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Combining molecular marker technology and participatory techniques: A case study for drought-tolerant rice in Eastern India. II: Farmer evaluation of SLS-MAS bulks in participatory plant breeding

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Abstract

We wish to test if participatory approaches and modern molecular marker techniques can be effectively combined. To do this we have integrated participatory plant breeding (PPB) with marker-assisted selection (MAS). The PPB has been carried out on six bulks selected with molecular markers via modified single large-scale MAS (SLS-MAS). The bulks were derived from the second backcross generation between Kalinga III and Azucena where Kalinga III was the recurrent parent (See Part I: Molecular Breeding Strategy, this volume). Four of the bulks had been selected to contain a quantitative trait locus (QTL) for root growth. One bulk was a selected subset of those with root QTLs which had also inherited a marker for aroma. A control bulk was selected from the same generation, which contained none of the targets and was used to test the effect of the target root QTL. Bulks were given to farmers in three states of Eastern India for evaluation over two seasons of collaborative PPB. The same bulks were also tested on-station through consultative PPB, with off-season seed multiplication.

Background

Modern biotechnological technologies have the capacity to create rapidly varieties with new combinations of genes, which are unlikely to be derived through conventional breeding methods. MAS is a potentially valuable strategy for breeding resistance to abiotic stresses but its value can only be proven by testing the products of MAS in marginal environments by the end-users; small-scale farmers. By involving farmers directly in the MAS breeding programme through PPB methods, the two technologies address the needs of farmers. However, the PPB methods that can be used in combination with MAS can differ greatly according to the degrees of farmer participation (Witcombe *et al*., 1996) with the extremes being on-station selection by farmers (consultative) and on-farm, farmer-led PPB (collaborative).

Results from collaborative PPB

In collaborative PPB farmers are given material to select amongst which they grow on their own farms (Witcombe, this volume; Virk *et al*., this volume). Three farmers, one in each of the three states, Orissa, Jharkhand and West Bengal, were given the six bulks (at the BC2F3 generation) to grow in plots alongside Kalinga III in the rainy season 2000. Harvested seed was returned to breeders from the farmer in Orissa only.

In the rainy season 2001 10 farmers were given the bulks, but a full set of yield data was only received from seven farmers. In both years farmers used their usual practices and were asked to make selections within each bulk. The farmers will continue the PPB programme with the selected material from all six MAS bulks in rainy season 2002, and the material will then be at the BC2F6 generation (Figure 1).

There was a great deal of variation within all the bulks in both years for height, tiller number, spreading or compact plant type, maturity, awn pigmentation, stem thickness and panicle length. To a lesser extent, grain shape varied, although all bulks had fine, slender grains. The bulks all had increased panicle length compared to Kalinga III, and were less prone to lodging. All bulks containing Azucena genes had greater biomass than Kalinga III and were not significantly earlier.

In the rainy season 2001 the farmers were asked to rank the plots (six bulks and check variety Kalinga III) in their order of preference. A score of 1 was given to the least preferred plot and 7 to the most preferred plot, for each criteria. The criteria used for ranking were: maturity, height, yield, straw, lodging, pest attack, grain colour and overall preference. Four farmers responded and they ranked all six of the MAS bulks higher than Kalinga III for overall performance, including the control bulk with no QTL (Table 1). Farmers' rankings for other criteria were confounded by the high levels of intra-bulk variation.

In making selections the farmers generally, although not exclusively, selected early lines in all bulks (Figure 2). They stated that earliness was the most important selection criteria, with plant height (tall plants with more straw for fodder) the second. Farmers differed in their opinion about grain shape, and while most farmers said that possession of fine grains was the third most important selection criteria, one farmer said that bold grains were more important.

Many farmers ranked the aromatic bulk highly and were excited to smell the aroma in the field during flowering. Due to limited seed availability the cooking quality still remains to be evaluated. This is the first time that aromatic upland rice has been available in Eastern India, and farmers' reactions were generally positive. Aromatic lines have greater market value than non-aromatic varieties and this could benefit poor farmers economically.

However, the introduction of aroma may have both environmental and economic consequences. The incidence of insect pests on the aromatic bulk was greater than on non-aromatic bulks. This, combined with the greater market value, could lead to increased use of insecticides.

Results from consultative PPB

Consultative PPB was carried out at the GVT/BAU upland farm and off-season multiplication carried out at CRRI, Cuttack, Orissa. In the rainy season 2001 all six bulks plus two check varieties, Kalinga III and Birsa Gora 102, were grown in a randomised

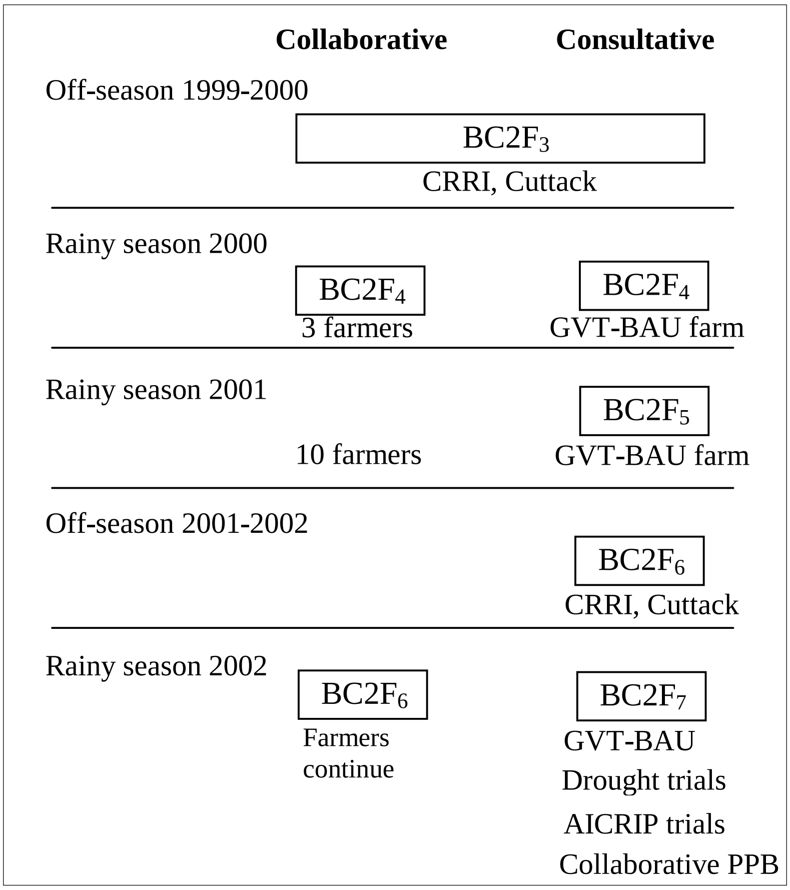

Figure 1. Schemes for collaborative and consultative PPB using SLS-MAS bulks. Each generation consisted of only selected material from the previous generation, and all six bulks were advanced simultaneously.

Table 1. Target QTL present in six bulks selected through modified SLS-MAS and the overall rank scores given by farmers in two states during collaborative PPB evaluation alongside Kalinga III check in the rainy season 2001.

Bulk	QTL[1]	Total score[2]
I	None (control)	19
II	7 (root length and mass)	22
III	9 (root length)	15
IV	11 (root length and penetration)	14
V	8 (aroma) plus one of either 2, 7, 9 or 11 root QTL	12
VI	2 (root length, thickness and penetration)	18
Kalinga III	none (check variety)	7

[1]From Azucena present on chromosome.

[2]From a maximum of 24 given by four farmers for overall rank.

Figure 2. Upland farmers in Udali district, Orissa, September 2000, making selections in segregating bulks selected via modified SLS-MAS for root trait QTLs and aroma from Azucena.

(Photo AK Paria, Community Organiser, GVT East).

block experiment. Within the all bulks and checks there was no significant difference for plant height or flowering time. For yield, three bulks were significantly different from Kalinga III; bulks IV and V yielded less, while bulk VI had a greater yield.

Twenty-one farmers (men and women) visited the plot 81 days after sowing. Selection and tagging of plants was carried out for four different environments: upland, medium upland, medium lowland and lowland. These selected bulks were advanced in the off-season and the BC2F7 generation will be given to farmers for paired comparisons with Kalinga III in the rainy season 2002 (Figure 1). In the off-season, plots of the selected bulks II, III and III were uniform after two generations of consultative selection. They have been recommended by BAU for entry into the All-India Coordinated Rice Improvement (AICRIP) trials and in state trials.

All six bulks at the BC2F7 generation will be tested in replicated field trials in both Eastern and Western India for drought resistance in the rainy season 2002. They will be grown under upland conditions with no irrigation to test the hypothesis that bulks containing root QTL are more adapted to withstand drought than the control bulk.

An additional 16 individual lines selected for target QTLs by pure MAS (from BC3F2 and pyramid generations) were also grown at the BAU farm in the rainy season 2001. Eleven of these were aromatic, four bulks were partial pyramids for two or three target root QTL and one was an advanced generation control line with no target QTL. Visiting farmers made selections within these plots and tagged selected plants according to four target environments.

Conclusion

MAS appears, from these preliminary results, to be successful in producing promising material. However, whether this is the result of introducing target QTL, or more generally the result of introducing small genomic contributions of Azucena into Kalinga III is not yet known. So far, the bulk with contributions from Azucena but without the target QTLs also appears superior to Kalinga III. Moreover, much of the assessments have, so far, been made on the heterogeneous bulks rather than in selections from them. We can conclude that there is no barrier to combining 'high-technology' breeding approaches with participatory ones.

Indeed, it provides an acid test for the real value of target QTLs. Only if MAS products are preferred by farmers can MAS be deemed successful.

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