Heritability and Expected Genetic Advance for Rice Characters in Relation to Yellow Orange Leaf Virus Resistance

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Abstract

Eight rice varieties, ARC11554, GS10719, Suphan Buri 60 (SPR60), RD9, RD1, RD23, RD7 and TN1 in addition to their 28 F_1' s obtained from the diallel crossing among the eight parents were evaluated for reaction to the yellow orange leaf virus (YOLV), based on differences in percent leaf yellowing, plant height, number of productive tillers, and grain yield per plant of infected plants. ARC11554 and GS10719 are classified as resistant, SPR60 and RD9 as moderately resistant, RD1 and RD23 as moderately susceptible, and RD7 and in1 as susceptible varieties. Heritabilities in narrow and broad senses were estimated by use of variance components calculated by the concept as described by Griffing [1]. Narrow sense heritability of about 0.7 and broad sense heritability of about 0.9 for each character were observed. The expected genetic advances in narrow and broad sense heritabilities were respectively 32.13 and 41.12 for percent leaf yellowing , 9.30 and 12.10 for centimeter plant height, 4.80 and 6.90 for number of productive tillers, and 19.10 and 23.60 for gram grain yield per plant. The results indicated that all four characters were heritable with slight effects of environmental factors.

1. Introduction

The yellow orange leaf virus (YOLV) infects rice plants and spreads throughout the Central Plain of Thailand where most farmers grow RD rice varieties for more than one crop a year. The virus is transmitted or spread from plant to plant or from area to area by green leafhopper vectors. Rice plants may be infected at any stage of plant growth from the seedling to booting. The most serious reduction of yield occurs when the rice plants are infected with YOLV at the tillering stage. The typical symptoms of infected plants are stunting and yellow-orange foliage [2]. Systemic insecticedes have only limited effectiveness in controlling YOLV vectors. In addition, the present economics of rice production in Thailand presents a problem so far as purchase of insecticides is concerned. Frequent rainfall also diminishes theefficiency of this control measure. PlantingYOLV tolerant varieties is therefore themost effective way to control the disease.In breeding rice for resistance, however,little information is available regarding the criterion or plant characteristics to use for selection of resistant plants. In addition, there have been very few reports on the inheritance of resistance to YOLV. The objectives of this study were to estimate heritability and genetic advance for the four characters, percent leaf yellowing , plant height, number of productive tillers and grain yield per plant.

2. Materials and methods

Eight rice (Oryza sativa) varieties, ARC11554, GS10719 (Nepal Basmati), Suphan Buri 60 (SPR60), RD9, RD1, RD23. RD7, and Taichung Native 1 (TN1) were used as parental varieties to represent a range in resistance and susceptibility to YOLV. ARC 11554 and GS10719 are resistant, SPR60 and RD9 are moderately resistant, RD1 and RD23 are moderately susceptible, RD7 and TN1 are susceptible. All of the varieties are non-sensitive to photoperiod.

The eight parents and 28 F_1's resulting from diallel crossing among the parents were studied. The F_1 seeds of the 28 crosses were obtained by crossing each pair of parental varieties in the greenhouse during March and April in 1993 at Pathum Thani Rice Research Center in Thailand.

The green leafhopper, Nephotettix virescens, was used to inoculate each 7-day-old seedling with YOLV. Viruliferous vectors were obtained by increasing in number of virus-free green leafhoppers on TN1 seedligs infected with YOLV in insect-proof mylar cages in the greenhouse at 34-35°C.

The parental and F_1 plants that were grown in rows in a randomized complete block experiment with three replications were inoculated by placing three to four viruliferous green leafhoppers on each seedling plant in a tray (2.1 x 1.2 x 0.2 m) covered with an insect-proof mylar cage. The insects on the seedlings in the cage were gently disturbed for sometime to ensure their even distribution on every seedling. After the green leafhoppers had fed on the seedlings for a 2-day period, they were killed by spraying with carbaryl and the cage was removed to let the symptoms develop on plants.

All infected plants from both the eight parental varieties and 28 F_1 crosses were trans planted on August 15, 1993, in a randomized complete block experiment with four rows of each parent and F_1 entry in each of three replications. Ten infected seedlings were transplanted in each row with a spacing of 25 x 25 cm between seedlings and rows, respectively. Fertilizer was applied at the rate of 37.5-37.5-37.5 kg/ha of N-P_2O_5-K_2O as basal application. An addition of 37.5 kg/ha of N was applied 30 days after transplanting. This experiment was conducted in the paddy field of Pathum Thani Rice Research Center in Thailand.

The reaction of each parent, and F_1 plants in each cross to YOLV infection was measured by percent leaf yellowing, plant height in centimeter, number of productive tillers, and grain yield per plant in gram.

Percent leaf yellowing was a visual estimation of the leaf area with distinct yellowing in comparison to the total leaf area of the plant. This observation was made ten days after inoculation.

Plant height was measured from the ground to the tip of the tallest panicle. This character was observed about two weeks prior. to harvesting.

Number of productive tillers was recorded by counting the tiller that had developed sufficiently to form a panicle. This character was observed about two weeks prior to harvesting.

Grain yield per plant was recorded after extensive sun drying and converted into grams per plant at 14 percent seed moisture content.

The phenotypic, genotypic, and environmental variance components were calculated by the concept described by Griffing (1956).

The heritabilities of percent leaf yellowing, plant height, number of productive tillers, and grain yield per plant were estimated from the formulae described by Allard [3] as :

$$\text{H(narrow sense)} = \frac{\sigma^2 A}{\sigma^2 P} = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 E}$$

$$\text{H(broad sense)} = \frac{\sigma^2 G}{\sigma^2 P} = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 E}$$

Where $\sigma^2 A$ = Additive genetic variance
$\sigma^2 D$ = Dominant genetic variance
$\sigma^2 G$ = Genotypic variance
$\sigma^2 P$ = Phenotypic variance
$\sigma^2 E$ = Environmental variance
H = Estimated heritability

The expected genetic advances for 10 percent selection intensity of percent leaf yellowing, plant height, number of productive tillers, and grain yield per plant were estimated from the formula described by Allard (1960) as :

$$G = k\sqrt{\sigma_p^2}H$$

where k = selection differential

3. Results and discussion

The means of the heritability estimates for percent leaf yellowing in the narrow and broad senses were 0.75 and 0.96, respectively, which gave expected genetic advances of 32.13 and 41.12% in the narrow and broad senses, respectively, at a selection intensity of 10%

(Tables 1 and 2). This indicates that resistance or tolerance to YOLV could be improved by selection for low percent leaf yellowing. Approximately means of 32 and 41% leaf yellowing based on narrow and broad sense heritabilities, respectively, would be increased within each generation of rice after the 10 % selection.

The means of heritability estimated for number of productive tillers in the narrow and broad senses were 0.67 and 0.98, respectively, giving expected genetic advances of 4.8 and 6.9 tillers, respectively (Tables 1 and 2). It is generally assumed that selection for high number of productive tillers could indicate resistance or tolevance to YOLV and axpproximately the means of five and seven productive tillers based on narrow and broad sense heritabilities, respectively, would be increased within each generation of rice after the 10 % selection.

Table 1. Heritability for each character calculated from estimated variance component

Character	Heritability	
	Narrow sense	Broad Sense
Percent leaf yellowing	0.75	0.96
Plant height	0.75	0.98
Number of productive tillers	0.67	0.98
Grain yield per plant	0.79	0.98

Table 2. Expected genetic advance for each character at 10 % selection intensity (K = 1.75)

Character	Heritability	
	Narrow sense	Broad Sense
Percent leaf yellowing	32.13	41.12
Plant height	9.30	12.10
Number of productive tillers	4.80	6.90
Grain yield per plant	19.10	23.60

The estimated means of heritability for grain yield per plant in the narrow and broad senses were 0.79 and 0.98, respectively, giving expected gentic advances of 19.1 and 23.6 grams, respectively (Tables 1 and 2). This at least indicates that selection of high grain yield per plant for improvement of YOLV resistance or tolerance would be highly effective, and the means of 19.1 and 23.6 grams per plant would be increased within each generation of rice after the 10% selection.

The results showed that additive genetic effects played a greater role in all the four characters than non-additive genetic ones. Since rice is a self pollinated plant, the expected genetic advance estimated from the narrow sense heritability as in this experiment is more accurate as compared with that estimated from the broad sense heritability. The expected genetic advance estimted from the broad sense heritability is however, beneficial to the purpose of hybrid vigor in the F_1 hybrid rice breeding program.

4. Conclusion

Narrow sense heritability of about 0.7 and broad sense heritability of about 0.9 for each character were observed. The expected genetic advance in narrow and broad sense heritabilities were respectively 32.13 and 41.12 for percent leaf yellowing, 9.30 and 12.10 cm for plant height, 4.80 and 6.90 for number of productive tillers, and 19.10 and 26.30 gm for grain yield per plant. The estimated heritabilities indicate that all the four characters were heritable and slightly affected by the environmental factors. The evaluated genetic advances indicate that improvement in population means can be obtained in crosses for all characters.

5. References

[1] Griffing, B. (1956), Concepts of General and Specific Combining Ability in Relation to Diallel Crossing Systems, Aus. J. Biol. Sci., Vol.9, pp.463-492

[2] Ling, K.C. (1979), Rice Virus Diseases, 4th ed., IRRI, Los Banos, Philippines.

[3] Allard, R.W. (1960), Principles of Plant Breeding, John Wiley and Sons, Inc., New York.