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INVESTIGATION OF THE INHERITANCE FOR DOWNY MILDEW, LEAF BLIGHT AND LATE WILT DISEASES IN FOUR MAIZE SINGLE CROSSES BY SIX-GENERATIONS MEANS ANALYSIS

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ABSTRACT: *This study was carried out at Sakha Agriculture Research Station. The aim of this work was to determine the mode of gene action which controls the inheritance of downy mildew (Prenosclerospora sorghi), leaf blight (Helminthosporium turcicum) and late wilt (Cephalosporium maydis) diseases under artificial condition in four maize single crosses. Significant heterosis of downy mildew disease was detected in all crosses except S.C. SK-52. Heterotic effect of downy mildew ranged from -42.56 to 29.85% with an average of -13.82%. The resistance of downy mildew was predominating over susceptibility in most crosses and the partial dominance was more important than over dominance gene action in the inheritance of this disease. Positive and significant heterotic effect to leaf blight disease was existed in S.C. SK-17 only toward susceptibility. Heterosis values of leaf blight ranged from-13.39 to 43.08 with an average of 7.96%. The three types of dominance gene action were operating in the inheritance of leaf blight disease. Two commercial hybrids (S.C.155 and S.C.129) exhibited negative and significant heterotic effect toward resistance of late wilt disease. The over dominance gene action played the major role in the inheritance of this disease.*

The additive and epistatic effects represented the most important contributors to the inheritance of downy mildew disease than dominance gene effects .While, additive, dominance and epistatic genetic effects were involved in the inheritance of both leaf blight and late wilt diseases, suggesting reciprocal recurrent selection and selective diallel mating are suitable breeding scheme for resistance improvement to these diseases.

Key words : *Gene action, Downy mildew, Leaf blight, Late wilt, Heterosis, Maize.*

INTRODUCATION

Maize yield production is affected by different biotic and abiotic factors. Diseases cause serious losses via reducing yield quantity and quality characters. Downy mildew caused by *Prenosclerospora sorgi*, leaf blight caused by *Helminthosporium turcicum* and late wilt caused by *cephalosporium maydis* are the most serious pathological problems affecting maize production in Egypt.

Several investigators studied the inheritance and type of gene action for resistance to these diseases have been reported. (Asnani and Bhusan, 1970); Deleaon, 1994 and EL-Zeir and Tolba, 1999). They found that the inheritance of downy mildew disease was controlled by additive gene effects.The information of the role of epistatic effects in the maize resistance to downy mildew disease are generally limited, however, Abd-EL-Aal (2002) indicated that epistatic gene effects are important in the inheritance of resistance of this disease. Partial dominance gene action in the inheritance of downy mildew disease have been reported (EL-Zeir and Tolba.,1999 and Amer *et al,* 2002). Also, EL-Shenawy (1995), Gabr (1997) and EL-Zeir and Amer (1999) found significant heterotic effect for downy mildew resistance in maize.

Additive genetic effects played the major role in the inhertance expression to leaf blight disease (Nawar and Salem, 1985 and lingam *et al,* 1989). However, Hughes and Hooker (1971) reported that additive, dominance and epistatic types of gene action were involved in the resistance of leaf blight disease . Recently Takamiya and Sendo (2000) reported that the resistance to leaf blight was controlled by both an additive and dominant gene effects. Nawar and Salem (1985) found that the over dominance gene action played an important role in resistance to leaf blight disease.

The inheritance of resistance to late wilt disease was controlled mainly by additive genetic effect (Galal *et al.,*1979 and Amer *et al.,*2002). While, Shehata and Salem (1972) and Amer *et al.*(1999) reported that dominance and epistatic gene effects played a major role in conditioning of resistance to late wilt disease. Also, EL-Itriby *et al,* (1984) stated that epistatic gene effects played an important role in the inheritance of this disease. Moreover, Salem (1977) found that additive, dominance and non-allelic interaction of gene effects seemed to control the resistance to late wilt disease. Labib (1972) indicated that resistance to late wilt was partially dominant,while, Amer *et al.* (2002) found that over dominance gene action represents the major role in the inheritance of resistance to late wilt disease. EL-Gresi (1978) found negative and significant values of inbreeding depression for resistance to late wilt disease.

This work aims to determine the mode of gene action and heterotic effect for resistance to downy mildew, leaf blight and late wilt diseases in maize.

MATERIALS AND METHODS

Two white single crosses, i.e. promising S.C. SK-17 (Gm-4 x SK-8238) and commercial S.C. 129 (G-612 x G-628) and two yellow single crosses,i.e promising S.C. SK-52 (Gm-1004 x SK-6241) and commerical S.C. 155 (Gm-1002 x Gm1021) were made in summer 2000 season. In 2001 season, the F1 plants at flowering were selfed and crossed with their parents to obtain F2 and two back crosses (BC1 and BC2) in each cross. In 2002 season, six populations P1,P2 ,F1,F2,Bc1 and Bc2 of each cross were grown in two separate experiments at Sakha Agricultural Research Station.

The first experiment was performed at field of downy mildew disease nursery to study the inheritance of susceptible to downy mildew disease. The field was previously sown by Sudan grass as a source of infection with downy mildew disease. Sudan grass was sown alternatively with maize rows with a ratio of 1: 2, respectively. This experiment was arranged in Randomized Complete Block Design (RCBD) with four replications. The plot size was two rows, 6 m long, 70 cm apart, 25 cm between hills.Two seeds were sown per each hill and lived without thinning. The infested plants were recorded after 35 days from planting date according to EL-Shenawy (1995) and adjusted into infestation percent. The angular transformation was used as outlined by Senedecor and Cochran (1967).

The second experiment was conducted to study the inheritance of susceptibility to leaf bilght and late wilt diseases. This experiment was sown in field of late wilt disease nursery. The artificial infection for leaf blight disease was done by *Helminthosporium turcicum*, which performed by spores suspension after 45 days from planting by spraying the individual plant. The severity of infection was recorded of leaf area infected and the reading was classified according to the ratting scale (0.5-5) of Eliott and Jenkins (1946). The artificial infection for late wilt disease was done by adding *Cephalosporium maydis* fungus to soil befor planting. This experiment was arranged in RCBD with four replications. The plot size was 2 rows,6m long, 80cm apart and 25 cm between hills. The three seeds were sown per each hill and thinning to one plant per hill. The all recommended practices were applied.The infested plants were counted after 105 days from planting date and adjusted into infestation percent. Also, the angular tramsformation for infestation percentage of the two diseases were used.

Statistical and genetic analysis:

Comparison among the different generation means in each cross were calculated using the analysis of variance of RCBD experiment to estimate the variance error (M.S.e).

Heterosis over the mean parental value (H%) was expressed as:

$$H\% = \frac{\overline{F1} - \overline{M.P}}{\overline{M.P.}} \times 100$$

and its significant was tested by the t-test as

$$t = \overline{F1} - \overline{M.P} \; / \sqrt{3M.S.e/2r}$$

Where $\overline{M.P}$ = mid parent = $(\overline{P1} + \overline{P2})/2$, r= No. of replications

M.S.e = mean square of error.

Also inbreeding depression (I) was expressed as:

$$I\% = \frac{\overline{F1} - \overline{F2}}{\overline{F1}} \times 100$$

and its significant was tested by the t-test as

$$t = \overline{F1} - \overline{F2} \, / \, \sqrt{2M.S.e/r}$$

Potence ratio (P) as outlined by Smith (1952) was estimated a criteria for nature and degree of dominance as shown in the following equation:

$$P = \frac{\overline{F1} - \overline{M.P.}}{\frac{1}{2}(\overline{P1} - \overline{P2})}$$

Where:

$\overline{F1}$ = first generation mean.

$\overline{P1}$ = the mean of the higher parent.

$\overline{P2}$ = the mean of the smaller parent.

Complete dominance is indicated where potence ratio is equal to (+1) or (-1); while, partial dominance is presumed when (P) is between (+1) and (-1), and over dominance existed if P ratio exceeded (+1). The positive and negative signs indicated the direction of dominance to either parents.

Six-parameter model of the generations mean proposed by Hayman (1958) and Gamble (1962) was used to estimate the various genetic components from the generations mean of each cross.

RESULTS AND DISCUSSION

Mean performance, heterosis, potence ratio and inbreeding depression of six generations (P1, P2, F1, BC1, BC2 and F2) for infestation percentage for downy mildew, leaf blight and late wilt diseases are presented in Table (1). The parent one (P1) had low values of infestation of downy mildew disease from parent two (P2) in all hybrids except S.C. 129. The result also showed that values of infection in both F1 and F2 generation were lower than the mid-parental values in all crosses except S.C. SK-17. Heterosis percentage was significant in four crosses except S.C. SK-52 and ranged from – 42.56 (S.C.129) to 29.85 (S.C. SK-17) with an average of –13.82%. This result meaning that S.C.129 had the highest heterotic value toward resistance of downy mildew disease. At the same subject, Gabr (1997) and EL-Zeir and Amer (1999) found significant heterotic effect for downy mildew resistance in maize. Also, EL-Shenawy (1995) found that the heterosis relative to mid-parent ranged from –47.0 to 39.0 with an average of 43.9% for resistance to downy mildew disease. Inbreeding depression was not significant for all crosses of downy mildew disease reflecting the importance of additive gene action in the control of this disease. Potence ratio of downy mildew disease pointed out the existence of partial dominance in S.C. SK-17,S.C.129 and S.C.SK-52 and over dominance in S.C. 155. These results indicated that resistance was predominating than susceptibility in most crosses and the partial dominance was more important than over dominance gene action in the inheritance of this disease. EL-Zeir and Tolba (1999) and Amer *et al* (2002) observed partial dominance gene action in the direction of susceptible to downy mildew disease.

Regarding to leaf blight disease (Table 1), the low value of infestation percentage was obtained for P2 in S.C. SK-17, S.C. SK-52 and S.C. 155 meaning that P2 was more resistance than P1 especially in S.C. SK-17while, the reverse was obtained in S.C.129. Moreover, the high resistant single cross in F1 and F2 generation was found with S.C. 129. No significant heterosis values were observed in all crosses except SK- 17, which gave positive significant value toward susceptibility. Heterotic effects ranged from –13.39 to 43.68 with an average of 7.96%. Potence ratio exhibited partial dominance in S.C. SK-17 and S.C. 129, complete dominance of S.C.SK-52 and over dominance with S.C. 155. These results mean that the three types of dominance gene action were operating in the inheritance of this disease. However, Nawar and Salem (1985) found that the over dominance gene action represent the major role in the inheritance for leaf blight disease. Estimates of inbreeding depression exhibited significant differences in the two white single crosses while the other yellow crosses were insignificant.

As shown in Table (1), the high resistance of late wilt disease was obtained of P1 in the two yellow hybrids and P2 in the two white hybrids. The result also showed that the F1 and F2 generation were more resistant than their mid-parental lines in all crosses except S.C. SK-52. Significant heterosis was observed for various crosses except SC SK-17. Heterosis over the mean parental values ranged from –28.55 (S.C. 155) to 16.96 (S.C. SK-52) with an average of –9.74%. In addition, S.C. 155 and S.C.129 had the highest heterotic value for resistance to late wilt disease. The estimates of degree of dominance showed partial dominance in S.C. SK-17 and over dominance gene action in the other hybrids. These results indicated that the over dominance represent the important role in the inheritance of resistance to this disease. These results were in harmony with those of Amer *et al* (2002). Inbreeding depression values were not significant for all crosses with exception of S.C. 129 which had negative and significant value toward resistance of late wilt disease. These results indicated that the selection is very useful to improve the resistance of this disease. The same results were obtained with EL-Gresi (1978) of this disease.

Six parameter model (m, additive (a), dominance (d), a x a, a x d and d x d) for the transformed mean of infestation percent to three diseases under study are shown in Table (2). The results revealed that the mean effects exhibited highly significant for all crosses in three diseases. Significant additive effects for downy mildew disease were existenced in four crosses except S.C. 129. Also, significant epistatic effects were risen in all hybrids whereas a x d in all hybrids, a x a in three crosses and d x d in two signle crosses. These results indicated that the additive and epistatic gene effects were the most important contributors to the inheritance of this disease. The dominance gene effects were low and may be negligible. Deleaon (1994) and EL-Zeir and Tolba (1999) found that the additive gene action was more important in the inheritance of resistance to downy mildew disease than dominance effects. Otherwise, Abd-El-Aal (2002) found that the epistatic gene effects were important in the inheritance of resistance to this disease.

With respect to leaf blight infection, significant additive, dominance and epistatic effects were involved in all crosses with exception of additive effects in S.C. SK-17 and epistatic effects in S.C. SK-52. These results indicated the importance of three types of genetic components in the inheritance of this disease. The most suitable breeding procedure for the improvement of resistance to leaf blight disease is therefore, reciprocal recurrent selection, which utilizes the kinds of gene effects. These results agreed with those obtained results of Hughes and Hooker (1971).They reported that additive, dominance and epistatic types of gene effects were involved in the inheritance of leaf blight disease. Meanwhile, Takamiya and Sendo (2000) found that the resistance to leaf blight disease controlled mainly by both additive and dominance gene effects.

The genetic effects of late wilt disease exhibited significant additive and dominance effects in S.C. SK-17 and S.C. 155, also S.C. 129 had significantly additive effects. Furthermore, epistatic effects were detected significant for a x a, a x d and d x d of S.C. SK-17; a x d and d x d of S.C. 129 Also, d x d gene effect of S.C. 155 was detected significant differance. Considering the prevalence both additive and non- additive genetic components in the inheritance of this disease. It can be concluded that, reciprocal recurrent selection and selective diallel mating are suitable breeding scheme for resistance improvement to late wilt disease. These consequences is consistently in accordance with that obtained by Salem (1977) who indicated that additive, dominance and non-allelic interaction of gene effects seemed to control the resistance to late wilt disease.

Table (1): Mean performance, heterosis relative to mid-parent (H%), potence ratio (P.R) and inbreeding depression (I.D%) of the six generations (P_1, P_2, F_1, BC_1, BC_2 and F_2) of infestation percentage (Arcsine) for downy mildew, leaf blight and late wilt diseases.

Character Crosses	Downy mildew				Leaf blight				Late wilt			
	S.C.SK-17	S.C. 129	S.C. SK-52	S.C.155	S.C.SK-17	S.C. 129	S.C. SK-52	S.C.155	S.C.SK-17	S.C. 129	S.C. SK-52	S.C.155
P1	15.05	75.03	62.78	62.73	31.03	5.7	31.95	33.0	17.33	15.30	17.35	20.03
P2	35.13	15.6	90	90	5.7	31.48	27.1	29.58	14.08	15.15	18.73	20.50
F1	32.58	26.03	70.5	49.78	26.58	20.4	27.1	27.10	15.25	11.50	21.10	14.48
BC1	32.70	32.05	60.28	58.75	22.6	15.38	30.0	25.88	12.85	17.98	19.35	13.40
BC2	37.73	30.70	66.38	55.50	20.93	26.65	26.33	32.38	16.10	15.03	20.18	15.2
F2	35.75	23.08	59.63	52.6	17.88	9.13	30.38	24.2	17.88	15.25	19.98	16.08
H%	29.85**	-42.56**	-7.71	-34.84**	43.68**	9.74	-8.21	-13.39	-2.89	-24.47**	16.96**	-28.55**
P.R	0.75	-0.64	-0.44	-1..95	0.65	0.14	-1.0	-2.45	-0.28	-49.7	4.43	-24.75
I.D%	-9.73	11.33	15.63	-5.66	32.73*	55.25*	-12.10	10.70	-17.24	-32.61*	5.30	-11.05
$\bar{x}$	31.49	33.75	68.32	61.56	20.79	18.12	28.81	28.69	15.58	15.04	19.45	16.62
C.V%	17.72	25.83	10.93	10.94	27.27	42.12	9.47	12.94	13.96	16.38	12.64	12.47
L.S.D	8.41	13.12	11.24	10.14	8.53	11.49	4.10	5.75	3.27	3.71	3.70	3.12

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

Table (2): Six- parameter model for infestation percentage of downy mildew, leaf blight and late wilt diseases in four maize crosses.

Character / Crosses / Six parameter	Downy mildew				Leaf blight				Late wilt			
	S.C. SK-17	S.C. 129	S.C. SK-52	S.C. 155	S.C. SK-17	S.C. 129	S.C. SK-52	S.C. 155	S.C. SK-17	S.C. 129	S.C. SK-52	S.C. 155
Mean (m)	35.75**	23.08**	59.48**	52.60**	17.88**	9.13**	30.38**	24.2**	17.88**	15.25**	19.98**	16.08**
additive (a)	-5.03**	1.35	-6.10*	4.65*	1.67	-11.27**	3.67**	-6.50**	-3.25**	2.95*	-0.83	-1.8*
dominance (d)	5.35	13.895	9.51	-6.4	23.76**	49.35**	-11.29*	-42.73**	-29.78**	1.295	2.20	-12.91**
axa	-2.14	33.18**	15.4*	20.22*	15.54*	47.54**	-8.86	19.72**	-13.62**	5.02	-0.86	-7.12
axd	5.01**	28.36**	7.51**	18.25**	-10.99**	1.62	1.25	-8.21**	-4.875**	2.875*	-0.14	-1.565
dxd	23.38**	-15.99	25.06*	1.52	-12.71	-53.62**	9.45	-19.46**	17.63**	-17.59**	0.080	19.41**

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

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التعرف على وراثة امراض البياض الزغبى وتبقع الاوراق والذبول المتاخر فى اربع هجن فردية من الذرة الشامية باستخدام تحليل متوسطات الست أجيال

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الملخص العربى

أجريت هذه الدراسة بمحطة البحوث الزراعية بسخا خلال اعوام ٢٠٠٠ ، ٢٠٠١ ، ٢٠٠٢ تحديد نوع الفعل الجينىالمتحكم فى وراثة مرض البياض الزغبي ومرض تبقع الأوراق ومرض الذبول المتأخر فى أربع هجن فردية من الذرة الشامية (سخا ١٧ أبيض ، فردى ١٢٩ أبيض ، سخا ٥٢ أصفر وفردى ١٥٥ أصفر) وذلك تحت ظروف العدوى الصناعية.

ويمكن إنجاز أهم المتحصل عليها فيما يلى :

-أظهرت جميع الهجن ما عدا هجين فردى سخا ٥٢ معنوية فى قوة الهجين للمقاومة لمرض البياض الزغبي وقد تراوحت قيمة قوة الهجين من –٦٥و٤٢ إلى ٨٥و٢٩ بمتوسط قدرة –٨٢و١٣ وكانت المقاومة سائدة على الحساسية وكانت السيادة الجزئية هي الأكثر أهمية فى وراثة هذا المرض.

-أظهر الهجين الفردى سخا ١٧ معنوية موجبة فى اتجاه الحساسية لمرض تبقع الأوراق وتراوحت قيم قوة الهجين من –٣٩و١٣ إلى ٠٨و٤٣ بمتوسط ٩٦و٧ .وقد لعبت الثلاث أنواع من السيادة دورا فى وراثة هذا المرض.

-أظهر الهجينان الفرديان التجاريان ١٥٥و١٢٩ معنوية سالبة لقوة الهجين فى اتجاه المقاومة لمرض الذبول المتأخر وقد لعبت السيادة الفائقة الدور الأهم فى وراثة هذا المرض.

-لعبت تأثيرات الفعل الجينى المضيف التفوقى الدور الأهم فى وراثة مرض البياض الزغبي وكان دور الفعل السيادى قليلا أو لا يذكر بينما وجدت الثلاث أنواع من تأثيرات الفعل الجينى وهى المضيف والسيادى والتفوقى فى وراثة كل من مرض الذبول المتأخر ومرض تبقع الأوراق مما يشير إلى أن طريقة الانتخاب التكراري العكسي واختيار نظام الدياليل هي طريقة التربية المناسبة لتحسين مقاومة هذه الأمراض.