

Comparison of Grain Quality of Bacterial Blight Resistant Near-isogenic Lines of Rice under Different Fertilization Levels

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ABSTRACT : This study was conducted in 2002 and 2003 to investigate variation on rice quality associated with cooking, and eating qualities under the three different fertilizer levels, none fertilizer level(N-P₂O₅-K₂O=0-0-0 kg/ha), ordinary fertilizer level(N-P₂O₅-K₂O=110-45-57 kg/ha), and heavy fertilizer level(N-P₂O₅-K₂O=180-90-110 kg/ha). The eight resistant near-isogenic lines(NILs) for bacterial blight in rice were examined for grain appearances, several physicochemical properties, and palatability value measured by Toyo taste meter. Significant variations in NILs(V), Years(Y), and VxY interaction were recognized in grain length and palatability value under the none fertilizer cultivation, in grain width under the heavy fertilizer cultivation, and in white belly ratio under the three different fertilizer cultivations, respectively. According to increase the fertilizer application rate, variation in grain length and grain width were not significant, but grain thickness was thinner under the ordinary and heavy fertilizer cultivations than under the none fertilizer cultivation. On the other hand, white belly ratio, protein content and Mg/K ratio increased, while amylose content and palatability value lowered. Alkali spreading value lowered under the heavy fertilizer cultivation than under the none and ordinary fertilizer cultivations. Palatability value was significantly low in the line carrying *Xa1J* than in the other lines under the ordinary fertilizer cultivations.

Keywords: rice, grain quality, eating quality, physicochemical properties, near-isogenic lines, fertilizer

Rice quality is affected by grain appearance, grain ingredient content, grain moisture content, variety, location of growth, cultural practice, drying, storage and milling operation. In rice grain appearance characteristics, forms of chalkiness show greater difference among locations of growth than among varieties. Moreover, chalkiness occurs more due to increase fertilizer amount and the late transplanting regardless of rice variety ecotypes (Oh *et al.*, 1991)

as well as disease damage (Shin *et al.*, 1992). Oh *et al.*(1991) reported that translucency of grain, 1000-grain weight and hardness of chalky grains were lower than those of head-rice, and also physicochemical properties and eating quality of chalky grains were worse than those of head-rice. The rate of perfect kernels decreased by increasing nitrogen amount and infection of diseases (Lee *et al.*, 2003; Nam *et al.*, 1995; Shin *et al.*, 1992). Among the physicochemical properties of rice grains, amylose content fluctuated by varieties and locations of growth or according to the position of grain in the same panicle (Choi *et al.*, 1994b; Matsue & Ogata, 1999a, 1999b), but variation of amylose content according to increasing of nitrogen fertilizer and harvest time differed among varieties (Chae & Jun, 2002; Lee *et al.*, 2003). Protein content increased by the excess of nitrogen fertilizer, disease infection, lodging and harvest delay (Chae & Jun, 2002; Ishizumi, 1978; Lee *et al.*, 2003; Matsue & Ogata, 1999a; Nam *et al.*, 1995). Also, protein content differed according to the position of grain in the same panicle(Matsue & Ogata, 1999a, 1999b), and fluctuated greatly among varieties and locations of growth (Chae & Jun, 2002; Choi *et al.*, 1994b). Mg/K ratio varied greatly according to varieties and locations of growth, and was the lowest in Odaemye having excellent cooking and eating qualities (Choi *et al.*, 1994b). Alkali spreading value did not show significant difference by variety or harvest year (Choi *et al.*, 1997). Palatability value lowered significantly due to the heavy fertilizer cultivation or harvest time delay (Chae & Jun, 2002; Lee *et al.*, 2003), and palatability value by transplanting time showed difference among varieties(Jung *et al.*, 2003). Varietal difference of palatability of cooked rice decreased under the heavy fertilizer condition ((Ishizumi, 1978). Global evaluation of cooked rice showed great difference by the locations of growth in the same variety (Choi *et al.*, 1994a, 1994b). This experiment was conducted to get the useful information on major characters associated with cooking, and eating qualities of the near-isogenic lines (NILs) with different bacterial blight resistant gene.

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MATERIALS AND METHODS

This experiment was conducted in the field and laboratory of the Honam Agricultural Reserach Institute in 2002 and 2003. Seven NILs developed by Shin *et al.*(1998) & Shin *et al.*(2000) with different bacterial blight resistant gene (*Xa1*, *Xa1J*, *Xa22*, *Xa1'*, *Xa2*, *Xa3*, and *Xa7*) including their recurrent parent, Suwon345 (*Xa0*) used as testing materials. Rice seeds were sown on 30th April. Rice seedlings were transplanted manually at the spacing of 30 x 15cm with one seedling per hill on 30th May. The experiment included three fertilizer levels, none fertilizer level (N-P₂O₅-K₂O=0-0-0 kg/ha), ordinary fertilizer level (N-P₂O₅-K₂O= 110-45-57 kg/ha), heavy fertilizer level (N-P₂O₅-K₂O=180-90-110 kg/ha). Nitrogen fertilizer was applied in three splits of 50-20-30% as basal-tillering-panicle initiation fertilizer, potassium fertilizer in two splits of 70-30% as basal-panicle initiation fertilizer, and phosphorus fertilizer is one split of 100% as basal fertilizer.

Grain length, width, and thickness of brown rice were measured using vernier calliper and estimated from the mean for 20 grains. Percentage of grains with chalkiness area of chalky endosperm was determined by grain with chalkiness ÷ total grains × 100 in a 20 g brown rice. Samples for component analysis used milled rice. The grain milled using Toyo laboratory miller (MC-90A, Yoyo, Japan) with the following procedure : 200 g of brown rice milled puting on pressure uniformly to 91% milled/brown rice ratio. Amylose and protein contents of milled rice were deterimined by Near-Infrared Grain Tester (AN-700, Kett, Japan). Mg and K contents of brown rice were determined using Near Infrared Spectroscopy (NIRS-6500, Perstorp analytical co., USA). Alkali spreading value was determined by visual scale (1-7) of spreading and clearing of milled rice kernel soaked

in 1.4% KOH solution for 23 hours at constant temperature of 30. Palatability value of cooked rice was determined using Toyo taste meter(MA-90B, Toyo, Japan). Statistical analysis was conducted by the PROC ANOVA procedure in Statistical Analysis System (SAS). Difference among treatment was evaluated for significance by the Duncan's multiple range test(DMRT) at 5%.

RESULTS AND DISCUSSION

Table 1 shows variation for rice grain appearance characteristics and physicochemical properties in the different fertilizer levels. Under the none fertilizer level, highly significant effect of NILs(V), year(Y) and their interaction(V×Y) was found on the grain length, white belly ratio, and palatability value. Grain width and amylose content revealed NILs' and yearly variations without significant V×Y interaction. NILs' effect in grain thickness and protein content, and yearly effect in alkali spreading value and Mg/K ratio without VxY interaction were detected significantly. Under the standard fertilizer level, highly significant effect of V, Y and V×Y was found on the white belly. Palatability value revealed marked V and V×Y variations. Significant V and Y were detected in grain width. Also, significant V effect in grain thickness and protein content, and significant Y effect in amylose content, alkali spreading value and Mg/K ratio were detected. Grain length was not exhibit the significant V, Y, and V×Y. Under the heavy fertilizer level, significant effect of V, Y, and V×Y was found on the grain width and white belly. Significant V and Y were detected in the grain thickness and protein content. Significant Y effect was detected in amylose content, Mg/K ratio, and palatability value were not exhibit the significant V, Y and VxY. Choi *et al.*(1997) reported that alkali spreading value did not

Table 1. F-value for rice grain quality characteristics with NILs and Years under the different fertilizer levels.

| Fertilizer (N-P-K, kg/ha) | Source of variation | Grain length | Grain width | Grain thickness | White belly | Amylose content | Alkali spreading value | Protein content | Mg/K equivalent ratio | Palatability value |
|------------------------------|------------------------|-----------------|----------------|--------------------|----------------|--------------------|------------------------------|--------------------|-----------------------------|-----------------------|
| None (0-0-0) | NILs(V) | 2.76** | 3.30* | 3.02* | 100.59** | 2.86* | 0.12ns | 4.04* | 0.55ns | 14.68** |
| | Year(Y) | 10.53** | 20.93** | 4.05ns | 582.05** | 65.32** | 5.76* | 0.23ns | 103.35** | 14.84** |
| | VxY | 6.00** | 1.41ns | 0.91ns | 86.88** | 0.36ns | 0.79ns | 2.19ns | 0.93ns | 7.40** |
| Ordinary (110-45-57) | NILs(V) | 1.76ns | 6.84** | 7.12** | 85.81** | 1.93ns | 1.41ns | 6.55** | 0.69ns | 4.91** |
| | Year(Y) | 0.04ns | 39.55** | 1.73ns | 1373.88** | 5.25* | 21.16** | 2.38ns | 12.63** | 4.12ns |
| | VxY | 0.38ns | 0.87ns | 1.81ns | 78.79** | 1.02ns | 1.05ns | 2.12ns | 1.67ns | 3.59* |
| Heavy (180-90-110) | NILs(V) | 2.17ns | 5.89** | 4.22** | 37.35** | 1.23ns | 0.15ns | 6.14** | 1.81ns | 1.71ns |
| | Year(Y) | 0.81ns | 19.56** | 15.39** | 684.72** | 6.23* | 1.69ns | 40.11** | 35.45** | 87.49** |
| | VxY | 0.45ns | 3.83* | 1.07ns | 31.15** | 1.75ns | 0.98ns | 1035ns | 1.21ns | 1.60ns |

*, **: Significant at the 5% and 1% levels, respectively.

Table 2. Rice grain quality characteristics of NILs under the different fertilizer levels.

| Fertilizer (N-P-K, kg/ha) | NILs | Grain length (mm) | Grain width (mm) | Grain thickness (mm) | White belly (%) | Amylose content (%) | Alkali spreading value (1-7) | Protein content (%) | Mg/K equivalent ratio | Palata- bility value |
|------------------------------|-------------|-------------------------|------------------------|----------------------------|-----------------------|---------------------------|---------------------------------------|---------------------------|-----------------------------|----------------------------|
| None (0-0-0) | <i>Xa0</i> | 5.23b [†] | 2.99ab | 2.04bc | 1.18d | 19.30ab | 6.15a | 7.45ab | 1.02a | 69.00c |
| | <i>Xa1</i> | 5.28a | 2.96b | 2.04bc | 1.10d | 19.40a | 6.15a | 7.40abc | 0.98a | 70.23bc |
| | <i>Xa1J</i> | 5.23b | 3.00a | 2.06abc | 1.25d | 19.23b | 6.13a | 7.43abc | 1.00a | 66.88d |
| | <i>Xa22</i> | 5.26ab | 3.00a | 2.07ab | 4.60b | 19.25ab | 6.13a | 7.58a | 0.98a | 72.40a |
| | <i>Xa1'</i> | 5.25ab | 2.96b | 2.02c | 2.75c | 19.28ab | 6.15a | 7.33bcd | 1.01a | 70.53b |
| | <i>Xa2</i> | 5.28a | 3.00a | 2.04bc | 3.60bc | 19.35ab | 6.13a | 7.53ab | 0.99a | 71.30ab |
| | <i>Xa3</i> | 5.28a | 3.01a | 2.05abc | 4.80b | 19.33ab | 6.18a | 7.15d | 0.98a | 70.45b |
| | <i>Xa7</i> | 5.25ab | 3.00a | 2.10a | 13.10a | 19.25ab | 6.15a | 7.20cd | 0.95a | 70.38b |
| | Mean | 5.26 | 2.99 | 2.05 | 3.92 | 19.30 | 6.14 | 7.38 | 0.99 | 70.14 |
| | CV | 0.53 | 0.78 | 1.33 | 20.72 | 0.51 | 1.68 | 2.00 | 5.26 | 1.22 |
| Ordinary (110-45-57) | <i>Xa0</i> | 5.24ab | 2.94b | 2.00c | 6.10ef | 19.13ab | 6.10a | 8.30a | 1.04a | 66.03b |
| | <i>Xa1</i> | 5.29a | 2.94b | 2.02bc | 3.35g | 19.15a | 6.10a | 8.13abc | 1.11a | 66.43ab |
| | <i>Xa1J</i> | 5.22b | 2.99a | 2.05ab | 4.50fg | 18.93b | 6.15a | 8.18ab | 1.09a | 64.03c |
| | <i>Xa22</i> | 5.24ab | 3.00a | 2.03b | 12.20c | 19.03ab | 6.18a | 8.10abcd | 1.10a | 65.70b |
| | <i>Xa1'</i> | 5.23ab | 2.94b | 2.00c | 14.60b | 19.00ab | 6.18a | 7.98bcd | 1.12a | 66.38ab |
| | <i>Xa2</i> | 5.27ab | 2.97ab | 2.02bc | 9.75d | 19.13ab | 6.18a | 7.93cde | 1.11a | 67.73a |
| | <i>Xa3</i> | 5.27ab | 3.00a | 2.05ab | 7.35e | 19.10ab | 6.13a | 7.88de | 1.07a | 66.85ab |
| | <i>Xa7</i> | 5.25ab | 2.98a | 2.07a | 20.60a | 18.93b | 6.03a | 7.70e | 1.10a | 67.03ab |
| | Mean | 5.25 | 2.97 | 2.03 | 9.81 | 19.05 | 6.13 | 8.02 | 1.09 | 66.27 |
| | CV | 0.67 | 0.78 | 1.06 | 12.75 | 0.69 | 1.44 | 1.86 | 5.24 | 1.50 |
| Heavy (180-90-110) | <i>Xa0</i> | 5.23b | 2.96b | 2.04ab | 5.45d | 19.00ab | 6.05a | 8.50bc | 1.12ab | 63.33ab |
| | <i>Xa1</i> | 5.26ab | 2.96b | 2.03b | 4.20d | 19.08a | 6.08a | 8.60abc | 1.13ab | 62.85ab |
| | <i>Xa1J</i> | 5.25ab | 2.99ab | 2.04ab | 6.15cd | 18.85b | 6.08a | 8.65ab | 1.08ab | 61.23b |
| | <i>Xa22</i> | 5.24b | 2.97ab | 2.04ab | 15.60b | 18.98ab | 6.08a | 8.83a | 1.06b | 62.85ab |
| | <i>Xa1'</i> | 5.27ab | 2.96b | 2.03b | 14.50b | 18.98ab | 6.03a | 8.40bcd | 1.14ab | 64.40a |
| | <i>Xa2</i> | 5.29a | 2.98ab | 2.03b | 13.00b | 19.00ab | 6.08a | 8.45bc | 1.06b | 64.35a |
| | <i>Xa3</i> | 5.28ab | 2.99ab | 2.05ab | 8.65c | 19.03ab | 6.08a | 8.38cd | 1.10ab | 63.83ab |
| | <i>Xa7</i> | 5.25ab | 3.00a | 2.08a | 20.75a | 18.90ab | 6.08a | 8.18d | 1.15a | 63.95a |
| | Mean | 5.26 | 2.98 | 2.03 | 11.09 | 18.98 | 6.07 | 8.50 | 1.10 | 63.35 |
| | CV | 0.56 | 0.69 | 1.13 | 17.31 | 0.67 | 1.57 | 1.87 | 4.69 | 2.53 |

[†]Means followed by a common letter in a column are not significantly at the 5% level by DMRT.

show variation in the variety, harvest year and variety × harvest year interaction. But in this experiment results, alkali spreading value and Mg/K ratio showed yearly variation in the none, ordinary and heavy fertilizer levels, respectively. While, white belly ratio showed highly significant variation in NILs, Year, and NILs × Year interaction in the three fertilizer levels, respectively.

Rice grain appearance characteristics and physicochemical properties of NILs under the different fertilizer levels are

given in Table 2. Grain length and width did not show significant difference due to increase fertilizer amount. But grain thickness was thinner under the heavy fertilizer level than the none and ordinary fertilizer levels. By the increase of fertilizer amount, white belly ratio and protein content increased significantly, in contrast, amylose content and palatability value were lowered. These results agree with the existing reports (Ishizumi, 1978; Lee *et al.*, 2003; Matsue & Ogata, 1999a; Oh *et al.*, 1991). Amylose content in the three

fertilizer levels ranged 18.98-19.30%. These values did not exhibit great difference to the extent of affecting palatability of cooked rice. Okamoto & Horino (1994) reported that amylose content was not correlated with stickiness of cooked rice. Alkali spreading value was lowered under the heavy fertilizer level than the none and ordinary fertilizer levels. According to increase fertilizer amount, Mg/K ratio was slightly elevated but did not show significant difference.

As shown in Table 2, in the grain length, grain width, grain thickness, amylose content, alkali spreading value, protein content, and Mg/K ratio, it showed slightly difference among NILs but significance was not recognized. The white belly ratio of most NILs was high under the none, ordinary and heavy fertilizer levels, particularly white belly ratio of NIL having *Xa7* gene was higher than that of the other NILs. Palatability value of NIL having *Xa1J* gene was lower than the other NILs under the ordinary fertilizer level, but it was not recognized significant difference among NILs under the none and heavy fertilizer levels. Grain length, width and length/width of brown rice showed difference among varieties (Kim *et al.*, 1998). Amylose content, protein content and Mg/K ratio were great variations among varieties (Choi *et al.*, 1994b; Choi *et al.*, 1997). On the contrary, Kim *et al.* (1998) reported that alkali spreading value, protein content and amylose content were not differed among varieties. It can be inferred that different reports of respective researchers as above mentioned are caused by used materials, tested year, tested location and analyzer. On the other hand, it suggests that factors relating appearance quality, cooking and eating qualities are influenced greatly by environmental conditions.

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