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Evaluation of New Popcorn Hybrids under Two Plant Densities

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ABSTRACT

Seven popcorn inbred lines were crossed in a half-diallel mating design in2019season. The resulting 21 F_1 hybrids were evaluated in 2020 season in a split plot design with three replications.Two plant densities (D) of 25000 and 31000 plant/feddan were arranged in the main plots and 21 popcorn hybrids were arranged in the sub plots.Data were recorded on days to50% silking, plant height, grain yield, No.of kernels/10g, popping volume, unpopped kernels% and ear diameter. The results showed that plant height,grain yield and unpopped kernels% were affected by plant density. The higher plant density produced taller plants , higher grain yield/ fed and low unpopped kernels% than those under low plant density.Significant variability among popcorn hybrids were detected for all traits. While the interaction between hybrid × plant density was not significant for all studied traits. Two popcorn hybrids(Sk4016×Hp6215)and (ZPB2×Hp6208) had high grain yield/fed and high popping volume. The additive gene effects were more important than non-additive genes effects for the inheritance of number of kernels/10g, popping volume and ear diameter. While, the non-additive gene effects were more important than additive genes in the inheritance of days to50% silking, plant height, grain yield/fed and unpopped kernels%. The desirable inbred lines for general combining ability effects were Hp6208 for earliness, plant height, grain yield/fed, unpopped kernels% and ear diameter, ZPB2 for earliness, number of kernels/10g, popping volume and unpopped kernels%and Hp6215 for earliness, grain yield and number of kernels/10g.The two hybrids (Sk4016×Hp6215andSk6013×Sk6014)exhibited desirable specific combining ability effects for grain yield and popping volume,respectively.

***Keywords**: Diallel cross, Additive gene effects, Non-additive gene effects, Popcorn, Popping volume.*

INTRODUCTION

Popcorn (*Zea mays* L. *everta*) is essentially a flint type of maize grown by native Indians in south, central and North America. The spread and distribution of maize in other parts of the world resulted in increased production, consumption and popularity of popcorn. In Egypt as a result of increasing the demand for consumption of popcorn, hence it is imported from foreign countries. So, the price of popcorn in Egypt is higher four times or more than that of common corn grain (Mosa *et al.* 2019). Not only genetic potential of hybrid (Halluer, 1994), but also cultural practices such as nitrogen fertilizer rates and plant densities have important effects on popcorn yield (Babic and Pajic, 1992). Optimum plant density is another important factor for high grain yield. Yield can be increased with increased plant density up to a maximum for some maize genotypes grown under a set of particular environment a management is increased further (Sezer and Yanbeyi 1997). Demonstrated that ear characteristics were negatively affected by increases in plant densities, although plant height and grain yield increased with increases in plant densities. Popping volume, defined as volume per unit of weight of a sample, is a primary characteristic of popcorn. The popping volume is highly depending on the chemical composition of the kernel, mostly the proportion of hard endosperm. Also the main indicators for popcorn popping volume are the percentage or number of unpopped kernels and grain moisture content at the time of popping. The grain moisture content of kernels is an important factor for high popping volume. Kernels contain a small amount of water stored in a circle of soft starch inside the hard outer surface. When heated the water expands, creating pressure within, until eventually, the casing gives way and the kernels explode and pop, allowing the water to escape as steam, turning the kernels inside out (Anon, 2007). Maximum popping volume was achieved with a grain moisture content ranging from 13 to 14.5%, with 13.5% being optimum (Ziegler *et al*. 1988). The quality factors include the percentage of unpopped kernels, size, and other traits (Ziegler, 2001 and Quinn *et al.* 2005). High yielding popcorn cultivars usually produce low popping volume. Whereas higher popping volume were recorded for low or medium yielding cultivars (Pajic *et al*. 2008). Diallel crosses analysis provide information regarding the general and specific combining ability of a set of genotypes, allowing reliable inference of the best hybrid combinations (Hallauer *et al.* 2010). The best strategy for simultaneously improving yield and expansion capacity would be to use material with good expansion capacity and then select plants with more than one ear (Broccoli and Burak 2004). Also path analysis revealed that cob weight showed very high positive direct effect on popping expansion followed by plant height, days to maturity and to 50% silking (Vijayabharathi *et al.* 2009). Babić and Pajic (1992) and Halluer (1994) mentioned that not only genetic potential of hybrid but also cultural practices such plant density have important effects on popcorn yield. Ülger (1998) demonstrated that highest popcorn yield obtained with planting 15cm intra-row and 70 cm inter-row spacing. Sezer and Yanbeyi (1997) reported that ear traits were negatively affected by increases in plant densities, although plant height and grain yield increased with increasing plant density. Junior *et al.* (2013) found that the increase in plant

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population causes a reduction in the number of grains per ear, but the popping volume index is not affected by row spacing or plant population. Miranda *et al.* (2008) and Pajic *et al.* (2008) concluded that additive gene effects were more important than non- additive effects for popping volume. Jele *et al.* (2014) found that the additive gene effects were more prominent than non- additive effects for unpopped kernels, moisture content and kernels/10g. Oliveira *et al.* (2019) found that the non- additive effects were the most important in the genetic control of grain yield and popping volume. This study aimed to evaluate the combining ability variances and effects for seven traits under two plant density levels and identify hybrids with greater potential for seed quality and superior agronomic traits to meet the increased demand on popcorn in Egypt.

MATERIALS AND METHODS

Seven yellow popcorn inbred lines in the selfing generation S_6 developed from the seven popcorn populations at Sakha Research Station were crossed in a half- diallel mating design according to Griffing's method 4 to generate 21 F_1 crosses in 2019 season. The resulting 21 hybrids were arranged in a split plot design with three replications. Main plots included two plant density of 25000 and 31000 plant per feddan (feddan= 4200 m^2), while sub plots included 21 hybrids in 2020 growing season. Each plot consisted of one row, 6 m long, distance between rows with 0.8 m width and 21 cm between hills in first density and 17.5 cm between hills in second density. The hybrids were managed using standard production practices recommended for maize in Egypt. The data were recorded on days to 50% silking, plant height (cm), ear diameter (cm) and grain yield expressed in ardab/feddan (ard/fed) (ardab= 140 kg) adjusted at 15.5% grain moisture. Popping traits taken on a grain sample from each plot were kernel size determined by number of kernels per 10g, for each classification of kernels, i.e. for large size (52-67), medium size (68-75) and small size (76-105), popping volume measured by placing 30g of grain in hot air popping machine (Volt: 220 v, Hz:50 Hz, power: 1200 w) for 2 minutes, then the popcorn volume was measured in a 2000 ml graduated cylinder and finally the popping volume was determined as the ratio between the expanded popcorn volume and the weight of 30 g of grains (ml/g) and percentage of unpopped kernels measured by dividing number of unpopped kernels on the original number of kernels in 30 g. Statistical analysis for all trails was done according to Steel and Torrie (1980). General and specific combining ability were estimated according to Griffing (1956) diallel cross analysis designated as Method 4 model - 1 (fixed model).

RESULTS AND DISCUSSION

Analysis of variance for seven traits is shown in Table 1. The effects of plant density (D) on plant height, grain yield and unpopped kernels% were significant or highly significant. While, days to 50% silking, No. of kernels/10g, popping volume and ear diameter were not affected by plant density. Also, significant differences among popcorn hybrids (H) were detected for all studied traits. While the interaction between H × D was not significant for all studied traits. Same results were obtained by Jele *et al.* (2014) and Mosa *et al.* (2019).

Table 1. Mean squares from analysis of variance for seven traits.

SOV	df	Days to 50% silking	Plant height (cm)	Grain yield (ard/fed)	No. of kernels/ 10g	Popping volume (ml/g)	Unpopped kernels (%)	Ear diameter (cm)
Rep	2	2.214	164.21	71.457	28.917	57.434	6.94	0.018
Density (D)	1	0.007	1905.5*	306.50**	23.383	4.089	9.895**	0.040
Error (a)	2	6.912	42.72	1.923	4.988	0.551	0.100	0.004
Hybrid (H)	20	17.02**	400.2**	125.04**	61.542**	71.901**	3.49**	0.148**
H×D	20	2.29	31.42	2.04	5.926	4.983	1.388	0.020
Error (b)	80	1.47	58.98	5.62	7.33	7.139	0.906	0.032

***, ** significant at 0.05 and 0.01 levels of probability, respectively.**

The results in Table 2, exhibited that the higher plant density (31000 plant/fed) produced taller plants, higher grain yield/fed and low unpopped kernels % than those under low plant density (25000 plant/fed). Gözübenli and Konuskan (2010) concluded that plant height and grain yield increased with increases in plant density. Junior *et al* (2013) demonstrated that the popping expansion index is not affected by plant density.

Table 2. Effects of plant density on the seven studied traits.

Density	Days to 50% silking	Plant height (cm)	Grain yield (ard/fed)	No. of kernels/ 10g	Popping volume (ml/g)	Unpopped kernels (%)	Ear diameter (cm)
25000 plant/fed	68.41	223.49	16.31	62.55	31.86	3.77	3.20
31000 plant/fed	68.39	231.26	19.43	61.69	32.22	3.21	3.17
LSD 0.05	2.015	5.011	1.063	1.712	0.569	0.242	0.048
0.01	4.649	11.559	2.452	3.949	1.312	0.559	0.111

Mean performance of 21 popcorn hybrids for seven studied traits is presented in Table 3. Means of days to 50% silking ranged from 66 days for Sk4017×Hp6215 to 73.3 days for Sk4017×Sk6014 with a grand mean of 68.4 days, the best hybrids for earliness were Sk4016×Hp6208, Sk4017×Hp6208, Sk4017×Hp6215, ZPB2×Hp6208 and Hp6215×Sk6013.

For plant height (cm), the means ranged from 213.5 to 240 cm for Sk4017×Hp6208 and Hp6208 × Hp6215, respectively, with a grand mean of 227.3 cm. The shortest hybrids were Sk4017 × Hp6208, Sk4017 × Sk6013, ZPB2 × Hp6208 and Hp6208×Sk6013, while the tallest hybrids were ZPB2 × Sk6013, ZPB2 × Sk6014, Hp6208 × Hp6215 and Hp6215×Sk6014.

The mean of 21 popcorn hybrids for grain yield ranged from 10.7 ard/fed for Sk4016×Sk6013 to 23.4 ard/fed for Hp6208×Hp6215 with a grand mean of 17.8 ard/fed. The higher hybrids for grain yield were Hp6208

×Hp6215 (23.4 ard/fed), Sk4016 × Hp6215 (23.3 ard/fed), ZPB2 × Hp6208 (23.2 ard/fed), Hp6215 × Sk6013 (22.8 ard/fed), Sk4017 × Hp6208 (22.7 ard/fed), Hp6208×Sk6014 (22.4 ard/fed) and Sk4016×Hp6208 (21.5 ard/fed). Generally, a popcorn ear is significantly smaller than ear of other types of maize; it's means give us the leads to a decrease in the production of popcorn grain yield. Followed by Oliveira *et al* (2019) reported that the average grain yield of popcorn hybrids ranged from 321.26 to 4496.31 kg/ha.

Table 3. Mean performance of 21 popcorn hybrids for seven studied traits.

Hybrids	Days to 50% silking	Plant height (cm)	Grain yield (ard/fed)	No. of kernels/ 10g	Popping volume (ml/g)	Unpopped kernels (%)	Ear diameter (cm)
Sk4016 × Sk4017	69.3	228.5	13.5	64.6	33.33	8.6	3.3
× ZPB2	67.8	236.6	13.9	68.4	37.5	8	2.9
× Hp6208	67.0	229.6	21.5	60	31.38	6	3.3
× Hp6215	67.3	229.6	23.3	63	31.88	7	3.2
× Sk6013	68	225.8	10.7	61.6	34.22	8.5	2.9
× Sk6014	70.1	227.5	12.6	61.6	35.44	7.6	3.0
Sk4017 × ZPB2	68.1	229.6	16.5	62.7	37.5	6.8	3.2
× Hp6208	67	213.5	22.7	61.5	26.22	5.5	3.4
× Hp6215	66	218.6	20.1	61.1	28.83	5.6	3.3
× Sk6013	70.8	217.1	11.3	56.2	32.22	7.1	3.4
× Sk6014	73.3	225.1	11.4	57.7	31.83	7.3	3.3
ZPB2 × Hp6208	67	216.6	23.2	62.3	30.27	3.6	2.9
× Hp6215	67.5	226.5	17.7	64.7	30.27	5.8	2.9
× Sk6013	68	237.5	17.6	62	34.72	4.8	3.1
× Sk6014	69.8	239.1	16.8	63.2	32.85	6.6	3.0
Hp6208 × Hp6215	68	240	23.4	66.8	29.83	7.8	3.2
× Sk6013	67.8	214.6	19.2	40.9	25.55	5	3.2
× Sk6014	69.5	222.1	22.4	41.8	30.16	3.5	3.2
Hp6215 × Sk6013	66.8	227.1	22.8	61.5	27.77	6.1	3.3
× Sk6014	67.5	239.1	21.0	65.1	33.38	7	3.1
Sk6013 × Sk6014	69.5	230	12.7	59.1	37.77	8.1	3.2
Grand mean	68.4	227.3	17.8	60.2	32.04	6.5	3.2
LSD 0.05	1.38	8.77	2.70	3.09	3.054	1.08	0.204
0.01	1.82	11.57	3.56	4.07	3.979	1.43	0.269

Number of kernels/ 10g indicates the size of kernel. The means ranged from 40.9 for Hp6208 ×Sk6013 to 68.4 for Sk4016×ZPB2 with an average of 60.2 kernels/10g, meaning that all hybrids had a large size, except the hybrid Sk4016×ZPB2 was medium. Lin and Anantheswaran (1988) reported that the large-sized kernels had a significantly higher popping volume than the small sized kernels. Although, Song *et al.* (1991) found that the middle sized kernels had the highest popping volume. Popping volume ranged from 25.55 to 37.77ml/g for Hp6208×Sk6013 and Sk6013×Sk6014, respectively, with a grand mean of 32.04 ml/g. The highest popcorn hybrids for popping volume were Sk6013×Sk6014, followed by Sk4016×ZPB2, Sk4017×ZPB2, Sk4016× Sk6014, ZPB2× Sk6013, Sk4016 ×Sk6013 and Hp6215× Sk6014. Song *et al.* (1991) found that popping volume is one of the primary measures of pop ability, since commercial buyers purchase popcorn by weight and sell by bulk volume. Oliveira *et al.* (2019) found that the popping expansion ranged from 11.8 to 56 ml/g, while Junior *et al.* (2013) observed popping volume of an average of 31 ml/g. Percentage of unpopped kernels is one of the most important quality traits. The means ranged from 3.5 to 8.6 % for Hp6208×Sk6014 and Sk4016×Sk4017, respectively, with an average of 6.5%. The desirable hybrids which had lowest unpopped kernels % were Hp6208 × Sk6014,ZPB2 × Hp6208,ZPB2×Sk6013,Hp6208×Sk6013, Sk4017 × Hp6208 and Sk4017 × Hp6215. Song *et al.* (1991) found that popcorn hybrids and kernels size were significantly affected the percentage of unpopped kernels. Öz and Kapar (2011) found that the unpopped kernels ranged from 2.8 to 10.1%. Ear diameter ranged from 2.9 cm to 3.4 cm for Sk4016× Sk6013 and Sk4017×Hp6208, respectively, with a grand mean of 3.2cm. The highest popcorn hybrids for ear diameter were Sk4017 × Hp6208, Sk4017 × Sk4016, Sk4016 × Hp6208, Sk4017×Hp6215 and Sk6215×Sk6013. to 56 ml/g. In general, from previous results the two popcorn hybrids Sk4016×Hp6215 and ZPB2×Hp6208 had high grain yield/fed and popping volume.

The mean squares of general and specific combining ability and their interactions with two plant densities for seven traits are presented in Table 4. Mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all studied traits, except (SCA) for ear diameter which was significant and the interactions with plant densities (GCA× D) and (SCA× D) which were not significant for all studied traits, except for GCA× D for days to 50% silking which was significant. The magnitude of K^2GCA was higher relative to K^2 SCA for number of kernels/10g, popping volume, and ear diameter, meaning that the additive gene effects were more important than non -additive gene effects for inheritance of these traits. Similar results were obtained by Pereira and Amaral Junjor (2001) and Jele *et al.* (2014), who indicated the predominance of additive effects for popping volume. Rangel *et al.* (2008) and Silva *et al.* (2010) reported that GCA and SCA were significant for grain yield and popping volume, suggesting the existence of additive and non additive effects in the genetic control of these traits. Larish *et al.* (1999), Pereira and Amaral Júnior (2001) and Li *et al.* (2007) found that the additive gene effects were more important in the expression of popping volume, Jele *et al.* (2014) found that the additive gene effects were more prominent than non-additive gene effects for number of kernels/10g.

Table 4. Mean squares of general and specific combining ability and their interactions with two plant densities for seven traits.

SOV	df	Days to 50% silking	Plant height (cm)	Grain yield (ard/fed)	No. of kernels/ 10g	Popping volume (ml/g)	Unpopped kernels (%)	Ear diameter (cm)
GCA	6	36.24**	641.82**	225.95**	132.168**	159.876**	9.84**	0.372**
SCA	14	8.76**	296.7**	81.426**	31.278**	34.2**	1.992**	0.054*
GCA×D	6	3.81*	55.73	3.597	6.294	7.227	1.953	0.024
SCA×D	14	1.641	21.015	1.374	5.766	4.02	1.152	0.018
Error	80	1.47	58.98	5.62	7.33	7.139	0.906	0.032
K^2GCA/ K^2SCA	-	0.33	0.30	0.463	1.56	1.92	0.06	1.01

***, ** significant at 0.05 and 0.01 levels of probability, respectively.**

The results in Table 5, exhibited that the desirable general combining ability (GCA) effects were obtained by the inbred lines, Hp6208, Hp6215 and ZPB2 for earliness, Sk4017 and Hp6208 for short plant, Hp6208 and Hp6215 for grain yield, Sk4016, ZPB2 and Hp6215 for high number of kernels/10g, Sk4016, ZPB2 and Sk6014 for popping volume, Hp6208 and ZPB2 for unpopped kernels% and Sk4017 and Hp6208 for ear diameter.

Table 5. Estimates of general combing ability effects of seven inbred lines for seven traits.

Lines	Days to 50% silking	Plant height (cm)	Grain yield (ard/fed)	No. of kernels/ 10g	Popping volume (ml/g)	Unpopped kernels (%)	Ear diameter (cm)
Sk4016	-0.152	2.709**	-2.313**	6.719**	2.298**	1.338**	-0.059*
Sk4017	0.847**	-6.323**	-2.283**	-5.181**	-0.468	0.404	0.183**
ZPB2	-0.419*	4.376**	-0.220	6.485**	2.165**	-0.661*	-0.192**
Hp6208	-0.819**	-5.523**	5.076**	-3.514**	-3.76**	-1.528**	0.057*
Hp6215	-1.452**	3.376**	4.286**	5.785**	--2.057**	0.071	0.0005
Sk6013	0.114	-2.39	-2.537**	-8.681**	-0.002	0.138	0.030
Sk6014	1.881**	3.776**	-2.007**	-1.614	1.831**	0.238	-0.0195
LSD g_{ij} 0.05	0.405	2.570	0.791	2.661	0.893	0.596	0.057
0.01	0.528	3.349	1.031	3.468	1.164	0.777	0.075
LSD g_i-g_j 0.05	0.619	5.115	1.209	4.065	1.365	0.911	0.088
0.01	0.807	6.666	1.576	5.297	1.779	1.187	0.115

***, ** significant at 0.05 and 0.01 levels of probability, respectively.**

The best hybrids for specific combing ability effects of 21 hybrid for seven traits is shown in Table 6. The most desirable hybrid was Sk4017×Hp6208 for earliness, grain yield and number of kernels/10g, Sk4017×Hp6215 for earliness, plant height and Popping volume kernels%, Sk4016×Sk6014 for plant height and number of kernels/10g, Hp6208×Hp6215 for number of kernels/10g and popped volume, Sk6013× Sk6014 for earliness and popping volume, ZPB2×Hp6208 and Sk6215× Sk6014 for earliness, Hp6215× Sk6013, ZPB2× Sk6013and Sk4016× Hp6215 for grain yield, Hp6208×Sk6014 for unpopped kernels%, and Sk4016×Hp6208 for ear diameter. These popcorn hybrids will be tested in advanced trails for further evaluation.

Table 6. The specific combing ability effects of 21 hybrid for seven traits.

cross	Days to 50% silking	Plant height (cm)	Grain yield (ard/fed)	No. of kernels/ 10g	Popping volume (ml/g)	Unpopped kernels (%)	Ear diameter (cm)
Sk4016 × Sk4017	0.233	4.733	0.244	6.089*	-0.545	0.4	0.034
× ZPB2	0.00	2.200	-1.419	5.756*	0.989	0.8	0.011
× Hp6208	-0.433	5.100*	0.868	-9.578**	0.811	-0.333	0.161**
× Hp6215	0.533	-3.800	3.541**	-9.878**	-0.40	-0.933	0.084
× Sk6013	-0.367	-1.867	-2.302*	0.589	-0.122	0.5	-0.212**
× Sk6014	0.033	-6.367*	-0.932	7.022**	-0.732	-0.433	-0.078
Sk4017 × ZPB2	-0.667	4.233	1.218	0.489	3.756**	0.567	0.034
× Hp6208	-1.433**	-2.033	2.121**	6.989**	-1.589	0.1	-0.015
× Hp6215	-1.800**	-5.767*	0.294	-3.644	-0.69	-1.333*	-0.075
× Sk6013	1.467**	-1.500	-1.716	-3.678	0.645	0.1	0.011
× Sk6014	2.200**	0.333	-2.162	-6.244*	-1.577	0.167	0.011
ZPB2 × Hp6208	-0.167	-9.567**	0.558	-2.344	-0.167	-0.667	-0.105
× Hp6215	0.967*	-8.633**	-4.152**	-4.478	-1.879*	-0.1	-0.048
× Sk6013	-0.100	8.133**	2.571**	1.989	0.513	-0.167	0.087
× Sk6014	-0.033	3.633	1.224	-1.411	-3.211**	0.567	0.021
Hp6208 × Hp6215	1.867**	14.767**	-3.832**	11.856**	3.613**	2.767**	-0.065
× Sk6013	0.133	-4.800	-1.209	-1.344	-2.722**	-0.133	-0.012
× Sk6014	0.033	-3.467	1.494	-5.578*	0.055	-1.733**	0.037
Hp6215 × Sk6013	-0.233	-1.200	3.214**	1.189	-2.211*	-0.567	0.111
× Sk6014	-1.333**	4.633	0.934	4.956	1.568	0.167	-0.005
Sk6013 × Sk6014	-0.900*	1.233	-0.559	1.256	3.898**	1.267*	0.014
LSD s_{ij} 0.05	0.800	5.068	1.561	5.248	1.762	1.176	0.114
0.01	1.042	6.604	2.034	6.839	2.297	1.533	0.148
LSD $s_{ij} - s_{kl}$ 0.05	1.073	6.800	2.095	7.041	2.365	1.579	0.153
0.01	1.398	8.861	2.729	9.175	3.081	2.057	0.199

***, ** significant at 0.05 and 0.01 levels of probability, respectively.**

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تقييم هجن جديدة للذرة الفشار تحت كثافتين نباتيتين

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قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

تم عمل تهجين بين 7 سلالات جديدة من سلالات الذرة الفشار في نظام النصف الداليل في موسم 2019. تم تقييم 21 هجين الناتجة فى موسم 2020 في تصميم القطع المنشقة في ثلاث مكرارات. كما اشتملت الدراسة القطع الرئيسية علي كثافتين 25000 نبات للفدان و 31000 نبات للفدان بينما القطع المنشقة اشتملت علي21هجين فيشار. أخذت البيانات علي الصفات عدد الأيام حتى ظهور 50% من حرائر النورات المؤنثة وارتفاع النبات ومحصول الحبوب للفدان وعدد الحبوب فى 10جم وحجم التفشير ونسبة الحبوب غير المفشرة وقطر الكوز. أظهرت النتائج أن ارتفاع النبات ومحصول الحبوب ونسبة الحبوب الغير مفشرة كانت أكثر تأثرآ للكثافة النباتية. وأن الكثافة العالية زادت من ارتفاع النبات ومحصول الحبوب للفدان وانخفاض نسبة الحبوب غير المفشرة بالمقارنة بالكثافة النباتية المنخفضة. كان هناك اختلافات معنوية بين هجن الفشار المقيمة لجميع الصفات تحت الدراسة. بينما تباين التفاعل بين الهجن والكثافة النباتية لم يكن معنويا في كل الصفات المدروسة. هجيني الفشار (Sk4016×Hp6215) و (ZPB2×Hp6208) جمعا بين محصول الحبوب العالي للفدان وحجم التفشير العالي. تأثيرات الفعل الوراثى المضيف كانت الأكثر اهمية فى وراثة عدد الحبوب فى 10جم وحجم التفشير وقطر الكوز ، بينما تأثيرات الفعل الوراثي غير المضيف كانت الاكثر اهمية فى وراثة صفات عدد الأيام حتى ظهور 50% من حرائر النورات المؤنثة وارتفاع النبات و محصول الحبوب للفدان ونسبة الحبوب غير المفشرة. كانت السلالات المرغوبة فى القدرة العامة على الائتلاف:,Hp6208 لصفات التبكير ومحصول الحبوب للفدان ونسبة الحبوب غير المفشرة و قطر الكوز والسلالةZPB2 لصفات التبكير وعدد الحبوب فى 10جم و حجم التفشير ونسبة الحبوب غير المفشرة والسلالة Hp6215 لصفات التبكير ومحصول الحبوب للفدان و حجم التفشير. كذلك اظهر الهجينين Sk4016×Hp6252 و Sk6013×Hp6014 قدرة خاصة على الائتلاف لصفتى محصول الحبوب للفدان و حجم التفشير.