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FIELD EVALUATION OF RICE LINES FROM IRRI AGAINST BACTERIAL LEAF BLIGHT IN THUA THIEN HUE – VIETNAM

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Abstract: *Xanthomanas campestris* pv. *oryzae* is a causal agent of rice bacterial blight, a destructive rice disease worldwide. This disease is widely spread in Vietnam. Many people have attempted to control this disease by chemical sprays. However, there are claims and counterclaims about the performance of many chemicals because they are hazardous to humans and environment. The most accepted and promising strategy is breeding resistant cultivars. In this study, 64 rice lines provided by IRRI were evaluated for the resistance to bacterial leaf blight in Thua Thien Hue province of Vietnam. The experiments were laid out in a completely randomized design (CRD) without replications in the Spring-Summer crop of 2015 in the open field at district Quang Dien, Thua Thien Hue province. The results showed that rice lines were highly resistant with bacterial leaf blight. The IR 12 line performed the highest resistant level to bacterial leaf blight. Based on the agronomic traits and level of bacterial leaf blight resistance, IR 3, IR 4, IR 46, IR 28, IR 6, IR 18, IR 14 and IR 26 lines were selected for the breeding program.

Keywords: Bacterial leaf blight, rice, resistant, CRD

1 Introduction

Xanthomanas campestris pv. *oryzae* is the causal agent of bacterial leaf blight (BLB). The disease caused the decline of photosynthesis and yield loss of 20–30 % (Ou, 1985) even more seriously from 80 % (Singh et al., 1997) to 100 % (Zhai and Zhu, 1999). The symptoms are typical as the appearance of pale-green to grey-green streaks, particularly at the leaf margins. The lesions coalesce and spread over the entire leaf, and the yellowish-white discoloration appears. Eventually, the whole leaf may become whitish and grayish. In susceptible cultivars, the leaf sheath may also be infected. The disease can occur in both tropical and temperate environments, particularly in irrigated and rain-fed lowland areas. In general, BLB disease favors temperatures of 25–34 °C, with relative humidity above 70 % (IRRI). BLB disease develops in the period of photosynthesis peak, under the hot and wet weather, and strong wind. It also occurs when high density is applied and there are pests available in the field (Vu Trieu Man, 2007; Nguyen Ngoc De, 2008).

In recent years, BLB disease has increased in the nearly entire country. In the Spring season and Summer-Autumn season of 2012, the infected area increased by 35–70 % compared with the year before in the north of Viet Nam. In 2013, the infected area throughout the country

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and in the northern provinces increased by 49 % and 66 %, respectively, compared with 2012. The disease trend was very complex. An area of 1443,1 ha in Nghe An was infected in the Summer-Autumn season of 2015 (Phu Huong, 2015).

At present, there is no specific pesticide to treat BLB, and other pesticides are used only to prevent the disease. The use of the resistant cultivars, seed treatments (Singh and Monga, 1985), and careful crop management (Padmanabhan, 1983) is suggested to reduce the incidence of the disease. Thus, this study was conducted to select promised rice lines that have a high level of BLB resistance, high yield, and good quality. These lines would be appropriate under local conditions and contribute to the breeding program in Thua Thien Hue province.

2 Material and method

2.1 Materials

A rice germplasm with 64 rice lines carrying resistant gene was provided by the International Rice Research Institute (IRRI). The HT1 variety cultivated in Thua Thien Hue was used as the control (Table 1).

Table 1. List of the rice germplasm provided by IRRI

Sign	Rice lines	Sign	Lines	Sign	Rice lines
IR 1	IRBB1 2013DS	IR 23	IRBB60 2013DS	IR 47	IRBL3-CP4
IR 2	IRBB3 2013DS	IR 24	IRBB61 2013DS	IR 48	IRBL5-M
IR 3	IRBB4 2013DS	IR 25	IRBB62 2013DS	IR 49	IRBL9-W
IR 4	IRBB5 2013DS	IR 26	IRBB63 2013DS	IR 50	IRBLK-Ku [C0]
IR 5	IRBB7 2013DS	IR 27	IRBB64 2013DS	IR 51	IRBLKh-K3 [C0]
IR 6	IRBB8 2013DS	IR 28	IRBB65 2013DS	IR 52	IRBLKm-T5 [C0]
IR 7	IRBB10 2013DS	IR 29	IRBB66 2013DS	IR 53	IRBL20-IR24
IR 8	IRBB11 2013DS	IR 30	IRBB24 2013DS	IR 54	IRBLZ5-CA (R)
IR 9	IRBB13 2013DS	IR 31	IRBLA-A	IR 55	IRBLSH-Ku [C0]IR85430
IR 10	IRBB14 2013DS	IR 32	IRBLA-C	IR 56	IRBLSH-S [C0]IR85424
IR 11	IRBB21 2013DS	IR 33	IRBLI-F5	IR 57	IRBLSH-B [C0]IR93322
IR 12	IRBB23 2013DS	IR 34	IRBLKS-F5	IR 58	IRBLZT-IR56 [C0]IR85429
IR 13	IRBB50 2013DS	IR 37	IRBLKP-K60	IR 59	IRBL5-M [C0]IR85413
IR 14	IRBB51 2013DS	IR 38	IRBLKH-K3	IR 60	IRBLKS-C0 [C0]IR85423
IR 15	IRBB52 2013DS	IR 39	IRBLZ-Fu	IR 61	IRBLKp-K60 [C0] IR85422
IR 16	IRBB53 2013DS	IR 40	IRBLZ5-CA	IR 62	IRBL1-C1 [C0] IR85411
IR 17	IRBB54 2013DS	IR 41	IRBLZT-T	IR 63	IRBL7-M [C0]IR85414
IR 18	IRBB55 2013DS	IR 42	IRBLTA-K1	IR 64	IRBLTa2-IR64 [C0] IR93325
IR 19	IRBB56 2013DS	IR 43	IRBLTA-CT2	IR 65	IRBLTa2-Pi [C0] IR93323
IR 20	IRBB57 2013DS	IR 44	IRBLSH-S	IR 66	IRBLTa-Me [C0] IR93324
IR 21	IRBB58 2013DS	IR 45	IRBLSH-B	**Control**	**HT1**
IR 22	IRBB59 2013DS	IR 46	IRBL1-CL		

2.2 Method

A completely randomized design without replications was applied. The plot size was 1 m^2 consisting of double rows spacing of 2 cm. The hills of HT1 variety were transplanted alternately with the other lines. In order to objectively assess the potential resistance, pesticides were not used during the growing. Sowing was on Jan 8th and transplanting was on Feb 3rd, 2015.

The growth characteristics included the total growth time, the number of effective tillers, and the plant height. They also comprise the panicle length, leaf senescence, the number of panicles/m^2, and the number of grains/panicle. The weight of 1000 grains was assessed according to the standards of QCVN 01-55: 2011/BNNPTNT.

Assessing the resistant level to BLB was based on the test documents of IRRI. The testing was performed once per 10 days with ten points per line, ten plants per point. The infected leaves were counted and the diseased level was classified. The severity index was performed from the disease incidences. The data were analyzed with mean and mean ± SE using an Excel software.

2.3 Weather condition

The weather conditions in Thua Thien Hue from January to April 2015 were recorded (Table 2).

Table 2. Meteorology data in Thua Thien Hue from January to April 2015

Target		January	February	March	April
Rainfall *(mm)*		70.8	64.2	180.1	151.7
Evaported water *(mm)*		47.4	44.5	64.3	67.6
Temperature (°C)	T_{min}	13.3	14.5	18.6	16.1
	T_{max}	29.1	33.5	35.8	39.0
	T_{av}	19.5	21.8	25.1	25.9
Humidity (%)	U_{min}	56	61	48	44
	U_{max}	89	90	88	87
Total of sunny time (hour)		119	135	167	198

Source: Centre for Hydrometeorology Forecast of Thua Thien Hue province, 2015

The data showed that the temperature increased from 19.5 °C (January) to 25.9 °C (April), whereas the high rainfall occurred mainly in March and April, and the humidity maintained at the 90 % level during the season. These weather conditions caused difficulties for sowing and the rice growth. They took advantages for pest development like blast disease, leaf blight disease, worm, mice, etc.

3 Results and discussion

3.1 Growth and development stages

The time from establishment to harvest is a genetic characteristic and affected by surrounding conditions. Regarding growth time, IRRI (1995) classifies rice varieties as very short-duration group (less than 90 days), short-duration group (91–115 days), medium-duration group (116–130 days) and long-duration group (more than 131 days). The rice germplasm used in this study was divided into 4 groups (Table 3). The very short-duration group has only line IR 45 (90 days); the short-duration group contains 39 lines (ranged from 95 to 115 days, accounting for 60 % of the germplasm), in which IR 40, IR 3, IR 12, IR 52, IR 2 and IR 5 have growth time less than 100 days; the medium-duration group includes 21 lines (116–130 days, 32.3 %); and the long-duration group includes IR 18, IR 61, IR 17 and IR 62 with total of time from 131–132 days (6.2 %). The control variety HT1 belongs to the third group (127 days). The data in Table 3 revealed that the length of the flowering stage is consistent with the National Technical Regulation on rice (QCVN 01-55:2011/BNNPTNT). 19 lines flowered concentratedly (less than 4 days, 29.2 %) with IR 45 being the earliest. The medium flowering group with 4–7 days had 42 lines, accounting for 64.6 % of the germplasm. There are 4 lines (IR 20, IR 63, IR 21 and IR 22) with long flowering stage (more than 7 days, 6.2 %).

The majority of the lines showed good adaptability in the Spring crop season in Thua Thien Hue. The medium-duration (4 – 7 days) varieties comprised most of the germplasm, 42 lines.

Table 3. The growth and development periods

No.	Rice group	Number of lines	Rate (%)
1	**Duration of flowering stage**		
	Short (< 4 days)	19	29.2
	Medium (4–7 days)	42	64.6
	Long (> 7 days)	4	6.2
2	**Total of growth time**		
	Very short– duration (< 90 days)	1	1.5
	Short-duration (91–115 days)	39	60.0
	Medium-duration (116–130 days)	21	32.3
	Long-duration (> 131 days)	4	6.2

3.2 Agronomical characteristics

Plant structure

The plant height, ability to tillering, number of effective tillers, and flag leaf age are important criteria to assess the growth ability, potential yield, and adaptability under local conditions. The rice germplasm was divided into different groups based on these characteristics (Table 4).

Table 4. Characteristics of the plant structure

No.	Classify	Number of lines	Rate (%)
	Plant height		
	Medium (100–120 cm)	11	16.9
	Short (< 100 cm)	54	83.1
	Tillering		
	Medium (10–19 shoots)	58	89.2
	Poor (5–9 shoots)	7	10.8
	Effective tillers		
	Medium (5–8 tillers)	61	93.8
	Rich (> 8 tillers)	4	6.2
	Leaf senescence		
	Long (level 1)	9	13.8
4	Medium (level 5)	50	76.9
	Early (level 9)	6	9.2

There were 2 groups in plant height: medium-plant height group (16.9 %) and short-plant height group (83.1 %). The lines belonging to medium-plant height group were from 100.4 cm to 113 cm tall. They are IR 66, IR 54, IR 40, IR 45, IR 42, IR 38, IR 44, IR 65, IR 48, IR 57, and IR 49. In the short group, the plant height ranged from 68.4 cm to 99.8 cm. Line IR8 was the shortest (68.4 cm). HT1 belongs to the second group (95 cm).

The tillering ability of the germplasm was divided into 2 groups: the medium tillering group (89.2 %) including 58 lines with 10–19 shoots and the poor tillering group including lines IR 63, IR 62, IR 23, IR 60, IR 57, IR 31, and IR 33 with 5–9 shoots. The number of effective tillers was divided into 2 groups. The medium tiller group (about 5–8 tillers) included 61 lines, and the rich tiller group (more than 8 tillers) had 4 lines IR52, IR38, IR39, and IR32. The total of flag leaf age reflects the degree of aging of leaves. The long-lasting green leaves indicate that there is a high potential yield. The data showed that the long-leaf age group included 9 lines: IR 11, IR 14, IR 21, IR 22, IR 27, IR 29, IR 38, IR 39, and IR 58 (13.8 %). The medium leaf age group had 50 lines and variety HT1, accounting for 76.9 %. The early leaf age group comprised 6 lines (9.2 %) with IR 12, IR 16, IR 19, IR 20, IR 26, and IR 39.

Flowering and grain characteristics

The characteristics of flowering and grains directly decide the rice yield. The high yield varieties have long panicles, more grains per panicle, high 1000-seed weight and long panicle axis. Table 5 illustrates these characteristics of the studied germplasma.

The panicle length was divided into 3 groups: short panicle length (12–15 cm) included lines IR 63, IR 2 and IR 50; medium panicle length (16–19 cm) involved 26 lines occupying 40 % of the germplasm; and long panicle length (over 20 cm) had 23 lines and the control (22.5 cm).

The rice lines that have long panicles are a promise for the high yield and need to save for selection and breeding.

The number of grains per panicle was observed into 3 groups. The very few grain number groups had 9 lines, accounting for 13.8 %. The few grain number group had 46 lines. The group of medium grain number included 10 lines: IR 26, IR 14, IR 11, IR 1, IR 10, IR 7, IR 30, IR 28, and variety HT1.

The 1000-grain weight was divided into 3 groups: the low P1000 group had line IR 39 and line IR 61; the medium P1000 group had 30 lines, accounting for 46.2 %; and the high P1000 group had 33 lines and variety HT1 (27.38 gram).

The panicle exsertion was observed in 2 groups. Most lines belonged to the well-exserted group (54 lines and variety HT1), accounting for 83.1 % of the germplasm. The just exserted group had 11 lines: IR 17, IR 20, IR 22, IR 23, IR 24, IR 30, IR 39, IR 61, IR 65, and IR 64 (16.9 %).

Table 5. Flower and grain characteristics in rice germplasm

No.	Rice group	Number of lines	Rate (%)
	Panicle length		
	Short (12–15 cm)	3	4.6
1	Medium (16–19 cm)	26	40.0
	Long (> 20 cm)	23	35.4
	Total of grain number/panicle		
	Very few (< 100 grains)	9	13.8
2	Few (100–150 grains)	51	78.5
	Medium (150–200 grains)	10	16.9
	High (> 200 grains)	0	0.0
	1000-grain weight		
	Low (< 20.0 g)	2	3.1
3	Medium (20.0–25.0 g)	30	46.2
	High (> 25.9 g)	33	50.8
	Panicle exsertion		
4	Well exserted (1)	54	83.1
	Just exserted (5)	11	16.9

3.3 Levels of bacterial leaf blight infection

The resistance to leaf blight infection depends on the biological characteristics of the Xanthomonas oryzae bacteria. They are diverse in terms of the physiological strains. In the northern part of Vietnam, 7 physiological strains are found alternately in the region. Thus, this resistance is unsustainable. The results of levels of bacterial leaf blight infection are presented in Table 6.

There was no detection of BLB disease in 32 lines. Three lines: IR 10, IR 7, and IR 54 were infected with the disease incidence of less than 30 %. There were 30 infected lines, accounting for 46.2 % in the germplasm. The BLB severity was recorded in line IR2 (78.94 %), while HT1 variety had the disease incidence of 44.44 %.

Table 6. The rate of bacteria leaf blight infection

Rice group	Line number	Rate (%)
Levels of disease infection		
Uninfected (DI = 0 %)	32	49.2
Low infected (DI = 1–30 %)	3	4.6
Infected (DI > 30 %)	30	46.2

3.4 Agronomical characteristics and yield components of bacterial leaf blight uninfected lines

The results of assessing BLB infected levels indicate that 32 uninfected lines are considered as promised ones for the selection and breeding program. The agronomical characteristics and yield components are described in Table 7.

Table 7. Agronomical characteristics and yield components of BLB uninfected lines

Sign	Plant height (cm)	Effective tiller number (tillers)	Panicle number/m² (panicles)	Grain/ panicle (grains)	Total of seed number (seed)	P1000-grain (gram)	Theory yield (quintal/ ha)	Actual yield (quintal /ha)
IR 3	77.4 ± 2.29	6.4 ± 1.40	269	102.2	113.40	25.13	69.07	60.30
IR 4	76.8 ± 3.11	9.2 ± 1.57	386	88.90	102.80	29.50	87.08	61.10
IR 6	77.8 ± 1.23	7.9 ± 1.37	332	99.30	119.60	28.25	75.83	64.50
IR 9	77.0 ± 4.38	5.8 ± 0.94	244	97.50	107.30	27.38	65.13	57.40
IR 11	72.0 ± 1.87	7.5 ± 1.23	315	108.90	119.90	25.13	76.75	59.50
IR 14	80.4 ± 9.73	7.0 ± 1.88	287	108.4	123.9	24.06	74.85	70.68
IR 18	81.3 ± 5.37	8.2 ± 1.22	287	103.2	126.6	25.08	74.28	69.90
IR 19	81.9 ± 4.06	6.7 ± 1.56	274	70.3	96.6	26.5	51.04	46.14
IR 21	76.8 ± 7.14	7.5 ± 2.41	307	77.4	94.7	25.37	60.28	55.89
IR 22	80.8 ± 5.39	6.2 ± 1.93	254	69.9	93.4	25.68	45.59	41.37
IR 26	77.0 ± 5.57	7.7 ± 1.56	290	107.2	129.5	24.48	76.10	71.69
IR 28	76.7 ± 2.26	6.9 ± 1.10	246	124.50	98.20	27.38	66.13	64.10
IR 29	77.5 ± 2.42	6.7 ± 1.34	298	96.00	77.00	25.50	58.51	55.92
IR 30	90.9 ± 2.85	7.0 ± 0.82	242	120.50	108.20	24.50	64.15	55.36
IR 32	75.9 ± 1.85	6.2 ± 0.63	308	57.00	132.80	20.00	20.20	19.85
IR 33	76.8 ± 2.20	6.5 ± 0.85	312	55.00	38.40	23.00	27.56	25.65
IR 38	105.0 ± 4.24	7.8 ± 0.94	323	60.70	74.20	24.63	48.29	43.33
IR 39	88.0 ± 2.36	7.3 ± 1.34	318	98.50	77.60	18.75	46.27	42.26
IR 41	89.4 ± 3.53	7.6 ± 1.35	352	69.25	50.20	24.50	43.29	40.18
IR 42	104.6 ± 3.43	6.9 ± 1.17	346	68.75	53.60	21.88	40.57	38.55
IR 45	102.6 ± 3.03	7.6 ± 0.91	315	63.60	77.90	22.38	44.55	40.83
IR 46	93.2 ± 2.87	7.6 ± 0.12	311	86.00	97.80	25.63	68.77	62.50
IR 48	110.4 ± 1.34	7.7 ± 0.98	319	70.20	82.20	22.38	49.80	44.17
IR 49	113.0 ± 1.58	7.6 ± 0.92	307	64.10	77.80	25.13	50.26	46.67
IR 52	99.2 ± 0.93	6.6 ± 0.69	277	88.00	118.90	23.38	56.98	37.40
IR 53	97.3 ± 6.68	8.1 ± 0.45	332	68.90	85.00	21.75	49.75	45.00
IR 56	95.5 ± 3.57	7.4 ± 0.12	303	79.40	98.60	24.13	58.44	52.50
IR 57	112.7 ± 2.10	7.1 ± 0.91	295	50.80	62.00	26.25	47.16	43.33
IR 60	90.2 ± 1.75	6.7 ± 0.39	278	76.60	95.00	23.38	56.49	52.50

IR 64	91.9 ± 2.85	6.9 ± 1.10	372	92.75	51.60	25.88	49.67	45.34
IR 65	105.9 ± 4.38	7.6 ± 1.07	314	78.25	70.40	22.88	50.57	48.06
IR 66	100.4 ± 2.95	6.5 ± 0.85	305	96.00	64.00	26.00	50.75	43.98
HT1	95.61 ± 4.85	6.5 ± 0.29	266	89.00	128.80	27.38	65.55	63.33

The plant height ranged from 72.0 cm for IR 111 to 113.0 cm for IR 49. The short or medium plant height may help plants to resist falling and suitable for intensive farming.

The number of effective tillers is one of the criteria that decide the panicle number per hill. The effective tiller number ranged widely from 5.8 tillers for IR9 to 9.2 tillers for IR4. Variety HT1 had 6.5 effective tillers, and lines IR 3, IR 9, IR 22, IR 32, and IR 66 contained the effective tiller number less or equivalent to that of HT1.

The panicle number per square metre closely relates to the actual yield and is decided by the effective tiller number. The panicle number may contribute up to 74 % yield and grain number, while the grain and seed number contribute 26 % to the yield. The panicle number per square metre ranged from 242 for IR 30 to 386 for IR 4. Variety HT1 had 266 panicles/m^2, which is higher than those of lines IR 9, IR 22, IR 28, and IR 30.

The number of grains per panicle ranged from 50.8 for IR 57 to 124.50 IR 28. Variety HT1 had 98 grains per panicle.

The total number of seeds ranged from 38.4 for IR 33 to 129.5 for IR 26. Variety HT1 reached 128.8 seeds.

The 1000-grain weight ranged from 18.75 g for IR 39 to 29.50 g for IR 4. The weight of 1000 grains of variety HT 1 was 27.7 g.

The theoretical yield ranged from 2.02 tons/ha for IR 32 to 8.71 for IR 4. Variety HT1 reached 6.56 tons/ha, which was lower than that of IR 3, IR 4, IR 6, IR 11, IR 14, IR 18, IR 26, IR 2,8 and IR 46.

The actual yield ranged from 1.99 tons/ha for IR 32 to 7.17 tons/ha for IR 26. The actual yield of variety HT1 reached 6.33 tons/ha. Lines IR 3, IR 4, IR 46, IR 28, IR 6, IR 18, IR 14, and IR 26 had the actual yield higher than 6.0 tons/ha.

4 Conclusions

In the germplasm of this study, there were 4 groups: the very short-duration group had only line IR 45; the short-duration group had 39 lines; the medium-duration group had 21 lines; and the long-duration group included IR 18, IR 61, IR 17 and IR 62.

All the lines gave the plant height from short to medium. No lines had a high plant. Most lines had the medium tillering ability and medium effective tiller number. The flag leaf age was mostly medium, except for 9 lines with the long flag-leaf age.

Most lines had the medium panicle length and few seeds per panicle. 83.1 % of lines had a good panicle exsertion.

32 lines were not infected with BLB disease in the experimental field. Lines IR 10, IR 7 and IR 54 had the disease incidence lower than 30 %. 30 lines were infected, and the most severely infected line was IR 12 at 78.94 %.

These rice lines had a relative resistance to BLB disease. Only line IR 12 was susceptible to BLB disease. Actual yield of lines IR 3, IR 4, IR 46, IR 28, IR 6, IR 18, IR 14, and IR 26 were more than 6.0 tons/ha.

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