BREEDING FOR BLAST RESISTANCE AT CIAT

H. Weeraratne and C. P. Martínez

There is currently a serious outbreak of hoja blanca virus disease in several countries in Latin America (Colombia, Venezuela, Perú and Ecuador) causing significant losses in yield. However, more than any other single factor, rice blast, caused by Pyricularia oryzae, reduces yield virtually in all Latin American countries and is considered the most destructive and common production constraint. A diversity of production systems ranging from irrigated to upland, large fields, thick direct seeding, heavy applications of fertilizers specially nitrogen, continuous cropping and infertile acid soils aggravate the situation. Besides, the genetic variability of the crop has been reduced since few distinct genotypes are extensively grown in large areas.

In general, rice production in Latin America is a very intensive one and uses a high input technology; besides, in many instances climatic conditions are conducive to blast epidemics.

Breeding for resistance to rice blast started in 1967 and continues to dominate the CIAT rice breeding program, which for many years has worked in close collaboration with the national program of the Colombian Agricultural Institute (ICA). Several resistant varieties originated from the said program but most of them were found to be short-lived as their resistance never lasted more than a couple of years. Only CICA 7 and CICA 8 have retained a certain degree of resistance for longer time.

Vertical or major gene resistance was the main emphasis in the earliest days but now it has shifted toward a more stable type of resistance. Diverse genetic strategies such as pyramiding resistance sources, backcrossing to tall resistance donors, accumulation of slow blasting factors, combination of slow blasting and vertical resistance factors, and recurrent selection through the use of genetic male sterility are being employed to exploit the possibilities of securing durable resistance.

Our program conducts its blast selection activities in a highly favorable, disease endemic location under both irrigated and upland conditions. The strongly acid, phosphorus deficient soil of our experimental sites, moderately low night temperature, high relative humidity, cloudiness and long dew period favours disease development in all growth stages. Adecuate field designs are use to challange the segregating populations and breeding lines with inoculum coming from susceptible spreaders made up of a mixture of many susceptible varieties.

Genetic strategies being explored to obtain a more stable type of resistance can be divided into two groups: genotype buffering and population buffering.

A. Genotype buffering

Refers to the development of a genotype that has the ability to reduce disease damage through the accumulation of resistant factors.

1. Pyramiding resistance sources

Major gene resistance has been repeatedly assailed as race-specific and short lived. However, many workers have postulated a pyramid of major genes to constitute the genetic basis of stable resistance.

Ten improved breeding lines carrying resistant genes from Tetep, Carreon, Colombia 1, Dissi Hatif and C46-15 were intermated to produce single crosses which were subsequently recombined into double crosses. Of a total of

26,000 F2 single plant selections over one hundred advanced lines (F6-F7) were identified which were subsequently reduced to four based on multi-location testing; line No. 5738 has been named as Oryzica 1 by ICA for cultivation in Colombia and line No. 5728 could also be named as a variety.

Another set of 12 promising lines originating from diverse cross-combinations has been selected for widespread testing in regional trials in Colombia as well as in many Latin American countries through IRTP. Finally, over one hundred F2 and F3 populations derived from cross-combinations with three distinct sources of blast resistance are being planted in a hot spot area in Villavicencio.

2. Accumulation of slow blasting factors

Longer latent periods, fewer and restricted lesions and reduced sporulations are believed to be the main components of slow blasting or the rate reducing-type of resistance. Twelve varieties of diverse geographic backgrounds from Africa, Surinam, Japan, and the Philippine were collected; as varieties from the same continent are likely to possess the same group of genes, to avoid duplication and for the combination of resistant factors from different continents,crosses were effected among varieties among countries; F1 populations were top crossed to high yielding widely adapted susceptible dwarfs.

152 F2 populations were field exposed in 1980 at Villavicencio to natural field infection. Many of the parental sources are typical upland types and did not recombine well; combinations with Sensho and IRAT 10 exhibited very high sterility, but Camponi (Surinam) and IR 11-452 (Costa Rica) combined well with top crossed parents. Over 1200 F6 progenies were field evaluated in pedigree rows at La Libertad, Villavicencio last year and 46 progenies were selected for yield trials this year.

3. Combination of slow blasting and vertical factors

Combination of the two types of resistance should impart better stability as the genes for vertical and horizontal resistance in combination are believed to complement the effectiveness of each other.

Single crosses among parents considered to have slow blasting characteristics were top-crossed to advanced breeding lines observed to be characterized by the vertical type of resistance under natural field infection. Over nine hundred selections were evaluated at CIAT last year and 30 F6 progenies were identified at La Libertad, Villavicencio as having resistance to blast, hoja blanca virus disease, grain spotting, good grain type and high yield potential. The best progenies come out of the following crosses: Camponi // 2940 / 3224 ; 5745 // Camponi / K 8 ; 5738 // IR 262 / Costa Rica ; and 5738 // 63-83 / Ceysvoni.

4. Concentration and conservation of slow blasting components through backcrossing to tall donor parents believed to be slow-blasters

Failure to recapture the entire complement of resistant factors from their respective donor parents has often been cited as a major cause of breakdown of varietal resistance. The transfer of an adequate load of the genetic complement of the tall donors through a single backcross to the tall donor was attempted.

B1 F2 generations of 21 crosses were planted at CIAT. Over 900 single plant selections were made, quality tested and advanced to F3 pedigree rows a La Libertad, Villavicencio. Almost all the selection were characterized by excellent grain quality but since all the tall recurrent parent donors are highly susceptible to hoja blanca virus disease, most of the progenies were affected by this disease. However, several F3 progenies from the following crosses were identified as promising:

Camponi ^{2} / CICA 4 ; Camponi ^{2} / 5863 ; Camponi // CICA 4/ IAC 25 and Eloni // CICA 4 / Costa Rica.

5. Recurrent selection for blast resistance through the utilization of genetic male sterility

Recombination of genetic factors from diverse sources of resistance through hand pollinations requires heavy labour. Sources of genetic male sterility have been suggested as a possible low cost solution.

Genetic male sterile sources in IR 36 background were obtained from IRRI and crossed to the following varieties: Colombia 1, IAC 165, Metica 1, CICA 4, CICA 7, CICA 8, IRAT 13, Suakoko, Camponi, Oryzica 1, and the breeding lines 5869, TOX 1010-45-1-1, 17631, 16838, 17067, 17100, 15352, 10750 and 18868.

F2 populations will be evaluated under severe disease pressure in Villavicencio. The procedure to be followed will be like this: in the F2 select individual plants from each cross basing selection on fertility, disease resistance, plant type, grain type and maturity duration; bulk all the selections from different cross-combinations and in the F3 generation select for low fertility (sterile but out-crossed plants with few seeds). The few seeds set on otherwise sterile plants should represent the first cycle recombinants. Repeat the procedure starting from the recombinants of the first cycle.

B. Population buffering

Refers to the development of a population that consists of many genotypes with distinct and diversified resistant genes which could result in less disease damage.

We recognize that each of the above mentioned approaches suffers two prominent drawbacks : a) resistance is accumulated in single genotypes that may or may not remain stable over time, ecosystems and large areas; and b) it is difficult to determine whether resistant genotypes have one, a few or several resistance genes.

These drawbacks disappear in approaches designed to accumulate resistance in populations as distinct from single genotypes. Population development strategies being considered at CIAT are: a) varietal mixtures and b) heterogenous bulks.

In the first approach advanced breeding lines with high yield potential, excellent grain quality, and similar phenotypes are mixed; these lines are believed to have distinct genetic backgrounds since they originated from crosses having different donors. The expected effects are a reduction in disease spread and extension of resistance durability . To test the idea, experiments were conducted by S. W. Ahn under field conditions at La Libertad, Villavicencio and at CIAT.

Advanced lines and cultivars were mixed in predetermined proportion to form various 5-component composites. These composites were planted together with their respective component lines in pure stands. Blast development on each composite was compared to the expected disease development obtained by the weighted sum of disease levels on respective component lines in pure stands. Each of the five composites had less leaf blast infection than their respective expected values; similar results were observed with panicle blast. Average reductions of leaf and panicle blast in composites were estimated to be 60 and 20 percent respectively. The effect of composites on yield measured at CIAT varied; composites 1 and 2 produced higher than expected yields, while composite 4 yielded less than expected. These results demonstrated that composites are a powerful means to manage rice blast; however, their stabilizing effect on fungal population pathogenicity, the possible occurrence of super races, differential agronomic behavior over locations and time and the optimum number of components need to be studied further.

The second approach concerning population buffering is outlined as follows:

1. Identification of a few superior breeding lines or varieties
2. Cross each with 10 to 20 known, different blast sources; preferred are advanced lines from resistant crosses even if they lack the full complement of donor genes.
3. Backcross once to the superior line .
4. Grow the F2 generations under upland conditions and select resistant plants (immune to slight blast); bulk them.
5. Grow the F3 generations under upland conditions; plant separately each bulk and select as above. Divide selections into three maturity classes of 110, 120 and 130 days. Bulk 110 day selections from all the crosses involving a common recurrent parent; ideally bulk 30 or more plants of each cross to ensure resistance variability. Repeat for 120 and 130 day maturity classes; this gives three bulks for each superior recurrent parent.
6. Grow F4 generations under upland conditions; select, within each maturity class, strictly for height, maturity, grain type and disease; ignore all minor differences in plant type.
7. Grow F5 in several key production areas. Continue to develop an agronomically uniform population for each class, stressing plant height, maturity and grain.
8. F6 on. Conduct yield trials of uniform bulks in disease areas.

The major advantage of this approach is the large number of resistant plants in the final bulks. Multilines and composites normally have less than 10 components. It differs from both in that bulking begins in the F2, not as fixed lines. The final product should be heterogenous for resistance and uniform phenotipically.