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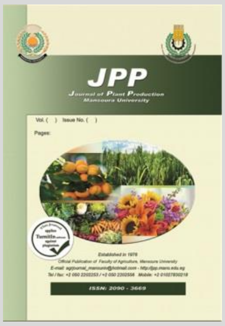
Estimation of Genetic Variance in Yellow Synthetic Maize "Moshtohor 108" with Reference to Expected Gain from Different Selection Methods

EL-Hosary, A. A. A.*

Department of Agronomy, Faculty of Agriculture, Benha University, Egypt.



ABSTRACT

The field work dealing with this study was conducted during successive seasons of 2019 and 2020 in order to improve synthetic variety "Moshtohor 108". Hybridization were made between 36 male and 4 different females to made design-I as outlined by Comstock and Robinson (1948) to produce 144 full-sib families in the first season. In 2020, 144 crosses were randomly divided into 4 sets and assigned at randomized complete block design with 3 replicates. The data were taken on maturity date, grain yield plant^{-1} and its components. Additive (σ^2A), dominance (σ^2D) variances, heritability and expected gain from various methods of selection were estimated within the synthetic "Moshtohor 108". Males/set and females/male/set mean squares were significant for all studied traits. σ^2D was significant and great than σ2A for most studied characters. High heritability in broad sense for all studied traits were detected and ranged from 85.83 to 79.79 along with low or moderate narrow sense were detected for all traits except 100-kerenl weight. Predicted genetic advance per cycle for improvement of "Moshtohor 108" were calculated for six methods of selection. High Δ g % for grain yield plant^{-1} were achieved by using methods of test cross, half-sib with selfed seed selection and S2 fill-sib selection and Δ g % reached 13.87, 8.4 and 8.27%, respectively. From this study, it is possible to improve the variety under study, since large variance within it and presence of additive variation with a medium degree. Thus the yield potential of this variety can be improved.

Keywords: Maize, Genetic variance, Additive, Dominance, Heritability, Selection methods

INTRODUCTION

The synthetic variety had important values for the maize breeder. It is utilized for various purposes like discover inbred lines distinguished with general combining ability, isolate new inbred lines or can be used for commercial production because of low prices of seeds producing. Thus, good breeder must know how can maintain and improve these synthetic variety.

Knowledge of genetic variance components in maize population is essential to improve population base. At the beginning of efficient breeding methodology for population enhancement (Hu *et al*., 2019), it is important that estimate the relative magnitude involved of additive and non-additive types of gene action within population (Santantonio 2020). If the estimates of genetic variance indicate that the additive genetic variance is of a major importance, heritability would be expected to be relatively high, and single plant selection should initially be effective in improving the trait under consideration. In contrast, existence of dominant or epistasis compared with low additive justifies the use of hybrid program.

Various models were sophisticated to partition the genetic variance to further components. The theory and methods for estimate genetic variance for quantitative characters were inferred by Comstock and Robinson (1948). These methods were reviewed by the same authors in (1952) and were identified later as Design I, II and III. Gardner (1961) obtained positive advance from mass selection for yield in maize after modifying the field procedures through minimizing the environmental variance and increasing the selection differential. To gain accuracy information on the genetic variance optimum female and male sample size were determined by El-Hosary (1987) and El-Badawy (2011). They reported that 4 females with more than 24 males are suitable for estimate of genetic variance and its implication on expected gain from selection.

This study was designed and implemented for evaluating the amount of genetic variance and its components in the synthetic variety "Moshtohor (M) 108 " as well as finding out extra magnified selection method that could be used to improve the yielding ability of this population.

MATERIALS AND METHODS

The field trail was conducted at the Agricultural Research and Experimental Center, Faculty of Agriculture, Moshtohor, Kalubia, Benha University, Egypt, during the two growing seasons 2019 and 2020. Before the onset of the field trial, yellow synthetic "Moshtohor 108" was available as base population which was formed from crossing between local and exotic good combiner materials by Prof. Dr. A.A. El-Hosary. In 25th June 2019, 60 ridges of 6 meter long involving yellow synthetic "Moshtohor 108" were hand-planted to produce the families (material grains of design-I mating) at the time of flowering according to Comstock and Robinson, (1948). Random one plant from each ridge used as pollen parent (male) to made hybridization with six ears of random female plants. At harvest, ears from the first four females per each male that had sufficient seeds were harvested. The insufficient grains were discarded. Only 36

* Corresponding author.
E-mail address: ahmed.alhossary@fagr.bu.edu.eg
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half-sib families (males groups) were obtained each had four females (full-sib families). Therefore, the total numbers of full-sib families were 144. The thirty six male groups (half-sib) were divided at random into four sets each one involved 9 half-sib families. In 6th June of season 2020, one hundred and forty four full-sib families were arranged in a randomized complete block design in sets with three replications. Each plot (full-sib family) consists of one ridge 5-m of 20 single-hill plants and ridge-to-ridge was spacing were kept at 70 cm. Favorable growing conditions permitted a normal expression of the characters and good yield performance. The optimum cultural practices were allowed as usual for ordinary maize field in the area. Data were recorded on guarded plants from each plot. Then, averaged data over the number of harvested plants were calculated. Data were scored on 10 guarded plants for each ridge for; days to maturity, ear length (cm), ear diameter (cm), No. of rows ear^{-1}, No. of kernels row^{-1} and 100-kernel weight (g) and grain yield plant^{-1} (g) adjusted to 15.5% moisture. Comstock and Robinson (1948) method of analysis procedure were followed to estimate the genetic components on mean of samples for each set (four sets) separately and then pooled for all sets. However, the variance of genetic components, heritability, expected genetic gain per cycle for different selection methods (mass selection, modified ear to row, half-sib, full-sib, test cross population as a tester and S_1 selection), and environmental variances were calculated according to Hallauer and Miranda (1988).

RESULTS AND DISCUSSION

Estimation of genetic and environmental parameters.

Statistical and genetical parameters estimated from the mating scheme (design I) as outlined by Comstock and Robinson (1948) are given in Table 1. In translating the various variance components in terms of additive and dominance variances, the assumptions were considered; random choice of the male and females, no maternal effects, regular diploid inheritance, no linkage and epistasis effects. Lack of success for any aforementioned assumptions is leading to imbalance in estimates of genetic variants and the parameters linked with them. The previous assumptions were fulfilled in the population under study. Synthetic yellow maize was used in this study namely "Moshtohor 108" is in linkage equilibrium**.**

The estimates of mean squares of set (s), male (m)/s, females/ m/s for all seven characters together are shown in Table 1. Significant or highly significant differences were detected for mean squares of male/s and females/m/s for all studied traits (Table, 1).

Table 1. Mean ($\bar{X}$), Average coefficient of variability (CV) and analysis of variance (ANOV) for the studied traits over sets.

S. O. V.	Df	Maturity date (day)	Ear diameter (cm)	Ear length (cm)	No of kernels row^{-1}	No of rows ear^{-1}	100-kernel weight (g)	Grain yield plant^{-1} (g)
Sets (s)	3	305.7**	0.33**	35**	415.95**	3.25*	58.69**	11366.71**
Rep/ s	8	20.07*	0.27	4.5	57.47**	1.26	15.52	1631.38**
Male/s	32	43.2**	0.46**	13.21**	156.77**	12.44**	146.52**	5270.72**
Females /m/s	108	28.17**	0.23**	9.09**	141.43**	8.97**	46.23**	4690.52**
Error	280	5.99	0.09	2.38	18.63	0.87	5.97	359.08
Cv		2.33	7.16	7.77	11.94	7.39	6.89	12.20
$\bar{X}$		105.3	4.3	19.9	36.1	12.6	35.4	155.4

***and** Significant at 5% and 1% level of probability, respectively.**

Additive, dominance, degree of dominance and heritability.

The amount of basis in the case σ^2A is a function of the additive type of gene action, while the bias in the dominance variance (σ^2D) is a function of dominance. Values of the additive and dominance genetic variance were significant for all the studied traits. Therefore, it could be concluded that the both additive and dominance were significantly influence traits within new synthetic "Moshtohor 108". Moreover, the amount of bias in the estimator of σ^2D is greater than the bias in the estimator of σ^2A (Ratio of σ^2D/σ^2A reflecting those results) and consequently the degree of dominance reached to be over dominance for all traits except 100-kernel weight where partial dominance was noticed. In general, the dominant genetic variance was more important than additive variance in the inheritance of all traits except 100-kernel weight. Also, most of reported results indicated that the additive genetic variance in the open-pollinated variety of maize were either negligible or had little contributions to the amount of genetic variations (El-Badawy 2011 and Wayan *et al.* 2015). *Vice versa*, additive genetic variance was predominant in the inheritance of yield and most of its component in maize (Revilla *et al.* 2004).

Briefly, Hallauer and Miranda (1988) explained additive σ^2A and dominance σ^2D variance from 99 scientific reports for several various traits. They demonstrated that using mating designs I, II and III were the most important in determined genetic variances. Also, breeder researchers adopt using F_2 population according Mather's models (1949) and diallel analysis albeit their many disadvantages. In addition, they found regarding yield that the high ratio excessed unity of dominance to additive variance was detected. Thus, dominance variance was substantial in the expression of yield trait. But, assuming linkage effects and no epistasis, on the average accounted 580.2 and 16745.52 for σ^2A and σ^2D, respectively of the total genetic variability for grain yield plant^{-1}. σ^2D/σ^2A ratios were extremely greater for yield and yield components traits. From the previous representation, our results were completely agreed with those presented in the review of literature. It is logic and expected that the acquired results herein may be due to genetic back grounds of the population and mating system designs used for estimating the genetic variance components in each case.

Estimation of additive, dominance and error variances were used to calculate the heritability in the narrow sense for fill-sib families. Heritability values for the different characters are given in Table 2. All traits in high heritability value in broad sense were detected, while, moderate to low heritability in narrow sense were dropped drastically for all studied characters except 100-kernel weigh. The heritability values were 93.67, 85.83, 91.84, 96.35, 97.38, 96.42 and 97.97 in broad sense and 15.87, 34.19, 14.09, 35.41, 10.44, 60.04 and 3.28 in marrow sense for maturity date, ear diameter, ear length, no of kernels row^{-1}, no of rows ear^{-1}, 100-kernel weight and grain yield plant^{-1}, respectively. These results confirmed the previous results which indicated the majority of dominance genetic variance in the total genetic variances in this respect. Moderate heritability value was obtained for the exceptional 100-kernel weight, suggested the important role of additive genetic variance obtained for this trait. In this respect, many authors reported estimates of heritability in narrow sense. For instance Nawar *et al*. (1983) found that heritability values in narrow-sense were (63.9%) for ear height, (57.4%) for days to tasseling (50.5%) for ear length and 44.4% for grain yield and (32.9%) for ear diameter. Nawar *et al*. (1985) showed that heritability in narrow-sense were high for plant height (63%), ear diameter (64%), no of grains row^{-1} (91%) and it was for grain yield (34%) in the composite variety "Shedwan 3". El-Hosary (1986) showed that heritability in narrow sense were high for plant height (84.04%), ear diameter (85.92%), No. of rows ear^{-1} (77.08) and it moderate for ear husk 47.51, ear length 52.22%, No. of kernels row^{-1} and grain yield plant^{-1} 62.11% in open pollinated variety "American Early". El-Hosary (1987) estimated heritability in narrow sense in the composite variety "Cairo 1" maize. Low to high heritability values ranged from 67.09 for number of kernels row^{-1} to 23.53 for number of rows ear^{-1}. Clavdio-Jobet and Borriga (1988) showed that heritability in narrow-sense was high for plant height (51%) and ear length 54% but low for grain yield 22% and 14% for number of ears plant^{-1}. Nawar *et al.* (1985) estimated heritability values in Giza2 maize population. They found that estimates of heritability were (46%) for number of rows ear^{-1}, (5%) for No. of kernels row^{-1} (13%) for 100-kernel weight, (37%) for ear length, (11%) for ear diameter, (21%) for plant height, (43%) for ear height, (96%) for days to tasseling, (46%) for days to silking. Barakat (2003) studied genetic variance for grain yield and other valuable traits in Gemmeiza yellow maize population. He found that estimates of heritability for all the studied traits were high. In general, Hallauer and Miranda (1988) summarized the heritability estimates either in broad and narrow sense for different traits.

Estimates of phenotypic (P.C.V. %) and genotypic (G.C.V. %) coefficients of variation, phenotypic (σ^2ph) and genotypic (σ^2g) variances were determined. This determination was made for all traits from synthetic variety moshtohor 108 in order to detect the characters that give higher values of genetic parameters. These were used as selection criteria for improving grain yield ability of the materials at hand. As show in Table 2, the moderate estimates of PCV and GCV were exhibited by grain yield plant^{-1}, no of kernels row^{-1} and no of rows ear^{-1}, while the other traits the values of PCV and GCV did not increase over 21.05%. Thus, this synthetic variety could be considered the most responsive ones to induction of more variability via selection, especially for grain yield. This can help maize breeder for increasing the efficiency of selection for high yield potentiality.

Table 2. Estimation of additive (σ^2A), dominance (σ^2D) genetic variance, degree of dominance (σ^2D/σ^2A), heritability in broad, narrow sense and phenotypic and genotypic coefficient of variation for all the studied traits.

Trait	σ^2A	σ^2D	σ^2D /σ^2A	h^2 b	h^2 n	G. C. V. %	P.C.V.%
Maturity date (day)	15.03±3.46	73.68±6.72	4.90	93.67	15.87	5.16	5.34
Ear diameter (cm)	0.24±0.04	0.33±0.06	1.51	85.83	34.19	0.18	10.99
Ear length (cm)	4.11±1.07	22.71±2.14	5.52	91.84	14.09	15.04	15.70
No of kernels row^{-1}	15.33±6.3	475.83±31.67	31.01	96.35	35.41	36.08	37.89
No of rows ear^{-1}	3.48±1.01	28.89±2.09	8.33	97.38	10.44	26.00	26.35
100-kernel weight (g)	100.29±11.12	60.78±14.84	0.61	96.42	60.04	20.67	21.05
grain yield plant^1(g)	580.2±146.24	16745.52±750.87	28.86	97.97	3.28	48.91	49.41

Predicted genetic advance from selection

The expected and predicted genetic gains for all traits from six methods of selection intra- population improvement are given in Table 3. In mass selection, half-sib family selection and modified ear-to-row selection, no controlled pollination is necessary but adequate isolation is essential. With mass selection when it is practiced on the maternal plants only (one sex), gain will be reduced because of lack of parental control for the pollen source (C=½). If the ratio is expressed before pollination, undesirable plants can be elimination to give parental control of both sex (C=1). Alternatively, pollen can be collected from selected plants, bulked and used to pollinate other selected plants, or the selected plant can be selfed and this grain can be planted in isolation of the following season for recombination. Obviously, selecting both sexes will give twice as much gain as selection for one sex only and will often justify the extra expense involved (Table 3). For characters such as yield with large interaction between genotype and environmental the phenotypic variance will be normally very large for mass selection in comparison with any method of family selection where trials have been grown in different environments. But expense also will be much less for mass selection than for family selection. The expected improvement percentage (Δ g %)for maturity date, ear diameter, ear length, No of kernels row^{-1}, No of rows ear^{-1}, 100-kernel weight and grain yield plant^{-1} per cycle using mass selection was 0.7, 2.90, 1.76, 0.92, 2.35, 10.69 and 1.39% based on one sex and 1.4, 5.81, 3.59, 1.83, 4.69, 21.37 and 2.78 based on two sexes for the mention traits, respectively.

Modified ear to row selection (Lonnquist, 1964) is a type of half sib selection in that selected ears are planted ear to row in a replicated test in different environments. One trial is grown in isolation and the ear rows are de-tasseled so that, pollen is provided by a bulk sample of all entries. Superior plants are mass selected within the highest yielding ear –row (based on family means over environments). This method has been extremely effective in improving the mean yield of the population. Our prediction gain by this method for improving the studied variety using modified ear to row selection as an average of two cycles for maturity date, ear diameter, ear length, No of kernels row^{-1}, No of rows ear^{-1}, 100-kernel weight and grain yield plant^{-1} per cycle using mass selection was 0.46, 1.38, 1.13, 1.91, 2.1, 5.13 and 1.68 based on one sex and 0.92, 2.76, 2.27, 1.81, 4.21, 10.26 and 3.36 based on two sexes, respectively.

The expected improvement from half-sib family selection were: 1.15 and 2.31; 3.45 and 6.90; 2.83; 5.66; 2.26 and 4.53; 5.26 and 10.52; 12.83 and 25.66; 4.20 and 8.40 for maturity date, ear diameter, ear length, No of kernels row^{-1}, No of rows ear^{1}, 100-kernel weight and grain yield plant^{-1} per cycle using remainant half–sib and selfed-seed for the mention traits, respectively.

Table 3. Expected genetic advance for all studied traits from six methods of selection.

Method of selection	Selection intense %	Crop season / cycle	Maturity date(day)	Ear diameter (cm)	Ear length (cm)	No of kernels row^{-1}	No of rows ear^{-1}	100-kernel weight(g)	Grain yield plant^{-1}(g)
			Expected gain per cycle (g)						
			Mass selection						
a) one sex	10	1	0.74	0.12	0.36	0.33	0.3	3.79	2.16
b) both sexes	10	1or 2	1.47	0.25	0.71	0.66	0.59	7.57	4.32
			Modified ear to row						
a) one sex	20	1	0.49	0.06	0.23	0.33	0.27	1.82	2.61
b) Both sex	20	2	0.97	0.12	0.45	0.65	0.53	3.64	5.22
			Half - Sib (H)						
a) Remainant half – sib	10	2	1.22	0.15	0.56	0.82	0.66	4.55	6.53
b) selfed - seed	10	2	2.43	0.29	1.13	1.64	1.33	9.09	13.05
			Full- Sib (F)						
a) S1	10	2	2.42	0.36	1.19	1.25	1.03	9.19	8.19
b) S2	10	2	3.5	0.49	1.74	2.03	1.55	11.73	13.30
Test cross population as a tester (HT)	20	3 or 4	3.61	0.44	1.83	3.19	1.79	9.99	21.55
S1 Selection			2.6	0.40	1.31	1.33	1.07	9.4	8.46
Method of selection	S int.%	C. S. / cycle	Expected improvement percentage (Δ g %)						
			Mass selection						
a) one sex	10	1	0.7	2.90	1.76	0.92	2.35	10.69	1.39
b) both sexes	10	1or 2	1.4	5.81	3.59	1.83	4.69	21.37	2.78
			Modified ear to row						
a) one sex	20	1	0.46	1.38	1.13	0.91	2.1	5.13	1.68
b) Both sex	20	2	0.92	2.76	2.27	1.81	4.21	10.26	3.36
			Half - Sib (H)						
a) Remainant half – sib	10	2	1.15	3.45	2.83	2.26	5.26	12.83	4.20
b) selfed - seed	10	2	2.31	6.90	5.66	4.53	10.52	25.66	8.40
			Full- Sib (F)						
a) S1	10	2	2.3	8.40	6	3.47	8.16	25.94	5.27
b) S2	10	2	3.32	11.38	8.77	5.63	12.28	33.11	8.27
Test cross population as a tester (HT)	20	3 or 4	3.43	11.34	9.2	8.83	14.13	28.18	13.87
S1 Selection			2.47	9.43	6.6	3.67	8.45	26.53	5.44

Full sib family selection require only two generations per cycle if plant to plant crosses are made between plants from different selected families because recombination and family formation will be accomplished simultaneously, i.e. season 1 (recombination family formation) and season 2 performance trails. Although gain will be proportional to (1/2 σ^2A), the phenotypic variance will be larger than half sib selection. If plants within each full sib family are selfed in the nursery the same season as the performance traits are conducted and bulk of seed from several elite selfed plants are used to represent each selected line for recombination. Our prediction gain by this method for improving the studied variety using full sib family selection as an average of two cycles for maturity date, ear diameter, ear length, No of kernels row^{-1}, No of rows ear^{1}, 100-kernel weight and grain yield plant^{-1} per cycle using mass selection was 2.3, 8.4, 6.0, 3.47, 8.16, 25.94 and 5.27 based on S_1 and 3.32, 11.64, 8.77, 5.63, 12.28, 33.11 and 8.27 based on S_2, respectively.

Horner *et al*., (1973) demonstrated that higher yield improvement in the test-cross for the Flureda 767 sub-strain amended with the population *per se* as tester. With the assumption of complete dominance at all loci and negligible epistasis, statistical theory would predict superiority for the use of an inbred line from the population as tester. The genetic variance among test cross would be higher, because an inbred line would have a gene frequency of 0.0 or 1.0 at all loci for the favorable allel. Our theoretical research indicated that high average predicted yield increase (Δ g %) was exhibited from the test cross selection exhibited reached 15.48% through one cycle. Abd El-Sattar (2003) estimate the expected and predicted gain per cycle by utilize method of test cross selection the value of Δg was 36.5 g (Δg % =21.64%) in Giza 2 population. EL-Seidy *et al*., (2010) found that expected gain from selection in grain yield plant^{-1} using test cross method of selection was 25.20 in Nobaria population and 18.81% with Gemmeza yellow populations. The expected and predicted genetic advance from S1 selection in the present investigation was 8.52g (Δg% = 5.48 %) in grain yield plant^{-1}. In the same order, El-Hosary (1987) predict genetic advance using S1 in American Early variety then found increase in yield reached 43.34g /cycle and Δg% = 16.6%. EL- Seidy *et al*., (2010) calculated the expected gain Δg% using S1 selection reached 20% in Nubaria population and 11.14% per cycle Gemmeza yellow populations. From the previous result it could be concluded that test cross and selection followed by full-sib family selection may be taken into consideration to improve this population under study where they showed the highest expected values of gain from selection.

The prediction gain by using test cross population as tester for improving the studied variety as an average of 3 or 4 cycles for maturity date, ear diameter, ear length, No of kernels row^{-1}, No of rows ear^{1}, 100-kernel weight and grain yield plant^{-1} per cycle using mass selection was 3.43, 11.34, 9.2, 8.83, 4.13, 28.18 and 13.87. however, the expected gain Δg% using S1 selection reached 2.47, 9.43, 6.60, 3.67, 8.45, 26.53, and 5.44, for the mention traits, respectively. It can be concluded that, it is possible to improve the variety under study "Moshtohor 108", because of large variance within it and presence of additive variation with a medium degree. Thus the yield potential of this variety can be improved and means of yield and other character can be enhanced.

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تقدير التباين الوراثى فى صنف الذرة الشامية التركيبي الاصفر"مشتهر 108" مع الإشارة للتحسين الوراثى المتوقع تبعا لطرق الإنتخاب المختلفة

احمد على الحصرى

قسم المحاصيل – كلية الزراعة – جامعة بنها

استخدم لتنفيذ هذه الدراسة التصمييم الأول الذى اقترحه روبنسون و كمستوك 1948 وذلك لتحسين الصنف التركيبي "مشتهر 108" ففى موسم 2019 تم عمل 144 عائلة شقيقية ناتجة من 36 ذكر لأربعة اناث كل على حدة بمزرعة كلية الزراعة بمشتهر – جامعة بنها. و أختبرت هذه العائلات فى تصميم القطاعات الكاملة العشوائية ذات ثلاث مكررات بعد تقسيمها الى 4 مجاميع فى موسم 2020 بهدف تقدير مكونات التباين الوراثى و الكفائة الوراثية و تقدير التحسين المتوقع الراجع الى الانتخاب باستخدام عدة طرق من الانتخاب. و قد اخذت القياسات التالية: تاريخ النضج , طول الكوز , قطر الكوز , عدد الحبوب بالسطر , عدد السطور بالكوز , وزن 100حبه ومحصول حبوب النبات. و كانت اهم النتائج : كان التباين الراجع الى كلا من الذكور و الاناث معنوى فى جميع الصفات المدروسة. كان التباين الوراثى الاضافى و السيادى معنويا و النسبة بينهم تتعدى الوحدة فى جميع الصفات تحت الدراسة عدا صفة وزن ال 100-حبة. كانت قيم الكفاءة الوراثية بالمدى الواسع عالية لجميع الصفات المدروسة و تراوحت بين85.83 الى 79.79 . بينما كانت قيمة الكفاءة الوراثية بالمدى الضيق متوسطة الى صغيرة فى جميع الصفات عدا صفة وزن 100 حبة. كانت قيم التقدم الوراثي الراجع الى الانتخاب لتحسين الصنف "مشتهر 108" بأستخدام طرق الانتخاب المبنية على اختبار النسل بواسطة كشاف و طريقة انتخاب العائلات النصف شقيقية مع انتخاب نسل النباتات المنتخبة و الملقحة ذاتيا و طريقة الانتخاب للعائلات الملقحة ذاتيا لمدة عامين هى 13.87, 8.4 و 8.27% على الترتيب. و من هذه الدراسة يمكن تحسين الصنف تحت الدراسة حيث ان التباين داخل الصنف تحت الدراسة كبير بالاضافة الى وجود التباين المضيف بدرجة متوسطة الى حد ما و بالتالى يمكن تحسين المقدرة المحصولية لهذا الصنف.