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GENERAL COMBINING ABILITY FOR FIELD RESISTANCE TO LATE BLIGHT IN POTATO

R. K. BIRHMAN, T. A. JOSEPH, H. C. SHARMA, S. K. BHATTACHARYYA AND H. S. CHAUHAN

Central Potato Research Institute, Shimla 171001

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ABSTRACT

Estimates of general combining ability of 19 potato parents were computed by the weighted least square analysis using data from greenhouse testing of field resistance to late blight in 32,552 seedlings from 28 crosses. SLB/P-9-12, Kufri Jyoti and SLB/R-11-10 were found to be the best parents for transmitting late blight resistance. Very high correlation ($r^{26} = 0.83^{**}$) between the observed and fitted percentage of resistant seedlings in different crosses indicated that useful information can be obtained through this model about the promising parents for late blight resistance from the data which are otherwise rejected. However, significant χ^2 value indicated that specific combining ability between parents also contributed to the observed variation.

Key words: Late blight resistance, combining ability, potato.

Late blight caused by *Phytophthora infestans* attacks the potato crop regularly in the hilly regions of the country in a devastating form. The disease invariably appears in the plains also. Hence, control of this disease is of paramount importance for increasing potato production. Since control of late blight through chemicals is inadequate, expensive, and environmentally hazardous, breeding cultivars resistant to the pathogen is the most effective way to control it. Due to multiplicity and plasticity of physiological races of the pathogen, the race-specific or vertical resistance, which, in addition to being short lived, also enhances the rate of formation of new and complex races, is not favoured by the potato breeders. The race-nonspecific resistance, popularly known as field resistance, and proposed to be governed by polygenes and of continuous (quantitative) nature is considered a better alternative [1–3]. For planning an effective breeding strategy for quantitative economic traits, the knowledge of combining ability of the parents is vital, more so in potato because of its tetraploid and highly heterozygous genetic constitution.

Recently a method has been proposed for estimating general combining ability (gca) of parents from the data collected in a breeding programme where crosses are not made following any systematic plan, the progenies in a cross are not limited to finite numbers,

and evaluation of the selected genotypes extends over a long period [4, 5]. Since no information is available on the gca effects of parents used in the country for improvement in field resistance to late blight, the same was estimated and reported in this paper. The estimation method followed was as proposed by Gilbert [4] as modified by Cox [6].

MATERIALS AND METHODS

During the 1980–1988 period, 64,992 potato seedlings of 85 crosses involving 71 parents of *Solanum tuberosum* L. were tested in the greenhouse for field resistance to the potato late blight fungus (*Phytophthora infestans*). The testing was done as described by [2, 7]. Two races 0 and 1.2.3.4.5.7.8.9.10 of the fungus were used for testing. Seedlings showing infection grade 1 and 2+ on the 0–5 scale of Black [8] were considered resistant.

STATISTICAL ANALYSIS

It is a minimal statistical requirement that the number of crosses should exceed the number of parents. This is obvious, as more often a parent is crossed with others, the more reliable would be the estimates of its gca, and in the extreme case when none of the parents is combined more than once with other, the reliability becomes indeterminate. Gilbert [4] has however, suggested the satisfaction of the following three conditions:

1. for p parents, preferably number of crosses $\geq 10 + p$;
2. each parent is combined with at least two other parents; and
3. the crosses are interconnected, i.e. one can travel from one cross to another through identical parents.

Let R_i, n_i denote the late blight resistant and total seedlings in cross i derived from parents s and t, m number of crosses, p number of parents, i = 1 to m, and s, t = 1 to p. All combinations of s and t however may not necessarily be available in all cases.

Cox [6] has suggested the modified analysis of the logistic transforms of the binary data (i.e. presence and absence of disease).

We have $Z_i = \log (R_i - 0.5) / (n_i - R_i - 0.5)$

The expectations of Z_i is $\beta_s + \beta_t = \log \frac{\theta_i}{1-\theta_i}$, where β_s and β_t measure the gca of parents s and t involved in cross i with θ_i as the expected resistant seedlings.

For computing the weighted least squares, we use the weights $1/V_i$, when V_i is defined as:

$$V_i = \frac{n_i - 1}{R_i\,(n_i - R_i)}$$

The estimating equations for gca are given by the matrix equation

$$\underset{\frown}{B}\ \underset{\frown}{B} = \underset{\frown}{U}$$

where
$$\underset{\frown}{B} = \begin{pmatrix} (B_{11}, & B_{12}, & \ldots\ldots\ldots\ldots\ldots, & B_{1p}) \\ (& & &) \\ (B_{21}, & B_{22}, & \ldots\ldots\ldots\ldots\ldots, & B_{2p}) \\ (\ . & & &) \\ & & & \\ (\ . & & &) \\ (\ . & & &) \\ (B_{p1}, & B_{p2} \ldots\ldots\ldots\ldots\ldots, & & B_{pp}) \end{pmatrix}$$

$$\underset{\frown}{\beta} = \begin{pmatrix} (\beta_1) \\ (\ ) \\ (\beta_2) \\ (\ .) \\ (\ .) \\ (\beta_p) \end{pmatrix} \qquad \underset{\frown}{U} = \begin{pmatrix} (U_1) \\ (\ ) \\ (U_2) \\ (\ .) \\ (\ .) \\ (U_p) \end{pmatrix}$$

and
$$B_{st} = \sum_{i=1}^{m} \frac{(\delta_{is}\,\delta_{it})}{(V_i)}$$

$$U_s = \sum_{i=1}^{m} \frac{(\delta_{is}\,Z_i)}{(V_i)}$$

$\delta = 1$ when s is one of the parents in cross i, otherwise 0.

A fitted number of resistant seedlings for a cross can be calculated by the formula

$$\hat{R}_i = n_i \,.\, \exp\,.\,(\hat{\beta}_s + \hat{\beta}_t) \quad / [1 + \exp\,(\hat{\beta}_s + \hat{\beta}_t)]$$

In our study, 28 crosses were tested for late blight resistance over the nine-year period. They involved 19 parents and satisfied the suggested conditions of Gilbert [4] except condition No. 1, which is not obligatory. Moreover, the deviation caused by this is of only

one degree of freedom to the residual in the regression analysis. The statistical analysis was done on a PC/AT with the help of a programme in BASIC developed and tested at the Institute. The programme is available with Dr H. C. Sharma.

RESULTS AND DISCUSSION

Different parents were used two to five times in the crosses. Total seedlings screened were 32552 and test seedlings in each cross ranged from 48 to 6758 (Table 1). The resistant

Table1. Observed and fitted number and percentage of resistant seedlings in 28 crosses of potato

Cross			Total number of seedlings	Number of resistant seedlings		Resistant seedlings (%)	
				observed	fitted	observed	fitted
Kufri Jyoti	x	Dekama	4254	128	137.2	3.0	3.2
	x	EX/A 680-16	6758	610	653.9	9.0	9.7
	x	PS 4904	2750	73	76.4	2.6	2.8
	x	Desiree	2832	427	372.0	15.0	13.1
SLB/J-61	x	Dekama	540	10	3.9	1.8	0.7
	x	Desiree	1200	32	38.0	2.6	3.2
	x	EX/A 680-16	1000	21	22.6	2.1	2.3
SLB/R-11-10	x	SLB/J-61	480	72	61.4	15.0	12.8
	x	Dekama	336	42	39.7	12.5	11.8
	x	SLB/J-81	288	15	35.8	5.2	12.4
VB/A-85	x	EX/A 680-16	2150	127	91.3	5.9	4.2
	x	Desiree	2000	29	117.9	1.4	5.9
K. Naveen	x	K. Jyoti	384	28	25.8	7.2	6.7
	x	Desiree	288	13	17.4	4.5	6.0
	x	PS 4904	540	8	6.5	1.4	1.2
K 2500	x	K. Bahar	432	28	30.8	6.4	7.1
	x	EX/A 680-16	336	26	23.4	7.7	7.0
SLB/M-70	x	JF 246	960	75	72.3	7.8	7.5
	x	Dekama	900	10	13.1	1.1	1.5
SLB/S-58	x	SLB/J-132	336	64	58.7	19.0	17.5
	x	K. Jyoti	48	6	13.5	12.5	28.1
SLB/P-9-12	x	SLB/J-81	228	63	50.5	21.8	17.5
	x	SLB/J-61	432	63	77.8	14.5	18.0
JH 214	x	Desiree	288	21	22.8	7.2	7.9
	x	PS 4904	1080	19	17.3	1.7	1.6
JF 246	x	EX/A 697-10	432	28	30.8	6.4	7.1
EX/A 679-10	x	K. Bahar	240	13	10.5	5.4	4.4
SLB/J-132	x	Desiree	620	41	46.7	6.5	7.5
			$\chi^2 = 133.1^{**}$ (d.f. = 9)		$r = 0.8259^{**}$		

$^{**}P <= 0.01$.

Table 2. Analysis of variance of logistic transforms of late blight data in potato

Source	d.f.	Mean sum of squares
Crosses	27	34.87
Gca	18	45.00*
Residual	9	14.60

*P <= 0.05.

seedlings varied from 1.1% to 21.8% in different crosses.

Analysis of variance carried out after the weighted least square analysis (Table 2) showed gca mean square to be significant when tested against the residual mean square. Therefore, the parents differed significantly in their general combining ability for late blight resistance.

General combining ability estimates for the 19 parents are given in Table 3. The gca estimates ranged from –2.67 (PS 4904) to 0.91 (SLB/P-9-12). Three parents, viz. SLB/P-9-12, Kufri Jyoti and SLB/R-11-10, had significant positive gca effects in order of merit while eight parents had significant negative gca effects (Table 3). Hence SLB/P-9-12, Kufri Jyoti and SLB/R-11-10 are considered to be good general combiner for field resistance to late blight. The reverse is true for VB/A-85, SLB/J-61, SLB/J-81, Dekama and PS 4904. Data on the frequency of resistant seedlings observed in different progenies indicate that, but for a few exceptions, one of the parents should be a good general combiner for obtaining higher percentage of resistant seedlings in the progeny of the cross.

Table 3. General combining ability estimates of 19 parents for field resistance to late blight based on logistic transforms of blight data in potato

Parent	Gca effects
SLB/P-9-12	0.91* ± 0.35
Kufri Jyoti	0.89* ± 0.37
SLB/R-11-10	0.50* ± 0.19
SLB/S-58	–0.05 ± 0.82
JF 246	–0.80 ± 1.09
Desiree	–0.99* ± 0.39
K 2500	–1.25 ± 0.82
Kufri Bahar	–1.32 ± 1.00
EX/A 680-16	–1.34* ± 0.40
JH 214	–1.46 ± 0.74
SLB/J-132	–1.51 ± 0.70
SLB/M-70	–1.71 ± 1.07
Kufri Naveen	–1.74* ± 0.57
EX/A 697-10	–1.77 ± 1.13
VB/A-85	–1.77** ± 0.50
SLB/J-61	–2.42** ± 0.46
SLB/J-81	–2.46** ± 0.73
Dekama	–2.51** ± 0.42
PS 4904	–2.67* ± 0.53

The fitted number and percentage of seedlings resistant to late blight for each of the 28 tested progenies are given in Table 1. The χ^2 value between the observed and fitted numbers of resistant seedlings in Table 1 is highly significant ($\chi^2 = 133.1$), indicating an imperfect fit. The gca estimates of parents, therefore, cannot entirely account for the variation of logistic transforms of the observed late blight data and some other components, notably specific combining ability between parents, must also contribute to the observed variation [9, 10]. But gca estimates, although decidely

imperfect, are good enough for practical purposes. Otherwise, plant breeding as currently practised would be impossible [4]. The correlation between observed and fitted percentages of resistant seedlings of the 28 crosses is very high ($r = 83^{**}$). Consequently, it can be concluded that the use of gca to evaluate the ability of the parents in transmitting their late blight resistance to the progenies, even if not completely accurate, would help in choosing late blight resistant parents for use in potato improvement programmes.

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