# FINAL TECHNICAL REPORT

**Project No. R7080** **Title:** Assessing the Feasibility of Using Marker Assisted Selection for Root Characteristics to Aid Participatory Plant Breeding (PPB) in Upland Rice in India.

## Executive Summary

The upland rice variety Kalinga III is most popular in drought prone areas of India but it has poor rooting ability and weak stems. The feasibility of using marker assisted selection (MAS) for improving Kalinga III for root traits in a participatory plant breeding (PPB) programme was studied. The study revealed the existence of polymorphism at QTLs for root traits among 12 Indian varieties. Polymorphism at up to 4 useful QTLs for root traits was detected with 5 RFLP probes. At these QTLs Kalinga III was shown to have the Bala type markers and 9 Indian varieties were shown to have the Azucena type markers. Several promising varieties have been identified for crossing with Kalinga III. Vandana and Birsa Dhan 102 have already been crossed with Kalinga III in India for future work.

The cross Sathi 34-36 x Kalinga III was identified as the most desirable for improving root traits of Kalinga III along with increasing plant height and straw strength. Useful markers for MAS have been detected on chromosomes 2, 7 and 11 that could be used to improve Kalinga III for root traits. The Sathi x Kalinga III cross has been (1) advanced to $F_5$, (2) random mated in $F_3$ to produce $S_3$ lines, and backcrossed to Kalinga III to produce selfed lines. The $F_4$ family bulks were evaluated by farmers in India and Nepal. Farmers have preferred the progeny of this cross for many superior traits.

## Background

Kalinga III variety of upland rice identified through participatory varietal selection by the DFID funded bilateral project in India has become very popular in rainfed areas of several states in India because of its early maturity and superior grain and cooking quality. However, it has poor rooting ability and weak straw. Unfortunately, no serious efforts are being made to improve Kalinga III in the India. Therefore Kalinga III was crossed with Sathi-34-36, a variety that has strong straw, tall plants and strong roots, to produce superior progenies for selection by farmers in India and Nepal. A feasibility study was undertaken to combine participatory plant breeding with marker assisted selection (MAS), for improvement of Kalinga III. Several Indian varieties were evaluated for existence of polymorphism at QTLs controlling root traits so as to detect appropriate parents for crosses with Kalinga III. The varieties tested are listed in Table 1 and the target QTLs are shown in Figure 1.

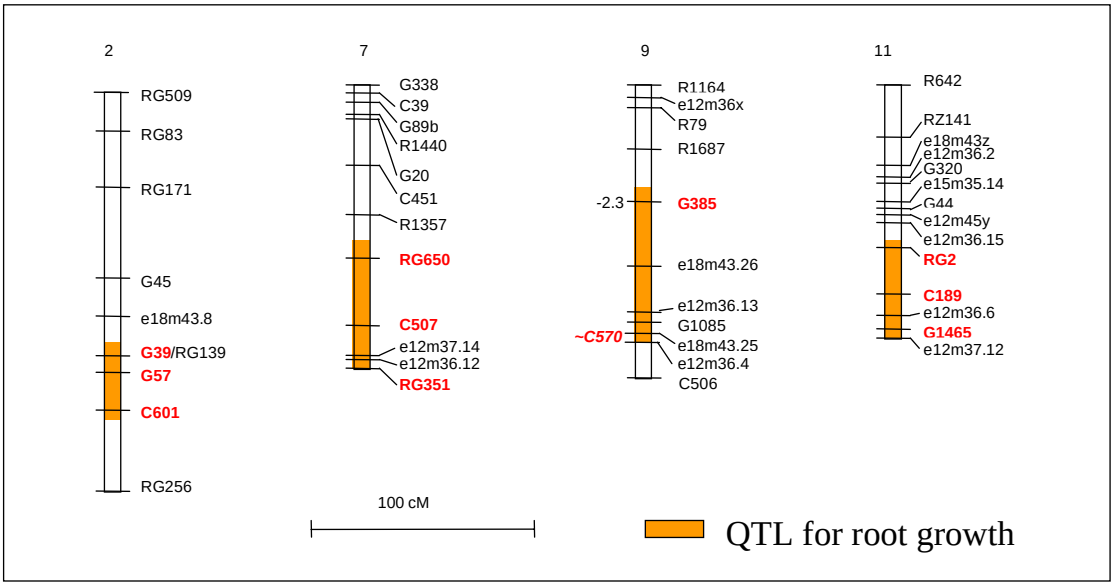


**Figure 1.** QTLs on chromosomes 2,7,9 and 11 for root morphology (Azucena alleles improve performance). RFLPs polymorphic between Azucena and Kalinga III are highlighted.

**Table 1. Description of Indian varieties of rice used in molecular marker studies.**

| Germplasms | Desirable trait | Type | Basis of selection |
|---|---|---|---|
| Kalinga III | Earliness, medium-tall plants, fine grains, good cooking quality. | Released for uplands in Orissa | Most farmer-preferred variety in Participatory Varietal Selection. Most widely adopted in drought prone uplands. |
| IR36 | High yield, stiff straw | Released variety | Improved variety |
| IR64 | High yield, fine grain | Released variety | Improved variety |
| Sathi | High yield, stiff straw, long roots, drought tolerance | Released variety in Gujarat | Performance in KRIBP(W) area |
| Nanisal | Drought resistance, delayed senescence | Landrace | Performance in KRIBP(W) villages |
| Vaghardha | Grain quality | Released variety for Banswara area of Rajasthan | Performance in station trials |
| Vandana | High yield, earliness, long roots and drought resistance | Released for uplands in India | Performance in farmers' field trials in KRIBP(W and E) |
| Vanprabha | High yield, earliness, long roots and drought resistance | Released for uplands in India | Performance in farmers' field trials in KRIBP(E) |
| Birsa Dhan 102 | Earliness, drought resistance and long roots | Released in Bihar. Developed by selection from a local landrace of upland rice , Brown Gora | Performance in farmers' field trials in KRIBP(E) |
| Dabra | Earliness and drought resistance | Landrace in KRIBP(W) villages | Observations in farmers' fields in KRIBP(W) |
| Ratta Chawal | Drought resistance, stiff straw, tall plants | Landrace in KRIBP(W) villages | Observations in farmers' fields in KRIBP(W) |
| Pathara | Drought resistance and earliness | Landrace in KRIBP(W) villages | Observations in farmers' fields in KRIBP(W) |

**Project Purpose**

Physiology of drought resistance in cereals understood and plant genes for drought resistance transferred into adapted backgrounds and resistant varieties in target areas.

**Research Activities**

- Sixteen rice varieties (including the 12 Indian varieties listed in Table 1) were screened for RFLP at QTLs for root traits using 55 probes, and diversity analysis was performed.
- Sathi 34-36 x Kalinga cross was advanced to $F_4$ (209 progenies) generation, and grown in India and Nepal for selection by farmers.
- $F_3$s of Sathi x Kalinga III were intermated and seeds of 213 $RMF_3$ lines have been produced.
- $F_3$ plants of Sathi x Kalinga III were backcrossed to Kalinga III, and seeds from 168 $BC_1F_2$ plants have been produced.
- Kalinga III was crossed to Vandana and Birsa Dhan 102 at BAU Ranchi and $F_3$ has been raised in winter 1998-1999.
- Vandana, Sathi, Kalinga III and Birsa Dhan 102 were screened for root traits under droughted and well watered conditions at Bangor.

**Outputs**

- Polymorphism at up to 4 useful QTLs for root traits has been detected with 5 RFLP probes that showed Kalinga III to have the Bala type marker and 9 Indian varieties to have the Azucena type marker. (These results are summarised in Table 2)
- Advanced generation ($F_4$) progeny bulks of Sathi x Kalinga III showed multiple farmer-preferred traits in India and Nepal,.
- Additional variation has been produced by intermating and backcrossing for increasing farmers' choice in selection.

| **Marker** | **enzyme** | **Chromosome** | **Varieties with Azucena allele** |
|---|---|---|---|
| C601 | *Bam*H1 | 2 | Dabra, Nanisal, Pathara, Ratta Chawal, Sathi |
| RG650 | *Hind*III | 7 | Dabra, Pathara, Ratta Chawal, Sathi, Vaghardha |
| C570* | *Bam*H1 | 9 | Dabra,IR64,Nanisal,Pathara,Ratta Chawal, Sathi |
| RG2 | *Eco*R1 | 11 | Dabra, IR64, Nanisal, Pathara, Ratta Chawal, Sathi, Vandana |
| C189 | *Dra*I | 11 | Birsa Dhan, Dabra, IR64, Nanisal, Pathara |

*C570 is not polymorphic between Azucena and Bala (used for QTL mapping).

**Contribution of Outputs**

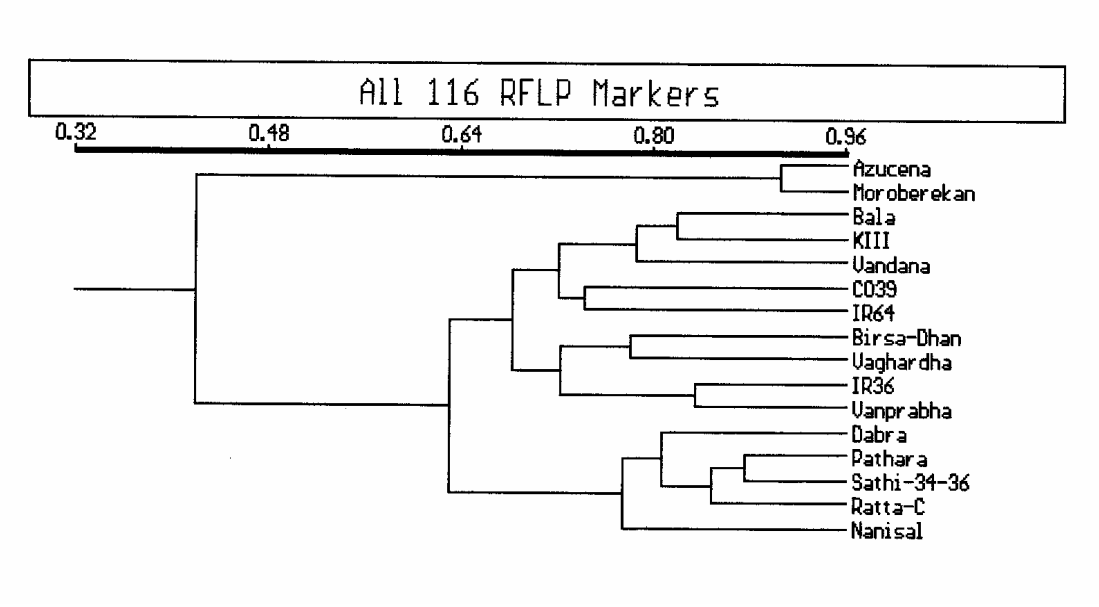
- The outputs of the project have been achieved. It has been shown that it is feasible for Indian varieties to be used as parents to improve root traits of Kalinga III by selecting Azucena type RFLP markers.
- Sathi was chosen as a parent because it has 4 desirable QTL markers. The advanced generation materials from Sathi x Kalinga III cross has been provided to collaborators in India and Nepal, and has already been exposed to farmers for selection.
- It seems feasible to combine PPB with MAS in rice.

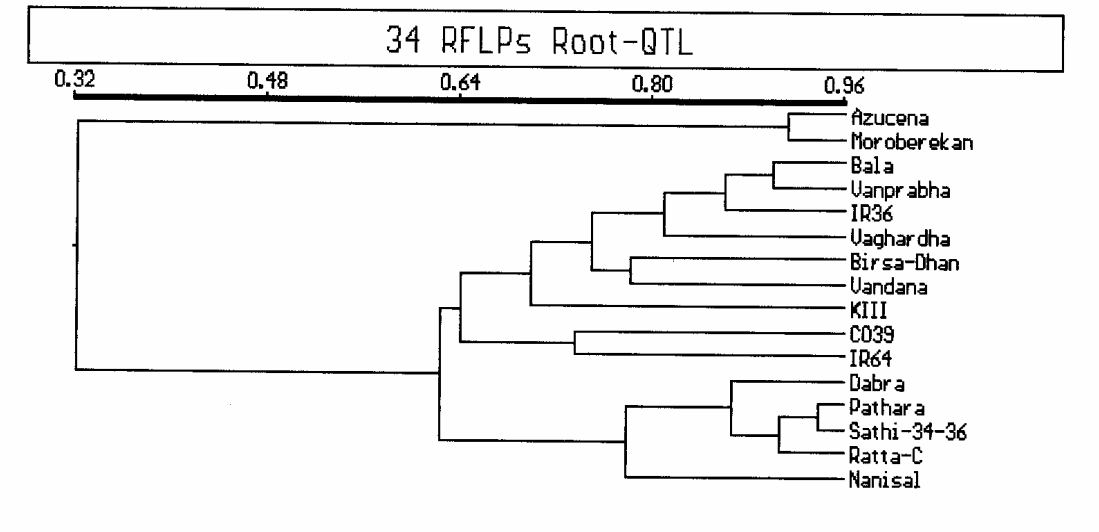
**Glossary of Acronyms**

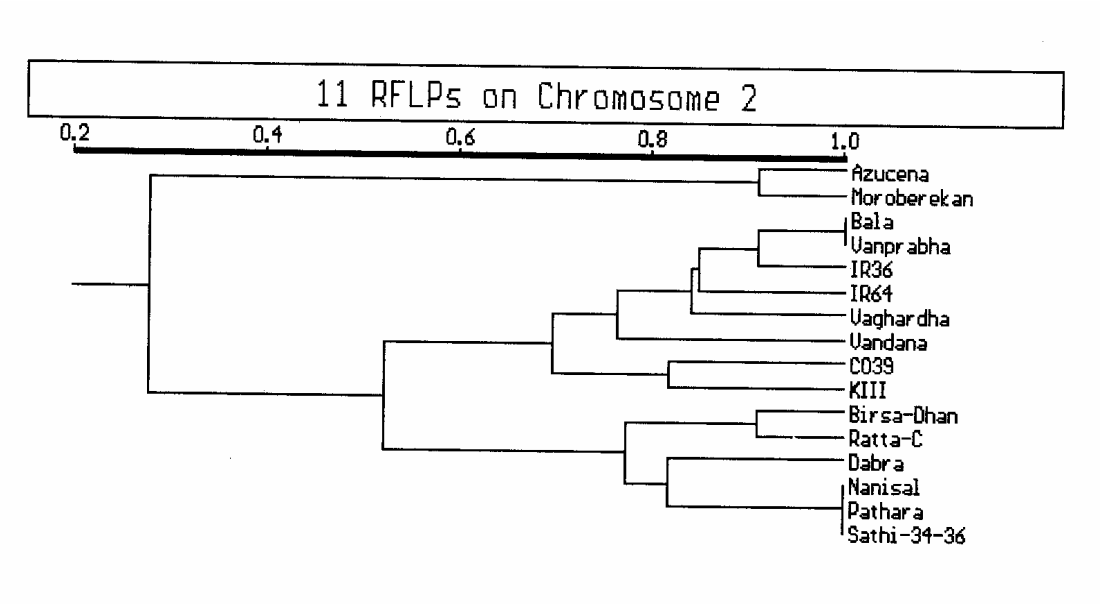
| | |
|---|---|
| BAU | Bihar Agricultural University |
| BC | Back cross Population |
| DFID | Department for International Development |
| KIII | Kalinga III |
| KRIBP | Krishak Bharati Co-operative Indo-British Rainfed Farming Project |
| MAS | Marker Assisted Selection |
| PPB | Participatory Plant Breeding |
| QTL | Quantitative Trait Loci |
| RFLP | Restriction Fragment Length Polymorphism |
| RM | Random Mating Population |

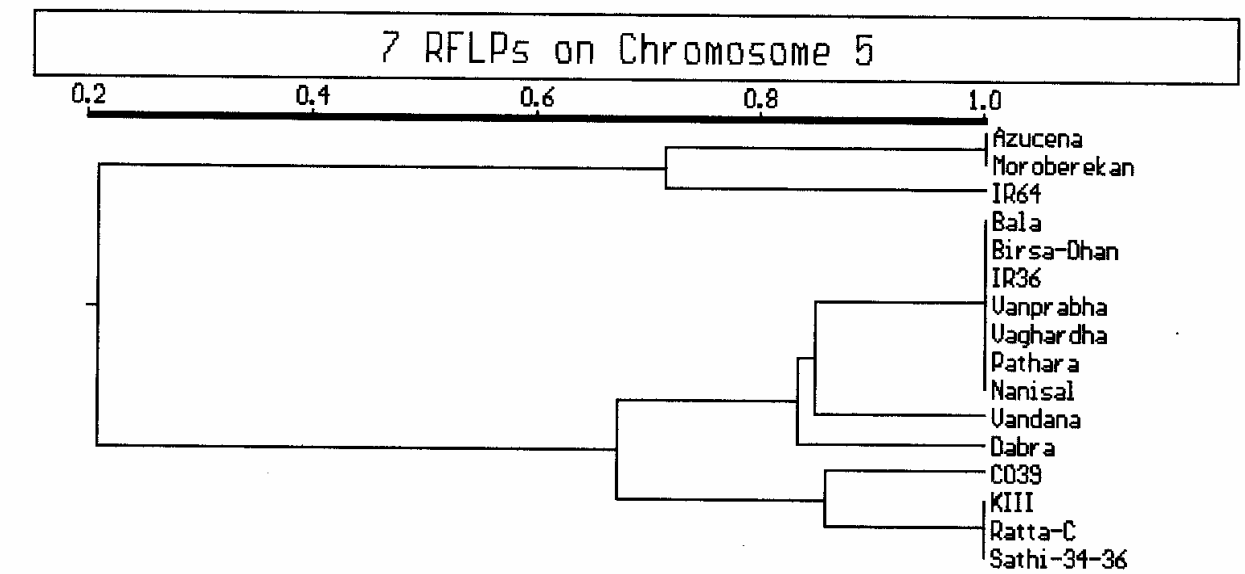
**Appendix**

Cluster Analysis of RFLP data was carried out to group the varieties according to molecular similarity. Probes located on 6 chromosomes (including four with target QTL) were tested on 5 enzyme digests, which were scored independently. Only major polymorphic bands were scored, and a data matrix based on presence or absence of each band was used for cluster analysis.




11 RFLPs on Chromosome 2
0.2
0.4
0.6
0.8
1.0
Azucena
Moroberekan
Bala
Vanprabha
IR36
IR64
Vaghardha
Vandana
C039
KIII
Birsa-Dhan
Ratta-C
Dabra
Nanisal
Pathara
Sathi-34-36


7 RFLPs on Chromosome 5
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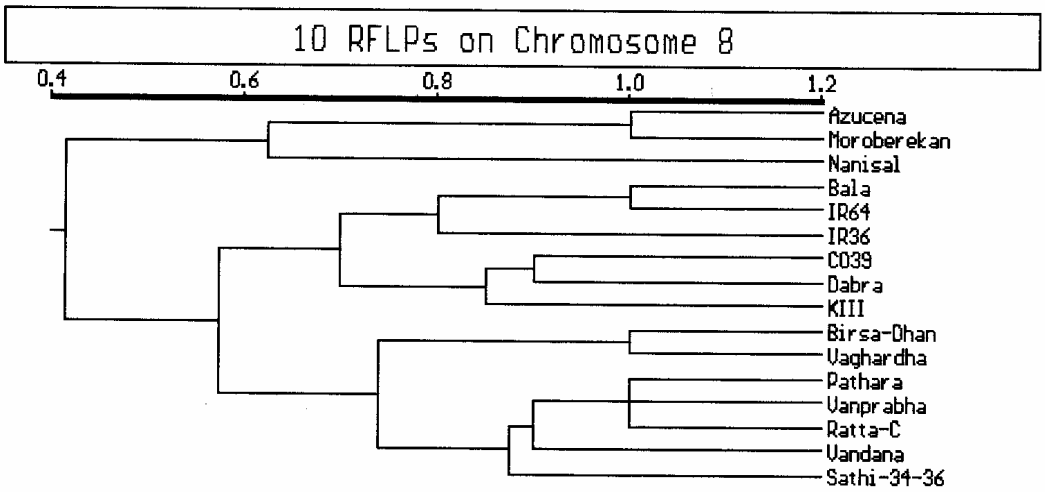
0.4
0.6
0.8
1.0
Azucena
Moroberekan
IR64
Bala
Birsa-Dhan
IR36
Vanprabha
Vaghardha
Pathara
Nanisal
Vandana
Dabra
C039
KIII
Ratta-C
Sathi-34-36


10 RFLPs on Chromosome 8
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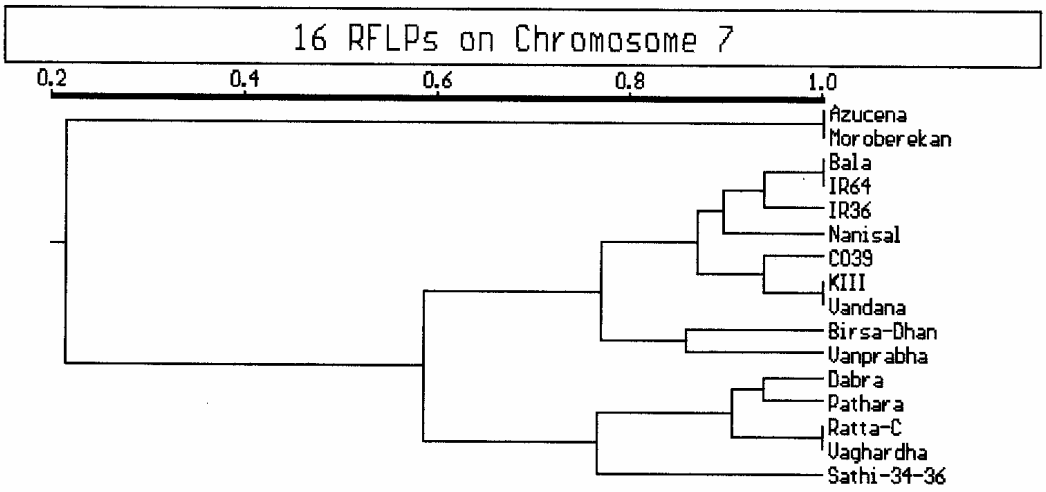
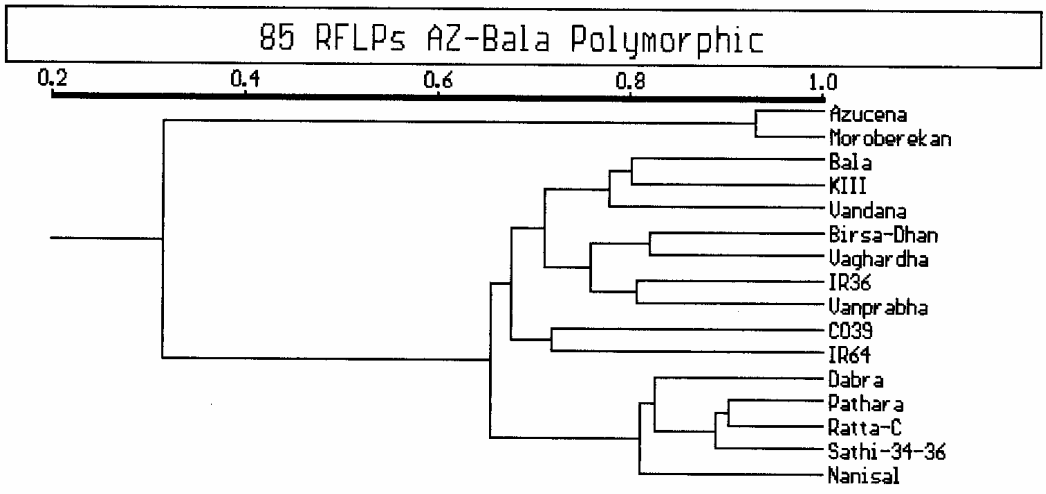
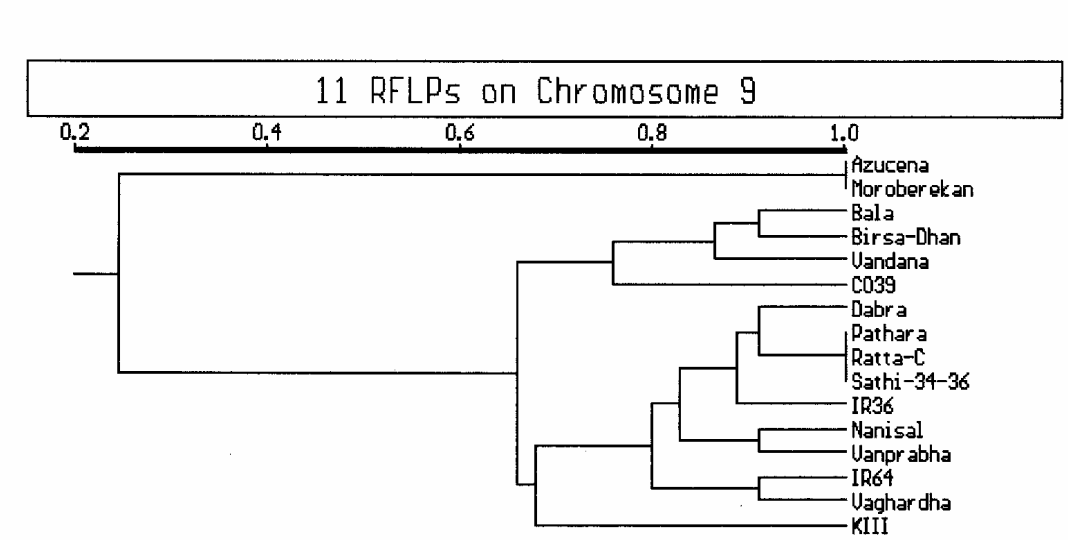
0.6
0.8
1.0
1.2
Azucena
Moroberekan
Nanisal
Bala
IR64
IR36
C039
Dabra
KIII
Birsa-Dhan
Vaghardha
Pathara
Vanprabha
Ratta-C
Vandana
Sathi-34-36


16 RFLPs on Chromosome 7
0.2
0.4
0.6
0.8
1.0
Azucena
Moroberekan
Bala
IR64
IR36
Nanisal
C039
KIII
Vandana
Birsa-Dhan
Vanprabha
Dabra
Pathara
Ratta-C
Vaghardha
Sathi-34-36


85 RFLPs AZ-Bala Polymorphic
0.2
0.4
0.6
0.8
1.0
Azucena
Moroberekan
Bala
KIII
Vandana
Birsa-Dhan
Vaghardha
IR36
Vanprabha
C039
IR64
Dabra
Pathara
Ratta-C
Sathi-34-36
Nanisal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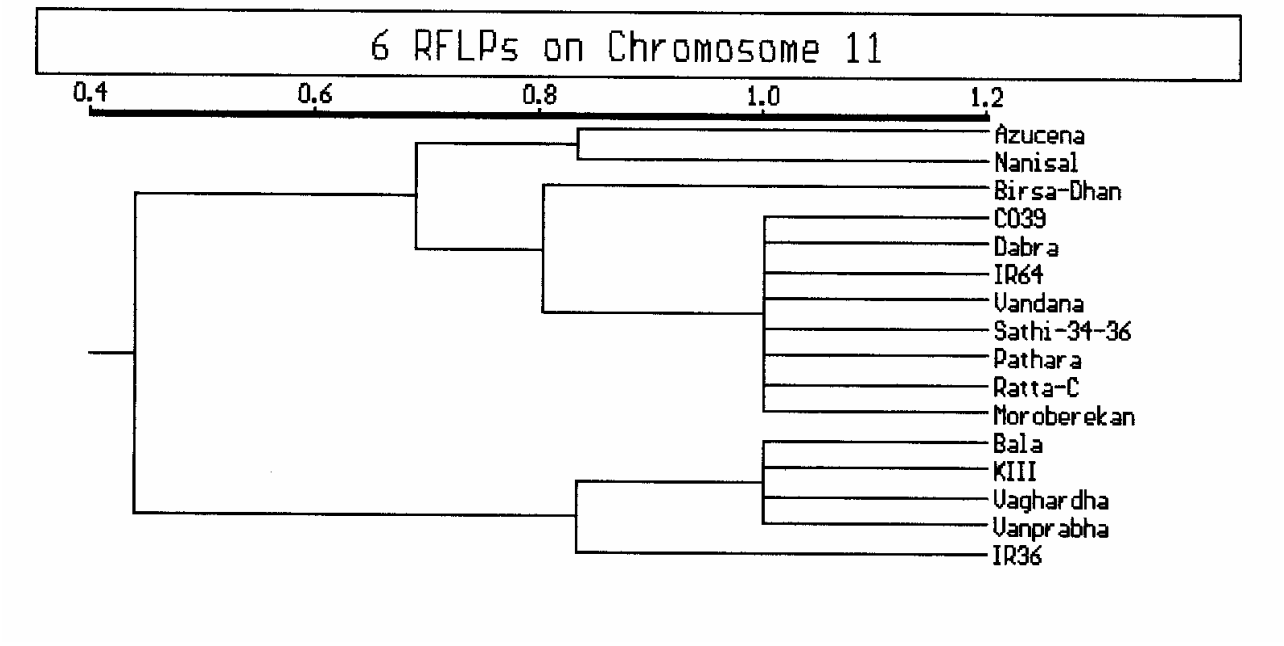
0.2
0.4
0.6
0.8
1.0
Azucena
Moroberekan
Bala
Birsa-Dhan
Vandana
C039
Dabra
Pathara
Ratta-C
Sathi-34-36
IR36
Nanisal
Vanprabha
IR64
Vaghardha
KIII


6 RFLPs on Chromosome 11
0.4
0.6
0.8
1.0
1.2
Azucena
Nanisal
Birsa-Dhan
C039
Dabra
IR64
Vandana
Sathi-34-36
Pathara
Ratta-C
Moroberekan
Bala
KIII
Vaghardha
Vanprabha
IR36