	(1×2) ×5	56.00	58.25	57.12
26	(1×3) ×5	53.75	61.00	57.38
27	Comparison cultivar	68.00	70.00	69.00
	L.S.D 0.05	2.33		1.64
	Mean	58.80	61.97	
	L.S.D 0.05	0.70		
	Inbred inbred lines Mean	60.20		
	Single hybrids Mean	62.62		
	Triple hybrids Mean	57.65		
	General Mean	60.38		

57.65 days, which is lower than the inbred in bred lines Mean, single hybrids and the general Mean. All genotypes, including parents and their single and triple hybrids were significantly superior over the comparison cultivar, which took the longest duration of 69.00 days to reach 50% Sulking, this is by a difference of 3.38 days over the most delayed single hybrids (3×2). In general, 14 genotypes exceeded over the general Mean, which showed that there was a variation between the genotypes for Sulking trait. The sulking date was influenced by many factors such as the nature of the genotype and the distance between plants, whenever the distance decreases, competition for carbon metabolism materials and the shading increases, which effects on the rapid of sulking emergence. This is consistent with (Tollenaar *et al*., 2006, Latheeth *et al*., 2009, AL-Rawi, 2012), where they showed that the number of days of silking varies with the genetic combination change of the genotype. As for the interaction, the results showed that there were a significant interaction between two plant populations and the genotypes, the interaction was towards increasing the number of days of Silking with increasing plant populations, where it increased in 20 genotypes and decreased in 6 genotypes, while the genotype (5×4)×2 was not affected by plant populations change. The maximum response to the increase in the number of days with the increases of plant populations by 10.5 days for triple hybrid (4×3) ×2 and did not differ significantly from the two hybrids (5×3)×2 and (3×2)×1.

Their increases in the number of days with the with the increases of plant populations was 9.5 and 8.5 days respectively, while the two hybrids (5×2) and (5×4) gave the lowest response reached 0.25 days and did not differ significantly from the two hybrids (4×3) and (2×1)×5.

Plant height (cm)

Table 3, showed that there were no significant differences between plant populations, while there were significant differences between the genotypes and the interaction between the populations and the genotypes. Although there was a difference in the plant height amounted to 5.88 cm, but it was not significant, since the plant height increased at a high populations and reached 197.29 cm compared to the low populations plants who's their plants height was 191.41cm. After the distance between plants decreases, this means increasing the number of plants per unit area, which increases the competing of plants with each other on the growth requirements of water, solar radiation, soil minerals and other materials, because they are limited. Therefore the number of sulking days, vegetative growth, size, number of leaves, leaves shading are increased, which stimulates the action of auxins, gibberellins to increase growth of the stem internodes cells and rapid its division, then it elongates and the stem height increases. This was consistent with Salama *et al*., (2007), Ramezani *et al*., (2011), Abdulla and Harchan, (2014) findings. Table 3 shows that there were significant differences between the genotypes, where the inbred line 5 exceeded by giving the highest plant height of 213.55 cm and differed significantly from the other inbred in bred lines. Followed

Table 3: Mean plant height (cm) for maize genotypes (inbred in bred lines, single, triple hybrids and comparison cultivar) under two plant populations for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	80	
1	1inbred line	173.15	159.75	166.45
2	2inbred line	169.45	165.20	167.33
3	3inbred line	160.25	171.10	165.68
4	4inbred line	141.55	158.95	150.25
5	5inbred line	210.55	216.55	213.55
6	(1×2)	175.65	172.90	174.28
7	(1×3)	198.25	222.30	210.28
8	(1×4)	186.40	180.10	183.25
9	(1×5)	199.95	214.45	207.20
10	(2×3)	196.00	194.85	195.43
11	(2×4)	175.85	171.30	173.58
12	(2×5)	173.20	186.70	179.95
13	(3×4)	188.65	211.20	199.93
14	(3×5)	218.70	218.25	218.48
15	(4×5)	181.70	191.90	186.80
16	(2×3) ×1	211.10	173.05	192.08
17	(2×5) ×1	186.20	195.65	190.93
18	(3×5) ×1	214.70	218.35	216.53
19	(4×5) ×1	186.75	206.95	196.85
20	(1×3) ×1	213.75	208.25	211.00
21	(1×4) ×2	207.00	213.25	210.13
22	(3×4) ×2	204.70	196.60	200.65
23	(3×5) ×2	221.75	214.90	218.33
24	(4×5) ×2	163.05	208.1	185.58
25	(1×2) ×5	221.40	217.25	219.33
26	(1×3) ×5	200.10	246.35	223.23
27	Comparison cultivar	188.25	192.75	190.50
	L.S.D 0.05	17.21		12.17
	Mean	191.41	197.29	
	L.S.D 0.05	NS		
	Inbred inbred lines Mean	172.65		
	Single hybrids Mean	192.92		
	Triple hybrids Mean	205.88		
	General Mean	194.35		

by inbred line 2 with a plant height of 167.33 cm and did not differ significantly from the two inbred in bred lines (1 and 3), while inbred line 4 it gave the highest plant height was 150.25 cm, it was observed that inbred line 5 was superior to the inbred in bred lines Mean and the general Mean. While the rest of the inbred in bred lines their plant height was decreased over their Mean and the general Mean. The single hybrid (5×3) was superior by giving the highest plant height of 218.40 cm and did not significantly differ from the hybrids (3×1), (5×1), which their height reached 210.28, 207.20 cm respectively. While the lowest plant height was 173.58cm for the hybrid (4×2) and did not significantly differ from the hybrids (2×1), (4×1), (5×2) the increase percentage between the highest and lowest single hybrids was 25.87%. The triple hybrid (3×1)×5 exceeded by giving the highest plant height of 223.23 cm and did not differ significantly from (5×3)×1, (3×1)×2, (5×3)×2 and (2×1)×5, which gave a plant height of 216.53, 211.00, 218.33 and 216.33 cm, respectively. The minimum height of the plant reached 185.58 cm for hybrid (5×4)×2 and did not differ significantly from the hybrids (3×2)×1 and (5×2)×1 and (5×4)×1. The triple hybrids Mean was (205.88 cm) that exceeded over the inbred in bred lines Mean, single hybrids and the general Mean of (172.66, 192.92 and 194.35 cm respectively). There were 16 genotypes (1 inbred line, 5 single hybrids and 10 triple hybrids) was superior over the general Meanwhile 10 genotypes were significantly superior over the comparison cultivar.

The variation of stem height between parents and their hybrids was constrained to the genetic traits and the reason for the hybrids superiority is their ability to exploit the available growth factors very well and this is consistent with Al-Dawdi *et al.*, (2015) and Anees *et al.,* (2017) pointed out. The interaction was significant between the genotypes and the plant populations and the interaction was towards increasing the plant height by the increases of plant populations. The number of genotypes that their height increased with increasing plant populations was 15 genotypes, while 12 genotypes their plant height decreased with increasing plant populations. The maximum response of plant height was for the genotype (3×1)×5, where its plant height increased by 46.25 cm with plant populations increasing from 60 thousand to 80 thousand plant ha^{-1} and the genotype (5×4)×2 was not significantly different with an increase of 45.05 cm. The response of these two genotypes differed significantly from the rest of genotypes, while the increasing of plant populations did not significantly increase the plants height

Number of rows per ear

The results of table 4 show that Mean number of rows per ear was significantly affected with the variation of plant populations and genotypes, whereas the interaction between them was not significant. The results of table 4 showed that plant populations was significantly affected on the number of rows per Ear. As the low populations (60 thousand plant/ha) exceeded in the number of rows per ear and gave a number of rows reached 15.59 row ear-1 and when increase the plant populations

Table 4: Mean number of rows per ear for maize genotypes) in bred lines, single, triple hybrids and comparison cultivar) under two plant population for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	80	
1	1inbred line	14.70	13.70	14.20
2	2inbred line	15.18	15.00	15.09
3	3inbred line	15.35	14.58	14.96
4	4inbred line	15.67	14.55	15.11
5	5inbred line	17.13	15.45	16.29
6	(1×2)	14.75	15.05	14.90
7	(1×3)	16.20	15.00	15.60
8	(1×4)	15.20	13.80	14.50
9	(1×5)	16.10	14.15	15.13
10	(2×3)	16.10	14.95	15.53
11	(2×4)	14.10	14.05	14.08
12	(2×5)	15.70	14.35	15.03
13	(3×4)	15.60	14.65	15.13
14	(3×5)	16.35	15.55	15.95
15	(4×5)	15.10	15.35	15.23
16	(2×3) ×1	16.00	14.50	15.25
17	(2×5) ×1	15.30	14.75	15.03
18	(3×5) ×1	14.90	14.50	14.70
19	(4×5) ×1	14.60	14.55	14.58
20	(1×3) ×1	16.30	15.00	15.65
21	(1×4) ×2	15.10	14.50	14.80
22	(3×4) ×2	15.98	15.70	15.84
23	(3×5) ×2	16.70	14.20	15.45
24	(4×5) ×2	15.10	14.55	14.83
25	(1×2) ×5	16.20	15.15	15.68
26	(1×3) ×5	15.60	15.05	15.33
27	Comparison cultivar	15.82	14.90	15.36
	L.S.D 0.05	N.S.		0.98
	Mean	15.59	14.72	
	L.S.D 0.05	0.25		
	Inbred inbred lines Mean	15.13		
	Single hybrids Mean	15.11		
	Triple hybrids Mean	15.19		
	General Mean	15.15		

to 80 thousand plantain gave the lowest Mean for this trait reached 14.72 row ear^{-1}, with an increase of 5.91%. This result was consistent with Sharifi *et al*., (2009) pointed out that the number of grains in row increased significantly by increasing the distance between plants. The results of table 4, showed that there were significant differences between the parents, their single and triple hybrids and comparison cultivar. It was observed that inbred line 5 was significantly superior over all inbred in bred lines by giving the highest Mean number of rows per ear reached 16.29 row ear^{-1}. While inbred line 1 gave the lowest Mean reached 14.20 row ear-1 and did not differ significantly from the inbred in bred lines 2, 3 and 4 and the inbred in bred lines Mean was (15.13) which is lower than the general Mean (15.15). As for the single hybrids, the hybrid (5×3) gave the highest Mean for the trait reached 15.95 row ear^{-1} and did not significantly differ from 6 hybrids (3×1) and (5×1) and (3×2) and (5×2) And (4×3) and (5×4). As well as, the single hybrid (4×2) gave the lowest Mean number of rows per ear reached 14.08 row ear^{-1} and did not significantly different from single hybrids (2×1), (4×1) and (5×2) which gave an Mean number of rows amounted to 14.90, 14.50 and 15.03 row ear^{-1} respectively. The Mean triple hybrids was higher than the inbred inbred lines Mean, single hybrids and the general Mean. The hybrid (4×3)×2 gave the highest Mean reached 15.84 row ear^{-1} and did not significantly differ from 7 of the triple hybrids) (3×2) ×1, (5×2)×1 and (3×1)×2, (4×3)×2, (5×3)×2, (2×1)×5 and (3×1)×5. Whereas the triple hybrid (5×4)×1 gave, the lowest Mean number of rows reached 14.58 row ear^{-1} and did not differ significantly from 7 of the triple hybrids. When comparing all genotypes with the synthetic cultivar, it observe that 8 genotypes was non-significant exceeded and also observe that 12 genotypes exceeded over the general Mean (1 inbred line, 4 single hybrids and 7 triple hybrids). The difference in genotypes in the number of rows per ear are due to the genetic factor, this is consistent with Anees *et al*., (2017) findings. Finally, the results of table 4 showed that the interaction was not significant between plant population and genotypes in the number of rows per ear.

Number of grains per row

The results of table 5 showed that the plant population levels had a significant effect on the Mean number of grains per row and the results showed that there were significant differences between the genotypes and their interaction with the plant population. Moreover, the results indicate that the decrease of plant population from 60 to 80 thousand plant/ha caused a decrease in the Mean number of grains per row, where the low population plants was significantly superior in the Mean number of grains per row reached 40.24 grain/row over the high populations plants of 2.71 grain row. The reason for the Mean number of grains per row increase is due to increase the Mean ear length in the low populations, this is consistent with (Abed-Alamir, 2017) findings. As well as, the results showed that there were a significant differences between genotypes, it was observed that inbred line 1 gave the highest Mean number of grains per row 36.33 grain row, which was not significantly different from the two inbred in bred lines 3 and 4, which they gave 34.83 and 34.33 grain/row respectively. Although, inbred line 2 gave the lowest Mean number of grains per row 33.05 grain row and did not differ significantly from the inbred in bred lines 3, 4 and 5, the inbred in bred lines Mean were lower than the general Mean, as their number of grains per row was 34.49 and 38.88 grain row respectively. As for the single hybrids, the hybrid (3×1) was significantly superior over the most single hybrids by giving the highest number of grains per row reached 41.59 grain/row, but it did not differ significantly from the hybrids (4×1) and (5×1), (3×2) and (5×4) which Mean 40.48, 38.93, 40.68 and 39.98 grain/ear respectively. Though, the hybrid (2×1) gave the lowest Mean was 36.57 grain/row and did not differ significantly from the hybrid (5×2), which its Mean number of rows per ear amounted to 36.63 grains row, the increase between the highest and lowest single hybrids was 5 grain row with an increase of 13.73%. Furthermore, table 5, showed that the Mean triple hybrids was higher than the general Mean and the highest Mean of 42.18 grain/row for the hybrid (5×3)×1 and did not significantly differ from 6 of the triple hybrids (5×4)×1 and (3×1)×2, (4×1)×2, (5×4)×2, (2×1)×5 and (3×1)×5. However, the hybrid (4×3)×2 gave the lowest Mean reached 37.62 grain/row and it did not significantly different from the hybrids (3×2)×1 and (5×2)×1. The Means number of grains per row for arents and their single and triple hybrids indicate that the latter was the highest, where the Mean triple hybrids was 40.39 grain row, which is higher than the general Mean of 38.88 grain row Because of varied the inbred inbred lines and their hybrids, it can observed that 17 genotypes (8 single hybrids and 9 triple hybrids) were superior over the general Mean 38.88-grain row As well as, 17 genotypes were significantly superior over the comparison cultivar (8 single hybrids and 9 triple hybrids), where its Mean number of grains was 36.43 grain row. The number of grains per row in ear is directly affected by fertilization and if suitable conditions availability and the pollination process is complete, grains are formed along the ear and this is consistent with Gassim and Hassan, (2016) and Abed-Alamir, (2017) findings. The results of table 5 indicated that there was a significant interaction between the plant population's levels and the genotypes and the interaction was towards decreasing the number of grains per row with increasing plant populations. Since the number of grains per row for all genotypes decreased with increasing plant populations except the single hybrid (5×4) and the triple hybrid (4×3)×2 in which the number of grains per row increased by increasing the plant populations. However, the increase was not significant (from 39.25 to 40.70 grain/row, from 37.44 to 37.80 grain row for the two hybrids respectively).

Table 5: Mean number of grains per row for maize genotypes (inbred inbred lines, single, triple hybrids and comparison cultivar) under two plant populations for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	**80**	
1	1inbred line	37.85	34.80	36.33
2	2inbred line	36.05	30.05	33.05
3	3inbred line	37.05	32.61	34.83
4	4inbred line	35.10	33.55	34.33
5	5inbred line	34.92	32.90	33.91
6	(1×2)	38.05	35.10	36.57
7	(1×3)	43.75	39.44	41.59
8	(1×4)	43.45	37.51	40.48
9	(1×5)	42.85	35.00	38.93
10	(2×3)	41.95	39.40	40.68
11	(2×4)	39.95	38.60	39.28
12	(2×5)	38.96	34.30	36.63
13	(3×4)	39.49	39.30	39.39
14	(3×5)	39.40	38.75	39.08
15	(4×5)	39.25	40.70	39.98
16	(2×3) ×1	38.95	36.95	37.95
17	(2×5) ×1	41.10	37.00	39.05
18	(3×5) ×1	43.40	40.95	42.18
19	(4×5) ×1	43.25	39.05	41.15
20	(1×3) ×1	41.70	38.75	40.23
21	(1×4) ×2	43.25	40.60	41.93
22	(3×4) ×2	37.44	37.80	37.62
23	(3×5) ×2	40.50	39.40	39.95
24	(4×5) ×2	41.60	40.40	41.00
25	(1×2) ×5	41.86	39.50	40.68
26	(1×3) ×5	43.25	39.50	41.38
27	Comparison cultivar	38.45	34.40	36.43
	L.S.D 0.05	2.98		2.11
	Mean	40.24	37.53	
	L.S.D 0.05	0.49		
	Inbred inbred lines Mean	34.49		
	Single hybrids Mean	39.26		
	Triple hybrids Mean	40.28		
	General Mean	38.88		

The maximum response of the number of grains per row was 7.85 grain/row for hybrid (5×1) and did not significantly differ over the hybrid (4×1) response and inbred line 2, which their responded was 6.24 and 6.00 grain row respectively. Finally, the lowest response of the number of grains per row was 0.19 grain/row for hybrid (4×3) and did not significantly different from 14 genotypes (3 inbred inbred lines, 4 single hybrids and 7

Table 6: Mean number of grains per ear for maize genotypes (inbred inbred lines, single, triple hybrids and comparison cultivar), under two plant populations for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	80	
1	1inbred line	554.8	480.3	517.6
2	2inbred line	547.0	451.0	499.0
3	3inbred line	565.3	475.6	520.4
4	4inbred line	548.8	487.8	518.3
5	5inbred line	595.9	508.1	552.0
6	(1×2)	560.8	526.7	543.7
7	(1×3)	708.2	591.9	650.1
8	(1×4)	658.9	516.9	587.9
9	(1×5)	688.8	495.0	591.9
10	(2×3)	674.4	587.9	631.2
11	(2×4)	562.3	540.7	551.5
12	(2×5)	605.2	490.3	547.7
13	(3×4)	615.8	573.9	594.8
14	(3×5)	643.1	602.2	622.6
15	(4×5)	592.4	623.1	607.7
16	(2×3) ×1	622.4	534.3	578.4
17	(2×5) ×1	628.0	565.3	585.0
18	(3×5) ×1	645.9	592.7	619.3
19	(4×5) ×1	631.0	567.3	599.2
20	(1×3) ×1	680.0	577.5	628.8
21	(1×4) ×2	652.8	586.7	619.8
22	(3×4) ×2	597.6	596.3	596.9
23	(3×5) ×2	676.3	558.6	617.5
24	(4×5) ×2	627.3	582.4	604.8
25	(1×2) ×5	676.9	598.9	637.9
26	(1×3) ×5	674.1	592.7	633.4
27	Comparison cultivar	608.1	514.9	561.5
	L.S.D 0.05	44.56		31.51
	Mean	623.8	548.0	
	L.S.D 0.05	9.90		
	Inbred inbred lines Mean	521.46		
	Single hybrids Mean	592.91		
	Triple hybrids Mean	611.00		
	General Mean	585.9		

triple hybrids).

Number of grains per ear

Data and Means of trait in table 6 indicate that there were significant differences between plant populations and between parents and their single and triple hybrids and the interaction between genotypes and plant populations in the number of grains per ear. It was observed that the number of grains per ear was significantly reduced when increased the plant populations from 60,000 to 80,000 plant/haby 75.8 grains, which formed a decrease percentage amounted to 12.15%. This was due to the fact that cultivating a plant at low populations, this mean increasing the distance between one plant to another has led to an increase in the number of rows per ear, as well as an increase in the number of grains per row as shown in table 4 and 5. As a result, there was an increase in the number of grains per ear and this is consistent with (Latheeth *et al*., 2009, Sharifi *et al*., 2009, Nomer, Al-Hosari, 2015, Farman and Al-Maeini, 2016) findings, where they indicating that the number of grains per ear increase significantly with decreasing plant populations. As shown in table 6, there were significant differences between the genotypes in the number of grains per ear. Where the inbred line 5 was significantly superior over all inbred inbred lines by giving the highest Mean number of grains per ear reached 552.0 grains, with a difference of 53 grains, compared over the inbred line 2, which gave the lowest Mean number of grains per ear reached 499.0 grains. The variation between the inbred inbred lines was reflected on the single and triple hybrids Means, where the Mean of highest single hybrids was 650.1 grains per single hybrid (3×1) and did not differ significantly from the hybrids (3×2) and (5×3). Moreover, the lowest Mean of the single hybrids for number of grains per ear was 543.7 grain/ear of single hybrid (2×1), that it did not differ significantly from the two single hybrids (4×2) and (5×2) which they have the same parent (2), where their number of grains per ear 551.5 and 547.7 grain/ear respectively. The Mean single hybrids 592.91 grain/ear was higher than the inbred inbred lines Mean and the general Mean (521.46, 585.90 grain ear respectively). As shown from the table that the highest number of grains per ear in the triple hybrids was 637.9 for the triple hybrid (2×1)×5 and did not differ significantly from the hybrids (5×3)×1, (3×1)×2, (4×1)×2, (5×3)×2 and (3×1)×5. While the hybrid (3×2)×1 gave the lowest Mean number of grains per ear was 578.4 grain/ear and did not significantly different from the triple hybrids (5×2)×1, (5×4)×1, (4×3)×2 and (5×4)×5 which gave an Mean of 585.0, 599.2, 596.9 and 604.8 grain/ear respectively. The Mean of triple hybrids was 611.0, which is higher than their parent's Mean (inbred inbred lines Mean, single hybrids) and from the general Mean. When comparing the genotypes with the comparison cultivar it found that 14 genotypes (5 single hybrids and 9 triple hybrids) was significantly exceeded over the comparison cultivar and when comparing the genotypes with their general Mean it found that 17 genotypes were higher than the general Mean. The reason for the single hybrid superiority (3×1) over the all genotypes in the number of grains per ear is due to it has the highest leaf area and its index as shown in table 6 and 7 respectively.

It was good source of nutrient processing and has a highest ear length, number of rows, number of grains per row and as a result, the number of grains per ear increased. This is consistent with (Gassim and Hassan, 2016) results. Table 7 also showed that the interaction between populations levels and genotypes was significant and it is observed that all genotypes (5 parents, 9 single hybrids, 11 triple hybrids and the comparison cultivar). the number of grains per ear decreased by increasing plant populations except the single hybrid (5×4), which its number of grains per ear increased by 30.7 grain/ear by increasing the plant populations from 60 to 80 thousand plant/ha. Which it is a non-significant increase, but it effected on increase the single plant yield by increased plant populations as explained in the next section. The number of rows per ear and number of grains per row for hybrid (5×4) also increased as shown in table 4 and 5, by increasing plant populations, this means that it is efficient in using growth sources of water, light and nutrients when increasing populations and the competition. The single hybrid (5×1) gave the highest response (decrease) reached 193.8 grain ear and differed significantly over the all interactions. So, the lowest response by increased the plant populations is 2.7 grain/ ear, which is a non-significant response for the triple hybrid (4×3)×2 and it was not differ significantly from 4 genotypes (2×1), (4×2), (4×3) and (5×3).

Grain yield of unit area (ton ha^{-1})

The results of table 7, showed that there were significant differences between plant populations and inbred in bred lines and their single and triple hybrids and their interaction. It was observed that whenever increase plant populations, the Mean grain yield per unit area increased significantly. The Mean yield at low populations was 9.68 ton/ha, while the Mean at high populations was 11.73 ton/ha, with an increase percentage in grain yield per unit area reached 21.18% over low populations. The reason for the high populations superiority is the increase in number of plants by 20,000 plant/h and these results are consistent with Latheeth *et al*., (2009) and Hassan, (2012) results, that as the number of plants per unit area increases, the yield increases. Table 7 showed that there were significant differences between genotypes (inbred in bred lines and their single and triple hybrids). The inbred line 4 was significantly superior over the other inbred in bred lines, where its Mean yield per unit area 9.36 ton/ha and it was significantly different from all inbred in bred lines. There were an increase of 13.45% from the lowest Mean 8.25 ton/ha which was for the inbred line 1 and did not differ significantly from the two inbred in bred lines 2 and 3 respectively, where the Mean inbred in bred lines was 8.704 ton/ha which is lower than the general Mean of 10.75 ton/ha. The differences in the Mean grain yield per unit area in the inbred in bred lines were reflected on the single hybrids. As it was observed that the single hybrid (3×2) was significantly superior over all the single hybrids and gave the highest Mean amounted to 11.43 ton/ha by an increase percentage of 24.51% compared to the lowest hybrids. However, it did not differ

Table 7: Mean grains yield per unit area (ton ha^{-1}) for maize genotypes) inbred in bred lines, single, triple hybrids and comparison cultivar) under two plant populations for fall season 2018.

Seq.	Genotypes	Plant populations thousand plant/ha		Mean
		60	80	
1	1inbred line	6.93	9.57	8.25
2	2inbred line	8.23	8.87	8.55
3	3inbred line	8.97	8.24	8.60
4	4inbred line	7.52	11.21	9.36
5	5inbred line	7.25	10.58	8.91
6	(1×2)	8.48	11.38	9.93
7	(1×3)	9.84	12.78	11.31
8	(1×4)	10.30	11.62	10.96
9	(1×5)	10.10	11.24	10.67
10	(2×3)	10.24	12.62	11.43
11	(2×4)	9.66	11.10	10.38
12	(2×5)	9.02	9.35	9.18
13	(3×4)	10.27	11.61	10.94
14	(3×5)	9.77	11.46	10.62
15	(4×5)	9.30	12.75	11.03
16	(2×3) ×1	9.67	11.82	10.75
17	(2×5) ×1	10.32	12.01	11.16
18	(3×5) ×1	10.62	12.35	11.48
19	(4×5) ×1	10.25	11.85	11.05
20	(1×3) ×1	11.13	11.87	11.50
21	(1×4) ×2	10.47	14.42	12.45
22	(3×4) ×2	10.97	12.85	11.91
23	(3×5) ×2	10.68	12.25	11.46
24	(4×5) ×2	9.06	13.94	11.50
25	(1×2) ×5	11.95	13.55	12.75
26	(1×3) ×5	10.72	13.29	12.01
27	Comparison cultivar	11.19	13.38	10.91
	L.S.D 0.05	0.64		0.45
	Mean	9.68	11.73	
	L.S.D 0.05	0.28		
	Inbred inbred lines Mean	8.73		
	Single hybrids Mean	10.65		
	Triple hybrids Mean	11.64		
	General Mean	10.75		

significantly over the hybrids (3×1) and (5×4), as their Mean grain yield was 11.31 and 11.03 ton/ha, respectively. Then followed by the hybrids (4×1) with an Mean grain yield of 10.96 ton/ha and did not significantly differ from the single hybrids (5×1), (4×3) and (5×3) with an Means of 10.67, 10.94 and 10.62 ton/ha respectively. Meanwhile, the Mean grain yield per unit area of hybrid (5×2) decreased significantly which gave the lowest Mean was 9.18 ton/ha and significantly different from all single hybrids. The Mean single hybrids was 10.65 ton/ha which was higher than their parents' Mean and lower than the general Mean. The triple hybrid (2×1)×5 was significantly superior over all triple hybrids except the (4×1)×2 hybrid, which did not significantly different from it, by giving the highest grain yield per unit area of 12.75 and 12.45 ton/ha, respectively. Then followed by hybrid (3×1)×5 with grain yield per unit area of 12.01 ton/ha and did not significantly differ from the hybrid (4×3)×2. The increase in the yield of the superior hybrid is 18.60%, compared to the hybrid (3×2)×1, which gave the lowest yield per unit area of 10.75 ton/ha and did not differ significantly from the hybrids (5×2)×1 and (5×4)×1. Where their Mean yield per unit area was 11.16 and 11.05 ton/ha, the Mean triple hybrids of 11.64 was higher than the Mean of single hybrids and their inbred in bred lines and the general Mean by 10.71 ton/ha. When comparing between the genotypes in general, it observe that the Mean of 15 genotypes were higher than general Mean. A 9 genotypes were significantly superior over the comparison cultivar (1 single and 8 triple hybrids), (3×2), (5×3)×1, (3×1)×2, (4×1)×2, (4×3)×2, (5×3)×2, (5×4)×2, (2×1)×5 and (3×1)×5 respectively. The reason for the two inbred in bred lines 4 and 5 superiority in this trait is due to their superiority in most of the vegetative growth characteristics and the yield components. Such as plant and ear height, number of leaves, the ear length, number of rows, number of grain per ear, number of ear and weight of 100 grains, thus increasing the total dry matter weight and the weight of the single plant grain yield. The superiority of these two inbred in bred lines was reflected in the single hybrids, such as the single hybrid (5×4) which gave the yield of a single plant and a relatively high unit area. As well as triple hybrids in which one or both parents participated (4 and 5), especially the hybrids (4×1)×2, (2x1)×5 and (3×1)×5, which gave a higher yield than the other hybrids. Since it bloomed relatively early, it also had a high plant and ear height, a high number of leaves, the ear length, number of rows and number of grains per row. Thus, the number of grains per ear increased with a high number of ear, all this led to reaching the highest total dry weight for the plant and with the high number of days to reach the physiological maturity soit had a very high growth rate that exceeded over the other hybrids. The single plant yield was also high for these hybrids and these results are consistent with (Majeed *et al*., 2017) findings, as they found significant differences between the genotypes by the superiority of second genotype over most of the genotypes and the comparison cultivar. That his superiority is due to the parents involved in the composition as (Hamood, 2019) observed that the superiority of the genotypes that gave the highest Mean number of ear and the number of grains per ear. The results of table 7 indicated that there were a significant interaction between the levels of plant populations and genotypes in the Mean grain yield per unit area. It is observed an increase in the grains yield per unit area for all inbred in bred lines and their single and triple hybrids with increasing plant populations from (60 thousand to 80 thousand plant ha^{-1}) except the inbred line 3thatits Mean decreased from (8.67 to 8.24 ton ha^{-1}) which is a significant decrease.

The maximum significant response in the genotypes to increase the grains yield per unit area when increase the plant populations was 4.88 ton/ha for triple hybrid (5×4)×2. Then, followed by a high response for each of the genotypes (4×1)×2, the inbred line 4, single hybrid (5×4) and the inbred line 3 and given responses of 3.95, 3.69, 3.45 and 3.33 ton/ha respectively. The lowest response to increase the unit area by increase the plant populations was 0.33 ton/ha for single hybrids (5×2) but did not significantly different from the inbred line 2 and triple hybrid (3×1)×2, the triple hybrid (5×4)×2 at the high populations gave the highest Mean grains yield per unit area of 13.94 ton/ha.

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