Hydrological Consequences of *Jatropha* Production on Wastelands in Developing Countries

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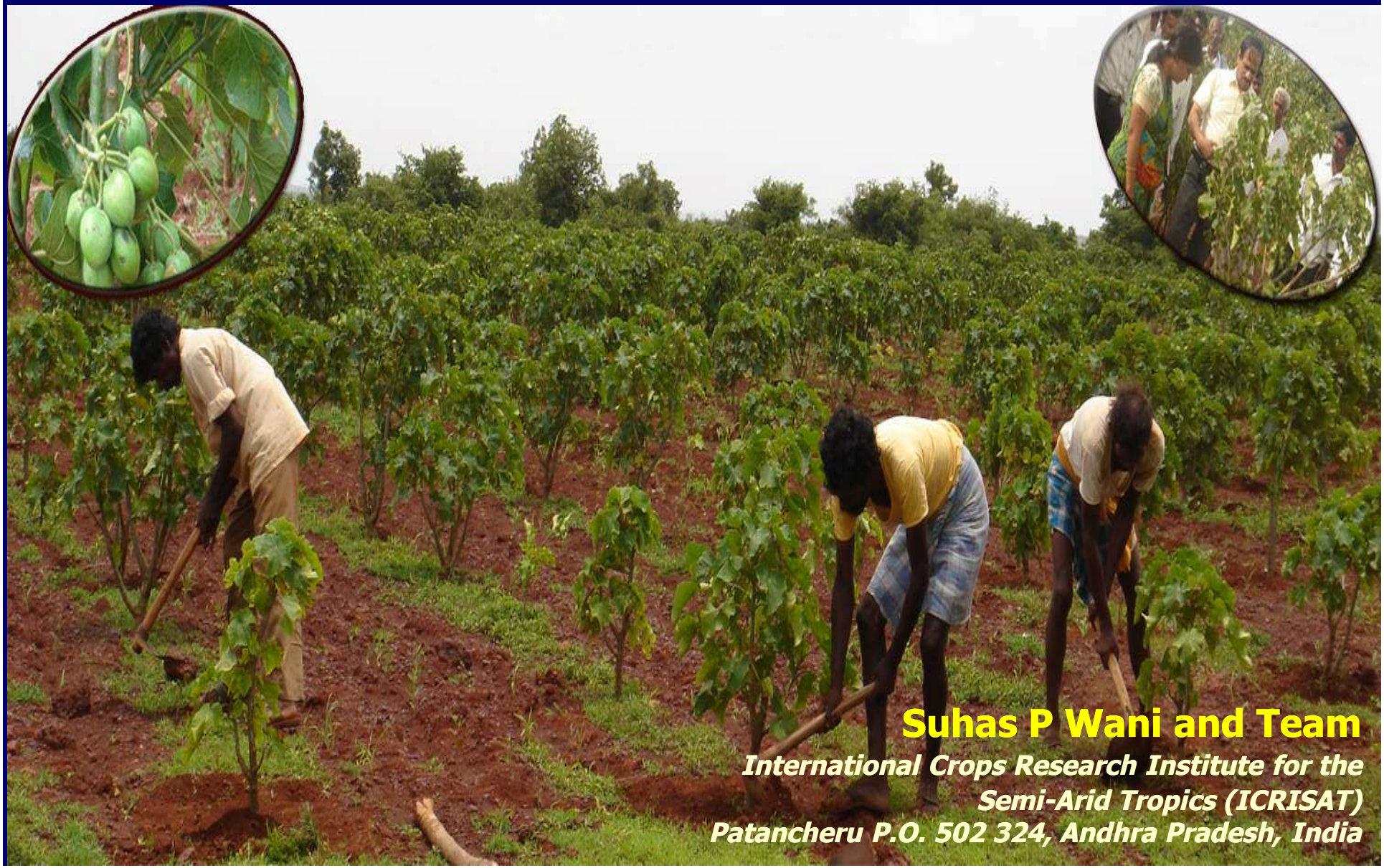

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Multiple and Interlocking Issues

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- Food security
- Fodder security
- Water security
- Energy security
- Human health

All are interlinked and we need to have holistic and long-term vision

Germplasm Variation and Selection

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Jatropha Accessions Variability and Harnessing Genetic Potential

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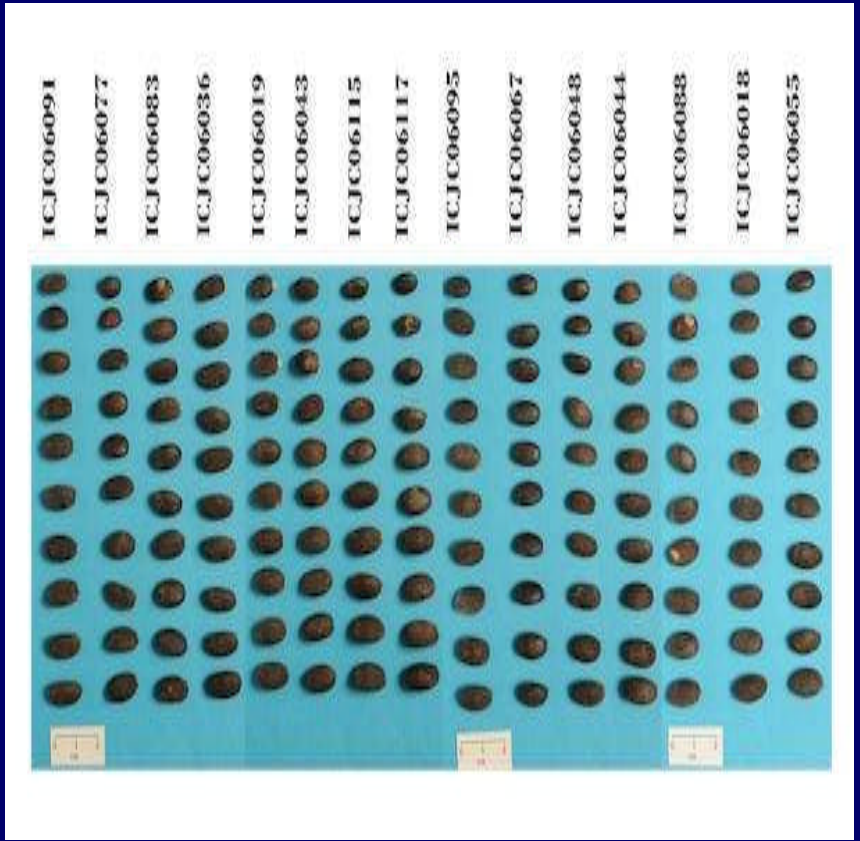
- 124 accessions evaluated in field and identified accessions with desired traits
- Variability in 48 accessions observed using molecular markers

- **Highest volume index. – ICJC 06087**
- **Lowest Female/male ratio – ICJC 06012**
- **Highest 100 seed weight – ICJC 06115**
- **Highest oil content – ICJC 06019**
- **Highest yielding accessions – ICJC 06004**



Principal component analysis (PCA) of Jatropha accessions based on 680 polymorphic AFLP fragments

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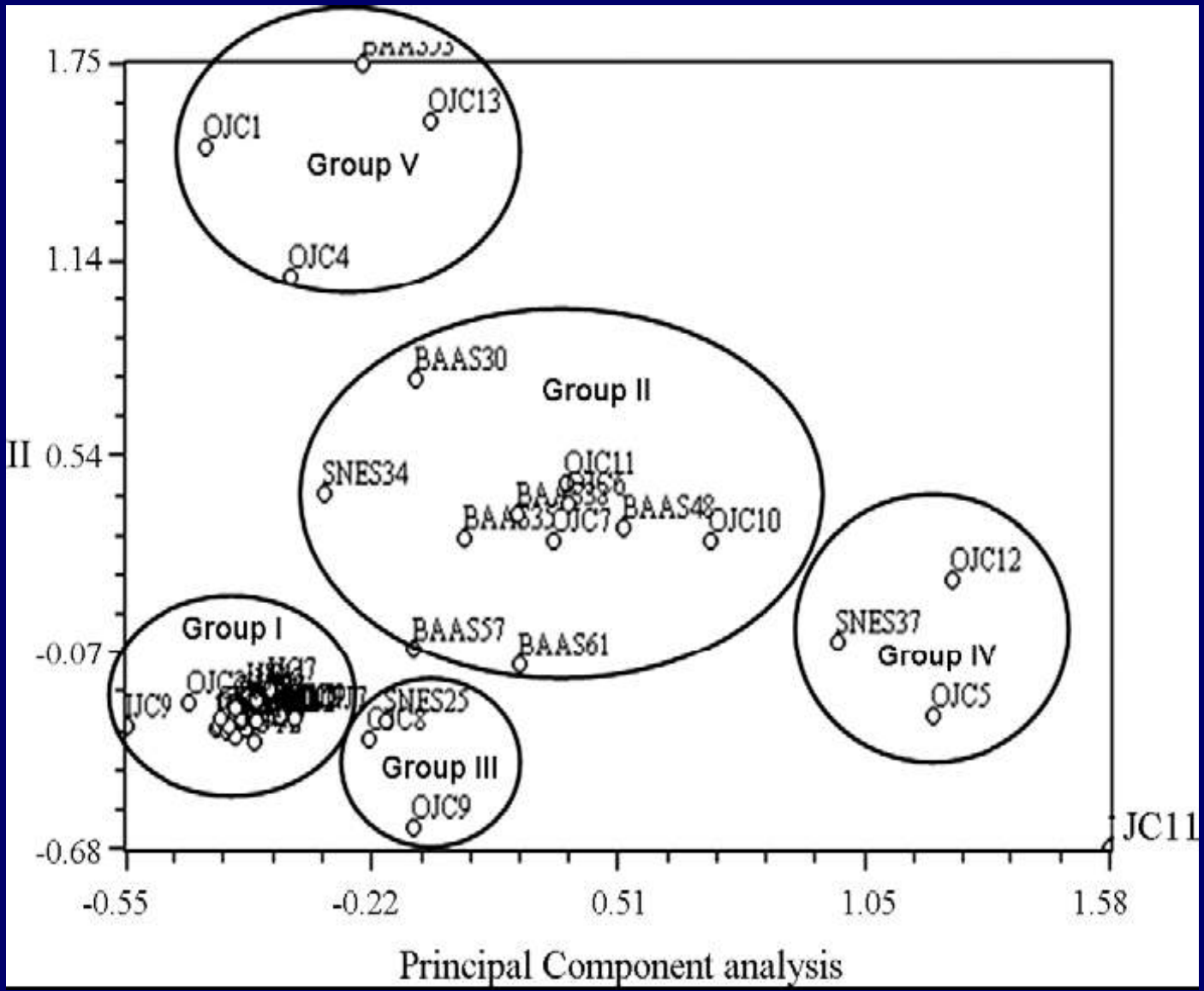
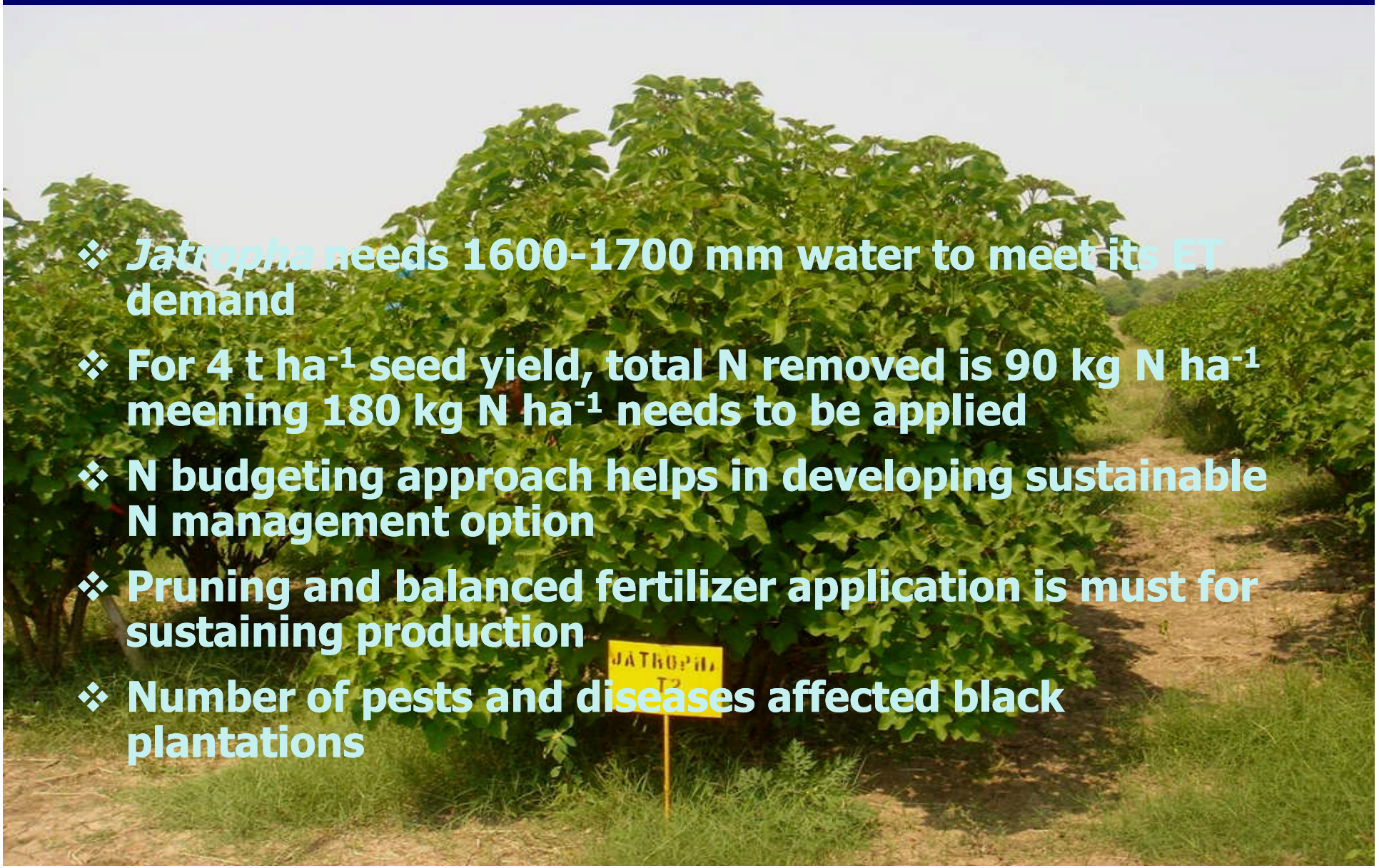


Agronomy to Increase *Jatropha* Productivity



- *Jatropha* needs 1600-1700 mm water to meet its ET demand
- For 4 t ha^{-1} seed yield, total N removed is 90 kg N ha^{-1} meening 180 kg N ha^{-1} needs to be applied
- N budgeting approach helps in developing sustainable N management option
- Pruning and balanced fertilizer application is must for sustaining production
- Number of pests and diseases affected black plantations

Seed Yield in *Jatropha* Across Years

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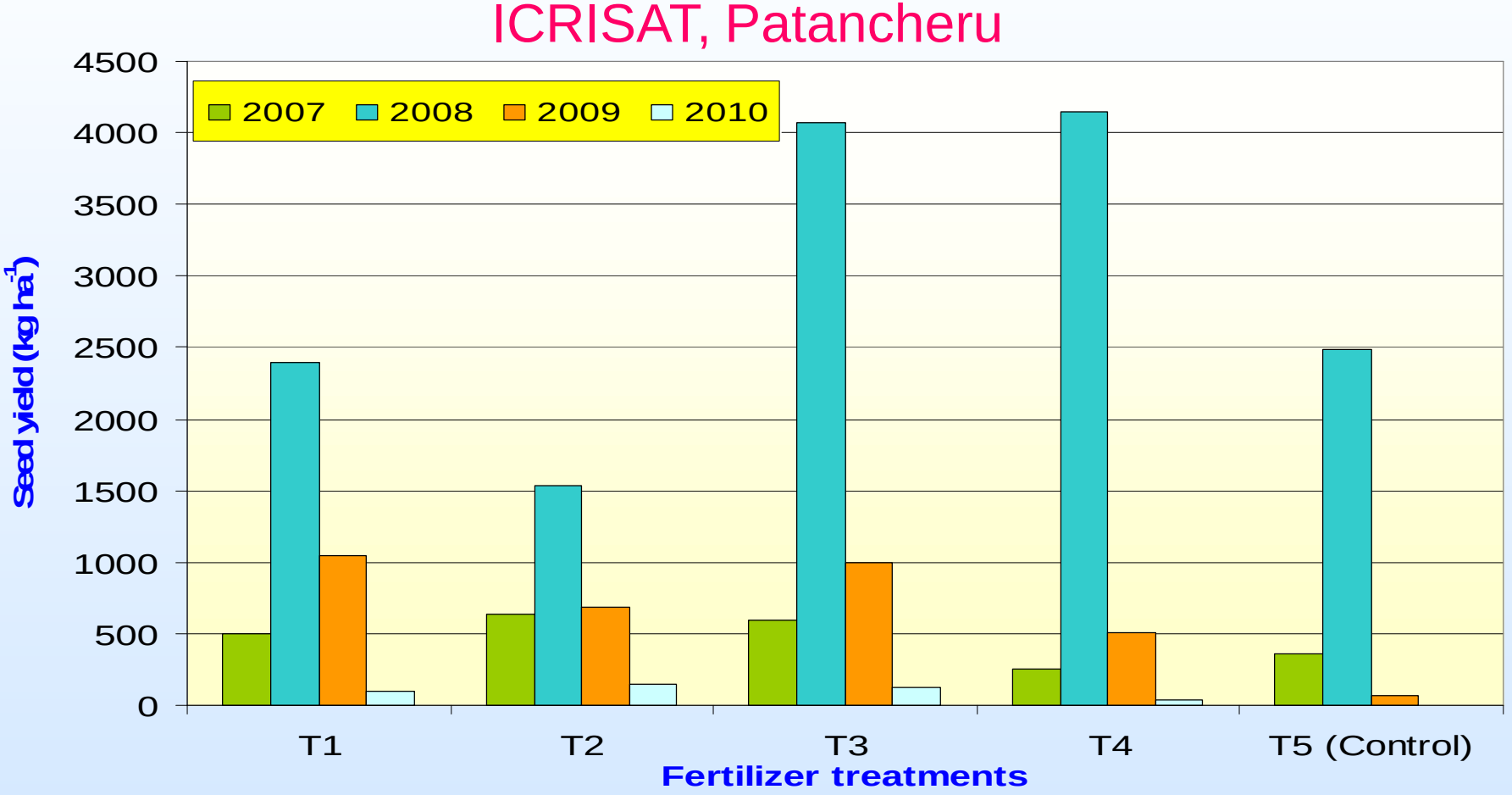

* In 2009, seed yields were affected due to delayed onset of monsoon by 93 days.

** In 2010, seed yields were affected due to heavy rainy season, excess/saturated soil moisture and unfavorable climatic conditions.

Jatropha Root Distribution

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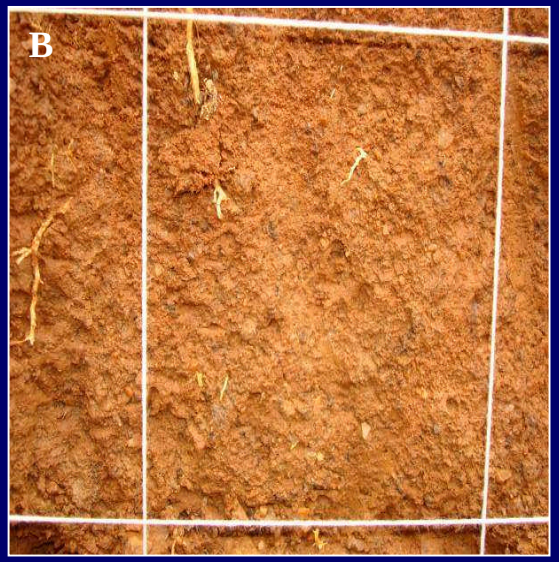

(A) Root measurements in Jatropha using a trench wall method. The exposed wall is marked into 10×10cm grids for root counts (B) the root intercepts within each grid

(A) The root distribution in Jatropha at the top 50cm soil horizon. The roots were initially exposed as a trench wall, 15 cm away from the tap root, and the plant base was exposed later by washing the soil away through a water hose. Notice the loss of tap root dominance, the profuse branching at the plow pan level and the lack of any further thicker roots approximately below 30 cm soil depth. (B) A small length of the primary root showing the further branching as well as large number of branch primordial, the root is split open to show the low density soft wood (C) Cluster roots: Some of the dug roots had shown cluster root morphology, an expression considered as an adaptation to poor nutrient, particularly P, status of the soil.

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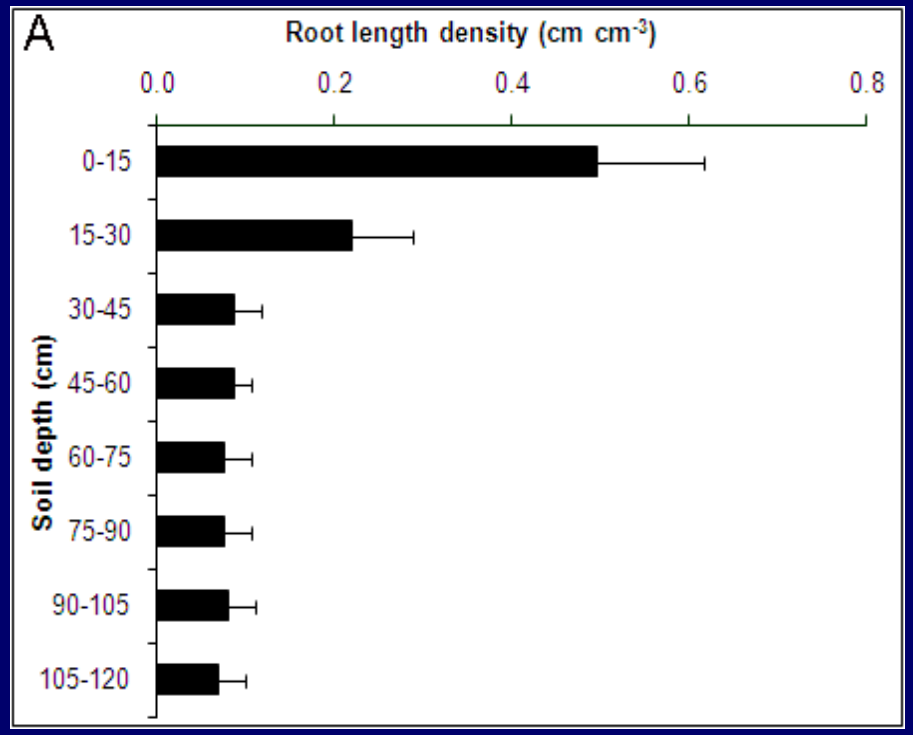
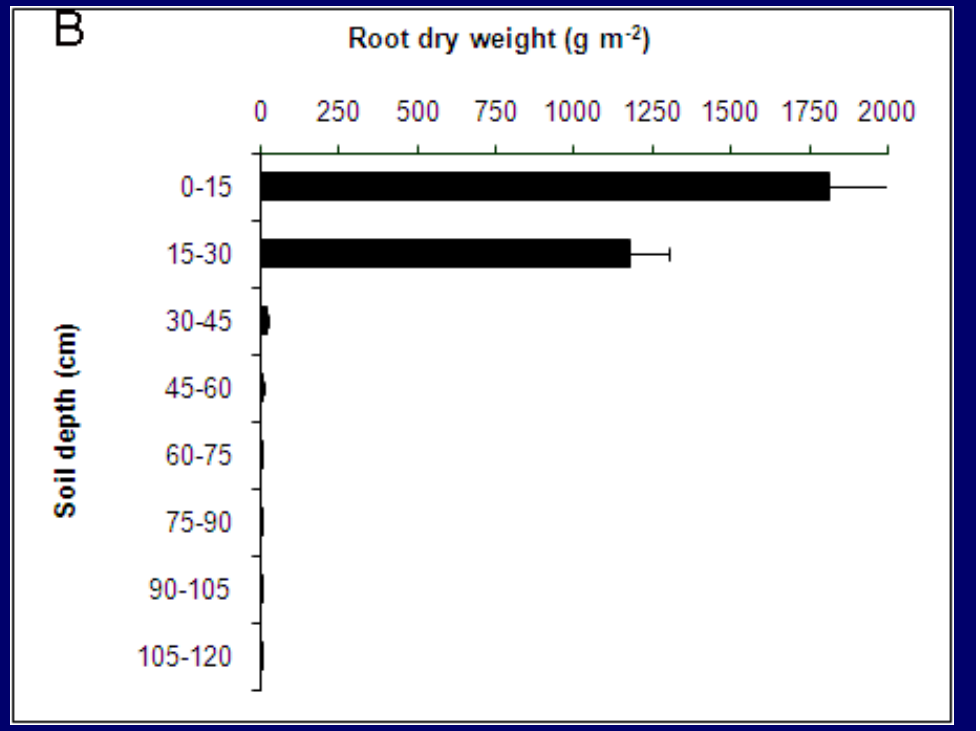
Jatropha Root Distribution in Alfisols





The root distribution in Jatropha as measured through a monolith method. Changes in (A) root length density across various soil depths and (B) in root dry weight across various soil depths in a 2.5 year-old plant. Such a large difference in distribution weight or length is primarily caused by the small section of tap root at the 0-30 cm soil horizon.

Jatropha Root Distribution as Measured thru a Trench Method

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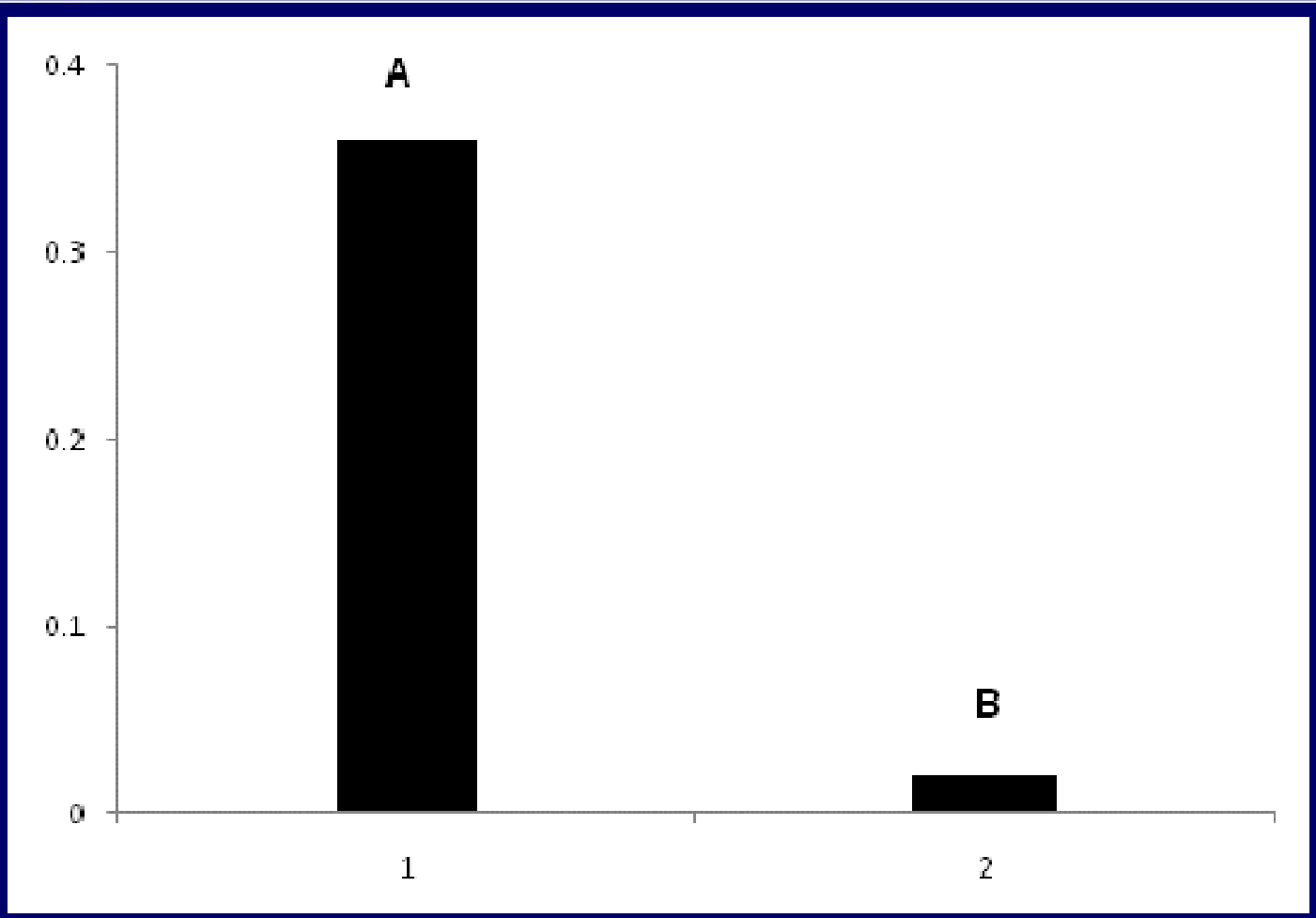
Soil depth (cm)	LC7	LC6	LC5	LC4	LC3	LC2	LC1	C	RC1	RC2	RC3	RC4	RC5	RC6	RC7	Total
0-10	20	18	33	16	18	20	7	16	20	18	18	18	14	23	11	270
10-20	11	8	18	11	14	16	12	8	21	17	18	16	16	5	11	202
20-30	7	6	3	8	3	8	13	10	15	21	9	9	3	7	1	123
30-40	8	4	3	3	5	6	5	7	6	10	3	13	5	8	8	94
40-50	7	2	3	4	7	3	8	1	3	12	5	4	4	3	5	71
50-60	1	3	5	8	7	6	9	4	6	6	1	6	1	4	8	75
60-70	4	3	5	1	5	6		1	2	3	3	2	3	3	6	47
70-80	2				7	3	6			1		2	1	6	3	31
80-90	1	1	2		2				1			2	1			10
90-100		1						3								4
100-110	1			1				3		1					1	7
110-120			2					5	4						2	13
120-130									1							1
130-140						1	1									2

The root distribution in Jatropha as measured through a trench wall method. Number of root intercepts that were totally measured in a 10 cm soil horizon and across 150-cm (70-cm on either side of the plants base). After exposing a trench wall close the plant base, the wall was washed with a fine spray of water and the protruding roots were trimmed before recording the observation. Only a single plant root growth was measured for this purpose. C in the X scale means centre grid, LCn means to the left of center and RCn to the right of center. The on each grid denotes the number of root intercepts within each 100 cm-2 grid and numbers on the right Y axis is the total number of intercepts in each 10cm soil horizon.

Biomass Ratio of *Jatropha*



The root to total plant biomass ratio of Jatropha (A) Comparison with all the roots considered. (B) comparison without considering the tap root stump at the 0-30 cm soil layer

Water Use of Jatropha

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Element	Year			
	2006	2007	2008	2009
Rainfall (mm)	875	712	1102	998
ET_o Jatropha (mm) reference crop evapotranspiration	1624	1631	1659	1760
ET_c Jatropha (mm) under non- water limiting conditions	1410	1432	1442	1538
ET_{actual} Jatropha (mm) under actual field conditions	798	614	751	930

Monthly rainfall and evapotranspiration requirements of *Jatropha curcas* at ICRISAT, Patancheru

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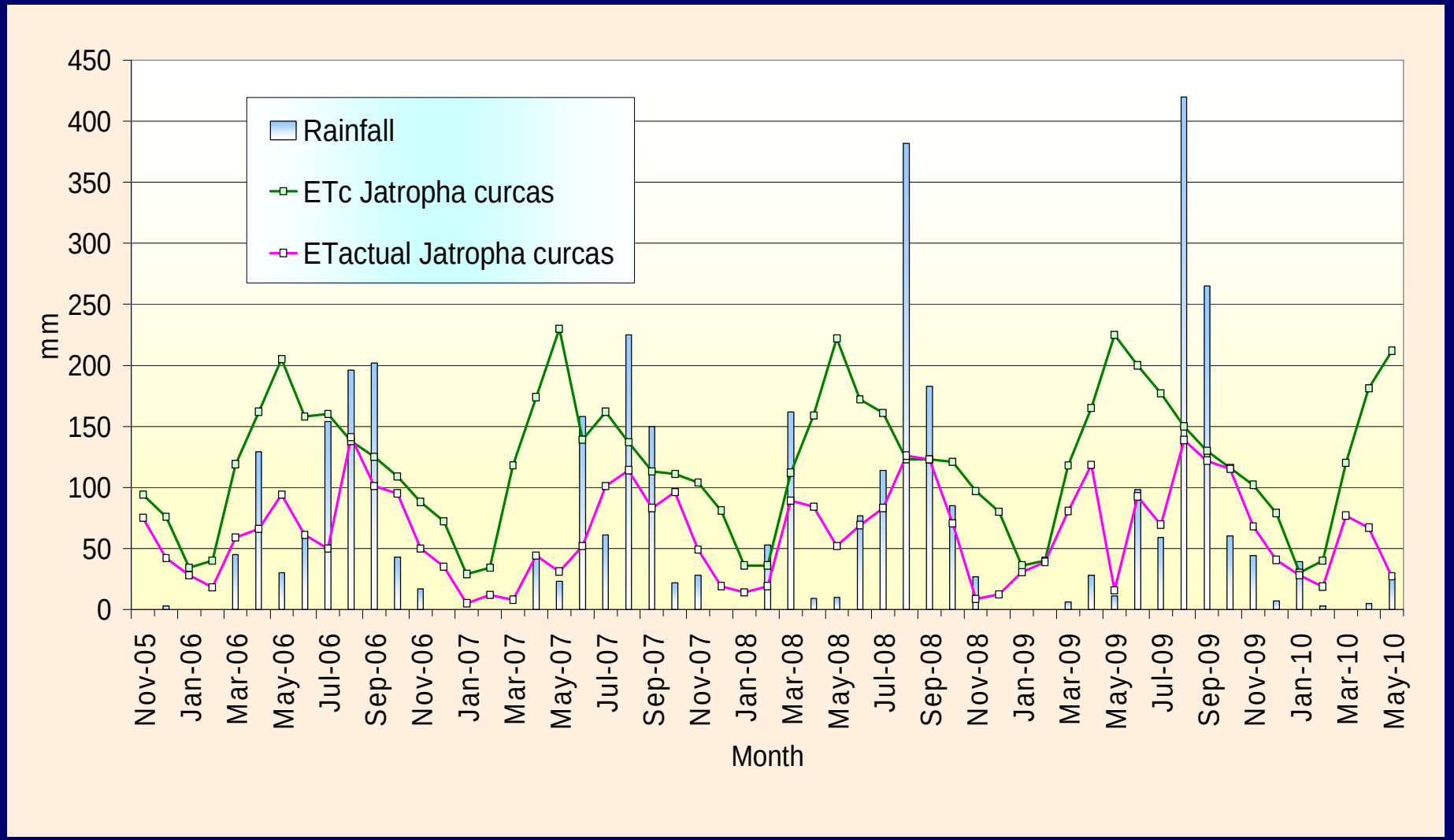
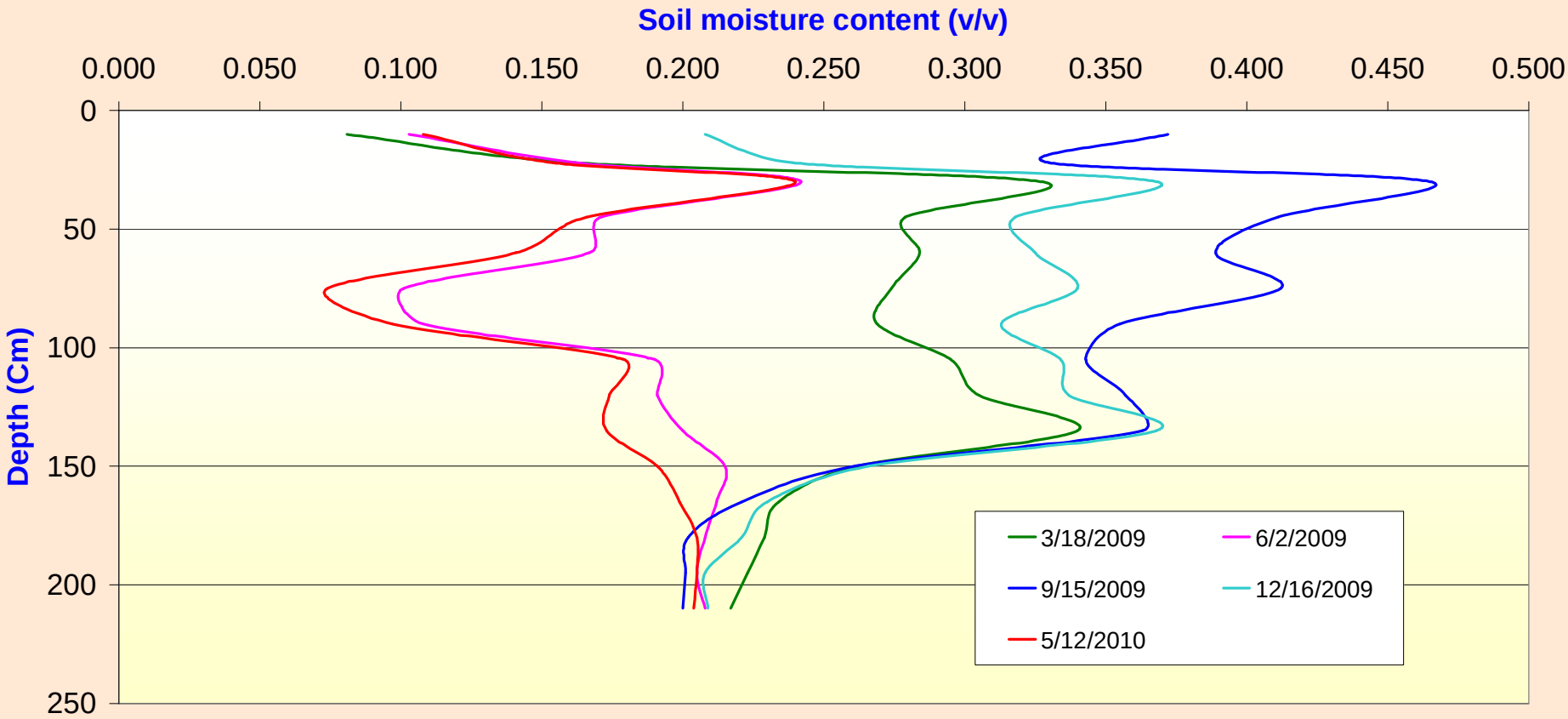


Soil Moisture Content (v/v)



Nutrient Budgeting for *Jatropha*

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Nutrient Demand

Nutrient	Seed yield (t ha^{-1})				
	1	2	3	4	5
N	22.2	44.4	66.6	88.8	111
P	4.8	9.6	14.4	19.2	24
K	8.1	16.2	24.3	32.4	40.5
S	1.4	2.8	4.2	5.6	7
B	0.015	0.03	0.045	0.06	0.075
Zn	1.7	3.4	5.1	6.8	8.5

Jatropha to Rehabilitate Degraded Lands

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- *Jatropha* is a good soil health builder
- Degraded lands can be rehabilitated with suitable soil & water conservation measures
- Landless people collectively could rehabilitate degraded lands and produce bioenergy

Soil evaporation and transpiration for two different land management (waste land and Jatropha cultivated land) scenarios

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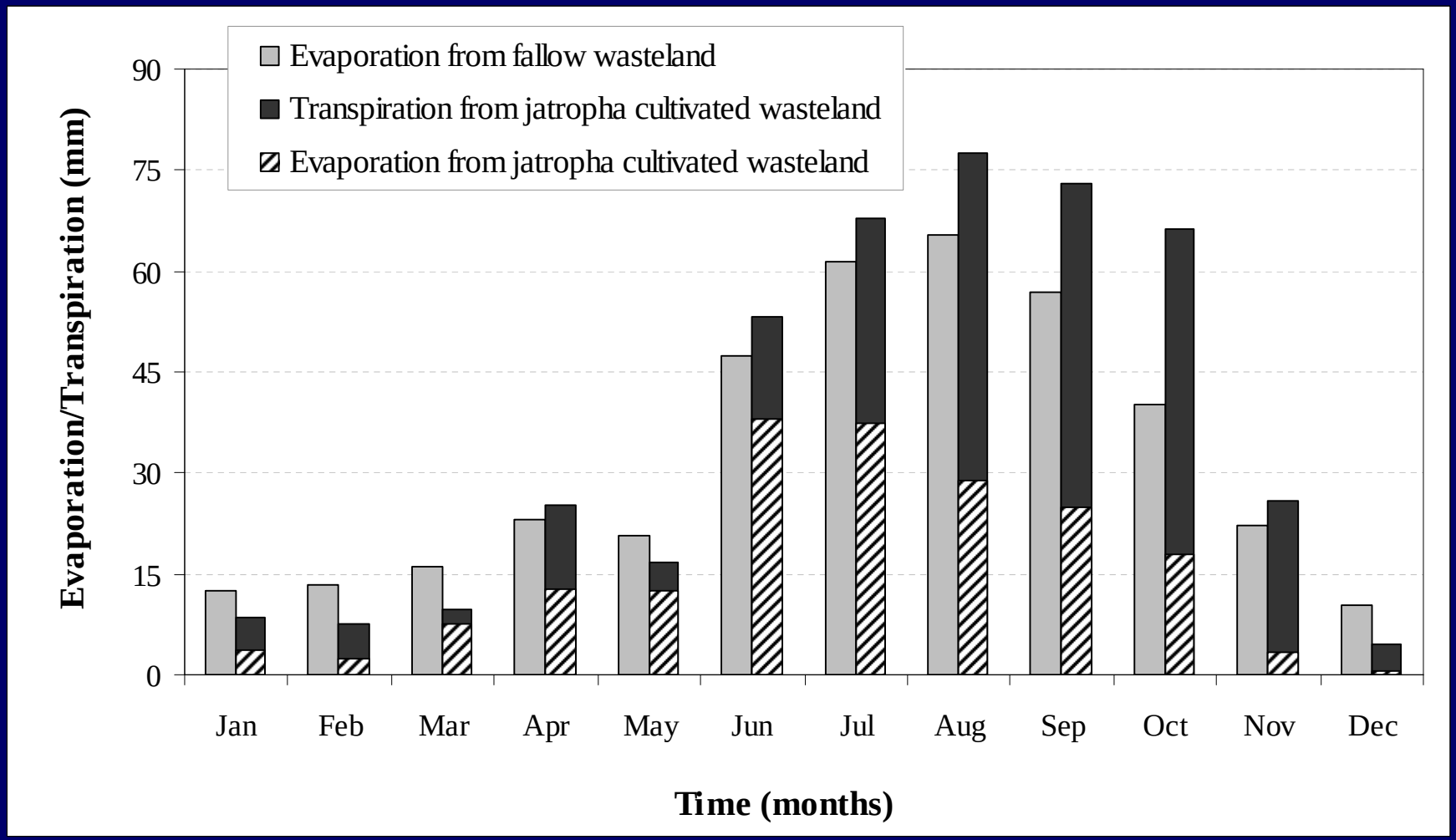

Annual Water Budget of *Jatropha* on Degraded Land at Velchal

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	Fallow land	Jatropha land with some mgt. practices
Rainfall (mm)	896	896
Outflow (mm)	393 (43%)	274 (31%)
E or ET (mm)	460 (52 %) (non-productive)	580 (64%) (productive use)
GW recharge mm)	43 (5%)	42 (5%)

Rainfall = Outflow amount + ET flow + GW recharge + Change in soil moisture content

Total runoff generation from the watershed , divided up into base flow and surface runoff, for three different land management scenarios during dry, normal and wet years (Data from 2001-2010)

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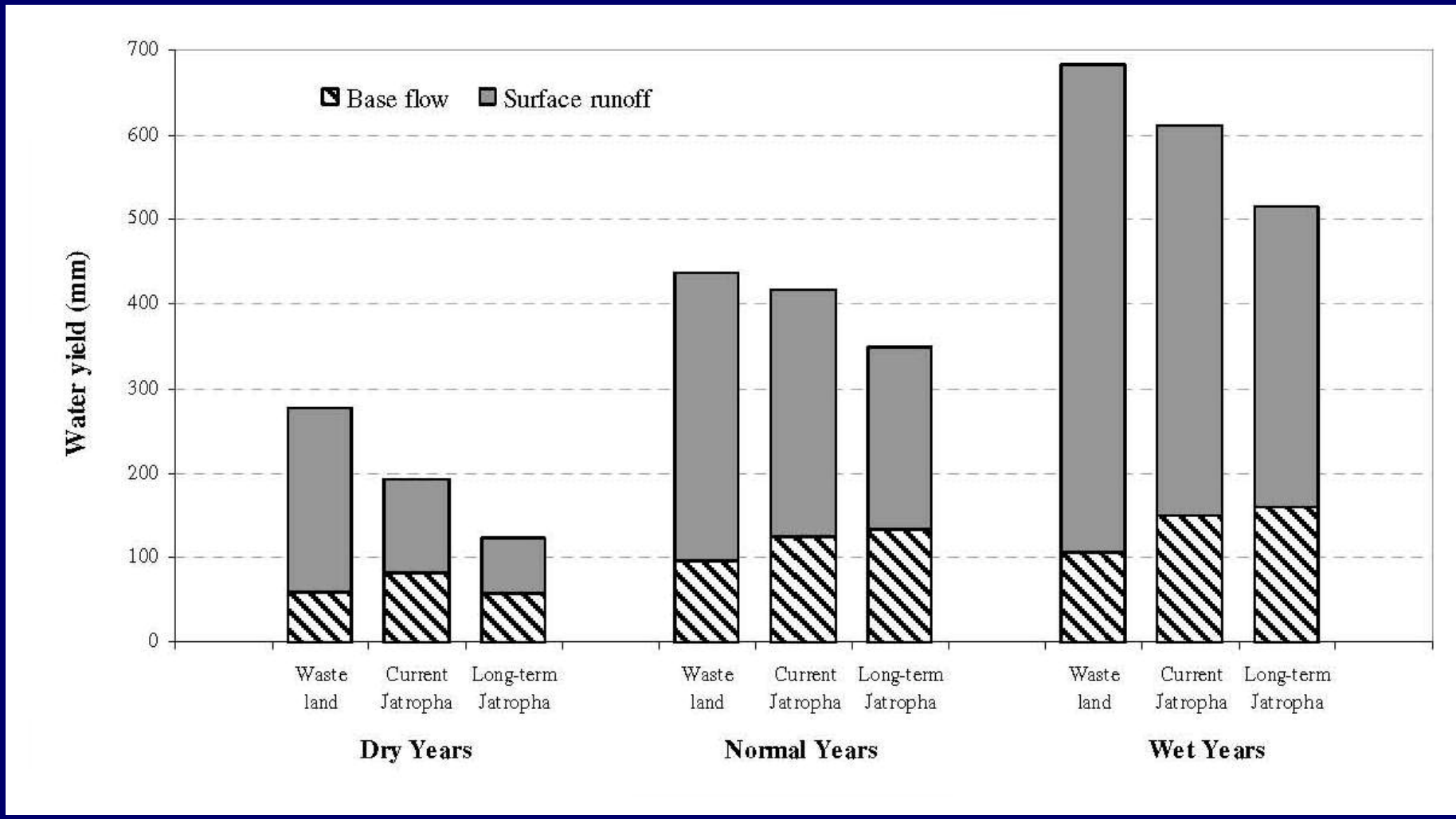

Water balance components of different land management scenarios during dry, normal and wet (data from 2001 to 2010)

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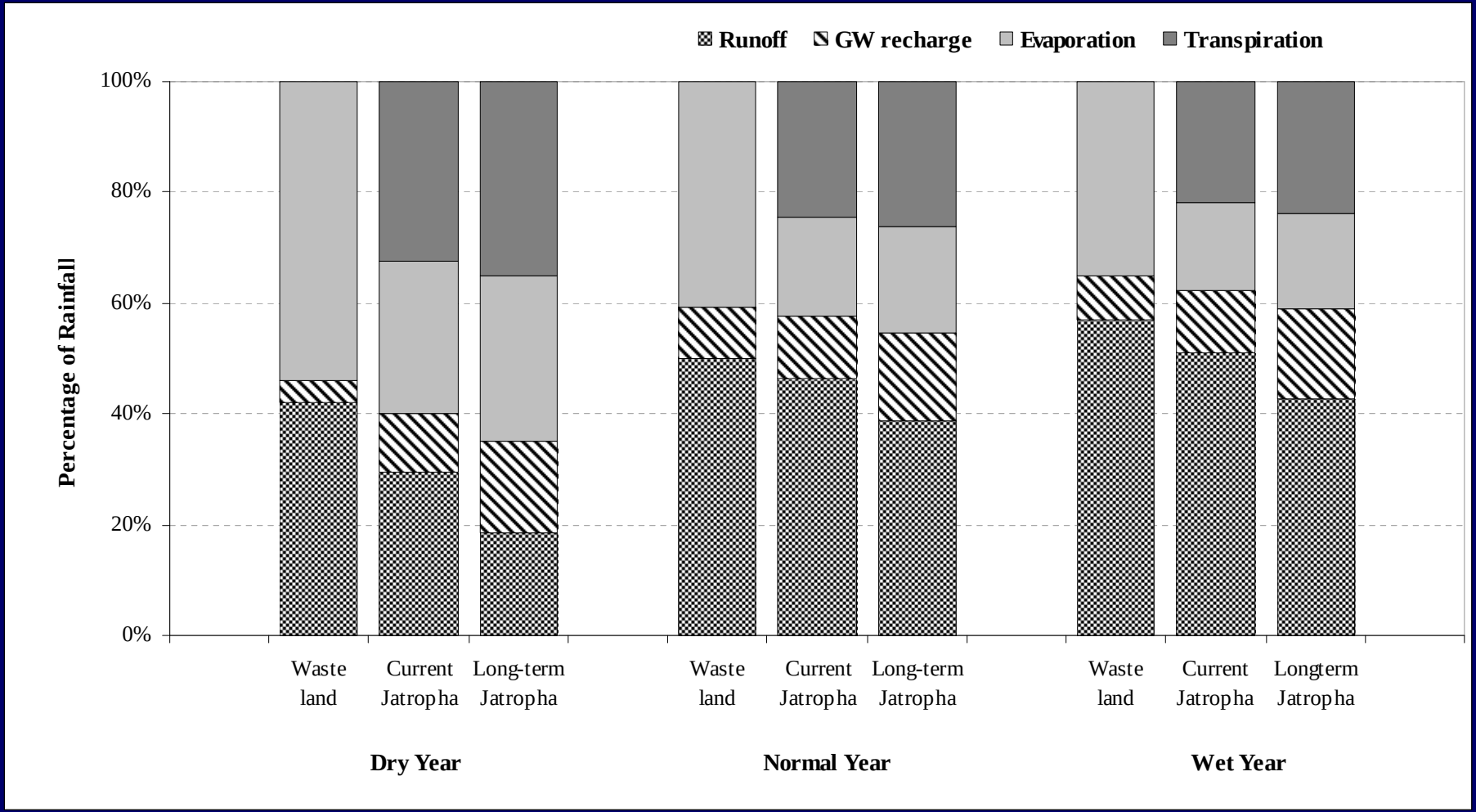

Total runoff generation from the watershed, divided up into base flow and surface runoff, for three different land management scenarios during dry, normal and wet years (data from 2001 to 2010)

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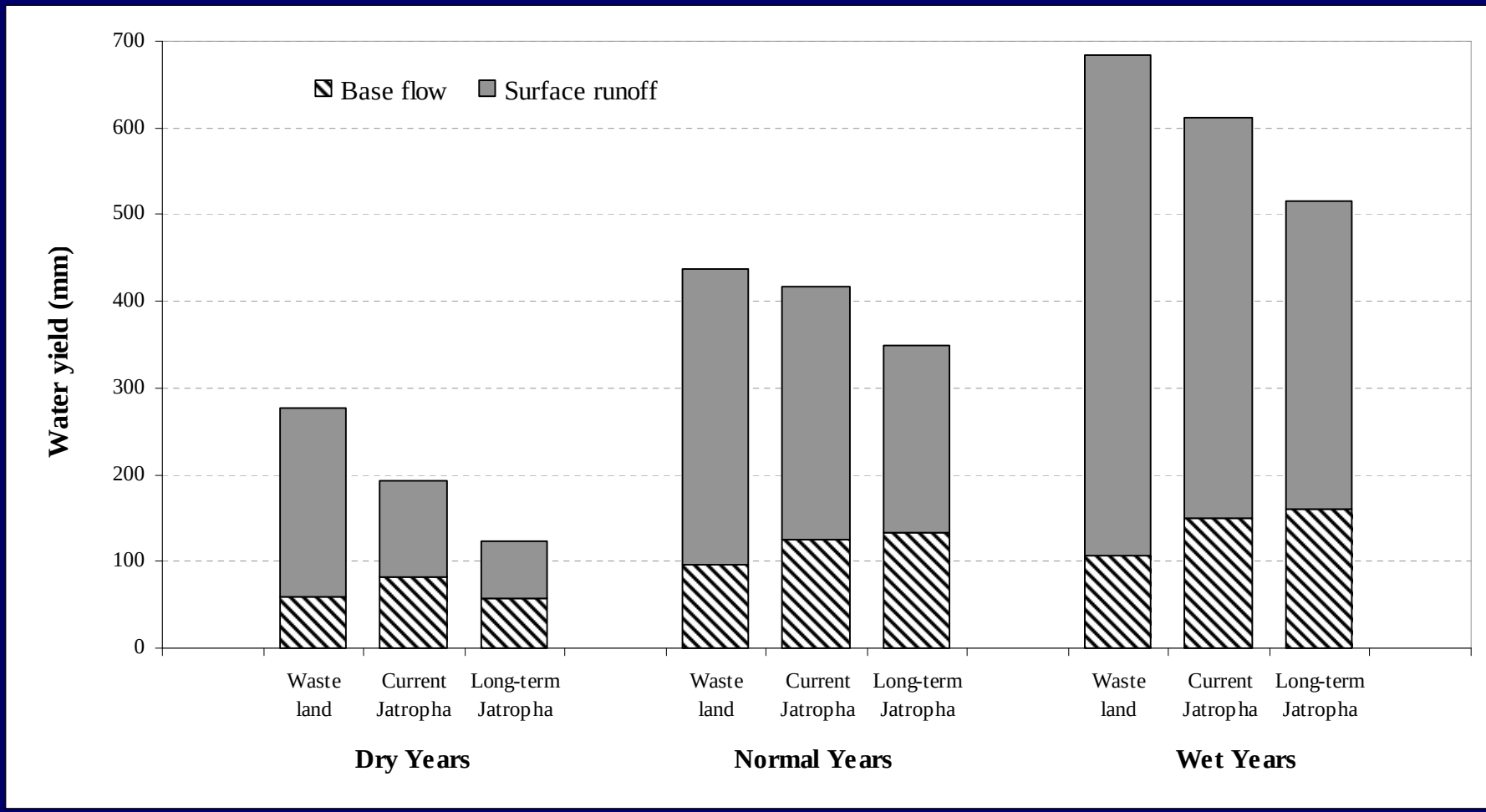

Cumulative soil loss (tons/ha) under different land management conditions (Data from 2001 to 2010)

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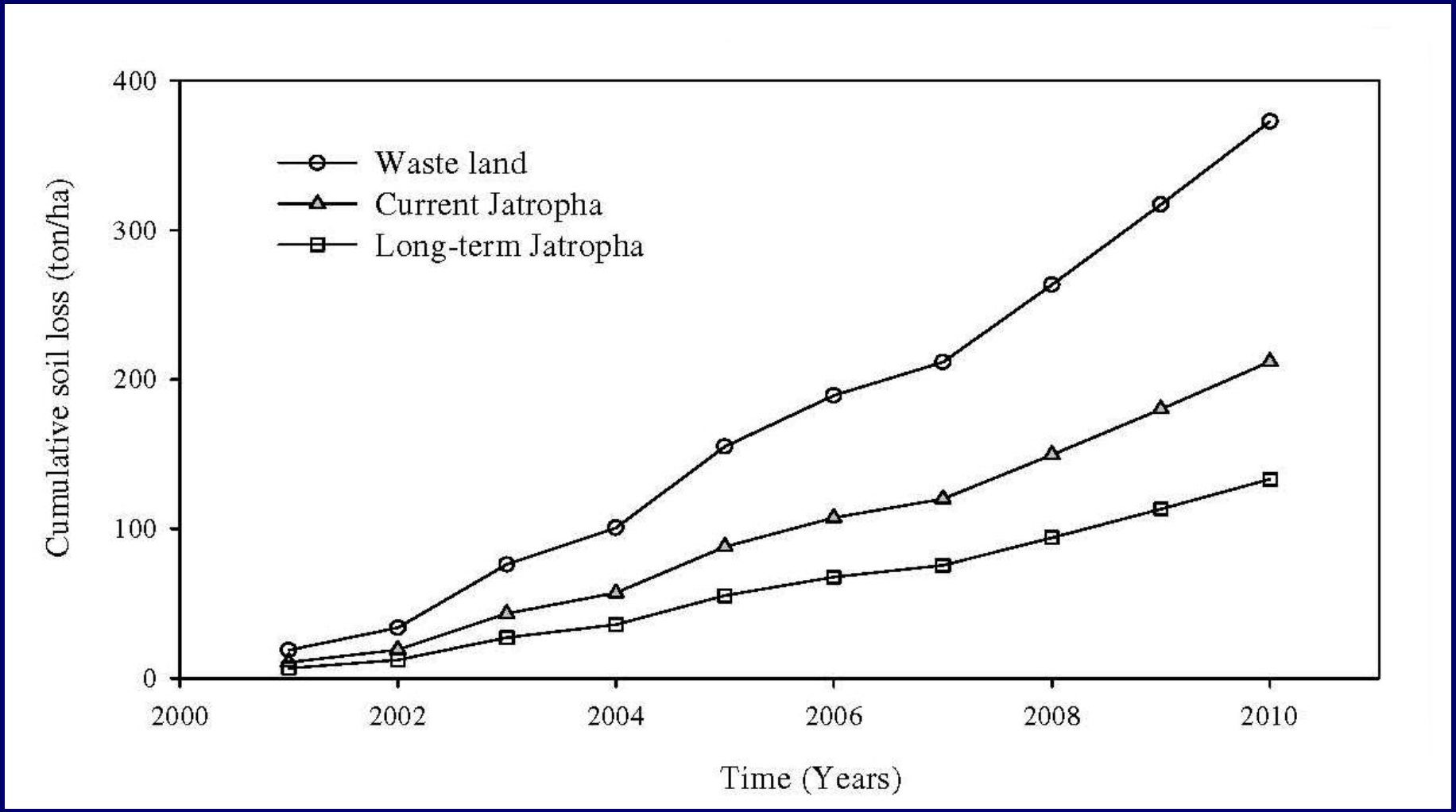

Jatropha: A Good Soil Fertility Builder

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- C-fixation through photosynthesis
- Leaf fall – recycling (1 t c ha^{-1} y^{-1} through 2.5 t ha^{-1} leaf fall)
- C- replacement (0.5 to 1.5 t ha^{-1} y^{-1}) in fuel through 1 to 3 t ha^{-1} seed yield

Carbon added to the soil through leaf fall and pruned lopping of *Jatropha* in on-station experiment at ICRISAT center, Patancheru, India, 2007-2009

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Age of the plant	Plant dry biomass (g Plant^{-1})	SE±	Plant dry biomass (kg ha^{-1})	SE±	Plant biomass C (%)	Plant biomass C (kg ha^{-1})	SE±
Leaf fall							
1st year	550	51	920	85	33	305	28
3rd year	1450	264	2420	441	33	800	146
Pruned loppings							
5th year	245	72	410	119	36	150	43

Total C sequestered through *Jatropha* plantation as C returned to soil, biodiesel C replacement per year and live plant C

C through *Jatropha* plantation	Plant part involved	Organic-C (kg ha^{-1})
C returned back to soil	Leaf fall	800[a]
	Pruned loppings	150 [a]
	Deoiled cake	495[b]
C replacement in fossil fuel	Jatropha oil	230 [b]
C in live plant	Shoots & roots	5120

[a] *Leaf and stem prunings added C every year;* [b] *Jatropha oil C (Fuel replacement) and deoiled cake added C from fourth year onwards every year*

Effects of the *Jatropha* plantation on the microbial biomass C, N and soil respiration at Velchal, Rangareddy district, Andhra Pradesh, India, 2009

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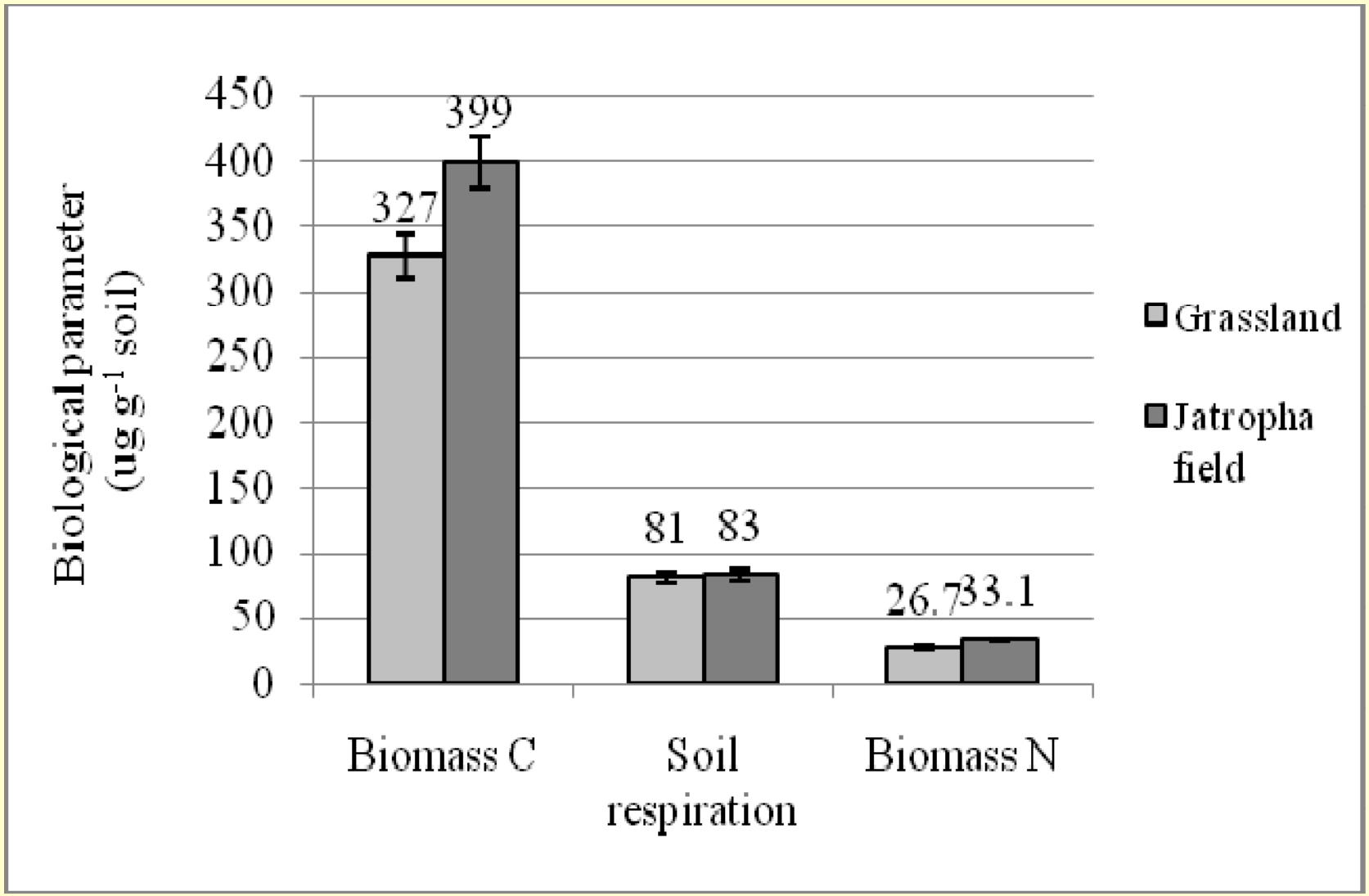

Chemical Composition of *Jatropha* Cake as Source of Plant Nutrient Used for the Study

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Nutrients	*Content*
Nitrogen (%)	4.91
Phosphorous (%)	0.90
Potassium (%)	1.75
Calcium (%)	0.31
Magnesium (%)	0.68
Zinc (ppm)	55
Iron (ppm)	772
Copper (ppm)	22
Manganese (ppm)	85
Boron (ppm)	20
Sulphur (ppm)	2433

Effect of *Jatropha* deoiled cake application on grain yield in Maize under rainfed condition

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Treatments	Plant height (cm)	Grain yield kg ha^{-1}	HI
Absolute control	220	6640	0.58
50 % of the basal dressing N (30 kg N/ ha) through deoiled cakes	217	9560	0.61
100% of the basal dressing N (60 kg N/ ha) through deoiled cakes	228	8490	0.60
Recommended N through inorganic fertilizer (120:60:40 NPK kg ha^{-1})	226	9200	0.59
SEd	6.24	366	0.02
LSD	NS	796	NS

Our contribution to Knowledge on *Jatropha*

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- Number of research papers including one review paper published
- Research findings presented in national and international workshops and conferences ("*Jatropha* and *Pongamia* plantations for improving livelihoods and rehabilitation of degraded lands", Pro-Poor Biodiesel Initiative for Rehabilitating Degraded Drylands)
- ICRISAT's work is documented by Hornung TV, Germany in a documentary broadcasted throughout Europe
- Our research is widely covered in IFAD, UNEP, WWF reports on *Jatropha*

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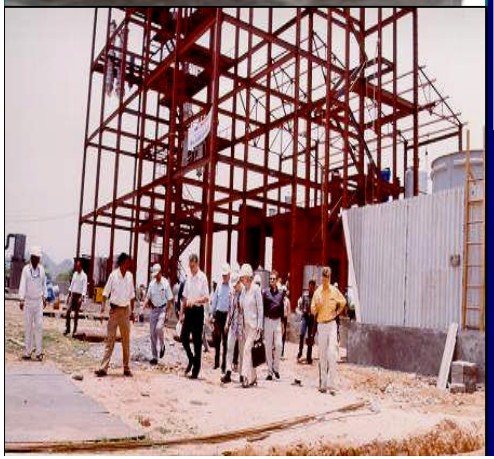
Conclusions

- *Jatropha* is a good candidate plant to grow on wastelands as source of biofuel
- *Jatropha* needs 1600-1700 mm water to meet its water demand at Hyderabad
- *Jatropha* plantation on wastelands reduced non-productive evaporation losses and increased ET without affecting groundwater recharge
- Jatroha plantation reduced erosive runoff and soil loss from degraded lands and improved downstream water availability
- Nutrient budgeting approach can help for sustainable *Jatropha* Production. *Jatropha* plantations can improve fertility status of degraded lands thru C sequestration




We Gratefully Acknowledge

IFAD

Thank you