Rice Varieties Compatible for Conservation Agriculture: Breeding Perspectives

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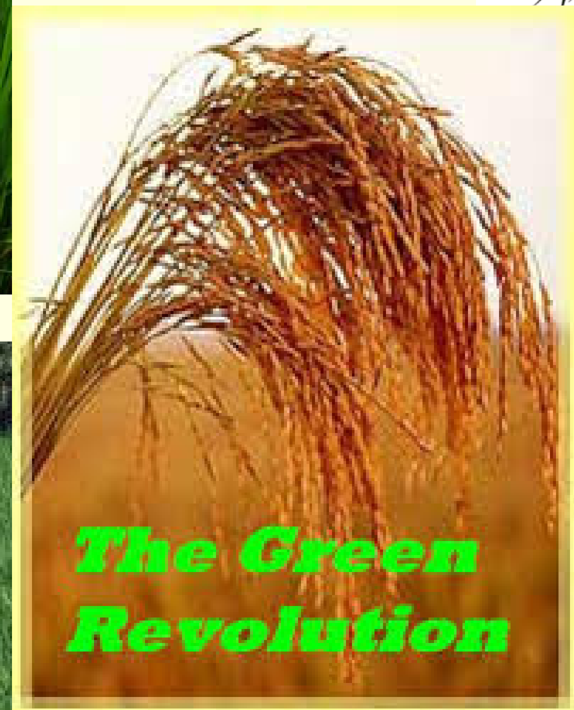


Green Revolution made India self-sufficient in food grains, thus improving agriculture productivity.

The production of rice which stood at 34.6 million tonnes in 1960-61 has increased to 74.3 million tonnes in 1990-91 to further 103 million tonnes of rice in 2012-13.

The impact of green revolution goes far beyond these immediate and very important results

Challenges faced by the farmer

Sustainable Agriculture
Ecological Intensification

Green Revolution	Post Green Revolution
Yield Maximization	**Yield with Efficiency Maximization**

Green Revolution – Yield Maximization

- Variety
- Water
- Fertilizer
- Pesticides
- Labour
- Energy

Post Green Revolution – Yield with Efficiency Maximization

- High level of precision-tillage, residue, and inputs
- Intensification
- Diversification
- Nutrition
- Adaptation to climate change

Food and Nutrition Security, Natural Resource Base, Environmental Quality, Economic Viability on a Sustainable Basis

Challenges Facing the Rice-Based System

- **Growing cereal demand vis-à-vis declining harvest area**
- **Declining/stagnating productivity**
- **Rising agro-chemical use and declining their use efficiency**
- **Degrading soil and water resource base**
- **Adverse changes climate changes**
- **Growing labor and energy shortages**
- **Land fragmentation**

Shift in transplanting to direct seeding

Puddled transplanting

Unpuddled direct seeding

Labor shortage

Water /energy Shortage

Soil health issues

Economics

Conservation Agriculture???

Conservation agriculture (CA) is a concept for resource saving agricultural crop production that strives to achieve acceptable profits together with sustained production levels while concurrently conserving the environment (FAO 2007).

CA characterized by three principles (FAO)

- ❖**Minimum mechanical soil disturbance for erosion ontrol**
- ❖**Maintenance of permanent organic soil cover**
- ❖**Diversified crop rotations for annual crops and plant associations of perennial crops**

Resource Conserving Technologies (RCTs)

Conventional | **RCTs**

1. No-tillage

2. Laser land leveling

3. Direct seeding of rice

4. Crop diversification

Conservation Agriculture enhances biological tillage instead of mechanical tillage

R.C. through use of laser land leveling

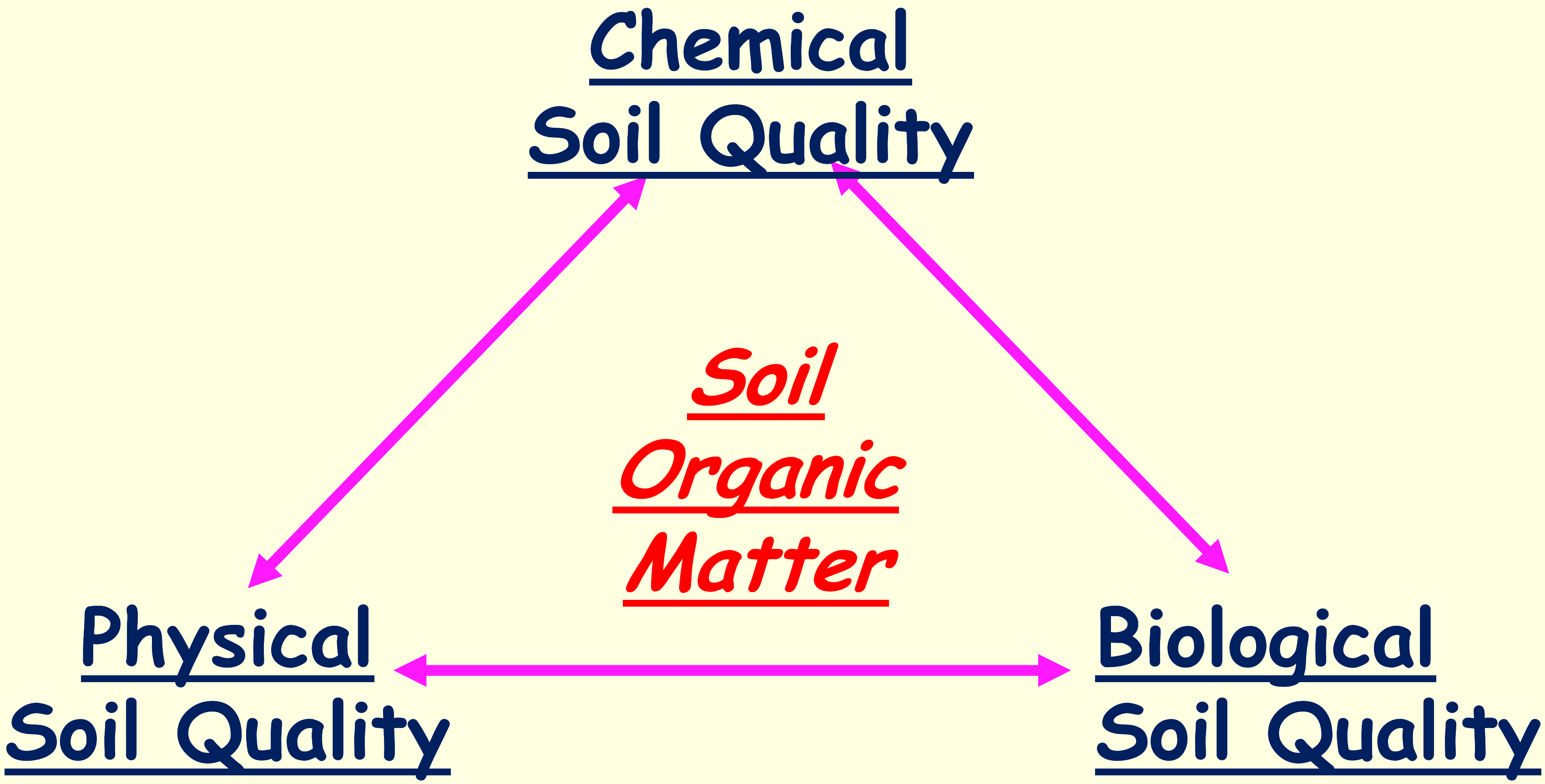
- Leveling by : animal & tractor drawn leveler –
- Poor crop stand, Over irrigation and uneven distribution due to Unevenness

Laser land leveler-

- increase water application efficiency up to 50%
- cropping intensity by 40%
- labour requirement by 35%
- crop yield by 15 to 66%
- Saving in time 24%
- 2.m.ha by laser land leveller: save 1.5 m. ha. m^3 of irrigation water

Yield & water saving for laser leveled field & traditionally leveled plots for rice crop

Properly Managed CA Encourages Sustainable Soil Management



Residue Management and Reduction in Environmental Pollution

- Paddy straw burnt
  - Pollution
  - GHGs
  - soil degradation (loss of organic matter)

Straw Cutter cum spreader

- mulch and promote ground water recharge
- reduces soil erosion

Components of conservation agriculture specific to rice

- Aerobic rice cultivation
- Alternate wetting and drying
- SRI cultivation
- Direct seeded rice
- Organic farming

Strategies for Developing Compatible Genotypes for Conservation Agriculture System

Basic strategies for Conservation Agriculture

- Zero tillage farming/ no till farming
- Residue retention
- Soil and water conservation
- In situ cultivation and incorporation as a cover crop
- Direct seeding
- Mulch based cropping system
- CA under different irrigation regimes
- Site specific integrated nutrient management

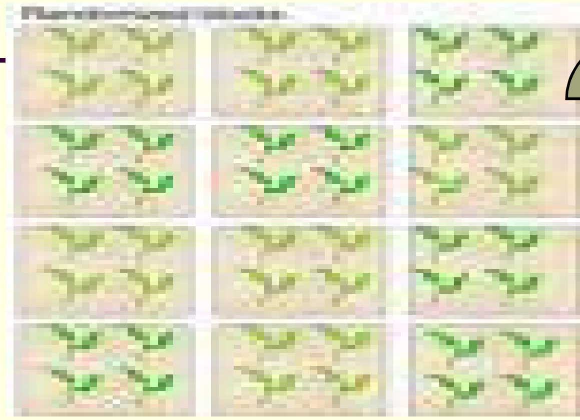
Pre-Requisites for Direct-Seeding

- Precise land leveling
- Good initial crop establishment (optimal seed rate and seeding depth)
- Precise water management
- Efficient and economical weed management
- Suitable rice variety

Objectives

- To screen germplasm and identify the parental material having suitable morphological and functional traits and their integration with tillage practices
- To implement a selection strategy to identify morphological and functional traits that facilitates selection criteria under zero tillage or reduced tillage
- To identify elite lines with superior adaptation to conservation agriculture technologies with stable yield which will ultimately serve as reference collection for conservation agriculture

Experimental methodology



Alpha Lattice Design with three replications/ Augmented design

- Conduct studies of germplasm as affected by conservation agriculture practices in different environments

  - Zero tillage/ minimum tillage with direct seeding followed by aerobic management
  - Control : Puddled transplanting condition
  - Experiments on direct seeding, transplanted as well as zero till direct seeding were conducted during Rabi and Kharif seasons.

Experimental Material

About >2000 rice genotypes consisting of germplasm, released varieties, genetic stocks as well as *O. glaberrima*, *O. rufipogan* and *O. Nivara* introgression lines and genotypes from International Upland Observational Nursery (IURON) were screened to identify promising genotypes with specific traits..

Breeding rice for conservation agriculture…

- selection of genotypes under direct seeding with key traits such as early vigor, high tillering capacity as well as on yield and yield components

- Development of various plant types suitable for dry seeding: Identification of appropriate donors with target traits

- Generating segregating populations by initiating hybridization among appropriate donors with target traits

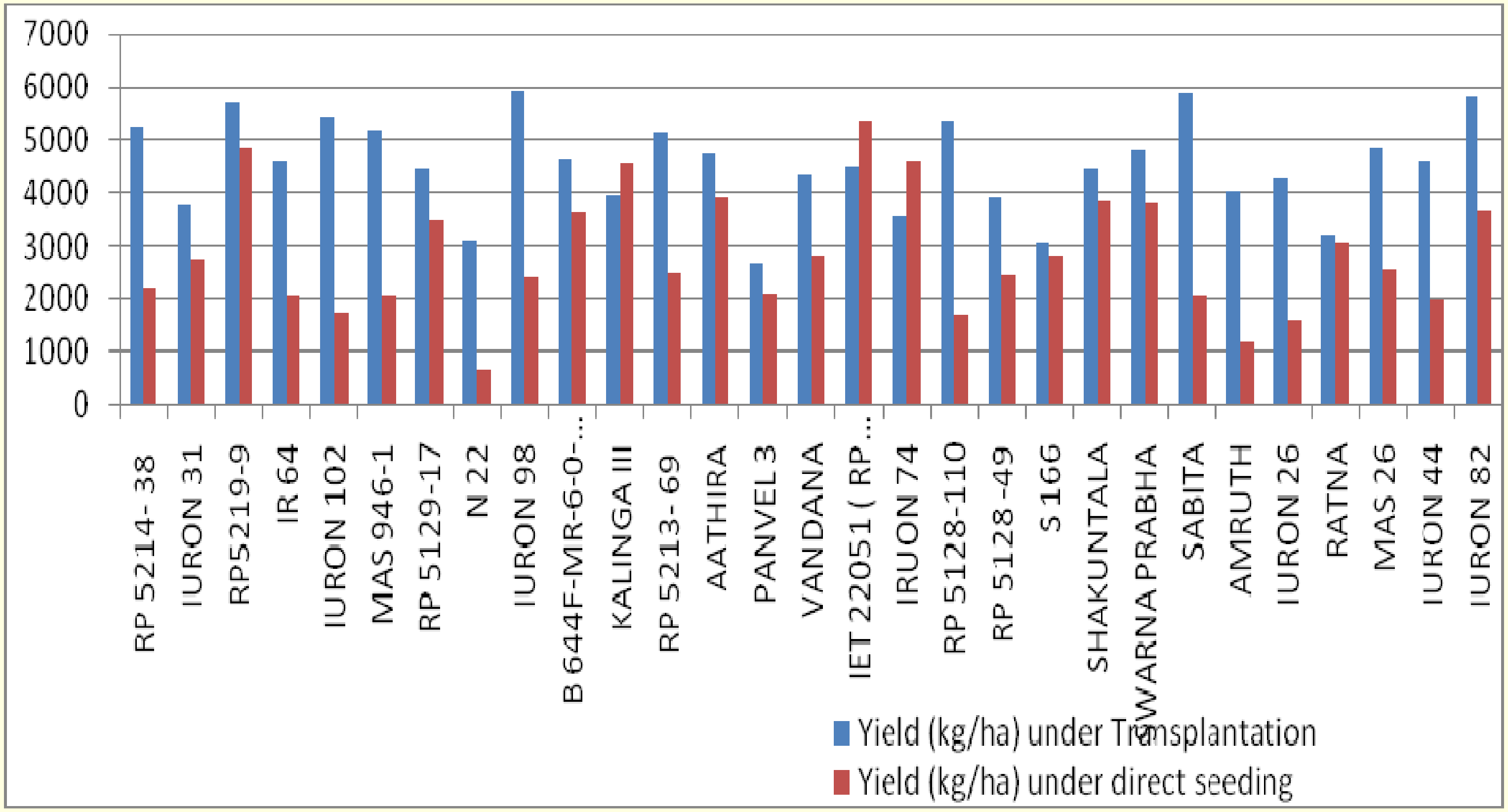
- Segregating populations selected under dry seeding conditions

- Establish a sub set (minicore/ reference collection for characters desired for conservation agriculture.

Summary of yield and yield components Kharif, 2011

Variable	Direct seeding Kharif, 2011			Transplanted, Kharif 2011		
	Mean	Min.	Max.	Mean	Min.	Max.
DFF	102	73	125	102	75	124
Pl.height (cm)	97.98	61.2	144.6	103.5	73.60	161.0
Total tillers	12.0	7.0	19.0	11.0	8.0	16.0
Prod. Tillers	9.0	5.0	10.0	11.0	6.0	14.0
Panicle length (cm)	23.14	17.50	27.80	23.7	18.80	27.50
Grain number /panicle	152	85.0	351	162	95	340
sterility%	15.21	5.77	26.37	9.72	2.64	18.96
Single plant yield (g)	12.32	8.0	24.45	20.5	11.9	36.20
Yield (kg/ha)	2822	644.53	5384	4527	2665	5946

Differential response of rice genotypes under direct seeding and transplanted conditions



Genotype x environment interaction

Variability for various traits to be exploited

The performance of genotypes varied in both the conditions. Interestingly, some of the genotypes were found to be perform better under both conditions, while some of them exhibited superior performance under direct seeded condition and *vice versa*.

The average yield under direct seeding was found to be 2822 kg/ha with yield range between 644 kg/ha (N22) to 5384 kg/ha (IET 22051: RP 5125-2-4)

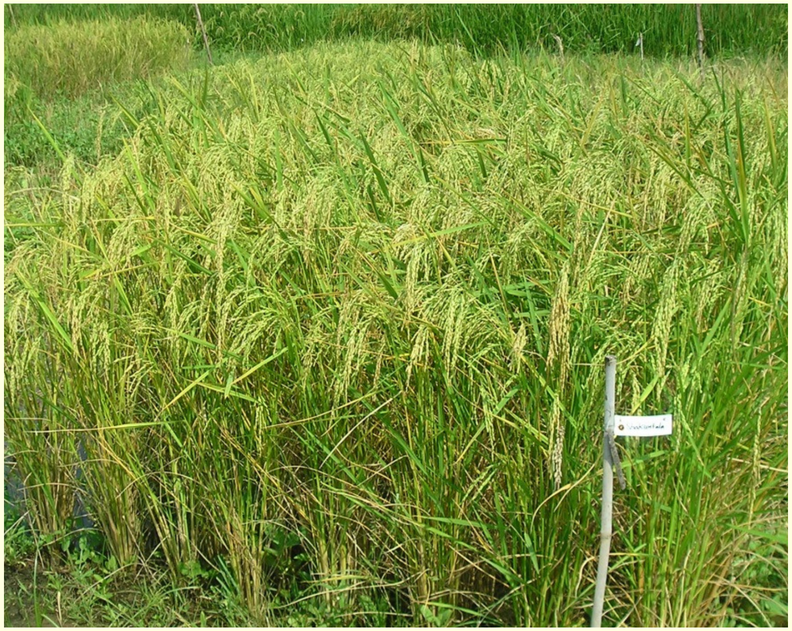
Under puddled transplanted condition the yield varied between 2665 kg/ha (Panvel 3) and 5946 kg/ha (IURON 98) with an average yield of 4526 kg/ha.

Although there was significant yield reduction under direct seeding condition as compared to transplanted situation, some of the genotypes exhibited superior *per se* performance under direct seeding. The introgression lines viz., RP 5219-9-6-7-3-2-1-1, RP 5125-2-4, RP 5129-17-8-3-2 recorded superior performance under direct seeding situation.

The genotypes *viz.,* Swarna Prabha, Kalinga III, Shakuntala and Aathira found promising under direct seeding and puddled transplanted condition.

The genotypes IURON 26 and IURON 44 were found to perform better under direct seeding condition

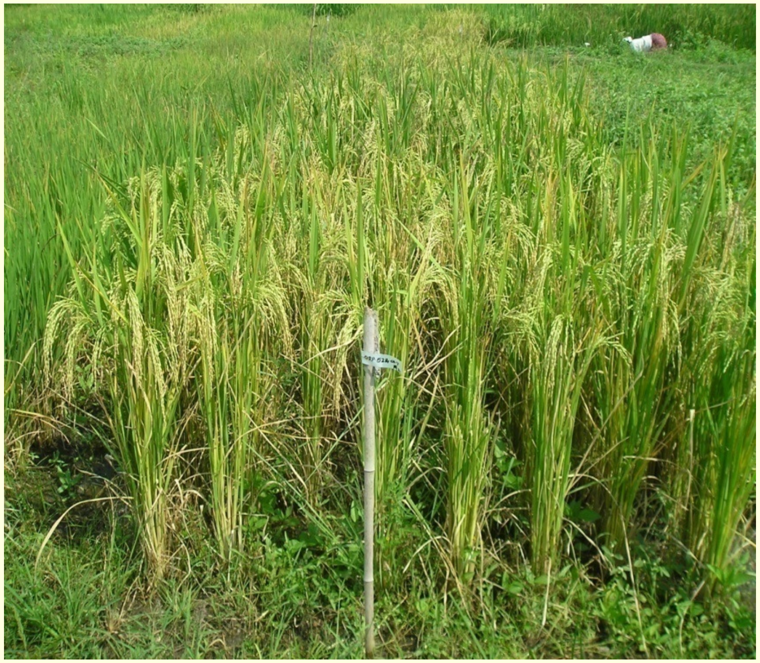
Under zero tillage conditions, the genotypes Aathira, IURON 26, IURON 73, Kalinga III and Swarna Prabha were found to be promising



In addition, the genotypes Kalinga III (4570 kg/ha), B644F-MR-6-0-0 (3645 kg/ha), Aathira (3906 kg/ha), Shakuntala (3847 kg/ha), Swarna Prabha (3782 kg/ha), IURON 82 (3678 kg/ha) *etc* exhibited superior performance during the all the years and seasons of testing.

Suitable plant type for CA

- Early emergence and early seedling vigour
- Weed tolerant and suppressing ability
- Semi tall plant stature
- Sturdy culms
- High tillering
- Yield *per se*



WEED TOLERANT GENOTYPES

To identify the genotypes which are weed tolerant, thirty genotypes were screened without any weed control measures

Initially, emergence and establishment of rice seedling did not affected by the presence of weeds.

After 15 to 40 days of sowing, the growth of the rice seedling was totally suppressed by the smothering nature of weeds leading to high mortality. The weed population consisted of annual grasses, sedges and broad leaved weeds

Rice seedlings and weed counts per sq. m were recorded and the number of weeds ranged from 45 to 136 per sq. m and the survival of rice in the presence of weeds was from zero to five seedlings per sq. m. and weed biomass varied from 50 gm to 153 g per sq. m.

Sabita which is found to be weed suppressive ability performed well during early stages of plant growth which could be be due to early seedling vigour.

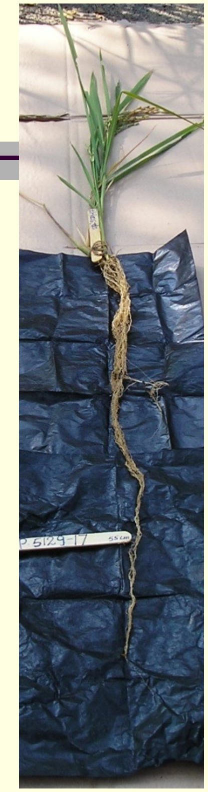
Three genotypes *viz.,* Shakuntala, Swarna Prabha and IURON 31 survived till maturity indicating that these genotypes are tolerant to weeds.

Root studies experiment to screen the genotypes for root characteristics.

Root traits play an important role in direct seeded rice

Twenty eight genotypes were initially screened under net house condition to study the root characteristics and are grown in 30" length and 12" width

Genotype	Root length (cm)	Genotype	Root length (cm)
Sabita	11	RP 5214- 38-14-9-5-2-1-B	14
Rasi	14	RP5219-9-6-7-3-2-1-1	14
Ratna	11	RP 5129-17-8-3-2	40
Mas 946-1	12	RP 5213- 69-13-3-4-1-2-B	22
IURON 44	24	RP 5128-110-6-3-8-2-5-B	16
IURON 31	12	RP 5128 -49-13-9-2-1-1-B	20
IURON 98	14	RP 5214-57-26-9-6-3-2-B	21
IURON 74	23	Amruth	14
IURON 82	16	IURON 102	16
Kalinga III	11	IR 64	15
Swarna Prabha	12	Vandana	15
S 166	15	Shakuntala	16

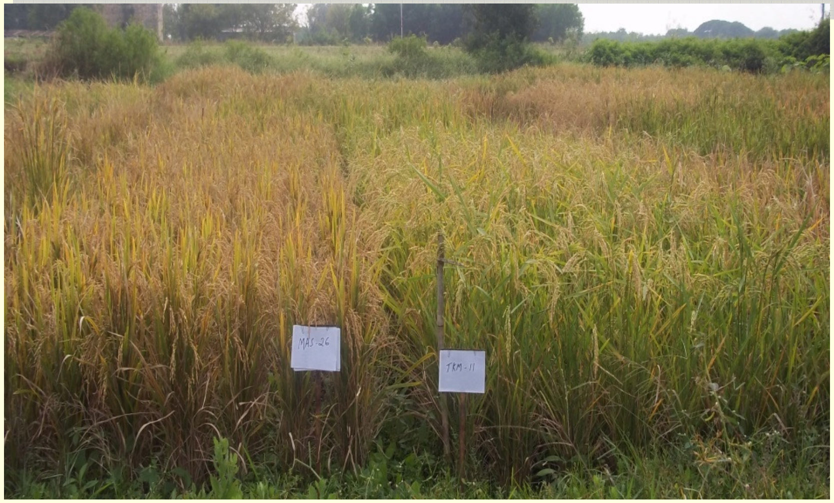


The genotypes RP 5129-17-8-3-2, RP 5214- 57-26-9-6-3-2-B, IURON 74, IURON 82 were found to be promising as they possessed deeper roots (up to 40 cm) and higher root volume as recorded by water displacement method

Selection of segregating breeding material suitable for direct seeding

A total of 1500 F2 populations derived from the crosses
IR 64 / Sabita (RP 5291), IR 64 x IR 79906-B-5-3-3 (RP 5292),
IR 64 x CR 691-58 (RP 5293),IR 64 x B 644F-MR-6-0-0 (RP 5294) and IR 79906-B-5-3-3 x Sabita (RP 5295) were evaluated under direct seeding condition.

378 superior segregants (SPS) from the above mentioned crosses were selected which are being evaluated in two row pedigree under direct seeding condition.



Standardization and Screening Rice Germplasm for Anaerobic Germination

Soil flooding is one of the most important abiotic constraints on rice yields, where farmers commonly encounter flooding after seeding, which results in partial to complete crop failure because of the high sensitivity of rice to the anaerobic conditions caused by flooding during germination.

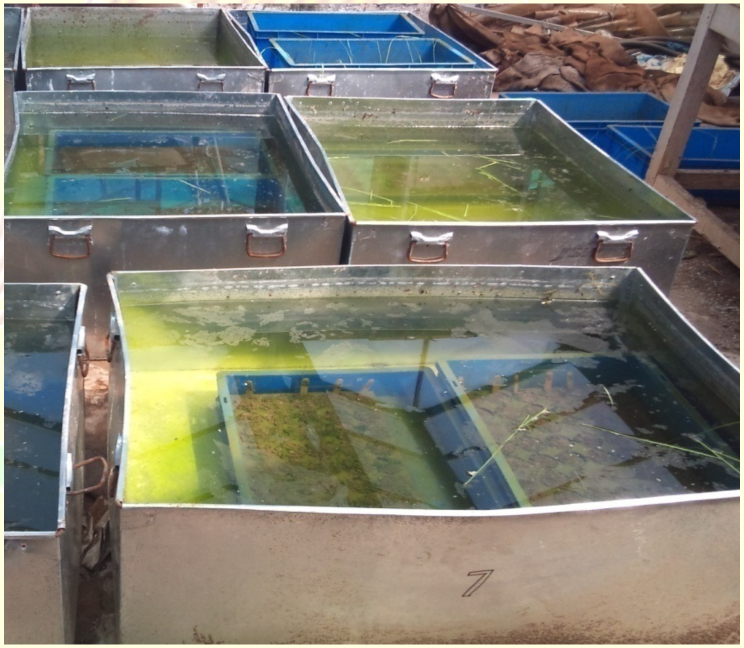
Breeding cultivars with tolerance of flooding during germination and early seedling establishment will help avoid these problems.

Tolerance of submergence during seedling and later vegetative growth is controlled largely by the Sub1 QTL on chromosome 9. Most varieties with the tolerance to SUB1A allele are not tolerant of flooding during germination, so these traits are independent.

Screening methodology for rice genotypes was standardized the rice seeds were sown in germination seeds covered with soil

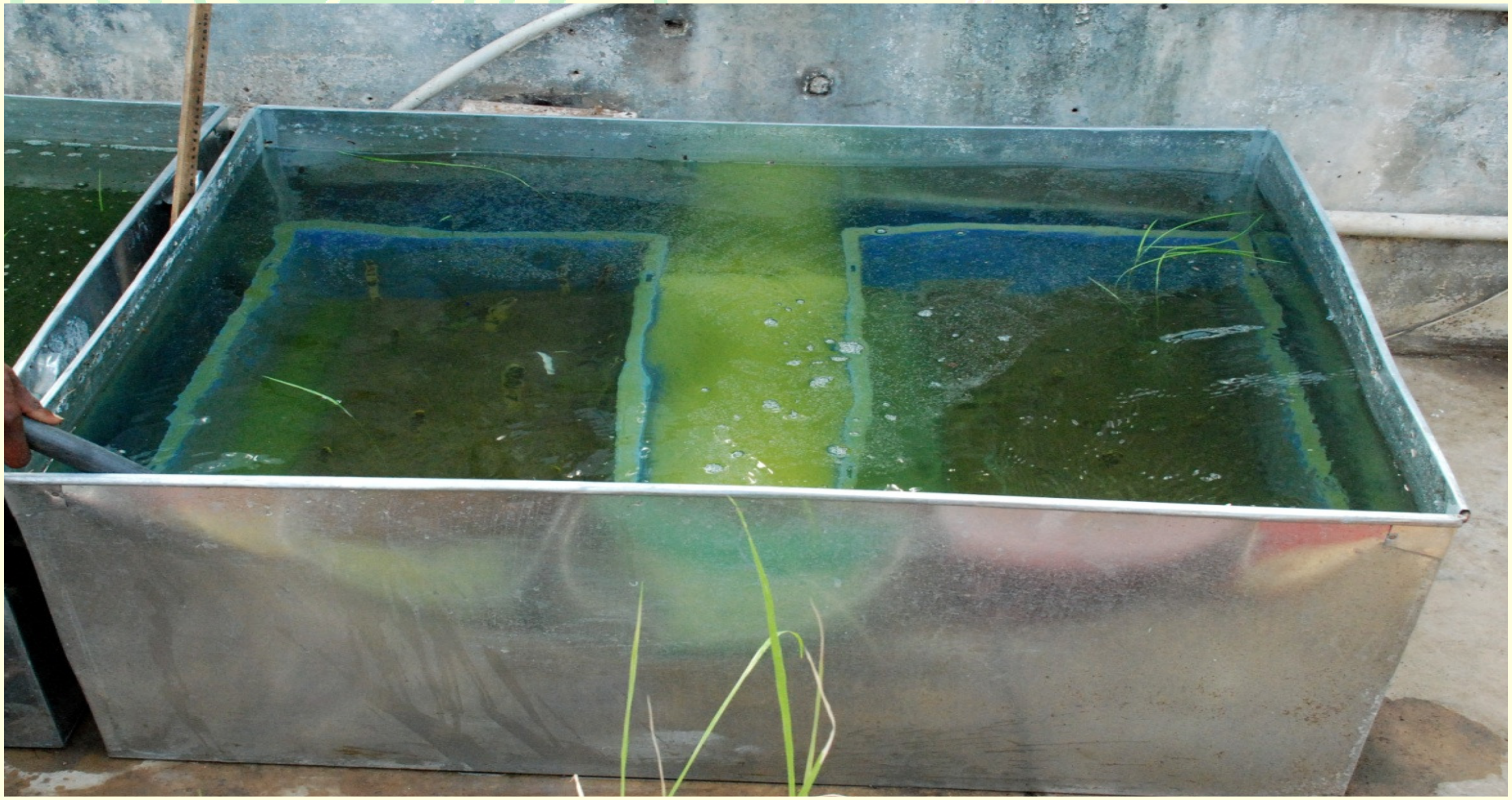
The trays containing the germination sheets were immersed in larger zinc trays 40cm x 30 cm x 16cm.

Anaerobic conditions were maintained for 15 days without disturbing the trays and scored after 15 days for germination.



Before the conduct of the experiment all these genotypes were tested for viability under normal condition and the genotypes showing 100 percent germination were further testing under anaerobic condition.

About 2500 germplasm accessions of rice were screened for anaerobic germination.



Majority of the genotypes screened did not germinate under water rather completely decomposed; only very few germinated and survived for more than 15 days of water inundation.

The lines E 1763, E 738 (IC 352760), E 773(IC 350189), E 1049 (IC466351), E 1701(IC 577070) and E 1158 (IC 576974) recorded more than 90% germination under anaerobic condition and survived under 40cm depth of water for more than 15 days.

Identification of appropriate donors with target traits

Sabita was identified to possess weed suppressive ability with early seedling vigor

RP5219-9-6-7-3-2-1-1 and RP 5214- 38-14-9-5-2-1-B with desirable plant type and higher yield

IURON 26 with stay green character

S-166 with thick and dark green leaves , higher number of grains per panicle and sturdy stem

Aathira, Swarna Prabha, Kalinga III, IET 22051 (RP 5125- 2-4) and B 644F-MR-6-0-0(AYT 2) for their desirable plant type, higher yield and over all phenotypic acceptability

RP 5129-17-8-3-2, RP 5214- 57-26-9-6-3-2-B for root characteristics.

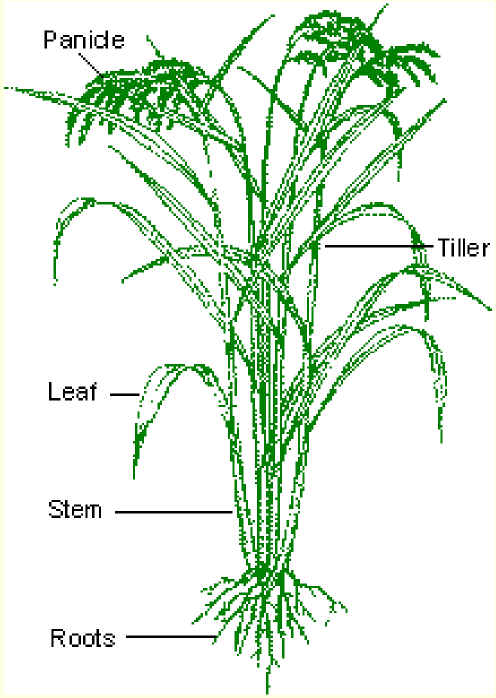
Entries nominated for AICRIP

Genotypes identified through germplasm screening under conservation agriculture were nominated under AICRIP for evaluation across locations under aerobic conditions. Among the two entries nominated one entry was promoted to final year of testing and identified for Varietal Identification committee during 49th ARGM 2014.

Mechanization in rice requires……

Development of suitable Variety compatible for direct seeding

Equipments for direct seeding for small quantity of seed.



WE Need to Follow CA Practices for sustainable rice production


THANK YOU