Workshop Reports

Workshop on Breeding for *Striga* Resistance in Cereals

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The phanerogamous root parasite *Striga hermonthica* (Del.) Benth. causes major yield reductions in the principal cereal crops of semi-arid Africa. A workshop on breeding for *Striga* resistance in cereals was held at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria, from 18 to 20 August 1999. The meeting was organized by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), IITA, the University of Hohenheim, Eberhard-Karls University of Tubingen, and the Rockefeller Foundation. Funding was provided by the Bundesministerium fur wirtschaftliche Zusammenarbeit (BMZ), Germany, the Rockefeller Foundation, and the International Fund for Agricultural Development (IFAD). The 56 participants comprised 26 cereal breeders or weed specialists from national agricultural research systems (NARS) of 17 African countries, and 30 scientists or representatives from the International Maize and Wheat Improvement Center (CIMMYT), Centre de cooperation internationale en recherche agronomique pour le developpement (CIRAD), ICRISAT, IITA, John Innes Centre (JIC), the Natural Resources Institute (NRI), Pan African *Striga* Control Network (PASCON), ProAgro Seed Company, the Rockefeller Foundation, Cornell University, University of Hohenheim, Purdue University, University of Sheffield, University of Tubingen, West Africa Rice Development Association (WARDA), and the Weizmann Institute of Science.

Objectives of the workshop were two-fold: 1) to summarize the "state of the art" of cereal breeding for *Striga* resistance (including conventional and biotechnological approaches), and; 2) to develop with NARS scientists future strategies for *Striga* control in sorghum, maize, millet and rice, emphasizing host plant resistance. The workshop included presentations related to physiology of the host/parasite interaction; resistance mechanisms; inheritance of resistance; new sources of resistance in wild relatives of sorghum; actual breeding programs for *Striga* resistance in maize, sorghum, millet, and rice; molecular markers for *Striga* resistance; identification of *Striga* tolerance genes in maize using transposable elements; other biotechnological approaches for *Striga* control; diversity of *Striga* populations and consequences for resistance breeding; and breeding towards integrated *Striga* control. Since so many presentations dealt with molecular markers, the workshop was preceded by a two-day training course on the application of molecular markers in plant breeding programs (16-17 August; training manual available on-line at http://www.icrisat.org/gt1/mol/molecular.htm). Participants visited the IITA screenhouses at Ibadan, and several field trials (on-station and on-farm) at Mokwa. On the final day, working groups discussed future strategies in *Striga* research and developed the following recommendations.

Strategies essential for efficient **conventional breeding** for *Striga* resistance include:

- careful definition of target environments;
- determination of the most important selection traits for each target environment;
- identification of adapted parents for use in a backcross program;
- training of NARS scientists to use both laboratory and field screening methods;
- transfer of available resistance into farmer-selected varieties, through combined use of laboratory (e.g., agar-gel and paper-roll assay) and field screening methodologies;
- combining different resistance mechanisms and tolerance to *Striga* in individual varieties; and
- networking and exchange of useful plant genotypes.

Population improvement through development of a random-mating population combining several different resistance genes could be very useful, but would have to be carried out on a large scale by a dedicated, able breeder.

Targeted searches for new resistance sources in pearl millet, sorghum, and their **wild relatives** are important using recently perfected field and laboratory screening methodologies.

Marker technology and QTL analyses were considered to be potentially very useful. Verification of results is essential, as preliminary results suggest complex QTL patterns and low repeatability of individual QTL across environments and different mapping population samples.

Future research efforts should continue to

- develop universal marker systems, especially allele-specific markers;
- develop isogenic lines to quantify QTL effects for *Striga* resistance;
- create an integrated, PCR-based sorghum reference map (begin by integrating *Striga* resistance mapping populations);
- identify adapted sorghum parents for use in marker-assisted selection programs;
- determine whether the low-stimulant genes in SRN 39 and IS 9830 are identical; and
- develop a sorghum data base (ICRISAT leadership).

Once resistance genes have been identified, efforts should be made to exploit **synteny** in sorghum, maize, rice and millet. Transfer of resistance genes from cowpea into cereals was not considered a priority.

The continued **search for resistance mechanisms** and their genetic basis should always run parallel to the marker approach, with a final aim of identifying allele-specific markers. Enhanced knowledge of the physiology of the host/parasite interaction is urgently required to:

- examine interactions between host root exudates and exudates from the *Striga* radicle;
- determine how *Striga* induces its strong sink reaction;
- study how early host plant flowering minimizes the "bewitching" effect of *Striga* on its host;
- clarify the role of ABA; and
- study mechanisms of antibiosis.

An unconventional approach to *Striga* control would **reduce *Striga* vigor by genetic engineering.** In this approach enzymes are identified that reduce the vigor of *Striga,* using deleterious transposons (DTs) to reduce *Striga* vigor. First model studies are underway at the Weizmann Institute of Science.

The development of cultivars with target site **resistance to acetolactate synthase (ALS) inhibiting herbicides** was considered to be (probably) appropriate for maize in Africa and pearl millet and sorghum in Asia (i.e., in regions where the crops do not have feral or weedy relatives). It seems less appropriate for rice in Asia and Africa, pearl millet in West Africa, and sorghum in Africa (i.e., in crop/region combinations where feral or weedy relatives are present).

Transposon-based mutation breeding may allow researchers to:

- find resistant phenotypes that previously did not exist, due to transposon insertion into relevant genes;
- tag genes that are involved in host response to *Striga* (forward genetics);
- isolate and clone the gene; and
- use the cloned gene in both the host and other host plant species.

Future research related to ***Striga* variability** should:

- study inheritance of isoenzyme and DNA markers;
- analyze linkage between markers;
- perform cytological studies on *Striga* chromosome number and degree of polyploidy;
- develop 10 to 15 micro-satellites for *Striga* diversity studies;
- estimate polymorphism in *Striga hermonthica* populations that are naturally adapted to different hosts;
- test more populations from wide geographic sites across Africa, and from a variety of different resistant and susceptible hosts;
- extend host range tests;
- standardize sampling procedures;
- include farmer consultation on field history;
- create genetic stocks of various *Striga* strains by developing full-sib families;
- develop a set of host plant differential lines; and
- elucidate mechanisms and inheritance of *Striga* virulence focussing on *Striga* sensitivity to germination stimulants, *Striga* penetration into host roots, and the role of exoenzymes.

Inter-Center collaboration is highly encouraged in this respect.

With respect to **integrated *Striga* control,** methodologies immediately available for technology transfer/extension services include:

- maize/legume (groundnut, soybean, cowpea) inter-cropping, plus weeding and fertilization: 100-120 kg N and 50-60 kg P_2O_5 for moist savannas;
- sorghum/cowpea intercropping: two rows sorghum + four rows cowpea, strip planting;
- rotations of cereals and legumes; and
- tied ridges for the Sahel.

Further research on integrated *Striga* control should focus on:

- location-specific laboratory screening of cultivars of non-host species for their ability to germinate *Striga* (cowpea, soybean, groundnut, cotton, pigeon pea, *Phaseolus* beans, cassava, sorghum, millet, maize, *Stylosanthes,* and sesame);
- participatory, on-farm development of individual, integrated *Striga* control packages, adapted to each target area; especially consider rotation or intercropping of sorghum/maize with legumes (soybean, cowpea, groundnut, *Phaseolus* bean); and
- impact studies.

Individuals/organizations have been identified to carry forward on most of the above topics. A CD proceedings of the workshop is in preparation.