J. Plant Production, Mansoura Univ., Vol. 5 (7): 1225-1237, 2014

EVALUATION OF SOME BREEDING METHODS ON FABA BEAN IMPROVMENT

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ABSTRACT

The present study was carried out during the five seasons 2008/09, 2009/10, 2010/11, 2011/12 and 2012/13 at Sakha Agricultural Research Station, Kafr El-Sheikh governorate, Egypt. The study aimed at evaluating the effectiveness of pedigree, bulk (natural selection), single pod descent (SPD) and mass selection breeding methods on improving faba bean seed yield and resistance to foliar diseases i.e, chocolate spot *Botrytis fabae* and rust *Uromyces fabae* .

Three F_2 populations derived from three crosses were used. Ten pure lines derived from each of the four breeding methods in each cross were tested for days to maturity, seed yield (ardab/fed.), reaction to chocolate spot and rust disases in a randomized complete block design with three replications. Significant seed yield differences existed within F_6 pure lines of each cross by applying each of the four methods.

Both cross-progenies and breeding methods squares were highly significant for all studied traits. The interaction of cross-progenies by breeding methods mean squares was highly significant for all studied traits and also the interaction of cross progenies by pure lines, breeding methods by pure lines and the second order interaction of cross-progenies by breeding method by pure lines were highly significant for seed yield (ardab/fed.) while the same interactions was not significant for the other traits i.e., days to maturity and reactions to chocolate spot and rust. The cross-progeny; Sakha 2 x TW was the earliest in maturity when bulk method was applied, while the cross-progeny; Sakha 1 x RM had the highest seed yield with the pedigree method and the cross-progeny; R.M. x Giza 3 was more resistant to both chocolate spot and rust under the breeding method of single pod descent.

Pedigree method recorded its superiority than the other breeding methods with respect to broad sense heritability and subsequently expected and predicted genetic advance in the cross-progenies; Sakha 1 x Rina Mora and Rina Mora x Giza 3 for seed yield/fed. While in the cross progeny; Sakha 2 x TW, the breeding method of single pod descent had the highest broad sense heritability, expected and predicted genetic gain upon selection of the highest 20% plants in the population for the same trait.

It could be concluded that the pedigree and SPD methods were more efficient and could be less expensive in breeding for improving seed yield and foliar diseases (chocolate spot and rust) resistance of faba bean.

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important leguminous crops worldwide as a source of plant protein and considered a major food crop in Egypt,It is grown mainly for human consumption as fresh green beans or cocked dried seeds. Chocolate spot caused by *Botrytis fabae* and rust caused by *Uromyces fabae* , diseases are considered the most destructive diseases on faba bean in Egypt causing serious damage to the crop, especially in the north part of Delta, where low temperature and high relative humidity favor its spread and severity (El-Helaly, 1939 and Mohamed, 1982). The crop is partially allogamous species having an intermediate level of out-crossing (in the 20-25% range). Increasing seed yield and improving its stability along with resistance to foliar diseases (chocolate spot and rust) are the main objectives of most breeding programs. Breeding methods employed in faba beans ranged from single seed descent as proposed by Brim (1966) through pedigree or bulk pedigree approaches to mass selection. Mass selection is the most widely used breeding method in faba bean improvement especially in upgrading local population following hybridization (Nassib and Khalil, 1982).Thus faba bean is a unique crop which has been handled in breeding programs in a number of ways, some of which have emphasized the self-pollinating nature of the crop while others have emphasized the cross pollinating nature of the crop. The main objectives of this investigation were to evaluate the effectiveess of pedigree, bulk, single pod descent (SPD) and mass selection breeding methods on improving seed yield and resistance to foliar diseases (chocolate spot and rust) in faba bean.

MATERIALS AND METHODS

This study was carried out in five seasons 2008/09, 2009/10, 2010/11, 2011/12 and 2012/13 at Sakha Agricultural Research Station, Kafr El-Sheikh governorate, Egypt.

The studied breeding materials were three F2 populations derived from three crosses among the following faba bean varieties :

1. Rina Mora (R.M)	Introduced from Spain
2. Sakha 1	Egypt
3. Sakha 2	Egypt
4. Giza 3	Egypt
5. Triple white (TW)	Introduced from Sudan.

The study aimed to evaluate the effectiveness of four breading methods namely: pedigree, bulk, mass selection, and single pod descent (SPD)on faba bean improvment.

Three F_2 populations of the following three crosses were used:

1. Sakha 1 x Rina Mora (R.M)
2. Rina Mora (R.M) x Giza 3
3. Sakha 2 x Triple white (T.W)

In 2008/09 growing season approximately 500 plants per each F_2 population were planted in the field at 20 cm hill spacing on ridges 60 cm apart . Throughout the growing season, plants were weeded and monitored for pests. The plants were sprayed three times with primer insecticide during the growing season to control virus-bearing aphid populations. From each cross progeny of F_2 population three groups of random plants were taken, each group consisted of 100 plants. The first group of random plants was handled by taking single pod from each plant to produce SPD, then plants were harvested in mass to produce bulk population. The second group of random plants were threshed each plant separately and weighed for seed yield, the top 20% plants were composted and used as mass selection. The third group of random plants were threshed separately to use in pedigree method. The F_3 seed from pedigree, bulk, SPD and mass selection populations were grown in 2009/10 season. At maturity, the SPD populations were obtained by composting a single pod taken from each plant. A random sample was taken from all bulk population plants after threshing. In mass selection populations, all plants were threshed and weighed individually and the top 20% of plants according to seed yield of the plant were massed. In Pedigree method, each selected individual F_2 plants for each cross-progeny was sown in one F_3 family and at maturity, selection was done in two steps: among F_3 families where the promising ones were labeled and the second step was the selection within each promising family, where the best 5 plants according to their phenotypic appearance were chosen and the best one was used in the next generation. In 2010/11 season, the F_4 population for pedigree, bulk, SPD and mass selection of the three cross-progenies were repeated as in $\mathbf{F_3}$ populations. In 2011/12 season, the F_5 population for each breeding method of the three cross-progenies was repeated as in F_4 populations. In 2012/13 season, ten F_6 pure lines derived from each breeding method over the three cross-progenies were tested a field trial for seed yield and other agronomic traits. Reaction to foliar diseases was recorded on mid February and mid March for chocolate spot and rust diseases, respectively, according to the disease scales by Bernier *et al*. (1993) as presented in table (1).

Table (1): Rating scale for chocolate spot and rust diseases

Rate	**Chocolate spot scale**
1	No disease symptom (highly resistant)
3	Few small discretes lesions (Resistant
5	Some coalesced lesions with some defoliation (moderately resistant)
7	Large coalesced lesions, 50% defoliations, some dead plants (susceptible)
9	Extensive lesions on leaves, stems and pods, severe defoliation, heavy sporulation, death of more than 80% of plants (highly susceptible)
	Rust scale
1	No pustules or very small non-sporulating flecks (high resistant)
3	Few scattered pustules covering less than 1% of the leaf area, and few or no pustules on stem (resistant)
5	Pustules common on leaves covering 1-4% of leaf area, little defoliation and some pustules on stem (moderately resistant)
7	Pustules very common on leaves covering 4-8% of leaf area, some defoliation and many pustules on stem (susceptible)
9	Extensive pustules on leaves, petioles and stem covering 8—10% of leaf area, many dead leaves and several defoliation (highly susceptible).

A randomized complete block design with three replications was used for each breeding method in each cross-progeny. Each replicate had 10 plots randomly assigned to the 10 pure lines of each breeding method. Each plot consisted of 5 ridges three meters length with 60 cm between ridges. Sowing took place as two rows per ridge, in double seeded hills, 20 cm apart. At harvest, the mid-three ridges per plot were harvested where the plot area was 5.4 m^2. The following characters were recorded:

1. Relative reaction to chocolate spot.
2. Relative reaction to rust.
3. Number of days to maturity
4. Seed yield (ardab/fed.),where 1 ardab =155 kg 1 feddan=4200 m2

The pattern of generation advance for pedigree, bulk, SPD and mass selection breeding methods is presented in Fig. 1.

F_2 population
Breeding method

Season	Pedigree	Bulk	SPD	Mass selection
2008/09	Selected 100 individual F_2 plant from each of cross-progeny were paged to sown in F_3 generation ↓	F_2 seeds of each cross-progeny were bulked and arandom sample was taken to sown in F_3 generation ↓	One pod from each plant of each cross-progeny was taken and then bulked to sown in F_3 generation ↓	The top 20% of plants from each cross-progeny were massed and sown in F_3-generation ↓
2009/10	Each selected individual plant for each cross-progeny was sown in one F_3 family and selection among and within families was done and the highest yielded plant of the best families was sown in the F_4 generation ↓	Repeated in the F_3 generation as in F_2 one ↓	Repeated in the F_3 generation as in F_2 one ↓	Repeated in the F_3 generation as in F_2 one. ↓
2010/11	Repeated in the F_4 generation as in the F_3 one ↓	Repeated in the F_4 generation as in the F_3 one ↓	Repeated in the F_4 generationas in the F_3 one ↓	Repeated in the F_4 generation as in the F_3 one. ↓
2011/12	Repeated in the F_5 generation as in the F_4 one ↓	Repeated in the F_5 generation as in the F_4 one ↓	Repeated in the F_5 generation as in the F_4 one ↓	Repeated in the F_5 generation as in the F_4 one ↓
2012/13	The highest 10 pure lines from each breeding method derived from F_5 generation were sown in randomized complete blocks design with three replications in three yield trials each for each cross-progeny.			

Fig. (1): Outline of generation advance for pedigree, mass selection, bulk and SPD breeding methods.

Statistical analysis:

The evaluation of pedigree, bulk, SPD and mass selection breeding methods was determined by sowing F_6 pure lines for each method in a trial of randomized complete block design. The four trials of each cross-progeny were subjected to combined analysis according to the procedure obtained by Snedecor and Cochran (1982).

The efficiency of the four breeding methods was compared based on the following:

The heritability in broad sense (H^2) was calculated as the percentage of genetic variance (σ^2g) to phenotypic variance (σ^2ph), where the latest equal the sum of (σ^2g) and (σ^2e) which calculated from the analysis of variance Table. The expected (Ga) and predicted Ga%) genetic gain upon selection of the highest 20% of the population were calculated according to Miller *et al*. (1958). Phenotypic coefficient of variance (P.C.V.) and genotypic coefficient of variation (GCV%) were calculated according to (Burton 1952).

RESULTS AND DISCUSSION

The average seed yield (ardab/fed.) and other agronomic traits of the 10 $_{F6}$ pure lines of each cross-progeny derived through the four breeding methods are presented in Tables 2, 3 and 4. Significant differences existed within the F_6 pure lines of each cross-progeny for most of the traits by applying each of the four methods. The combined analysis (Table 5) revealed that the differences among the three cross-progenies and also for the four breeding methods were highly significant for all studied traits due to the highly significant mean squares of cross-progenies and breeding methods.

The cross progenies by breeding methods interaction mean square was highly significant, indicating that the behaviour of the three cross-progenies varied with the change of breeding method for these traits. On the other side, the cross-progenies by pure lines interaction mean squares was highly significant for seed yield (ardab/fad.) indicating that the seed yields of the pure lines were different in the three cross progenies, however, the same interaction mean squares was not significant for days to maturity and reaction to chocolate spot and rust diseases, indicating that these traits were not rliable different from cross progeny to another. The same trend was observed with regard to breeding method by pure lines interaction and also for the second order interaction i.e., cross progenies x breeding method x pure lines, where seed yield (ardab/fed.) was highly significant and the other traits were not.

2

3

4

Table (5): Mean squares of combined analysis of variances of F_6 pure line for reaction to chocolate spot and rust diseases, days to maturity and seed yield (ardab/fed.) traits resulted by applying four methods in the three cross-progenies.

SOV	df	Chocolate spot reaction	Rust reaction	Days to maturity	Seed yield (ardab/fad.)
Reps. (R)	2	5.07**	4.35**	14.48	24.98**
Cross progenies (C)	2	11.73**	9.65**	78.48**	68.34**
Error (a)	4	1.75	0.51	34.33	5.07
Methods (M)	3	27.61**	25.48**	75.2**	67.54**
C*M	6	7.68**	8.44**	248.76**	21.97**
R*M	6	1.30**	0.61	7.82	26.04**
R*C*M	12	1.51**	1.51**	68.23**	1.54
Error (b)	18	1.44	1.21	48.09	9.71
Pure lines (PL)	9	0.22	0.51	10.05	7.99*
C*PL	18	0.33	0.32	7.42	16.22**
M*PL	27	0.76	1.17*	9.16	7.05**
C*M*PL	54	0.53	0.47	10.16	8.63**
Error (c)	216	0.38	0.54	11.69	3.45

The data in Table (6) illustrated the effect of cross progenies by breeding method interaction on the studied traits. The pedigree method when applied with Sakha 1 x RM cross progeny produced the highest seed yield (ardab/fed), which exceeded bulk, SPD and mass selection by 22.6, 17.8 and 24.6%, respectively. With respect to days to maturity, applying of bulk method in Sakha 2 x TW cross-progeny gave the earliest maturity followed by RM x Giza 3 cross-progeny when SPD or mass selection were applied, where the maturity date did not significantly differ in all cases. These results are in agreement with those reported by El-Refaey and Radi (1997), Destro *et al*. (2003) and Shalaby (2011)

While the SPD method when applied with either Sakha 1 x RM or RM x Giza 3 cross-progenies produced the lowest values for reaction to diseases, i.e. chocolate spot and rust. These results confirm that the SPD method give desirable results for reaction to foliar diseases comparing with the other breeding methods.

The data shown in Table (7) revealed that broad sense heritability of seed yield ranged from 0.61 with mass selection to 0.87 with pedigree method for Sakha 1 x Rina Mora cross progeny، from 0.22 with mass selection to 0.82 with bulk method for Rina Mora x Giza 3 cross-progeny and from 0.50 with mass selection to 0.81 with bulk method for Sakha 2 x Triple white cross-progeny. However, it could be observed that mass selection method had the lowest values of broad-sense heritability in all cross-progenies indicating the uneffective selection with this breeding method in the present material. The obtained results are in good agreement with those reported by El-Refaey (1992), Toker (2004), Yodeta *et al*. (2006) and Shalaby (2011).

It could be observed that, high genetic advance is always associated with high heritability and phenotypic coefficient of variation and vice versa according to the equation of expected genetic advance.

Table (6): Average F6 pure line for chocolate spot and rust diseases reaction,days to maturity and seed yield (ardab/fed.) traits as affected by cross-progenies and breeding method interaction.

Crosses	Reaction to chocolate spot					Reaction to rust				
	pedigree	Bulk	SPD	Mass	average	pedigree	Bulk	SPD	Mass	average
Sakha 1 x R.M	4.4	4.9	2.9	3.1	3.8	5.1	5.3	3.3	3.4	4.3
R.M x Giza 3	3.7	4.1	2.8	3.4	3.5	4.3	4.5	3.9	3.6	4.1
Sakha 2 x T.W	3.9	4.3	3.5	4.7	4.1	4.5	4.9	4.2	4.9	4.6
Average	4	4.4	3.1	3.7	3.8	4.6	4.9	3.8	3.9	4.3
L.S.D at 0.01	0.83					0.74				
Crosses	Days to maturity					Seed yield (ardab/fed)				
	pedigree	Bulk	SPD	Mass	average	pedigree	Bulk	SPD	Mass	average
Sakha lin xR.M	137.14	141.7	137.4	139.5	138.9	15.2	12.4	12.9	12.2	13.2
R.M x Giza 3	141.2	137.7	135.9	135.1	137.5	13.5	11.8	13.1	11.6	12.5
Sakha 2 x T. W	139.8	134.1	139.9	137.7	137.7	12.5	11.8	10.3	12.1	11.7
Average	139.4	137.8	137.7	137.4	138.7	13.7	12.0	12.1	11.9	12.4
L.S.D at 0.01	4.73					2.12				

From this point of view, the highest expected (G_a) and predicted(Ga%) genetic advance under the selection intensity of 20% were found to be 2.79% ardab/fed. and 18.39%, respectively in the cross progeny of Sakha 1 x Rina Mora with applying the pedigree method; 2.52 ardab/fed. and 18.67%, respectively in the cross progeny of Rina Mora x Giza 3 with the pedigree method and 2.41 ardab/fed.. and 23.40%, respectively in the cross-progeny of Sakha 2 x Triple white by single pod descent method. In all cases the highest values of expected genetic advance were due to the highest values of broad-sense heritability and phenotypic coefficient of variation. However, mass selection breeding method had the lowest values of both expected and predicted genetic gain upon selection due to the lowest values of both broad-sense heritability and phenotypic coefficient of variation. These results were in the same lines with those reported by El-Refaey (1992), El-Refaey and Radi (1997**),** Yadeta *et al*. (2006) and Shalaby (2011).

The amount of genetic variability retained by this method accounts for this result. Increasing the size of F_2 population would have an impact on the genetic variability and could ultimately increase the efficiency of the pedigree and SPD breeding methods. Breeders have applied one or more different breeding methods in order to investigate or compare their efficiency in selecting for high seed yield. Among those, Torie (1958), Allard and Adams (1969), Omar (1989) and Shalaby *et al*. (2001**)**, working on barley, wheat and faba bean and using two or three or four methods of breeding, came to conclusion that bulk method was more efficient than the visual pedigree selection as indicated by the number of superior lines retained by teach.

Table (7): The genetic parameters estimated for seed yield (ardab/fed) of the F_6 pure lines families derived through the four breeding methods for three cross progenies.

Parameter	Yield (ardab/fed)			
	Pedigree	bulk	SPD	Mass selection
	Sakha 1 X Rina Mora			
Genotypic variance ($\sigma^2 g$)	4.58	1.13	2.13	1.49
Phenotypic variance (σ^2_{Ph})	5.27	1.56	2.96	2.47
Heritability (H^2)	0.87	0.73	0.72	0.61
G_a	2.79	1.27	1.73	1.34
G_a%	18.39	10.29	13.38	11.05
PCV%	15.1	10.05	13.27	12.94
GCV%	14.0	8.25	11.26	10.05
Mean(ardab/fed)	15.20	12.40	12.96	12.14
	Rina Mora x Giza 3			
Genotypic variance ($\sigma^2 g$)	4.13	1.33	1.34	0.32
Phenotypic variance (σ^2_{Ph})	5.33	1.63	2.41	1.44
Heritability (H^2)	0.78	0.82	0.56	0.22
G_a	2.52	1.46	1.22	0.37
G_a%	18.67	12.37	9.34	3.15
PCV%	17.10	10.78	11.91	10.35
GCV%	15.05	9.79	8.88	4.88
Mean(ardab/fed)	13.50	11.84	13.03	11.59
	Sakha 2 X Triple white			
Genotypic variance ($\sigma^2 g$)	1.29	1.37	3.95	1.92
Phenotypic variance (σ^2_{Ph})	3.96	1.68	5.28	3.81
Heritability (H^2)	0.58	0.81	0.75	0.50
G_a	1.61	1.46	2.41	1.36
G_a%	12.92	12.50	23.40	11.29
PCV%	15.92	11.02	22.28	16.13
GCV%	9.08	9.95	19.27	11.45
Mean(ardab/fed)	12.50	11.76	10.31	12.10

On the other hand, Reuper and Weber (1953) evaluated bulk and pedigree methods of breeding in four soybean crosses, found that the different methods of selection did not differ. While, Ahmed *et al*. (2008) compared three breeding methods on three F_2 to F_4 crosses of faba bean,and found that the pedigree method was more efficient than the other mass selection and SPD breeding methods.

To sum up, the present study indicated that the pedigree and SPD methods retained higher genetic and coefficient of variability as well as number of superior pure lines compared to other two breeding methods. Considering the partial allogamous nature of the crop, it may be concluded that the pedigree and SPD breeding methods were more efficient and less expensive in improving faba bean seed yield and its resistance to the foliar diseases chocolate spot and rust.

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تقييم بعض طرق التربية لتحسين الفول البلدى

رفعت عبد السلام إسماعيل أبو مصطفى [1] ، إيهاب على ضياء سرحان [2] ، مروى عبد الله محمود عطوة[2] و زينب السيد غريب[3]
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3- المعمل المركز لبحوث التصميم والتحليل الإحصائى مركز البحوث الزراعية ـ جمهورية مصر العربية

يهدف هذا البحث إلى تقييم فاعلية أربعة طرق تربية مختلفة ؛ هى النسب والتجميعى (إنتخاب طبيعى) وطريقة إنتخاب القرن الواحد والاجمالى فى تحسين إنتاجية محصول الفول البلدى وبعض الصفات الزراعية الأخرى. وقد نفذت هذه الدراسة فى خمسة مواسم زراعية 2009/2008 ، 10/2009 ، 11/2010 ، 12/2011 ، 13/2012 وذلك بمحطة سخا للبحوث الزراعية/كفرالشيخ وقد أختيرت لهذه الدراسة ثلاثة عشائر ناتجة من ثلاثة هجن وقد تم تقييم 10 سلالات نقية فى الجيل السادس منشقة من كل طريقة واستخدم تصميم القطاعات كاملة العشوائية فى ثلاث مكررات. وقد أظهرت النتائج وجود معنوية بين سلالات الجيل السادس لكل هجين على حدة لصفة محصول الفدان بالأردب عند إستخدام طرق التربية الأربعة. بينما لم تظهر أى معنوية لصفات عدد الأيام إلى النضج ونسبة الإصابة بمرض التبقع البنى ونسبة الإصابة بمرض الصدأ.

أظهر تباين كلا من أنسال الهجن وطرق التربية معنوية عالية لجميع الصفات تحت الدراسة وكان التفاعل مابين أنسال الهجن وطرق التربية عالى المعنوية لجميع الصفات وأيضا كانت التفاعلات بين كلا من أنسال الهجن والسلالات النقية ، طرق التربية ، والسلالات النقية وأيضا التفاعل من الدرجة الثانية بين أنسال الهجن وطرق التربية والسلالات النقية عالية المعنوية لصفة محصول البذور للفدان بينما كانت نفس التفاعلات غير معنوية للصفات الأخرى وهى عدد الأيام من الزراعة حتى النضج والحساسية لمرضى التبقع البنى والصدأ وكان نسل الهجين (TW × سخا2) أكثر تبكيرا فى النضج عندما طبقت طريقة التجميع. بينما كان نسل الهجين (رينا مورا × سخا1) الأعلى محصولا عندما استخدمت طريقة النسب وكان نسل الهجين (جيزة 3 × رينامورا) أكثر مقاومة للأمراض الورقية وهى التبقع البنى والصدأ عندما استخدمت طريقة التربية قرن واحد من كل نبات.

كانت التربية بالنسب الأكثر تفوقا عن باقى طرق التربية المستخدمة بالنسبة للمكافىء الوراثى فى معناه الواسع وأيضا فى كل من التقدم الوراثى المتوقع والمتنبأ به فى نسل الهجينين (رينامورا × سخا 1) ، (جيزة 3 × رينامورا) بينما فى نسل الهجين (TW × سخا2) حققت طريقة التربية قرن واحد لكل نبات أعلى قيمة للمكافىء الوراثى فى معناه الواسع والتقدم الوراثى المتوقع والمتنبأ به عند أعلى 20% من نباتات العشيرة لصفة محصول البذور للفدان

ويتضح من النتائج المتحصل عليها أن طريقتى النسب والقرن الواحد فى الفول البلدى هما أكثر الطرق كفاءة مقارنة بالطريقتين الأخريين. وإذا أخذنا فى الاعتبار طبيعة هذا المحصول وهو خلطى جزئيا نجد أن هاتين الطريقتين أكثر كفاءة وأقل تكلفة فى تربية هذا المحصول.

Table (2): Reaction to chocolate spot and rust diseases , days to maturity and seed yield (ardab/fed) traits of 10 pure lines derived from the cross (Sakha 1 x Rina Mora) through pedigree, bulk, single pod descent (SPD) and mass selection breeding methods.

Family	Chocolate spot Reaction				Rust Reaction				No.of days to maturity				Seed yield (Ardab/fed.)			
	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection
1	4.66	5.00	3.33	3.00	5.00	5.33	3.67	3.01	137.00	142.00	139.67	142.02	18.84	12.23	15.29	12.44
2	5.00	5.00	3.00	3.00	5.00	5.67	3.00	3.32	138,33	140.67	135.00	139.33	14.83	12.88	12.04	12.82
3	4.33	5.00	2.33	3.33	4.33	5.67	2.67	3.33	139.67	142.67	138.00	140.74	13.91	13.19	10.24	11.43
4	4.66	5.00	2.33	2.33	5.00	6.00	3.33	3.02	137.00	140.67	138.33	139.34	10.72	11:98	14.33	10.88
5	4.00	5.00	2.67	3.30	4.67	5.67	3.00	3.32	138.33	143.67	138.00	136.72	14.57	11.32	13.01	13.94
6	4.33	5.00	3.67	2.00	5.00	5.33	4.67	2.33	137.00	142.00	139.67	143.00	17.76	15.23	12.22	' 9.23
7	3.33	4.67	3.67	4.00	4.33	4.67	3.33	3.74	139.33	140.67	133.67	137.70	16.13	11.80	13.43	13.92
8	5.00	4.67	3.67	3.70	5.67	5.00	3.67	4.02	135.33	J42.00	135.67	140.70	15.05	10.54	15.53	10.74
9	4.00	4.33	2.00	3.70	5.33	4.67	2.33	4.03	136.67	140.67	136.67	135.34	13.61	12.40	11.14	13.23
10	4.66	5.00	2.67	3.00	6.00	5.00	3.67	3.71	135.33	142.00	139.67	140.72	16.57	12.40	12.34	13.24
mean	4.40	4.87	2.93	3.13	5.03	5.30	3.33	3.37	137.40	141.70	137.43	139.53	15.20	12.40	12.96	12.14
LSD 0.05	1.03	0.53	1.09	1.20	1.47	0.79	1.20	1.32	4.09	4.54	8.44	5.81	2.45	1.93	2.71	2.92
LSD 0.01	1.42	0.72	1.49	1.64	2.01	1.08	1.65	1.81	5.60	6.23	11.56	7.95	3.36	2.65	3.71	4.01

Table 3: Reaction to chocolate spot and rust diseases, days to maturity and seed yield (ardab/fed) traits of 10 pure lines derived from the cross (Rina Mora x Giza 3) through pedigree, bulk, single pod descent (SPD) and mass selection breeding methods

Family	Chocolate spot Reaction				Rust Reaction				No.of days to maturity				Seed yield (Ardab/fed.)			
	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection
1	3.67	4.00	3.00	3.34	4.67	4.67	3.67	3.34	142.67	136.00	136.67	132.02	13.60	12.28	12.10	12.42
2	4.00	4.33	2.67	3.04	4.33	4.67	4.00^	3.33	138.33	138.33	138.33	136.73	9.03	10.30	14.21	11.11
3	3.67	4.33	2.67	3.73	4.33	5.00	3.33	3.72	143.66	136.00	135.00	135.33	13.93	13.91	15.90	11.92
4	3.66	4.33	2.67	3.32	4.33	4.67	4.00	3.33	142.33	138.33	135.00	138.34	16.74	13.19	11.44	13.74
5	3.33	4.00	3.00	3.74	4.33	4.33	4.00	3.74	142.00	135.33	133.67	135.32	15.77	11.14	10.72	11.83
6	3.67	4.67	2.67	3.73	4.00	4.67	4.00	3.72	139.66	140.00	136.67	135.34	11.63	11.62	14.09	10.12
7	4.00	3.67	2.67	3.34	L4.00	4.33	3.67^	3.70	139.67	136.67	137.00	132.03	15.23	9.63	13.55	9.80
8	3.67	4.00	2.67	3.33	4.00	4.67	4.00	3.70	139.67	140.00	135.33	136.74	12.87	11.62	11.98	10.50
9	4.00	3.33	3.33	3.73	4.33	4.00	4.33	4.04	141.66	136.33	135.33	137.04	14.81	12.35	13.79	12.63
10	3.67	3.67	3.00	3.04	4.66	4.00	4.00	3.33	142.33	140.00	136.00	132.03	11.63	12.35	12.53	11.94
mean	3.73	4.03	2.83	3.40	4.30	4.50	3.90	3.57	141.20	137.70	135.90	135.07	13.52	11.84	13.03	11.59
LSD 0.05	1.37	1.12	1.10	0.80	0.81	1.42	1.77	0.98	5.59	21.18	7.44	6.35	3.25	1.61	3.06	3.13
LSD 0.01	1.88	1.54	1.51	1.09	1.11	1.95	2.43	1.34	7.66	29.02	10.19	8.70	4.45	2.218	4.20	4.29

Table (4):Reaction to chocolate spot and rust diseases, days to maturity and seed yield (ardab/fed) traits of 10 pure lines derived from the cross (Triple white x Sakha 2) through Pedigree, bulk, single pod descent (SPD) and mass selection breeding methods

Family	Chocolate spot Reaction				Rust Reaction				No.of days to maturity				Seed yield (Ardab/fed.)			
	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection	Pedigree	Bulk	SPD	Mass selection
1	4.33	4.33	2.67	5.03	4.33	5.33	3.00	5.02	140.67	130.33	138.33	139.72	7.52	10.66	6.20	12.53
2	4.33	4.67	4.00	4.33	4.67	5.67	5.00	4.30	139.67	133.67	139.67	137.02	12.97	11.20	10.24	11.33
3	4.00	4.33	2.67	5.04	4.33	4.67	3.33	5.00	139.66	133.67	139.67	138.33	12.87	11.80	12.95	13.34
4	4.00	4.33	4.67	4.32	4.33	5.33	5.67	4.71	138.33	135.33	143.00	135.34	11.74	13.07	9.28	9.64
5	4.00	4.00	3.67	4.33	4.67	4.67	4.00	4.72	139.67	133.67	138.33	136.72	14.93	11.26	14.27	15.72
6	3.67	4.33	4.33	4.34	4.33	5.33	5.00	4.73	140.67	133.67	143.00	138.34	13.47	10.48	7.83	9.64
7	3.66	4.00	3.33	5.02	4.33	4.33	4.00	5.74	140.67	133.67	139.67	135.03	13.91	11.92	10.06	14.13
8	4.00	4.67	3.00	5.00	4.66	5.33j	3.67	5.04	140.67	136.33	137.00	139.74	12.97	9.99	11.02	10.82
9	3.67	4.33	3.33	5.30	4.33	4.67	4.00	5.00	139.00	136.33	142.00	138.32	12.87	13.61	10.72	12.72
10	4.00	4.00	3.33	4.71	4.67	4.33	4.33	4.72	138.66	133.67	138.33	138.31	11.74	13.61	10.54	11.41
mean	3.97	4.30	3.50	4.73	4.47	4.97	4.20	4.87	139.77	134.03	139.90	137.67	12.50	11.76	10.31	12.10
LSD 0.05	1.10	0.81	1.27	0.95	0.86	0.94	1.73	1.27	4.53	4.40	3.63	4.29	5.69	1.66	3.43	4.08
LSD 0.01	1.51	1.11	1.75	1.30	1.18	1.28	2.37	1.74	6.20	6.03	4.97	5.88	7.79	2.27	4.70	5.59