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Tomato Breeding For Early Blight Disease Resistance

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Abstract: *Early blight is one of the most destructive diseases for tomato crop; traditional breeding programs are the main way to produce new cultivars for early blight resistance. In this study, five different genotypes namely: NCEBR-6 as a resource of early blight resistance and five domestic genotypes i.e., LA 2399, Edkawi, UCT5, Super strain-B and Peto-82 were used and the crosses were made to produce five populations and to be evaluated for early blight disease under nature infection of early blight during three seasons under the field and greenhouses conditions. Results indicated that, there were significant differences in the degree of resistance (P > 0.05) between tomato genotypes and its crosses. NCEBR-6 cultivar was resistant for early blight and F_1 hybrid (Super Strain B × NCEBR-6) recorded the highest degree of resistance compared with the other crosses. The relative potency ratio of gene set for parent showed high partial dominance in the cross (Super strain-B × NCEBR-6) = 0.74. There was negative complete dominance for the cross (Edkawi × NCEBR-6) value = -1 trending to smaller parent. The correlation between resistance for yield, yield components and fruit quality was established, there were highly positive relationship between resistances for fruit set %, fruit number and were moderate with yield. as, r = 0.949, 0.749 and 0.609 respectively. This data revealed that the cultivars did not super pass the resistant parent. Further, this study needs more information to investigate the inheritance and genetic analysis to improve commercial cultivars to get the completely resistance.*
Keywords*: Tomato breeding, Early blight Resistance, Alternaria solani, Solanum lycopersicum, Inheritance.*

I. Introduction

Tomato (*Solanum lycopersicum* Mill) is one the most important vegetable crops at all over the world as well as in Egypt. Early blight disease caused by (*Alternaria solani*) is one of the most destructive common fungal diseases affecting primarily the leaves, stems, flowers and fruits of tomato. **(Çalıs and Topkaya 2011).** The leaf spots are generally from dark brown to black, often numerous and enlarging with concentric rings. Lower leaves are attacked first, and then disease progresses upward and affected leaves turn yellow and dry up. Stems lesions can develop on seedling, and may form canker and kill the plant. The disease can attack can attack fruits when they approach maturity at the stem end where the symptoms may be small or may enlarge to cover most of the fruit **Rotem, 1994,** Agrios, 1997 ; **Chaerani and Voorrips,** and **2007**;**).** Pathogen Alternaria solani produces several toxic to infect tomato plants. Among these toxins altrnatic acid and solan apyrone that induce necrotic symptoms with encircled chlorosis and enhance the pathogen infection and the development of necrotic symptoms. (Langsdorf et.al., 1990) .The early blight disease is controlled mainly by the application of agrochemical against the worldwide trends towards environmentally safe methods. So, breeding program is the best suitable way to achieve this aim, to improve the commercial varieties and found new resistance lines.

In North Carolina **Gardner (1988)** long-term breeding program developed two sister lines NC1CELBR and NC 2CELBR to combine early blight and late blight resistance into adapted fresh-market tomato backgrounds. The pedigree of the two breeding lines traces back to NC 215E-1(93), has a D.M. Spooner source PI 126445 and NC complex pedigree extending back to NCEBR-1, which has moderate foliage resistance to early blight derived from the *Lycopersicon hirsutum* L. (currently Solanum habrochaites S. Knapp & S. Knapp &D.M. Spooner) source PI 126445 NC EBR-2, which has moderate foliage resistance and a high level of stem lesion resistance to early blight derived from Campbell 1943. Also, Nash and Gardner **(1988)** evaluated the most utilized method of screening tomato for early blight resistance**.** Evaluating plants under natural conditions and recording disease progress throughout the entire life of the plant were recorded by **Kumar and Srivastava (2013**).

Field evaluation for Early blight resistance can identify the resources of resistance but the major drawbacks are the lengthy duration of the tests, uncontrolled environmental conditions necessary for infection and the presence of other pathogens (Fooled et. al., 2000, Randy et al., 2010), NC1CELBR and NC 2CELBR genotypes are determinate as a moderate resistance to early blight *Alternaria solani*, large-fruited, fresh-market tomato (*Solanum lycopersicon* L.) NCEBR-6 is advanced resistance line for early blight disease, was provided by Genetic Resource Center, University of California Davis, USA., with its origin and the crosses were obtained throughout the long term breeding program. Screening of tomato genotype against early blight occur during the different growth stages and caused a decrease in fruit quantity and quality and lead to complete defoliation.

Genetic studies on the inheritance of early blight resistance revealed different sources for resistance, in tomato lines and their hybrids to understand their performances, genetics and resistant reaction of selected accessions of plant. The classical studies on the inheritance of EB resistance reached the conclusion that the resistance is a quantitative trait that is controlled polygeneticaly (**Chaerani and Voorrips, 2007)**. Data revealed that early blight resistance in NCEBR2 and NCEBR4 was quantitatively controlled by more than one gene or quantitative trait locus under controlled glasshouse environment, **(Çalıs and Topkaya 2011)).**

The aim of the present study is to evaluate some certain genotypes of tomato for resistance to early blight caused by (*Alternaria solani*) under the plastic greenhouses and field conditions. The disease occurs naturally on the plants grown in the north coast of Egypt whereas, the dew, rainfall and humidity.

II. Materials And Methods

The present study was conducted at two growing seasons from autumn to spring of 2008/2009 – 2009/2010 to screen six different genotypes of tomato against natural infection of early blight disease that caused by *Alternaria solani*. Seedling were sown in greenhouses and in the field of the experimental farm of Maryout Research Station, Desert Research Center, and Alexandria Governorate.

Seeds of NCEBR-6 as a resistant cultivar to early blight were kindly provided by Dr. John I. Yoder, Professor of tomato breeding at the vegetable crops department, California University, Davis, USA and the other five seeds of varieties or inbreed lines were provided by Dr. R. Chetelat, Professor of tomato breeding at Tomato Genetic Resource Center, California University, Davis, USA, The pedigree of the tested six tomato genotypes are showed in Table 1.

Table 1: Common names, code numbers, and origin of five tomato *Lycopersicon. esculentum* genotypes, screened in the present study.

No.	Germplasm Common Names & /or Code Numbers	Resistance degree	Origin
1	cv. NCEBR-6 LA 3846	Resistant	U.S.A
2	LA 2399 (UCT5)	susceptible	U.S.A
3	LA 2711 (Edkawi)	susceptible	Egypt
4	Super strain-B	susceptible	U.S.A
5	Peto-82	susceptible	Peto seed com.

Plants of all tomato genotypes were selfed for two generation before crossing, and the following crosses were made between the resistant parent (NCEBR-6) and the other five domestic genotypes to produce four populations as the following:1- (Edkawi × NCEBR-6), 2- (UCT5 × NCEBR-6), 3- (Super strain-B × NCEBR-6) and 4- (Peto-82 × NCEBR-6). Seeds of F_1 and its parent were germinated separately under greenhouse in trays containing mixture peatmoss and vermiculite. Crosses and their parents were transplanted on the 20$^{th\ of\ October}$ under plastic greenhouse and11th of October 2009 into the field and repeated transplanted on 24 November 2009, season 2009-2010 under greenhouses. The experimental were designed in a randomized complete block design with four replications. Minimum and Maximum temperature degrees with relative humidity, wind speed and solar radiation were recorded daily for seven months, form October,2008 to May2009 as well as 2010. The average metrological values for the different previously mentioned measurements were obtained from Maryout climate Station are illustrated in Table 2 1The metrological data of Maryout climate station during the growing 2008/2009 - 2009/2010 and presented in Table 2

Table 2: The monthly metrological values obtained from Maryout climate station during October–May 2008/2009 and 2009/201 growing season.

Month	Temperature. °c		evapotranspiration rate		Relative Humidity %		Average wind speed km/h
	Maximum	Minimum	Maximum	Minimum.	Maximum	Minimum	
2008/2009							
October	26.70±0.535	20.63±0.253	28.88±0.655	20.24±0.297	78.50±0.794	52.55±1.34	6.26±0.385
November	22.04±0.446	17.54±0.003	23.07±0.364	17.37±0.113	76.34±0.877	54.89±1.60	6.81±0.59
December	19.84±0.277	15.07±0.448	20.68±0.342	14.65±0.388	73.35±1.99	51.28±.525	9.24±0.496
January	19.59±0.619	14.04±0.259	20.34±0.580	13.95±0.183	74.58±1.222	52.25±1.043	8.5±0.8311
February	21.03±1.624	14.29±0.736	21.91±1.160	14.01±0.626	73.04±1.235	47.83±2.734	9.04±0.709
March	21.27±1.222	14.45±0.710	22.95±0.838	14.24±0.678	75.82±1.839	50.89±1.149	9.12±0.618
April	23.16±1.178	14.99±0.545	25.57±1.115	14.87±0.547	76.64±0.914	46.68±2.106	7.66±0.614
May	24.65±1.062	15.54±0.677	27.12±0.965	15.32±0.571	80.17±0.954	47.96±2.744	6.97±0.457
2009/2010							
October	26.40±0.339	18.54±0.426	29.49±0.290	18.27±0.453	83.86±1.154	55.31±2.252	6.641±0.581
November	24.16±0.946	18.88±0.404	27.12±1.150	18.73±0.521	79.89±1.202	56.95±2.739	6.731±0.511
December	23.16±0.708	18.09±0.956	25.19±0.781	17.70±1.016	76.15±0.752	52.31±2.077	7.286±0.387
January	19.41±1.116	14.34±1.210	20.82±1.009	13.96±0.532	76.79±0.699	55.56±2.306	8.099±0.593
February	18.565±0.464	13.17±0.371	20.06±0.506	12.45±0.358	71.91±1.323	49.55±1.968	8.025±1.146
March	18.520±0.975	12.557±0.27	20.18±0.960	11.85±0.245	72.02±1.033	46.37±1.796	9.967±1.119
April	19.620±1.132	12.897±0.42	22.09±0.546	12.11±0.323	73.23±1.916	47.89±2.833	8.635±0.642
May	20.885±0.614	13.11±0.287	23.94±0.825	12.31±0.354	77.97±1.456	48.91±1.143	8.18±0.432
Jun	22.70±0.712	13.98±0.614	25.93±0.623	12.97±0.637	79.47±1.898	49.82±2.319	7.455±0.827

Disease assessment:

The individual plants of different tomato genotypes were kept under close observations to determine their resistance and reaction to early blight disease and their performances.

Early blight resistance was evaluated based on lesion size on leaf area in the plant. According to (Poys and Tu 1996).

Disease eventually was rated 1:10 scale as 10 most resistant and1most susceptible, 10 asymptomatic, 9= few small lesions, 8=several small lesions. 7=,<10% leaf area with infection, 6=20 - 30%, 5=31-50%, 4=51-80%, 2=81-90%, 1=99 plant dead.

Yield and fruit characteristics:

The following data were recorded per plant on 9o day – old tomato plants grown under greenhouse in, ten plants in a replicate for each genotype.

Fruit weight, fruit number, fruit set, fruit diameter, fruit length, and fruit yield per plant, fruit flesh thickness, locules and the total soluble solids. The experimental design used in conducting this experiment was randomized complete block design (RB) with four replicates.

Statistical Analysis:

Analysis of variance, correlation and calculations of the mean and its standard error for the different characters were estimated according to the methods described by **Gomez and Gomez (1984) and Briggs and Knowles (1977).**

Nature of Dominance:

The nature of dominance was determined by calculating the potence ratio of gene set (P) **described by Smith (1952).**

III. Results And Discussions

There was a naturally infected tomato leaf and fruits showing blight symptoms and identified as *Alternaria solani,* based on the morphological characteristics (**Ellis 1976)** reported that in plastic greenhouses and field **Sallam and Kamal (2012).**

Data presented in table1 showed that the significant differences in the degree of resistance to early blight caused by Alternaria solani based on scale ranged from 10 (most resistant) to 1(most susceptible). The highest value of resistance (10) was recorded in NCEBR-6 was (10) and followed by the cross UCT5 × NCEBR-6 (7.5). The lowest value was found in cv. Super Strain B (1.75), *Alternaria Solani* affected this cultivar in all its parts with lesions, dark rings in leaves; stem and fruits.

Table 3: Reaction of certain tomato genotypes to natural infection with early blight disease in yield and fruit quality at 2009 growing season under greenhouse conditions.

Genotypes	Degree of resistance	Fruit set %	Fruit number	Fruit weight (g)	Yield g/plant	Fruit diameter (mm)	Fruit length (mm)	Flesh thickness (mm)	Locules NO.	T.S.S %
NCEBR-6	10	71.75	21.50	47.72	1066	4.425	5.24	5.25	2.50	5.58
Super strain B	1.75	45.00	14.50	56.15	790	4.72	4.75	5.25	3.70	5.45
UCT5	5.50	73.75	20.25	231.20	2799	8.20	5.75	6.95	7.50	5.70
FUCT5 × NCEBR-6	7.50	61.50	25.75	184.20	4580	7.20	6.60	6.50	3.25	5.70
LSD 0.05	1.19	10.61	6.94	30.17	859.57	0.687	0.62	1.11	1.59	0.67

Degree of resistance to early blight based on a scale ranged from 10 (most resistant) to 1(most susceptible).

Significant differences were recorded in yield the hybrid UCT5 × NCEBR-6 exhibited the highest yield per plant (4580g) followed by cv. UCT5 (2799g), which is known as vigor and, perfect horticulture variety with large fruits. On the contrary, it is lowest value was observed in cv. Super Strain B (790 g/plant) which had the lowest value in the degree of resistance. NCEBR-6 had a moderate value (1066 g/plant), similar results were reported by **Marisa and Timothy (1990**) as his tomato breeding lines exhibiting field resistance to early blight have been developed, but most were of low yielding.

Significant differences were observed among the screened genotypes in fruit weight and fruit number where, UCT5 had exhibited the highest value of fruit weight but the cross UCT5 × NCEBR-6 appeared the highest value of fruit number per plant (25.25) more than its parents. Data showed in fruit set % the highest value was found in UCT5 (73.25%), NCEBR-6 and UCT5 × NCEBR-6 were intermediate. Table (3) showed also that the lowest value of fruit sett per plant, fruit number and fruit yield 45%, 14.5 and 790 g. was recorded

in cv. Super Strain B. No significant differences was recorded for total soluble solids among different genotypes.

Data presented in Table (4) showed yield and yield components and some characteristics of fruit in the F_1 hybrid Edkawi × NCEBR-6 and their parents under field conditions. Data revealed the highest degree of resistance (10) in cv. NCEBR-6 followed by the F_1 hybrid (7.5).

Table 4: Performance of NCEBR-6, Edkawi and their F_1 hybrid for resistance to early blight disease under field conditions at 2009 growing season

Genotypes	Degree of resistance	Fruit set %	Fruit number	Fruit weight (g)	Yield g/plant	Fruit diameter (mm)	Fruit length (mm)	Flesh thimckness (mm)	Locules No.	T.S.S %
NCEBR-6	**10.00**	**100**	**44.00**	**58**	**2528.6**	**4.25**	**5.25**	**7.00**	**2.75**	**5.95**
Edkawi	**7.00**	**88**	**18.25**	**152**	**2556**	**7.67**	**4.80**	**6.75**	**7.75**	**5.50**
F1 Edkawi × NCEBR-6	**7.50**	**83.8**	**15.75**	**147**	**2688.3**	**7.65**	**4.40**	**5.50**	**6.50**	**5.92**
L.S.D. at 0.05	**0.99**	**13.1**	**9.15**	**25.80**	**322.43**	**1.09**	**0.39**	**1.85**	**1.25**	**0.62**

Degree of resistance to early blight based on a scale ranged from 10 (most resistant) to 1(most susceptible).

The resistant parent NCEBR-6 showed the highest value of fruit set (100%), fruit number (44), fruit length 5.25 mm, fruit thickness (7) mm and T.S.S. (5.95%) while it exhibited the low values in fruit weight (58g.), fruit locules (2.75) and fruit diameter (4.25 mm) **Gardener and Panthee (2010)** reported that fruit size of both lines were smaller than the hybrid cultivars with fruit trending to be smaller for NC2CEBR and NC1CEBR.

There was no significant differences in yield between the cross Edkawi × NCEBR-6 and their parents. Significant differences were found in the degree of resistance also, fruit set, fruit, number, and fruit weight Table 4 under natural field infection conditions.

The results presented in Table (5) showed significant differences among the different tomato genotypes under greenhouse for resistance degree to early blight where NCEBR-6 exhibited the highest degree of resistance (10) followed by cross Super Strain B × NCEBR-6 (9), the low values were found in Super Strain B (2.25) and Peto 82 (5.75) while their crosses which derived from them and NCEBR-6 were high resistance (9) and (8) respectively to Alternaria solani **Calis and Topakya (2011)** reported that none of tomato cultivars was fully resistance to early blight disease because all the tomato lines exhibited variable level of susceptibility from low to high incidence of necrotic spots on inoculated leaves.

Table (5) showed increasing values in fruit number in the cross Super Stain B X NCEBR-6 was (57) per/plant it was higher than parent. No Significant differences were observed in tomato genotypes in fruit set %, while high value was recorded in NCEBR-6 (100%) and then came its hybrid Super Stain B X NCEBR-6 (89.75%).

Data in Table 5 indicated significant differences in fruit diameter among different tomato genotypes with the highest value was in Edkawi (8.23 mm) under greenhouse. This was followed by its cross Edkawi × NCEBR-6, while the hybrid Peto82 × NCEBR-6 was the smallest value in fruit diameter (3.35mm) and (3.47mm) for cv. Peto82 **Gardener and Panthee (2010)** reported that NC1CEBR and NC2CEBR, both lines were late in maturity and showed much lower yield of fruit than the hybrid cultivar.

Table 5 Degree of resistance to early blight disease and yield and yield components of the screened under greenhouse conditions at the 2010 growing season.

Population	Degree of resistance	Fruit set %	Fruit No.	Fruit Diameter (mm)	Fruit Length (mm)	Flesh thickness (mm)	Locules NO.	T. S. S. %	Fruit Weight	Yield g/plant
NECBR-6	**10.00**	**100.00**	**42.50**	**4.27**	**5.60**	**5.75**	**2.50**	**5.95**	**50.77**	**2203.02**
Peto-82	**5.75**	**66.0**	**17.75**	**3.47**	**4.75**	**6.50**	**2.50**	**5.85**	**54.92**	**984.75**
Super strain-B	**2.25**	**45.50**	**13.75**	**4.15**	**4.60**	**6.25**	**4.00**	**6.55**	**51.70**	**711.75**
Edkawi	**8.00**	**81.00**	**34.50**	**8.23**	**4.82**	**6.00**	**7.50**	**5.85**	**149.20**	**4214.15**
F_1 Peto-82 × NECBR-6	**7.75**	**74.75**	**29.25**	**3.35**	**3.90**	**4.75**	**2.75**	**7.60**	**58.67**	**1720.27**
F_1 Super Strain-B × NECBR-6	**9.00**	**89.75**	**57.00**	**4.30**	**4.57**	**4.25**	**3.25**	**6.50**	**47.20**	**2399.75**
F_1 Edkawi × NECBR-6	**8.00**	**77.00**	**26.25**	**5.85**	**4.10**	**4.25**	**6.50**	**5.85**	**134.07**	**3440.27**
L. S. D. 0.05	**0.606**	**2.95**	**7.35**	**1.41**	**1.43**	**1.20**	**1.47**	**0.818**	**22.36**	**618.90**

Degree of resistance to early blight based on a scale ranged from 10 (most resistant) to 1(most susceptible).

Average fruit weights presented in Table (5) showed that Edkawi had the highest fruit weight followed by F_1 hybrid Edkawi × NCEBR-6, 149.2 and 134.7g respectively, the desirable fruit weight depends on the purpose of tomato production, putting in consideration the fruit quality characteristics required for a certain

purpose. Peto-82, NCEBR6 and Super strain-B showed smaller values than Edkawi, but they have a very good fruit quality.

Data recorded for total yield per/plant showed, significant differences among evaluated different cultivars and hybrids, the lowest value of total yield gram per plant was recorded in plant of Super strain-B 711.75 under green houses and the high value in plants for Edkawi (4214,19g) followed by hybrid . Edkawi × NCEBR-6 (3440 g/plant) and (2399.76g) for the F_1 hybrids Super strain B × NCEBR-6, respectively, while Peto 82 × NCEBR-6 and NCEBR-6, value was 1720.27and 2203g/plant, **Barksdale (1971) and Gardner (1988)** reported that two lines NCEBR-1 and NCEBR-2 were relatively of low yielding and late maturing. **Poysa and Tu (1996)** reported that in NCEBR-1 and NCEBR-2 is primary determined by additive genetic screened annually for early blight resistance in a mist chamber similar to that describe by **Gardner(1990).**

These obtained results revealed that it can improve fruit quality and quantity through backcrosses of different tomato lines. **Poysa and Tu (1996)** suggested that this can provide also an estimate of resistance to early blight disease in a range of plant material currently available for commercial development.

Table 6 Correlation coefficient between the degree of resistance to early blight disease and fruit yield and quality of the screened tomato genotype, under greenhouses conditions during 2009/2010 growing season.

Traits	Resistance of degree	Fruit set %	Fruit no.	Fruit diameter	Fruit length	Flesh thickness	Locule	T. S. S	Fruit weight
Fruit set	**0.949***								
Fruit number	**0.749***	**0.811***							
Fruit diameter	**0.227**	**0.154**	**0.024**						
Fruit length	**0.211**	**0.375**	**0.169**	**0.139**					
Flesh thickness	**-0.372**	**-0.321**	**-0.400**	**0.223**	**0.401**				
Locule	**0.056**	**-0.037**	**0.028**	**0.829***	**-0.180**	**o.035**			
T. S. S	**-0.091**	**-0.124**	**0.021**	**-0.406**	**-0.505***	**-0.155**	**-0.254**		
Fruit weight	**0.205**	**-0.088**	**-0.078**	**0.757***	**-0.134**	**-0.177**	**0.792***	**-0.348**	
Fruit yield	**0.609***	**0.521***	**0.429**	**0.734***	**-0.005**	**-0.667***	**0.663***	**-0.304**	**0.853***

***Significant at 5% level significance.**

Figure 1 Correlation coefficient between the degree of resistance to early blight disease and fruit yield and quality of the screened tomato genotype, under greenhouses conditions during 2009/2010 growing season.

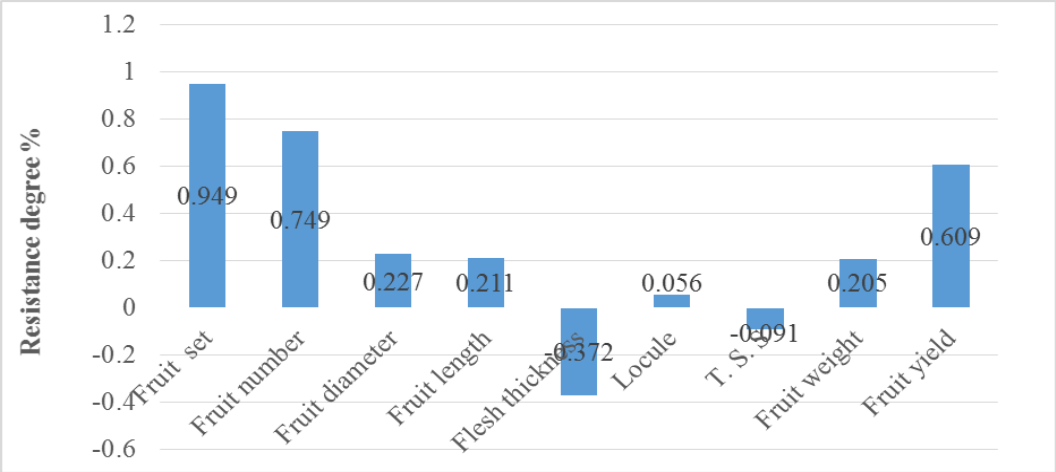

Table (6) presented correlation between the degree of resistance and other characteristics. The results indicated to positive relationship for resistance degree with fruit set, fruit number and yield. The estimates values were 0.949, 0.749 and 0.609 and they were highly significant. It can explained resistant plants performed well against early blight and had a reasonable yield while the susceptible infected plants suffered in foliage and in all parts negatively reflected in loss in yield and yield components from the beginning as they had a reduction in fruit set, fruit number and yield under greenhouse conditions.

Results in Table (6) and figure (1) revealed a positive relationship between fruit set and fruit number and it was highly significant 0.811, while it was 0.521 with yield. Meantime, fruit diameter showed positive correlation with locules, fruit weight and yield but, there was a negative relationship with total soluble solids. Data also detected that T.S.S. had negative correlation with most of measurements such as resistance, fruit set, fruit flesh thickness, fruit weight and yield. This characteristic needs more studies in breeding programs to select plants which have high degree of resistance to early blight and also carry genes for total soluble solids desirable characters of quality. These results indicated that NCEBR-6 is a resistance source to early blight disease.

Results presented in Table (7) indicated the relative potency of gene set (P) for the degree of resistance in comparison between three F_1 hybrids. The (P) exhibited highly partial dominance in F_1 hybrid Super strain × NCEBR-6 and the value has (0.74) a trend to the resistant parent. On the other side, there was negative complete dominance (-1) as for F_1 hybrid as Edkawi × NCEBR-6 has a trend to the smaller parent, whereas there was no high differences between Edkawi and resistance parent. NCEBR-6 in the degree of resistance, in future breeding program needs more studies to choose right cultivars in combination between them resistance lines to get more progress against early blight. **Marisa and Timothy (1990**) reported that this situation complicates evaluation of resistance and progress toward release of early maturing resistant cultivars. Of the resistant breeding lines evaluated, NCEBR-2 has the greatest potential for future breeding of a resistant commercial cultivar.

Table 7: Relative potency of gene set ratio (P) and better parent heterosis for the degree of resistance against early blight disease under greenhouse at 2009 growing season.

Genotype	Mean	Potency Ratio(P)	Mid_Better Parent Heterosis %	Better Parent Heterosis %
Super strain-B × NCEBR-6	9	0.74	47.07	-1o
Edkawi × NCEBR-6	8	-1	-11.11	-20
Peto- 82 × NCEBR-6	7.75	0.058	-1.52	-22.5

L. S. D. 0.5 to compare between means of different F_1 populations =0.488

The estimates value for Mid Parent Heterosis for the degree of resistance was positive (47.05%) for the cross F_1 hybrid Super strain × NCEBR-6 and were negative (-1.52% and -11.11%) for the F_1 hybrids Peto-82 × NCEBR-6 and Edkawi × NCEBR-6 respectively (Table7).

The estimates value for Better Parent Heterosis was -22.5%, -10% and 20% for the crosses hybrids Peto-82 × NCEBR-6, Super strain-B × NCEBR-6 and Edkawi × NCEBR-6 respectively (Table7). These results mean these three crosses did not super pass the better parent (resistant parent).

Table 8: Relative potence ratio (PR) and better parent heterosis for yield against early blight disease under green house at 2010growing season.

Genotype	Mean	Potency Ratio(P)	Mid_Better Parent Heterosis %	Better Parent Heterosis %
Super Strain × NCEBR-6	2399,75	1.26	64.60	8.9
Edkawi × NCEBR-6	3440.27	0.23	7.22	-18
Peto 82 × NCEBR-6	1720,27	0.20	7.98	-0.22

L. S. D. 0.5 to compare between means of different F_1 populations =0.488

Also, results presented in Table (8) indicated that over dominance in yield was 1.26 in the cross Super strain B × NCEBR-6 trends to high yield. This result revealed that in screening plants to early blight disease, it appeared expressions of genes whereas, there are variations between parents.

The F_1 hybrids Peto-82 × NCEBR-6 and Edkawi × NCEBR-6 had slightly positive partial dominance (P = 0.23 and 0.20) from mid parent means trend to high parent Edkawi in total yield under greenhouse conditions.

The NCEBR-6 is a genetic resource for early blight resistance. This study needs to test more isolates of the pathogen at controlled greenhouse environment to get more information about inheritance and genetic analysis for horizontal resistance and to obtain tomato cultivars with complete resistance to early blight disease.

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