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Developing Bioenergy Crops to Optimize Marginal Land Productivity Through Mutation Breeding And Related Techniques

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Project Background

- Energy crises in the region, including in Indonesia
- Available renewable resources of bioenergy
- Great plant diversity can be used for bioenergy
- Available large amount of marginal land
- Regional collaboration in developing technology
- The role of nuclear technology
- Available research facilities and manpower
- Support of national program on bioenergy

Marginal Land in Indonesia

- Limitation for Indonesian agriculture development
  - Drought → in the eastern part
  - Soil acidity → in the western part
  - Salinity → along the coastal areas
- Worsening of climate change
- Need adaptable crops for such conditions
- The crop should have good economic values
- The choice fell on sorghum
- Potential crop for hot and dry climate of Indonesia

Why Sorghum ?

- Wide adaptability, drought tolerant
- Suitable for hot dryland agriculture
- Low input crop (less agricultural input)
- Potential for most parts of Indonesia
- Its use as Food, Feed, Fuel, Fiber (4Fs crop)
- Available sorghum germplasm collection
- Integrated national research program
- Released sorghum mutant varieties
- Promising mutant lines of sorghum
- Supported by IAEA/RCA RAS5070 Project

Sorghum Use

Grain contains carbohydrate for food or bioethanol (bioenergy)

Stem juice contains sugar for liquid sugar (syrup) or bioethanol (bioenergy)

Stem and leaves (biomass) for animal feed, fiber products, or cellulose-based bioethanol (bioenergy)

Sorghum Development

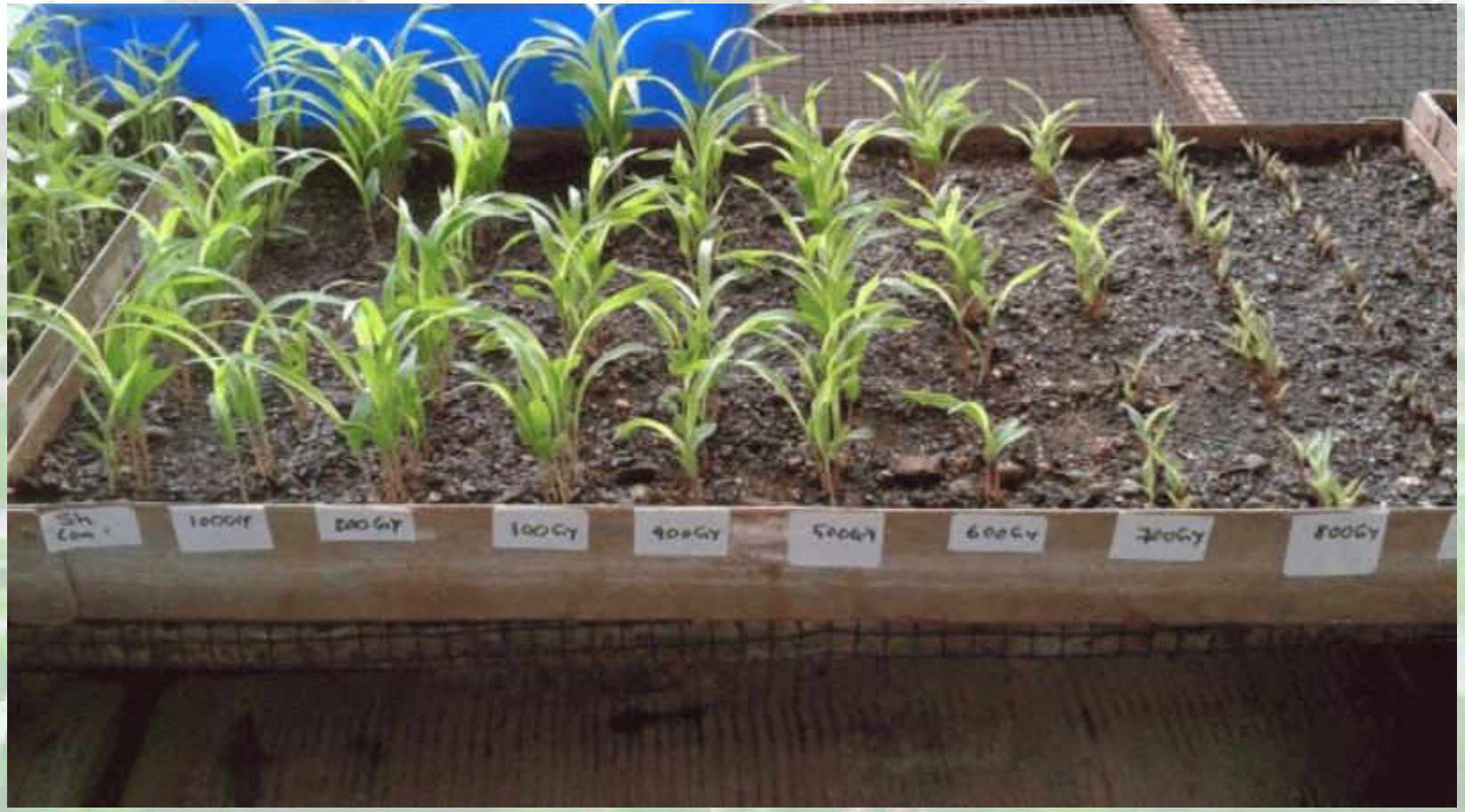
- Directed for dryland agriculture areas
- Available dryland of 25.3 million ha
- Intercropping in plantation (oilpalm, rubber)
- Superior sorghum varieties are needed
- Available germplasm: local and introduction
- Development through mutation breeding
  - 3 mutant varieties have been released
  - Many promising mutant lines under investigation

Sorghum Breeding Objectives

- To improve abiotic stress tolerance:
  - drought (for drought prone areas)
  - acidity (for areas with acid soil problem)
- To improve agronomic characters:
  - Plant stature
  - Earliness, grain and biomass yields
- To improve quality:
  - For bioenergy: sugar (brix) content

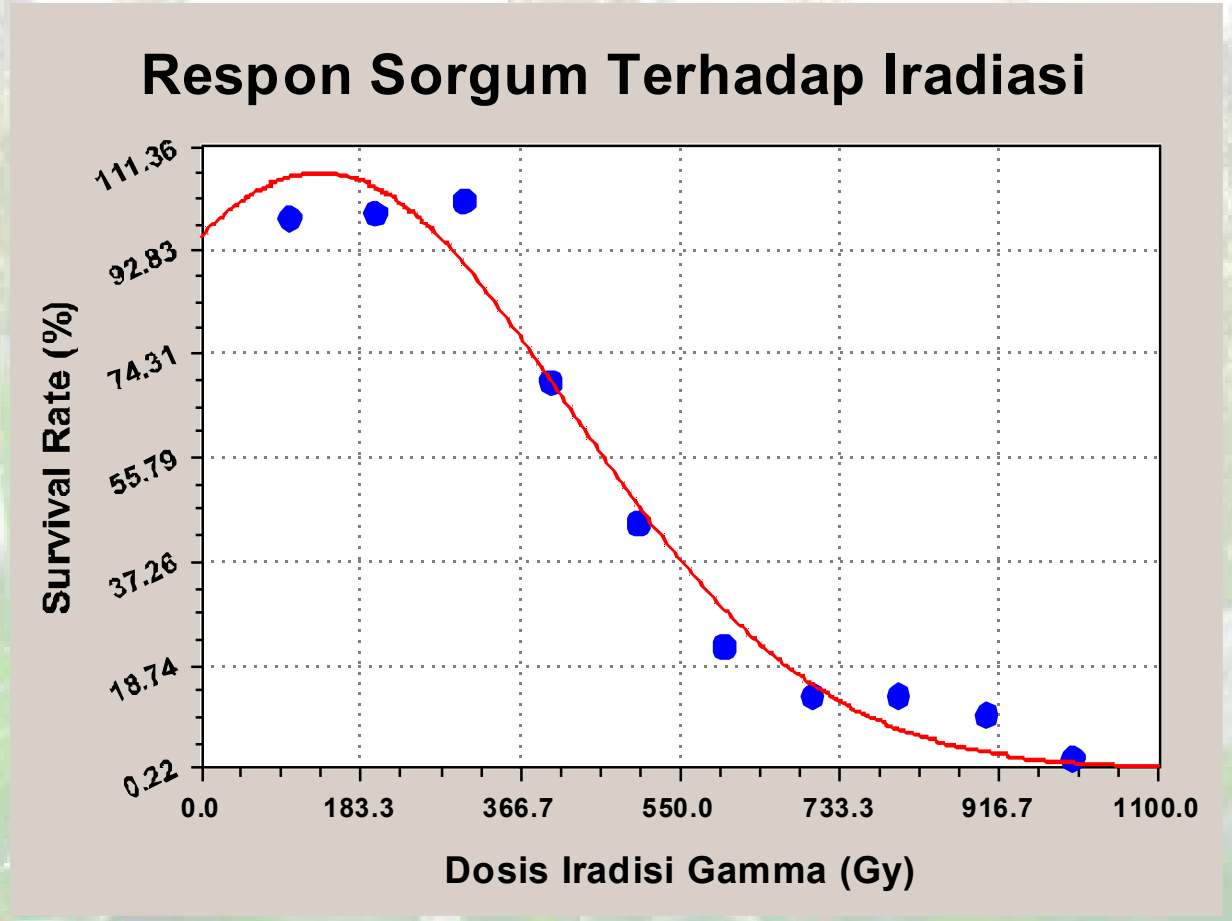
Data Measurement (Methodology)

- Study of radiosensitivity for sorghum
  - Conducted in the greenhouse
  - Optimal irradiation for sorghum 250-400 Gy
- Mutant selection started in the M2 population
- Agronomy: plant growth, grain and biomass yield
- Quality data: sugar (brix) content
- Mutant screening for tolerance to abiotic stress:
  - Drought (PEG Method)
  - Acidity ($AlCl_3$ Method)

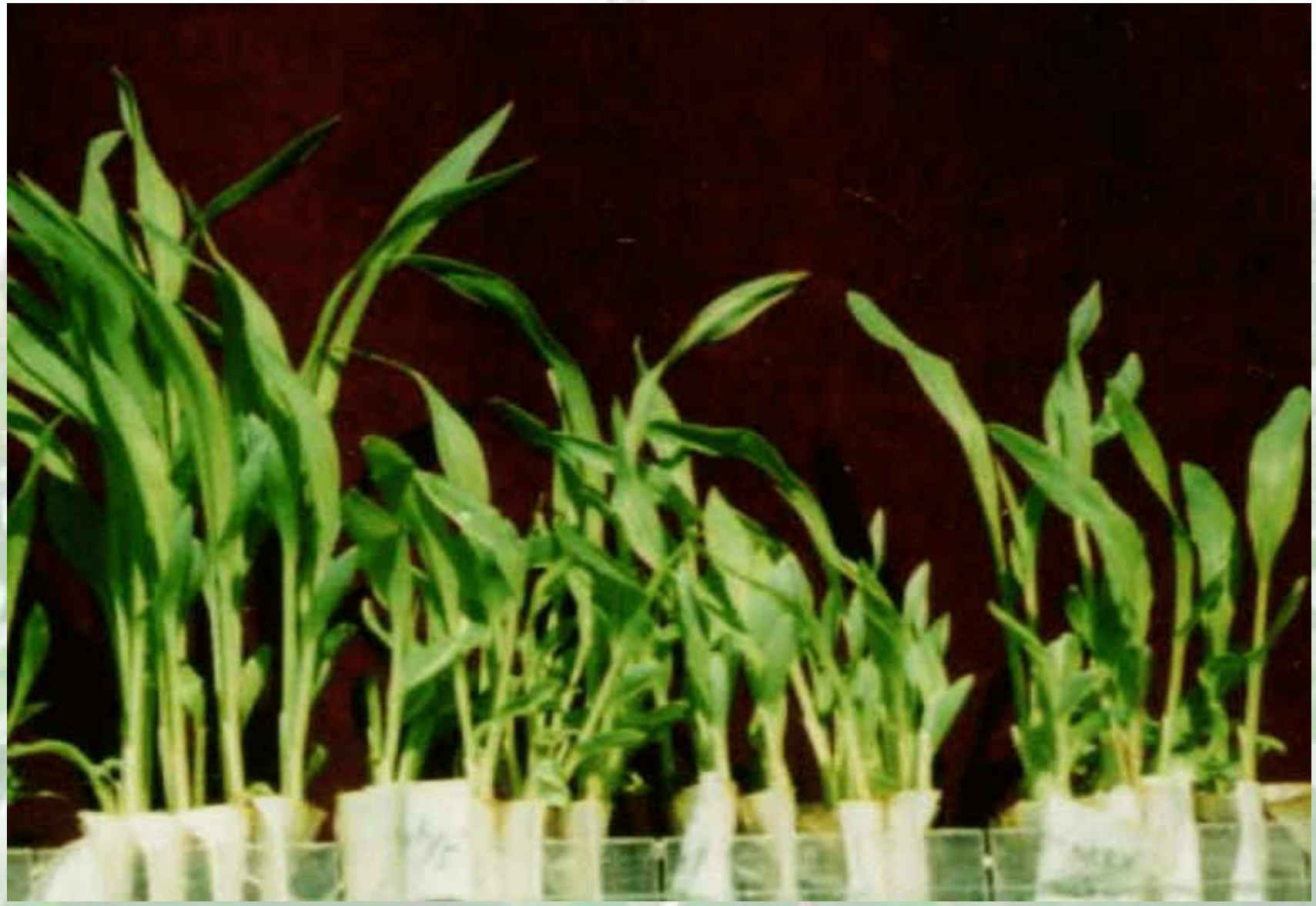


Radiosensitivity of Sorghum to Gamma Irradiation

Estimation of Optimal Irradiation Doses

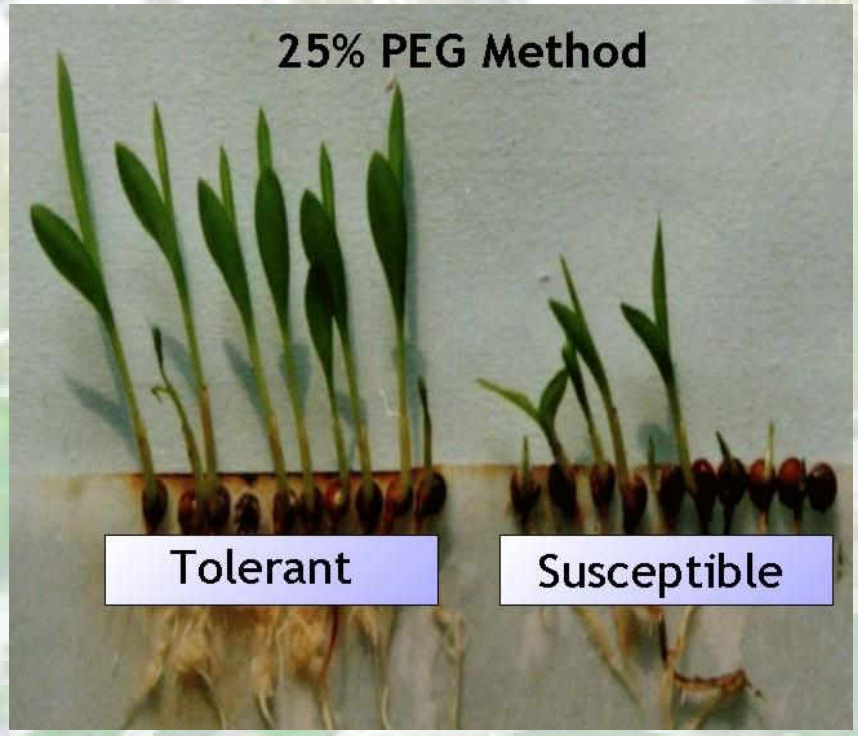


Gaussian Model: y = f(x) = a*exp((-(b-x)^2)/(2*c^2))
Coefficient Data: a = 106.46282; b = 134.77204; c = 286.19445
LD-20 = 251.13 Gy and LD-50 = 406.63 Gy
Optimal Dose = 250 – 400 Gy



Plant variability in the M2 generation

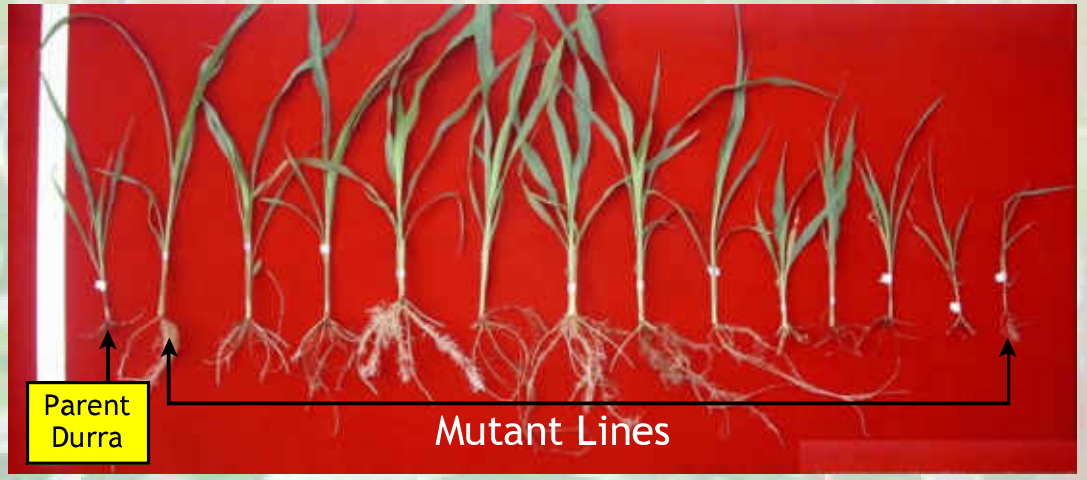
Screening for Drought Tolerance



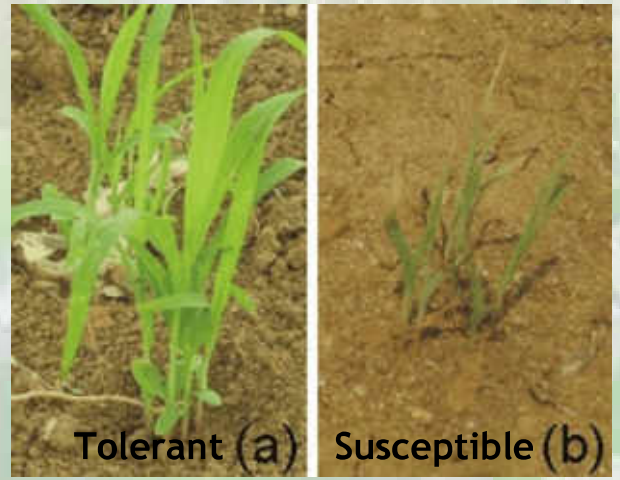
Screening in the laboratory

Direct screening in the field

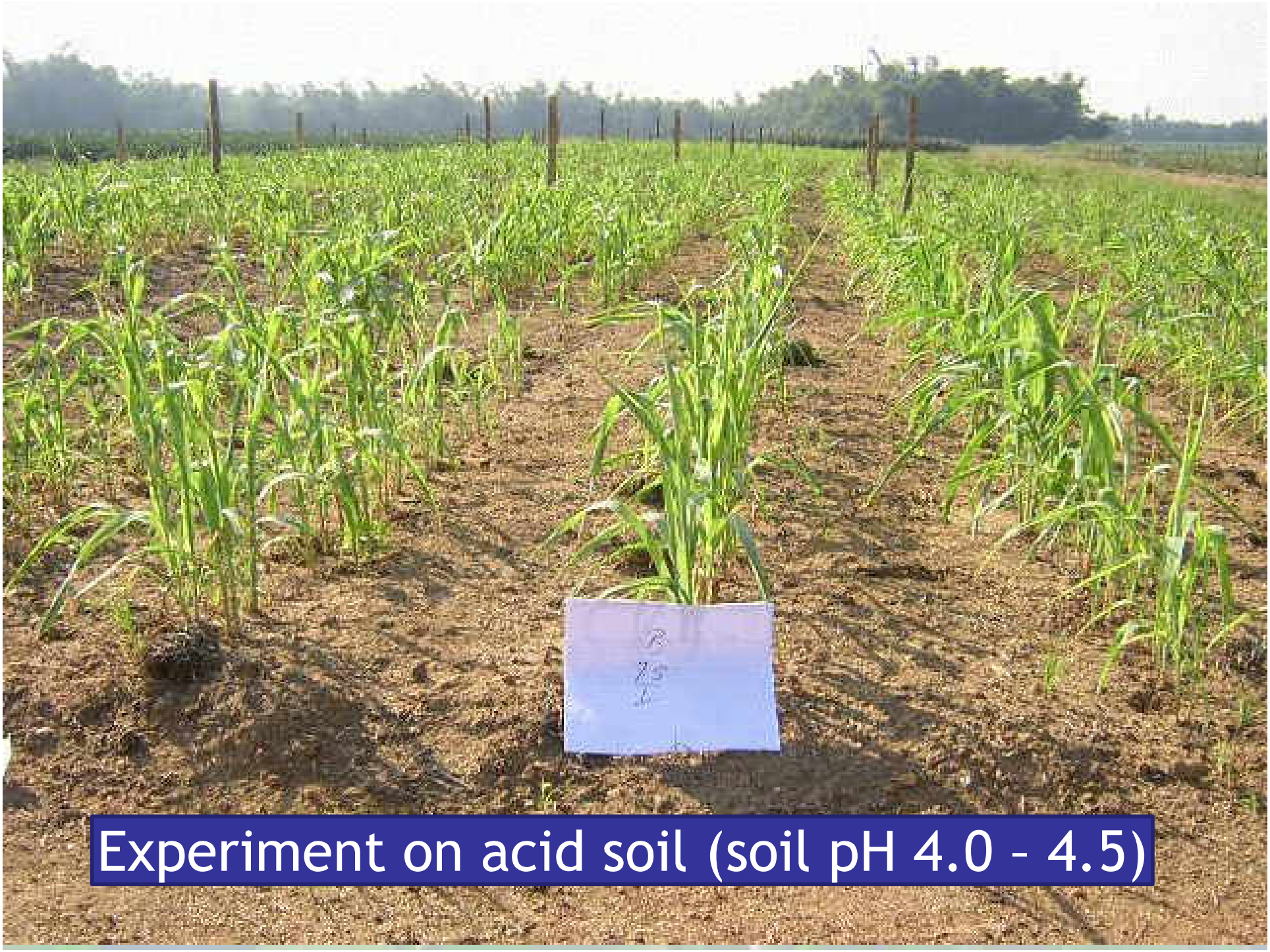
Screening for Acidity Tolerance



Screening in laboratory ($AlCl_3$ Method)



Direct screening in the field


Experiment on acid soil (soil pH 4.0 – 4.5)

Soil Data of the Experimental Site

No.	Parameter Pengujian	Metoda	Satuan	Nomor dan Kode Contoh		
				2042	2043	2044
				B 1	B 2	B 3
1	*pH					
	H_2O	SNI 03-6787-2002		4.1	4.5	4.0
	$CaCl_2$			3.9	3.1	3.5
2	*C Org	SNI 13-4720-1998 (Walkey & Black)	%	1.04	2.10	2.01
3	*N Total	SNI 13-4721-1998 (Kjeldahl)	%	0.14	0.25	0.21
4	Rasio C/N			7.4	8.4	9.6
5	*P Tersedia	SL-MU-TT-05 (Bray I/II)	ppm	1.59	2.42	3.44
	Kation-kation dapat ditukar					
6	*Ca	SL-MU-TT-07 a-e (Ekstrak Penyangga NH_4OAc 1,0 N pH 7,0)	cmol/kg	3.82	2.23	5.86
7	*Mg		cmol/kg	0.90	0.52	1.20
8	*K		cmol/kg	0.17	0.14	0.14
9	*Na		cmol/kg	0.30	0.25	0.26
10	Total		cmol/kg	5.19	3.14	7.46
11	KTK		cmol/kg	25.85	22.82	22.07
12	KB		cmol/kg	20.1	13.8	33.8
	Al – H dd					
13	Al^{3-}	SL-MU-TT-09 (KCl 1N)	me/100g	16.32	13.98	3.17
14	H^{+}		me/100g	1.25	2.89	1.24
	Tekstur 3 Fraksi					
15	Pasir	SL-MU-TT-10 (Hidrometer)	%	10.8	8.4	11.6
16	Debu		%	15.0	20.8	17.0
17	Liat		%	74.2	70.8	71.4

Available Infrastructure & Facilities

- Gamma Irradiators
- Plant Breeding Laboratory
- Tissue Culture & Biotechnology facilities
- Mutant Seed Germplasm Storage Room
- Greehouse & Mutant Nursery Facilities
- Experimental Fields, Tractors & Processing Unit
- Office Building & Meeting Room

Available Gamma Irradiators

GC-4000A

GC-220

Panoramic Batch

Iradiator Lateks

Plant Breeding Laboratory

Tissue Culturing Facility

Biotechnology Laboratory

Mutant Seed Storage Facility

Greenhouse Facility

Protected Sorghum Mutant Nursery

Experimental Field


RAS5070 PROJECT IMPLEMENTATION
Preparing experimental plot 4x5 m²


Planting in row by dibbling method


Sowing sorghum seeds


Seedling growth stage


Demplot I
I.1
Vegetative growth stage


1.2
Vegetative growth stage


I.3
Vegetative growth stage


Demplot II
Vegetative growth stage


II.1
Vegetative growth stage


Demplot III
Vegetative growth stage

Recording plant data in the field

Future Plan for Sorghum

- Mutant screening for abiotic stresses
  - drought and soil acidity
- Multiplying seeds of the selected mutants
- Homogeneity test of the mutant lines
- Preliminary yield trials
- Conducting multi location trials
- Preparing proposal for varietal release
- Holding sorghum field day on marginal land
- Conducting workshop, seminar, FGD etc.

OTHER RAS5070 ACTIVITIES

RAS5070 RTC, 23-27 May 2016

Lecture for RAS5070 RTC

Laboratory Work for RAS5070 RTC

Greenhouse Work for RAS5070 RTC

Field Work for RAS5070 RTC

Technical Visit for RAS5070 RTC

Thank You