BIOTECH FARMING

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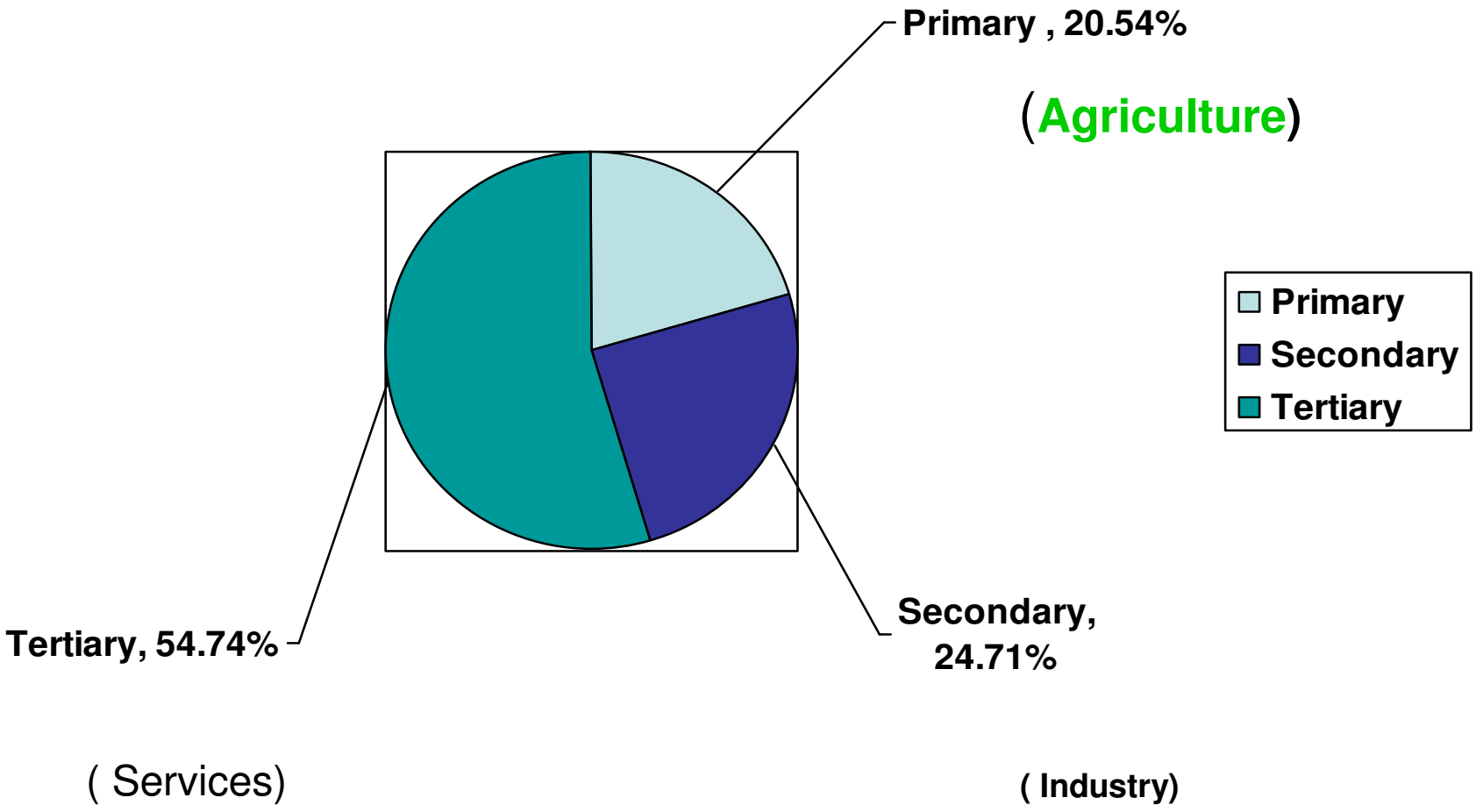
Share of different sectors in India's Economy (2006-07)



SUSTAINING AGRICULTURE

- **Development and release of high-yielding crop varieties**
- **Development of efficient crop production and protection technologies**

SUSTAINING AGRICULTURE

- **Use of quality agrochemicals (fertilizers, pesticides)**
- **Assured irrigation**
- **Developing crop varieties with greater water-use efficiency**

- **Biotechnology provides powerful tools for the sustainable development of agriculture, fisheries and forestry, as well as the food industry. When appropriately integrated with other technologies, it can be of significant assistance in meeting the needs of an expanding and increasingly urbanized population in the next millennium. (FAO, 2000)**

BIOTECHNOLOGY ASPECTS: RELEVANCE TO AGRICULTURE

- **Tissue culture/micropropagation**
- **Haploid/ doubled-haploid breeding**
- **Transgenic technology**
- **DNA-marker technology**

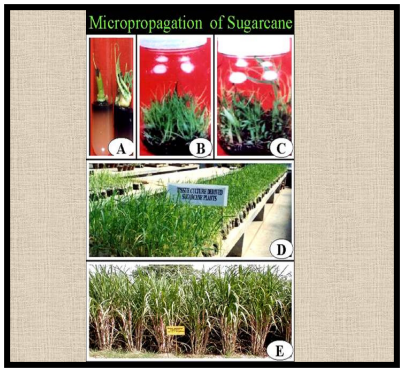
TISSUE CULTURE MICROPROPAGATION

Micropropagation involves the production of plants from very small (1 mm) plant parts through tissue culture. Micropropagation of selected ornamentals, field, fruit and forest plant species is one of the best and most successful examples of commercial applications of tissue-culture technology.

APPLICATIONS OF MICROPROPAGATION

1. PRODUCTION OF SUPER-ELITE PLANTING MATERIAL (SEED) OF VEGETATIVELY PROPAGATED SPECIES.
2. QUICK SPREAD OF NEW VARIETIES OF VEGETATIVELY PROPAGATED SPECIES.
3. REJUVENATION OF OLD VARIETIES OF VEGETATIVELY PROPAGATED SPECIES.

- **Micropropagation protocols developed at PAU**: Total 17 species

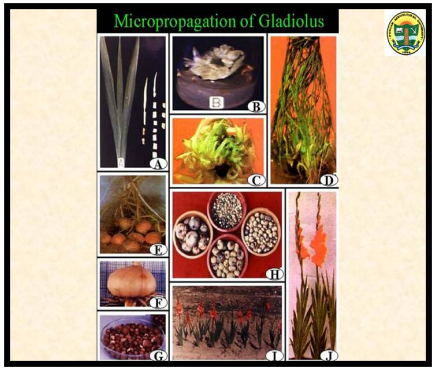

Micropropagation of Sugarcane
A
B
C
D
E

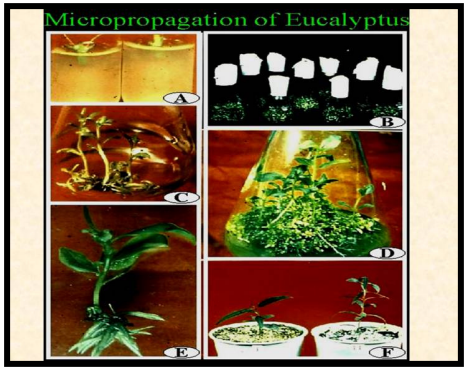

Micropropagation of Mint
PUPEMINT
SCOTCHMINT
SPEARMINT
A
B
C
D
E

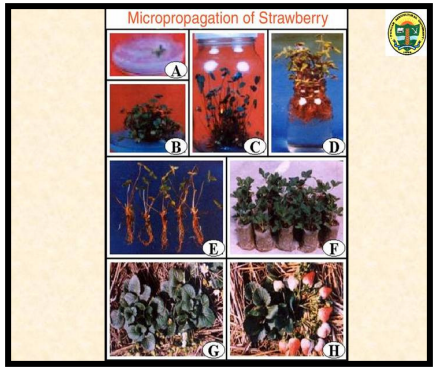

MICROPROPAGATION OF POTATO
THROUGH MINITUBER PRODUCTION

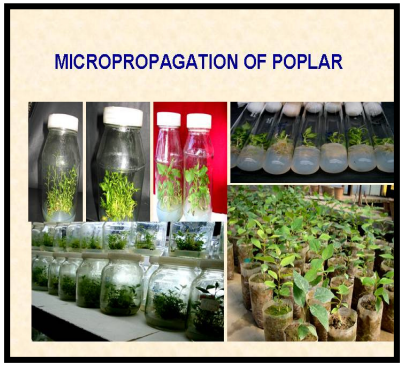

MICROPROPAGATION OF POTATO

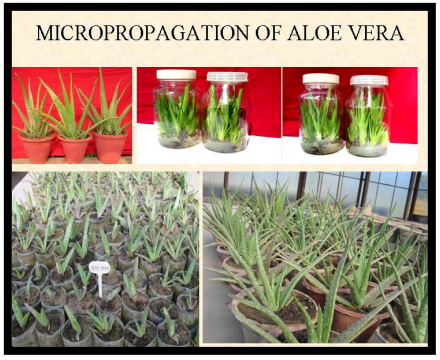

Micropropagation of Mint
PUPEMINT
SCOTCHMINT
SPEARMINT
A
B
C
D
E

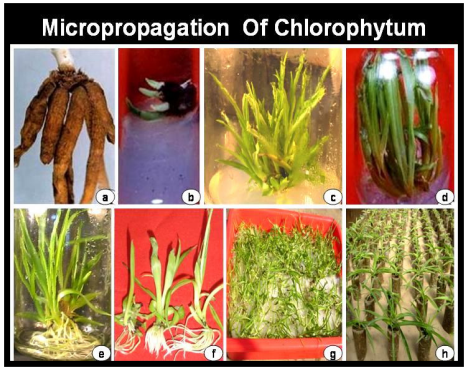

Micropropagation of Gladiolus


Micropropagation of Eucalyptus
A
B
C
D
E
F


Micropropagation of Strawberry
A
B
C
D
E
F
G
H


MICROPROPAGATION OF POPLAR


MICROPROPAGATION OF ALOE VERA


Micropropagation Of Chlorophytum
a
b
c
d
e
f
g
h


BANANA

MICROPROPAGATION PROTOCOL Developed at P.A.U.

FIELD CROPS

Sugarcane
Potato

FLOURICULTURAL PLANTS

Gladiolus
Chrysanthemum
Carnation
Lilium

FRUIT CROPS

Citrus
Banana
Strawberry

FOREST CROPS

Eucalyptus
Neem
Poplar
Paulowinia

MEDICINAL PLANTS

Mentha
Brahmi
Safed musli
Aloe vera

MASS PROPAGATION THROUGH MICROPROPAGATION

- Sugarcane
- Potato
- Mentha
- Banana

STEP-4: TRANSFER TO SOIL

MICROPROPAGATION OF POTATO THROUGH MINITUBER PRODUCTION

POTATO (TC_1 GENERATION) IN THE FIELD

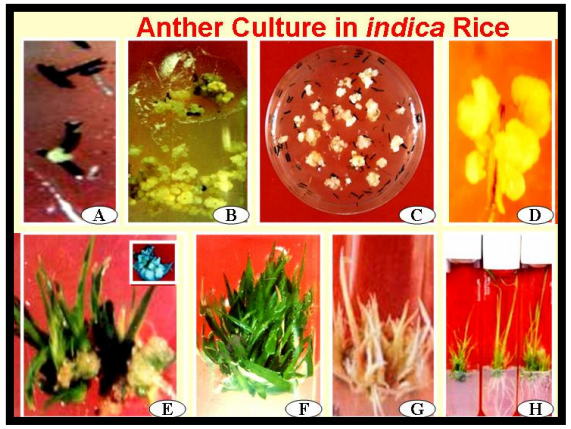
SPREAD OF MICROPROPAGATION TECHNOLOGY

- More than 500 million plants belonging to different plant species are annually produced through micopropagation in the world.
- There are more than 100 commercial tissue-culture units in India

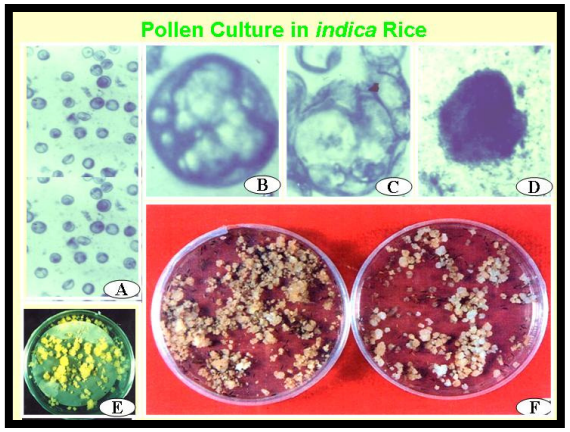
HAPLOID/DOUBLED-HAPLOID BREEDING

Production of haploids/doubled haploids through anther and pollen culture from F_1 plants, and embryo culture from wide crosses is a very useful technique for shortening the breeding cycle and early release of varieties.

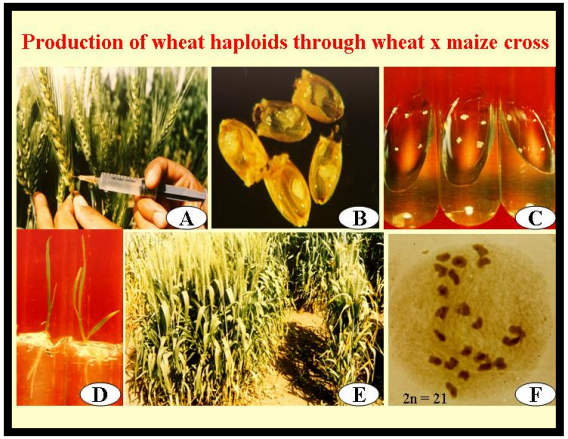
DOUBLED-HAPLOID BREEDING AT PAU



ANTHER CULTURE IN RICE



POLLEN CULTURE IN RICE



PRODUCTION OF WHEAT HAPLOIDS THROUGH WHEAT X MAIZE CROSSES

Field Trials of Anther & Pollen-Derived *indica* rice

APPLICATIONS

- ***In vitro*** **production of haploids/doubled-haploids from F1 plants results in true-breeding plants in less than one year, which otherwise takes 7 to 8 generations through conventional methods.**
- **Several cultivars are either in tests or have been released in rice, wheat, maize, rapeseed and mustard in China, Canada, Denmark, USA and France.**

TRANSGENIC TECHNOLOGY

- **Useful genes cloned from viruses, bacteria, fungi, insects, animals, human beings and even the genes synthesized in the lab can be introduced into plants.**
- **Unlike conventional plant breeding, only the specific, cloned gene (s) is (are) being introduced without the co-transfer of undesirable genes from donor. No need for repeated backcrossing.**

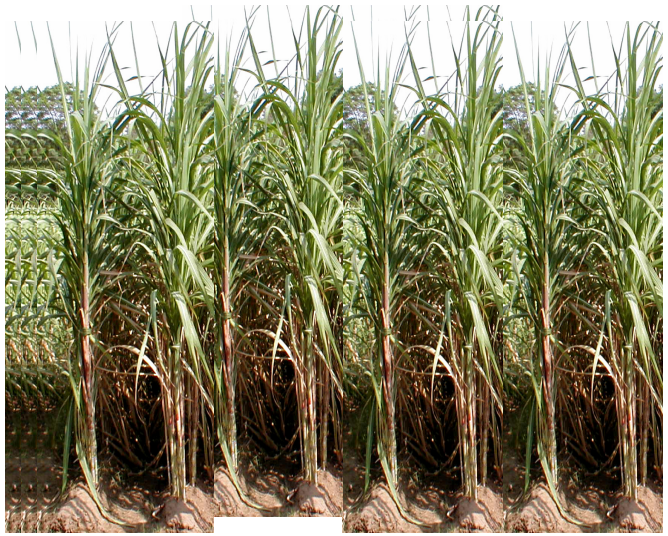
TRANS-ORGANISMS

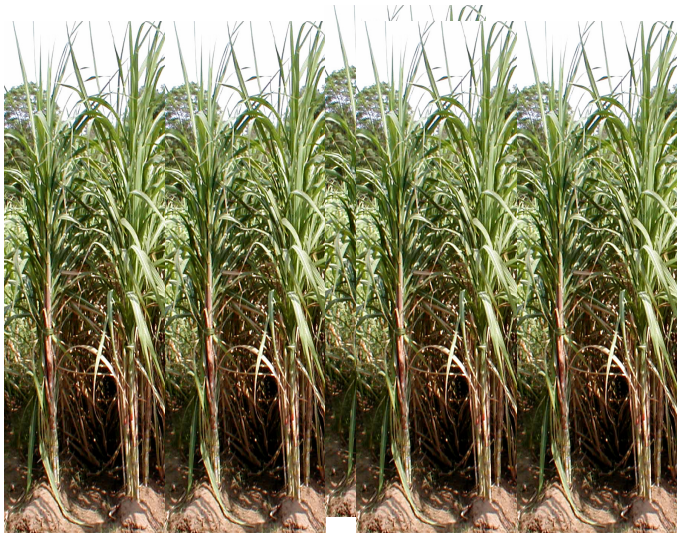
VIRUSES
BACTERIA
FUNGI
INSECTS
ANIMALS
HUMANS
UNRELATED PLANTS

CLONED TRANSGENE(S)

NORMAL PLANT
OR
NORMAL CROP

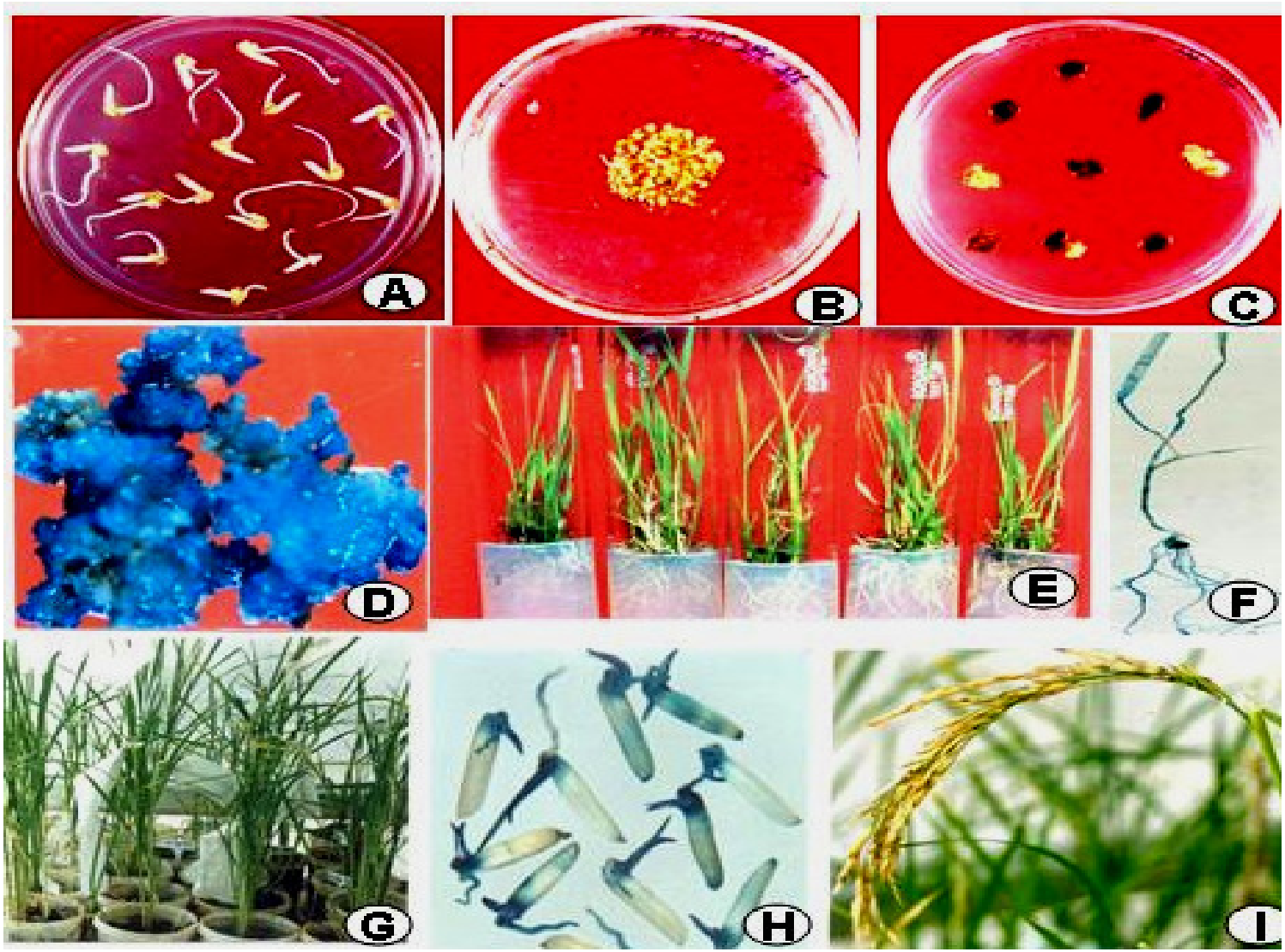
GM (TRANSGENIC) PLANT
OR
GM (TRANSGENIC) CROP





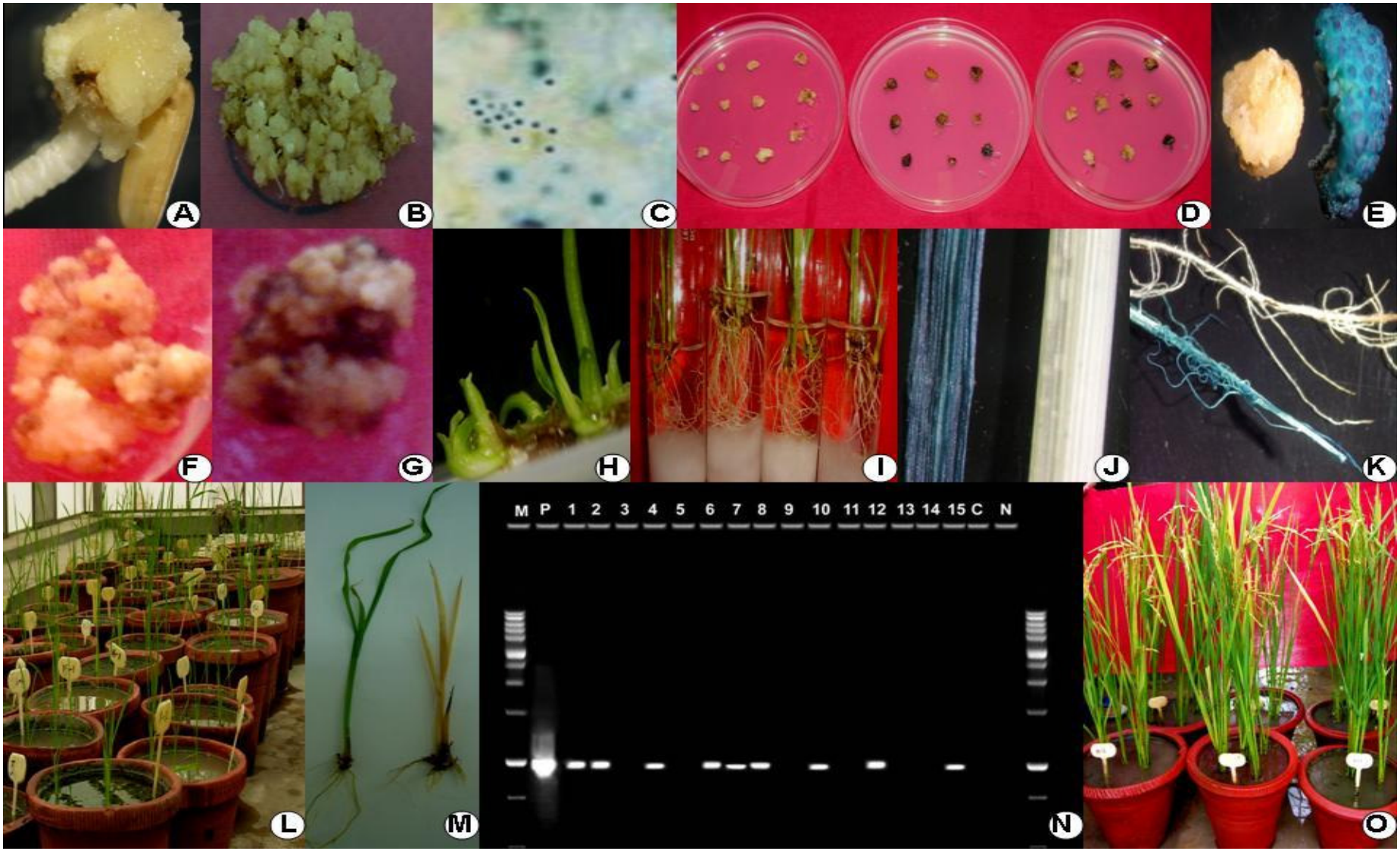
TRANSGENIC RESEARCH AT PAU

Development of Bt transgenic rice



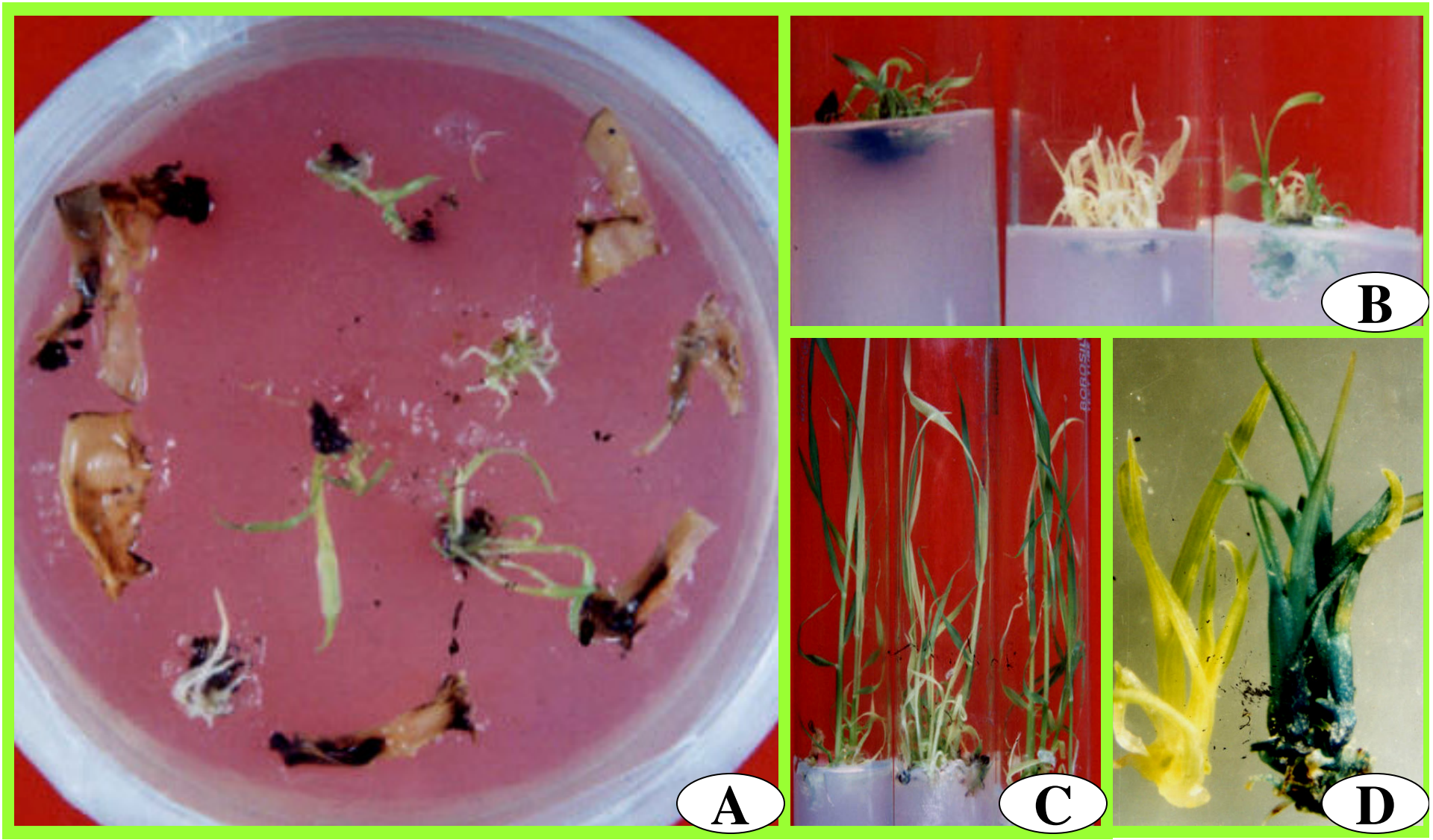
Biologia Plantarum 50 (2): 311-314.

GENETIC ENGINEERING OF RICE FOR GREATER WATER-USE EFFICIENCY



Biologia Plantarum (In press)

Agrobacterium-Mediated Genetic Transformation of Sugarcane



T1 GENERATION OF SELECTED TRANSGENIC SUGARCANE PLANTS

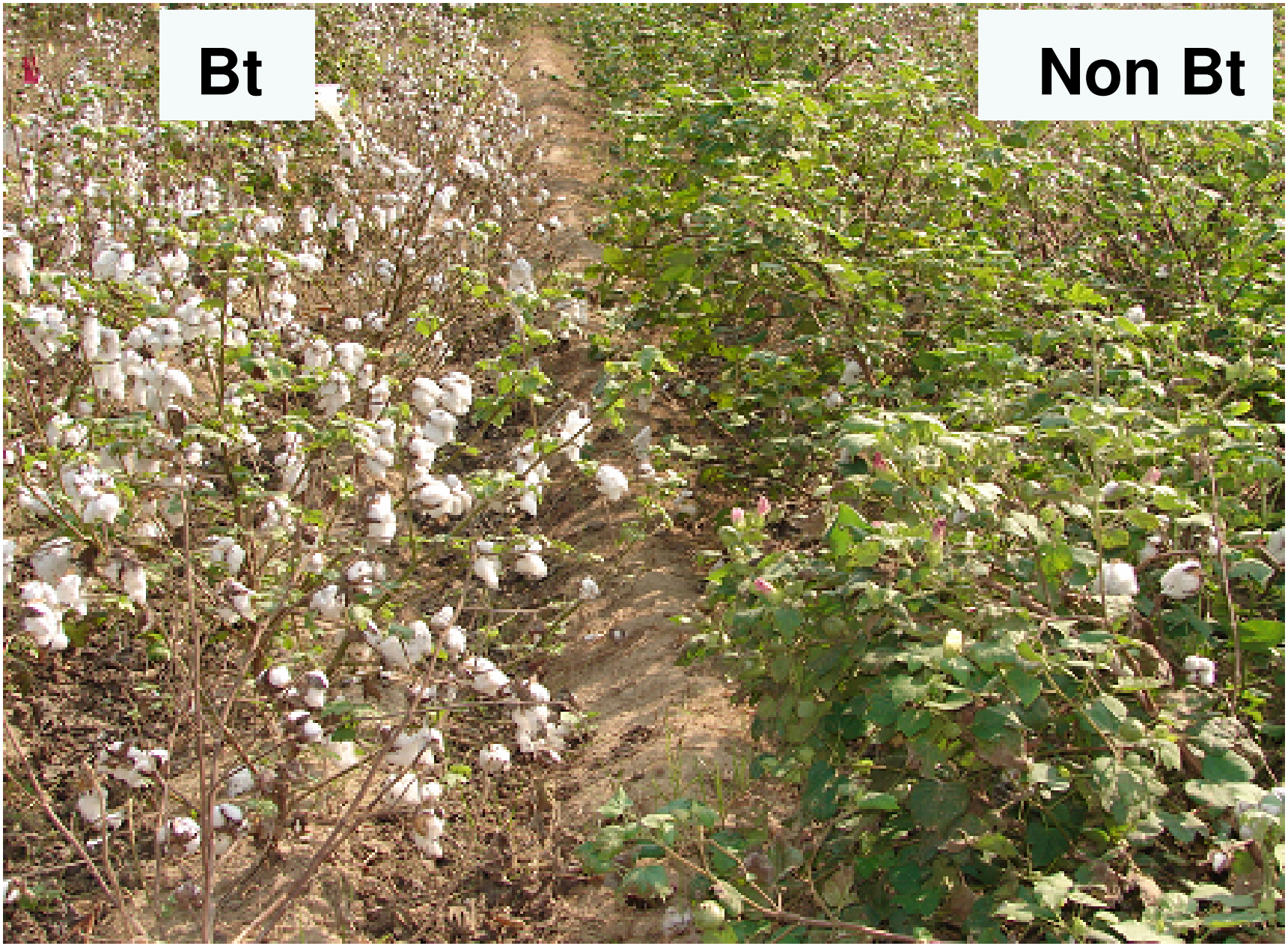
INTERNATIONAL STATUS OF TRANSGENIC CROPS

- **Total countries growing transgenic crops =25**
- **Total area under transgenic crops in the world= 125 MH**
- **Total crops: 10**
- **Total area under transgenic crops in India = 7.6 MH**
- **Area under Bt cotton in Punjab: About 5.5 lakh hectares (~0.5 MH) (i.e., about 90 % area is under Bt cotton)**

India's Status
James Clive: 2008

- **USA: Soy, maize, cotton, canola, squash, papaya, alfalfa, sugarbeet**
- **Argentina: Soy, maize, cotton**
- **Brazil: Soy, maize, cotton**
- **India: Cotton**
- **Canada: Canola, maize, soy, sugarbeet**
- **China: Cotton, tomato, poplar, peunia, papaya, sweet pepper**

Bt Cotton



Bt COTTON IN PUNJAB

- **PAU has recommended 6 Bt cotton hybrids developed by different seed companies for cultivation in Punjab.**
- **Total area under cotton: 6.5 Lakh hectares (Area under Bt cotton : 90%).**
- **Pesticides have been reduced by almost 90%.**
- **State is heading for a white-gold revolution.**

GENETICALLY MODIFIED FOODS FOR FUTURE

High-lycopene tomato

Tomato with high flavonols / flavonoids as anti-oxidants

Bt Brinjal

Cavity-fighting apples

GENETICALLY MODIFIED FOODS FOR FUTURE

- Golden rice
- Iron-pumping rice
- Golden brassica
- Proteinaceous potatoes
- Decaffeinated tea & coffee

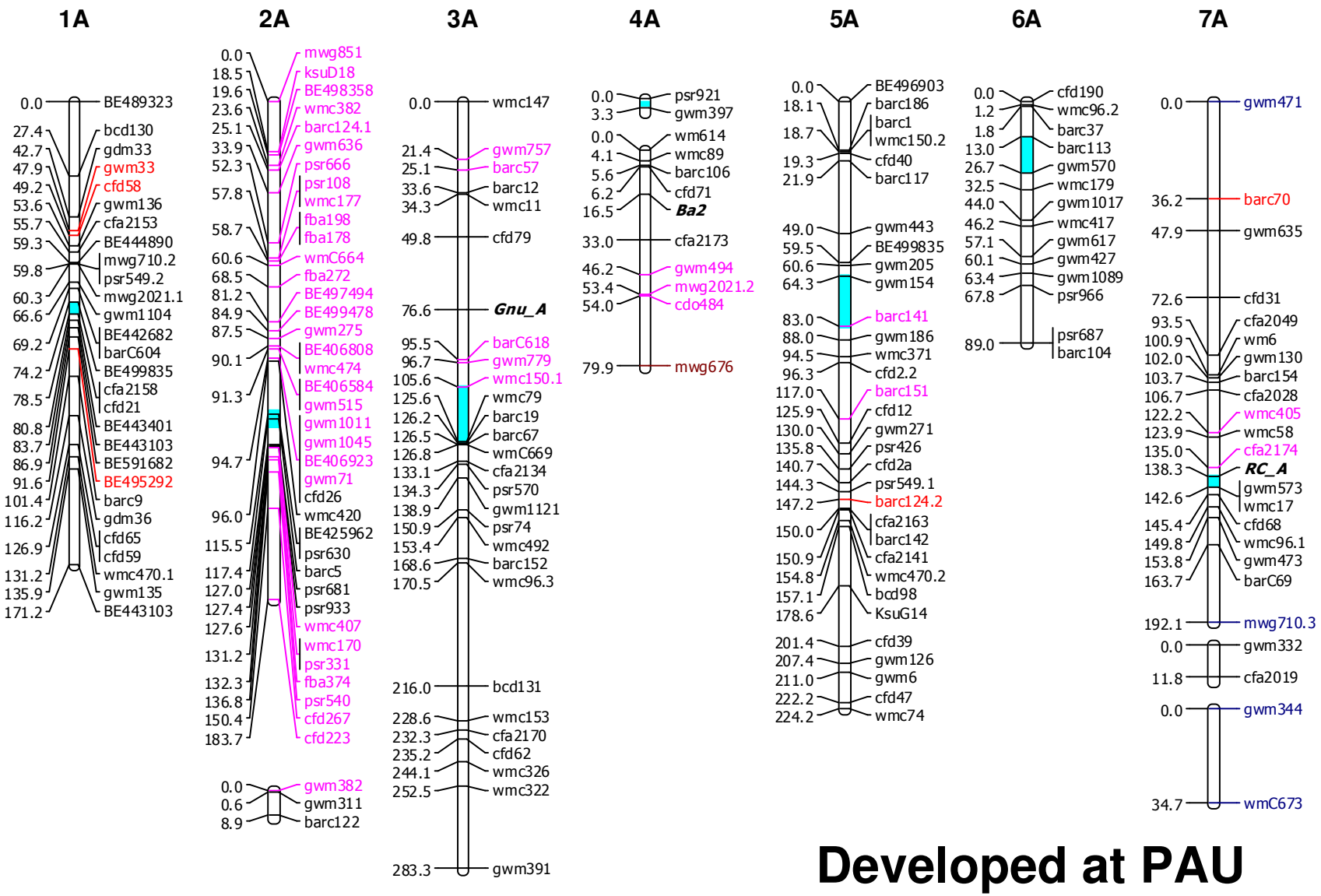
MOLECULAR-MARKER TECHNOLOGY

- Development of saturated linkage maps
- DNA fingerprinting for varietal identification
- Phylogenetic and evolutionary studies
- Molecular markers and heterosis breeding

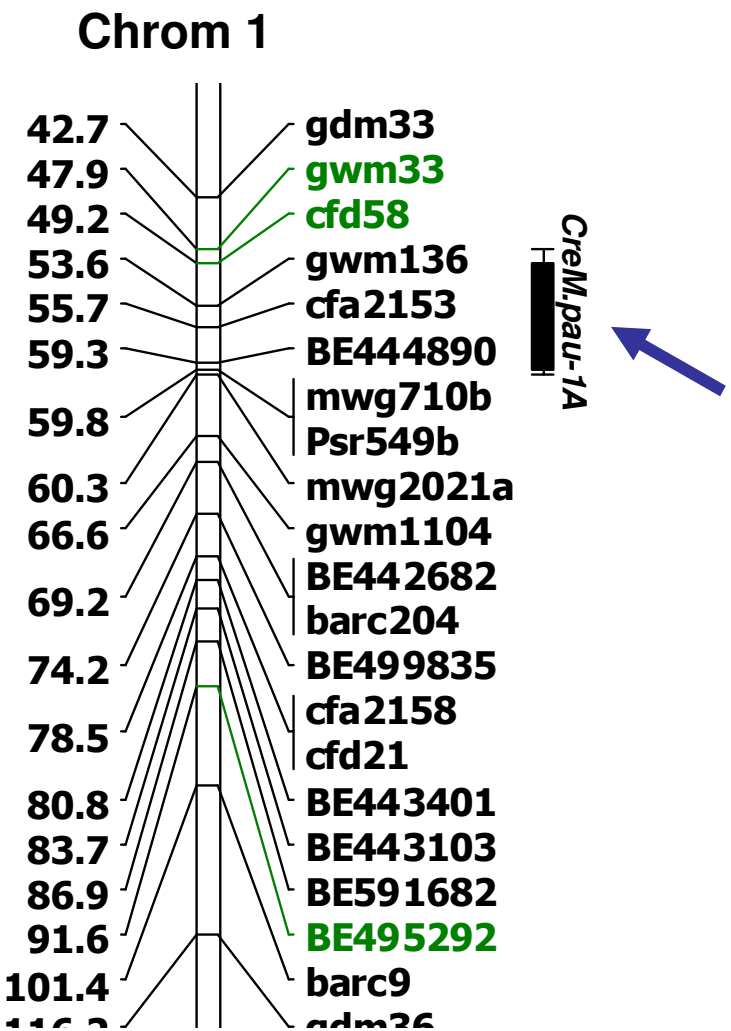
MOLECULAR-MARKER TECHNOLOGY

- Gene tagging
- Marker-assisted selection
- Marker-assisted alien-gene introgression
- Map-based gene cloning

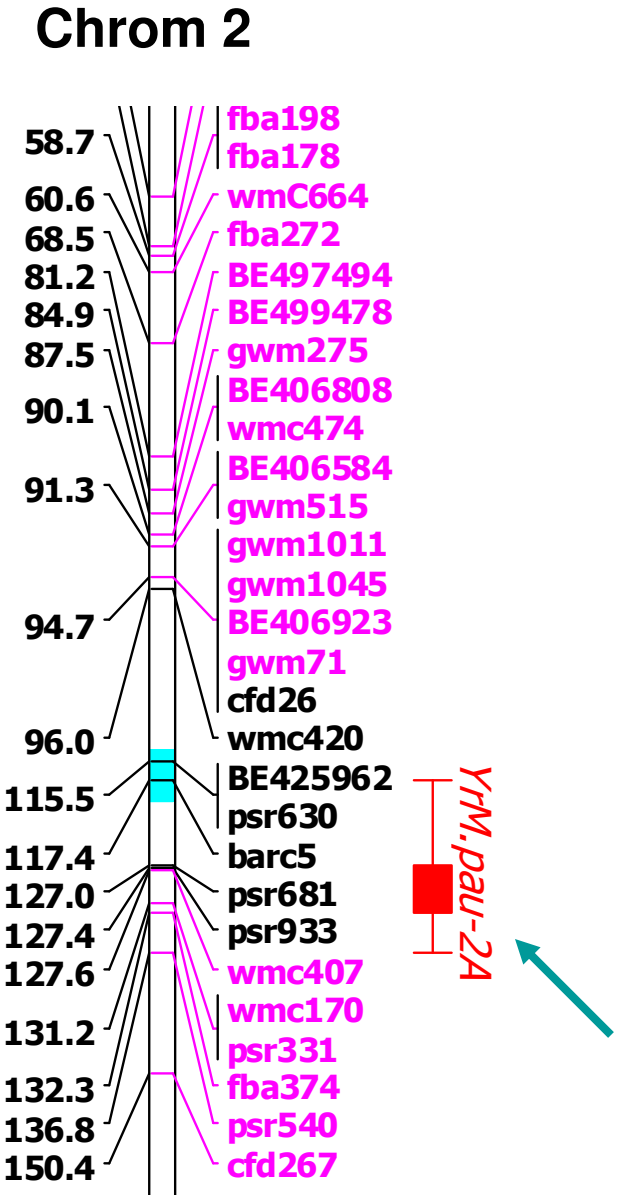
Molecular linkage map of diploid wheat *Triticum monococcum*



Developed at PAU

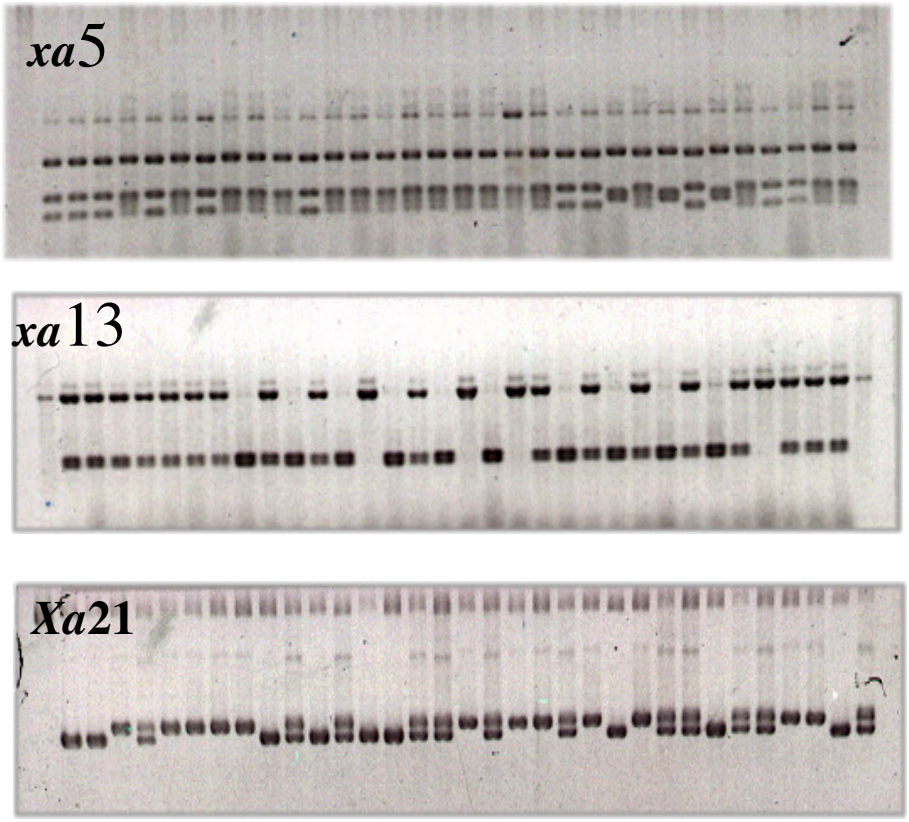


Cereal cyst nematode resistance gene mapped in *T. monococcum*



Stripe rust resistance gene mapped in *T. monococcum*

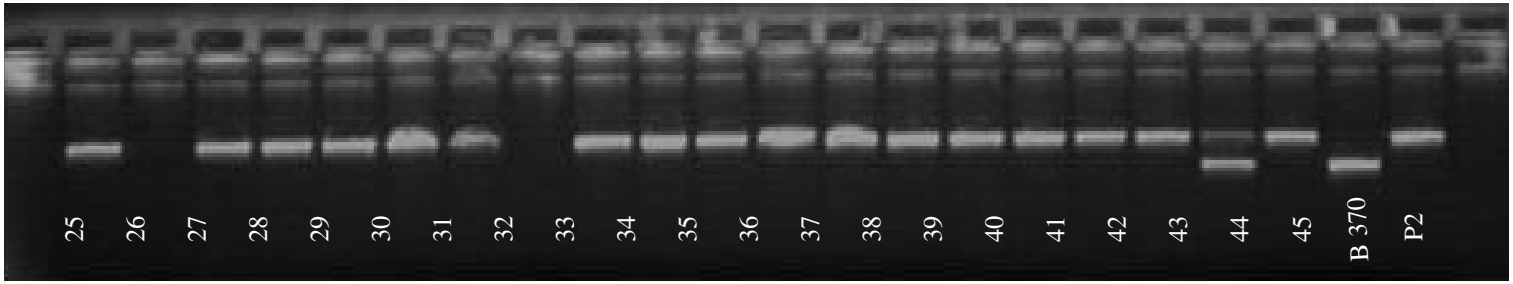
PYRAMIDING OF BACTERIAL BLIGHT RESITANCE GENES IN RICE THROUGH MAS



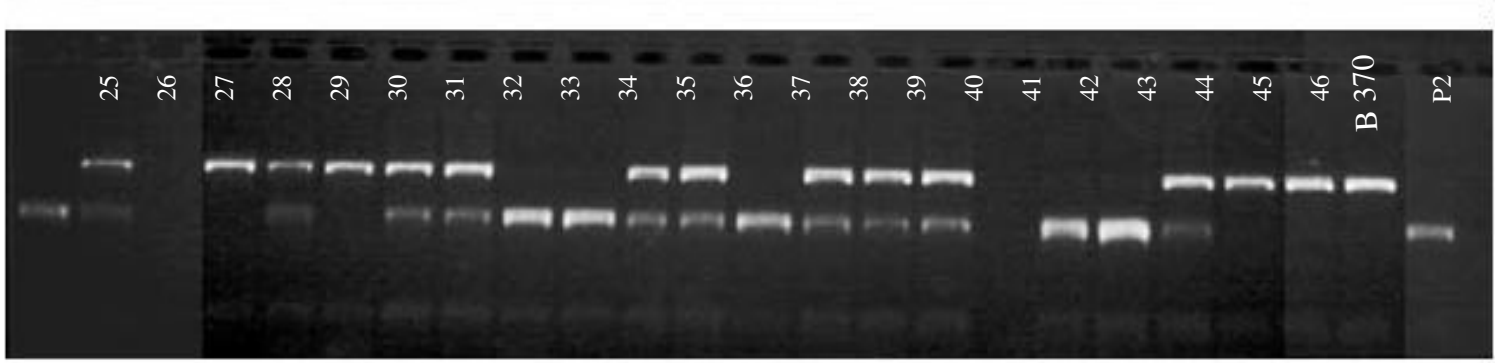
Pyramiding of Bacterial Blight resistance genes, xa5, xa13 and Xa21 in the background of PR106 and Pusa 44

BB reaction (artificial inoculation) of released varieties and pyramid lines

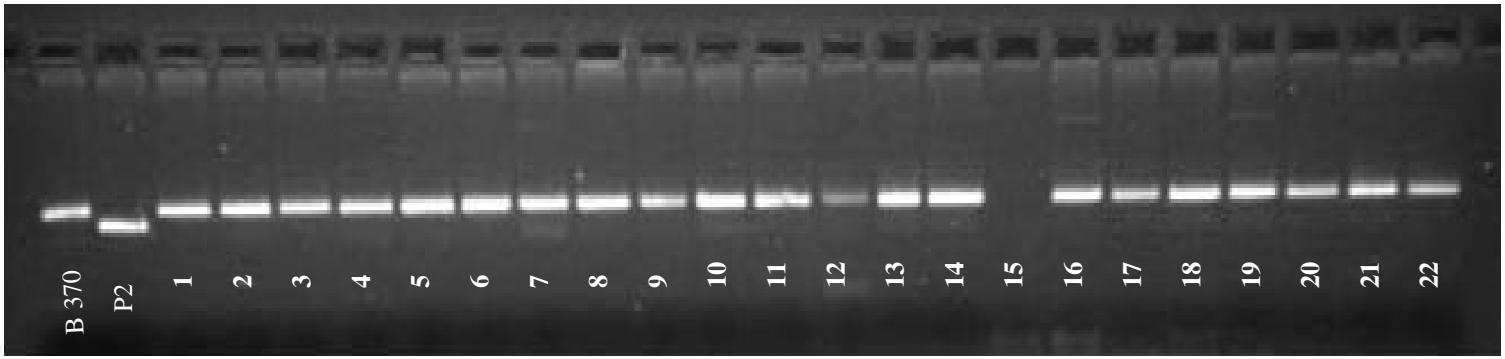
MAS: Basmati rice Improvement



***Xa*21**

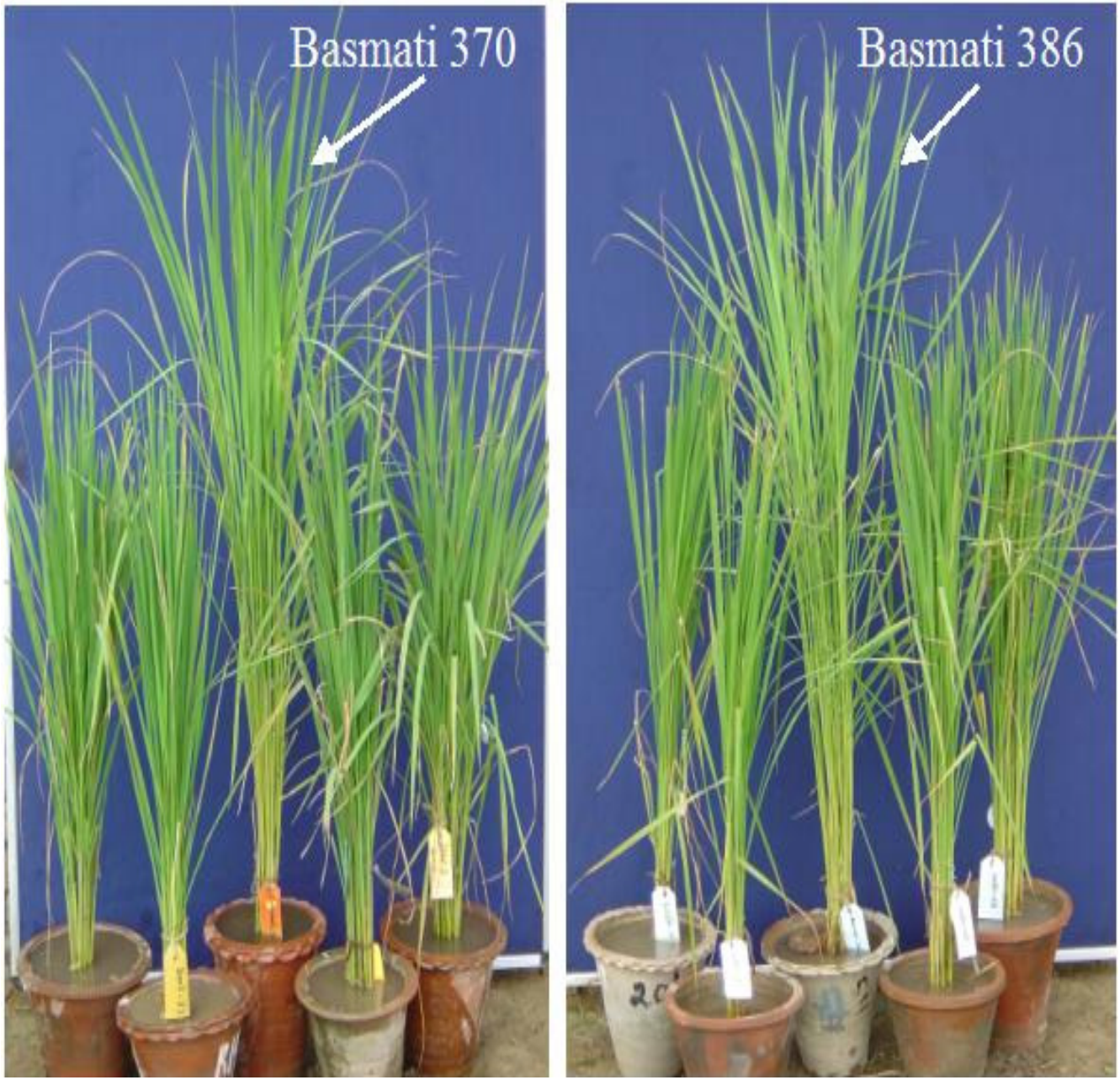


***xa*13**



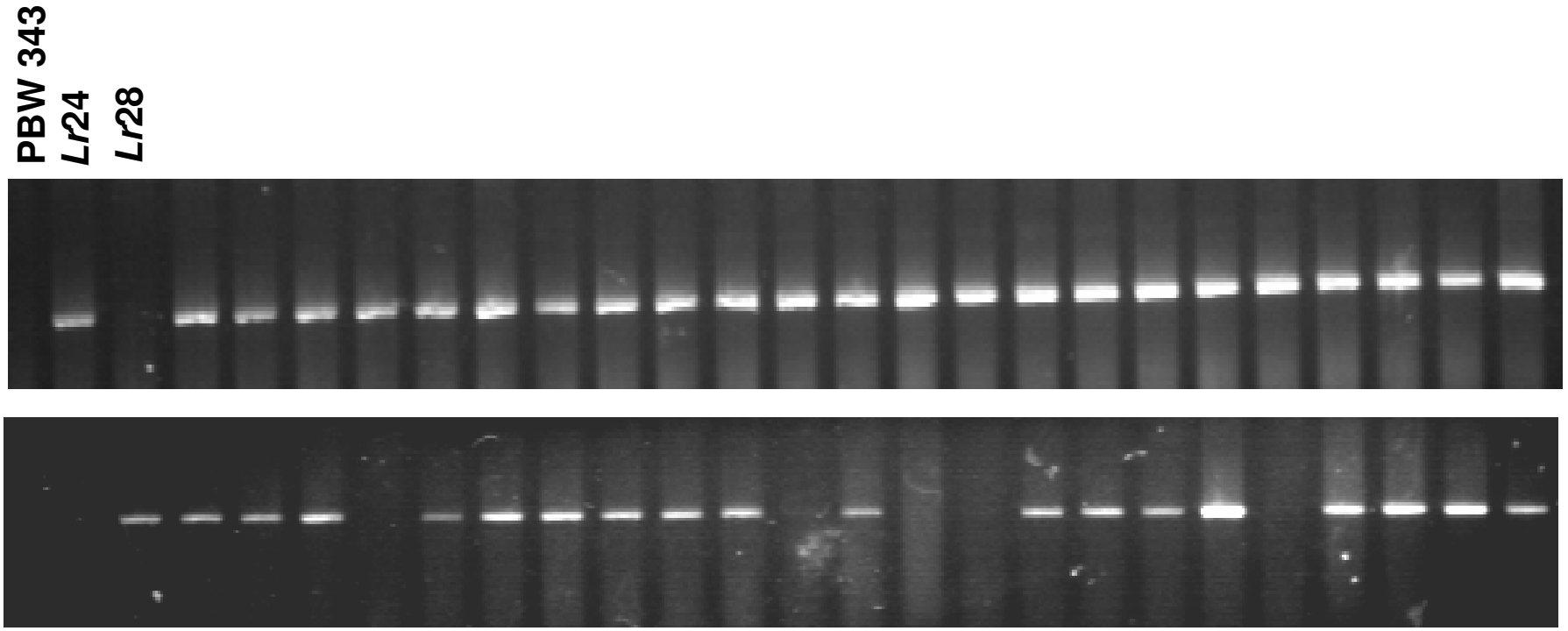
RM339

Linked to amylose content

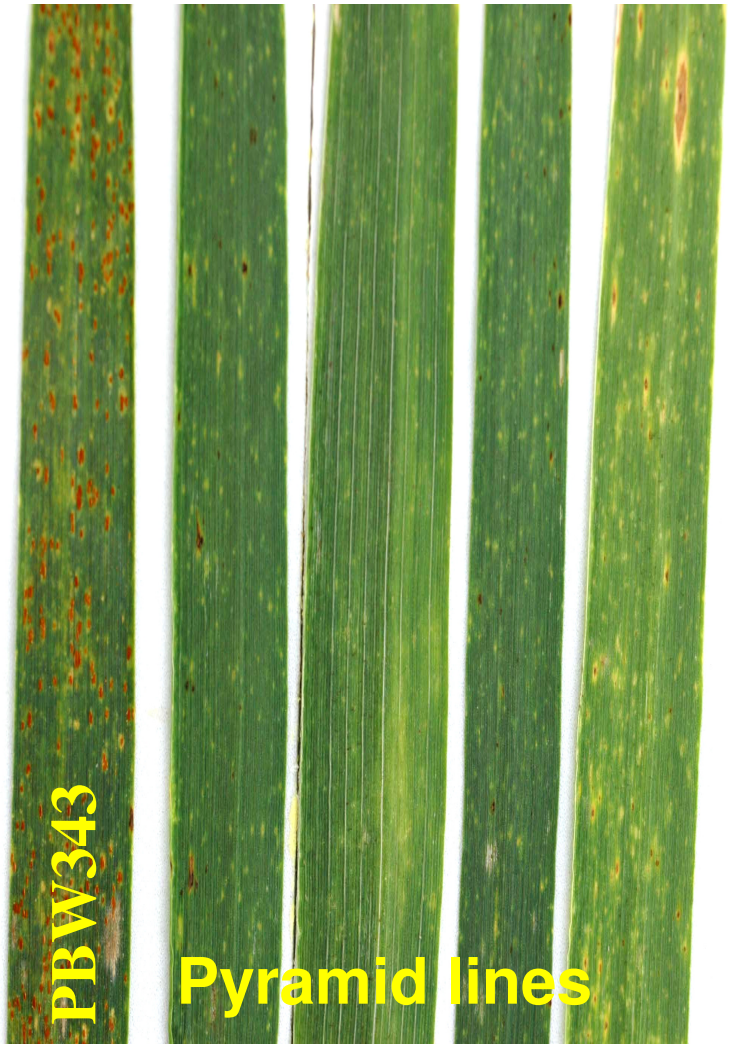


Semidwarf plants obtained in the BC_1F_3 progenies of the crosses Basmati 370/ IET 17948//Basmati 370 and Basmati 386/ IET 17948//Basmati 386

MAS: Pyramiding Leaf Rust (Lr) genes in wheat



MAS: Leaf rust reaction of *Lr*24 +*Lr*28 pyramid lines



Microbial biotechnology

- **Biofertilizers**
- **Biopesticides**
- **Bioherbicides**

Biofertilizers

- **PAU has developed seven *Rhizobium* cultures for seven leguminous crops - The technology has been transferred to Department of Agriculture, Punjab.**

- **Certain fungi are also being investigated for use as biofertilizers**

Biopesticides

PAU has isolated some strains of *Trichoderma*, *Pseudomonas*, *Bacillus subtilis* and *Fusarium* for biocontrol of soil-borne plant pathogens of potato, chickpea, rice and sunflower.

Fungus to control nematodes in soil

Biopesticides

The potato seed-tuber treatment with *Trichoderma* has been recommended for control of black scurf disease of potato in Punjab.

Summary: AgBiotech products

- Micropropagated plants
- Transgenic crops
- Pyramided lines/varieties
- Gene Chips
- Biofertilizers
- Biopesticides
- Bioherbicides
- Disease diagnostic kits

Innovate

Shown at http://www.sportbikes.dhs.org

THANKS