RFLP mapping of brown planthopper resistance gene *Bph1* in rice.

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The nine brown planthopper (BPH) *Nilaparvata lugens* resistance genes identified so far have not yet been located on the linkage map in detail. In this study, we determined the *Bph1* locus using several restriction fragment length polymorphism (RFLP) markers. BPH-resistant indica variety IR28 (*Bph1*) was crossed with Koshihikari, a susceptible japonica variety. We tested 92 F_3 lines of the cross for resistance in a mass screening using biotype 1 BPH and IR28 and Koshihikari. DNA was extracted from young leaves of the parents and F_3 lines using the cetyltrimethyl ammonium bromide method. The RFLP probes, except XNpb, were provided by NIAR/STAFF.

The F_3 lines from the cross Koshihikari/ IR28 segregated into 68:24 for resistant homozygous or heterozygous (R+H) and homozygous susceptible (S). Although susceptible lines died after infestation, we could not distinguish between resistant homozygous and heterozygous plants. This segregation showed a good fit to the expected 3(R+H):1 (S) ratio ($\chi^2 = 0.058$). We initially used several markers located on chromosome 4, based on the study of Ikeda and Kaneda (1983). That reported the location of *Bph1* on chromosome 4 by trisomic analysis. However, our RFLP analysis showed that *Bph1* was not linked to 11 markers on chromosome 4. We then used several RFLP markers located on chromosome 1.

The *bph2* gene, allelic or closely linked to *Bph1*, was linked to the *d2* gene on chromosome 4 at a 39.4% recombination value (Ikeda 1985). Ikeda et al (1984) reported that *d2* was located on chromosome 1 using RFLP analysis.

However, *Bph1* was not linked to the 21 RFLP markers on chromosome 1. We therefore used several RFLP markers located on the other 10 chromosomes to obtain the marker linked to *Bph1*. The results showed that *Bph1* was linked to G148, C185, XNpb248, and XNpb304-1 on chromosome 12 at recombination values of 18.4, 11.5, 10.7, and 11.9%, respectively (see table). Thus, we conclude that *Bph1* is located on chromosome 12. These loci are arranged as G148 - C 185 - *Bph1* - XNpb248 - XNpb304- 1 - XNpb319 - XNpb304-2 (see figure).

However, results of earlier studies (Ikeda and Kaneda 1983, Ikeda 1985) were inconsistent with our findings. Mistakes during trisomic analysis for insect and disease resistance are possible. Weak and scanty trisomic plants that have the resistance gene may appear susceptible under resistance selection pressure. The recombination value of 39.4% between *bph2* and *d2* is also too distant to confirm a linkage relationship. Previous studies did not use marker genes on chromosome 12.

Use of several RFLP markers on all chromosomes enabled us to determine the location of *Bph1* on chromosome 12.

Cited references

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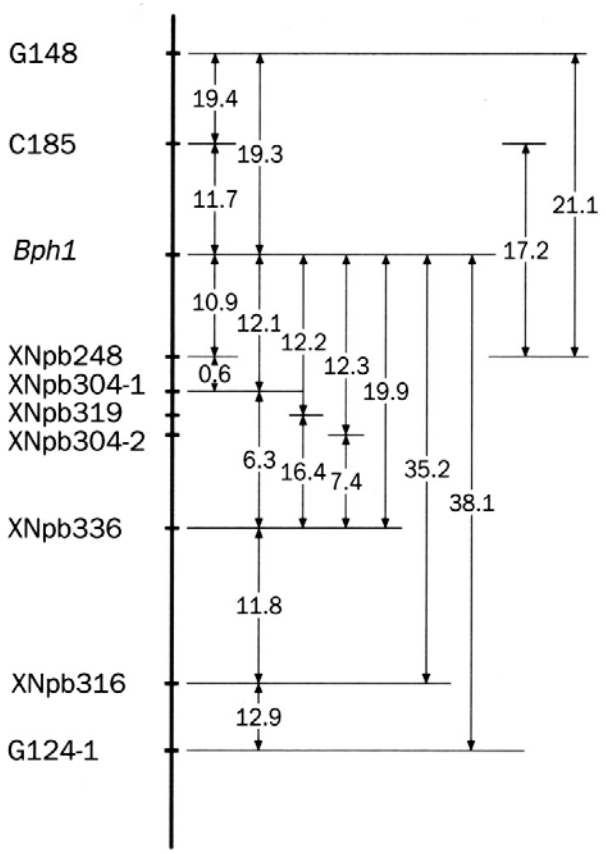
Linkage analysis between Bph1 and RFLP markers on chromosome 12.

Gene pair	Segregation mode in F_3							Recombination	Genetic map
AB	A_BB	A_Bb	A_bb	aaBB	aaBb	aabb	c 2 [a]/	value (%)	distance (cM)
Bph1 - G148	20	0	41	1	0	24	10.9 (<0.01)	18.4 ± 10.1	19.3 ± 10.3
Bph1 - C185	61	0	5	7	0	17	39.1 (<0.001)	11.5 ± 3.6	11.7 ± 3.6
Bph1 - XNpb248	20	42	6	0	4	20	54.5 (<0.001)	10.7 ± 3.4	10.9 ± 3.4
Bph1 - XNpb304-1	19	42	6	0	5	19	48.6 (<0.001)	11.9 ± 3.6	12.1 ± 3.6
Bph1 - XNpb319	18	42	6	0	5	19	48.6 (<0.001)	11.9 ± 3.6	12.2 ± 3.6
Bph1 - XNpb304-2	21	40	6	0	5	19	49.1 (<0.001)	12.1 ± 3.6	12.3 ± 3.6
Bph1 - XNpb336	20	38	9	1	6	17	33.0 (<0.001)	18.9 ± 4.5	19.9 ± 4.5
Bph1 - XNpb316	21	33	14	2	9	13	12.5 (<0.01)	30.3 ± 5.6	35.2 ± 5.6
Bph1 - G124-1	18	36	7	2	14	8	6.6 (<0.01)	32.7 ± 5.9	38.1 ± 6.0

[a]/ Calculated based on the ratio of 3:6:3:1:2:1 (df 2).



Arrangement of *Bph1* and RFLP markers on chromosome 12. The genetic distances are given in centiMorgan units.

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