FOSRIN and Ricebean: a general introduction

End of project workshop, Nagarkot, Nepal
Feb 1 – 4, 2010

Ricebean Network

SIXTH FRAMEWORK PROGRAMME

FOSRIN

- Food security through ricebean research in India and Nepal
- EU FP6, 2006 – 2010
- Partners
  - CAZS-NR, Bangor, UK
  - CAU Kiel, Germany
  - UB, Bergen
  - GVT, India
  - CSKHPKV, India
  - AAU, India
  - NARC, Nepal
  - LI-BIRD, Nepal

Overall objective

- To widely popularise ricebean by
  - identifying and measuring diversity within germplasm available in India and Nepal
    - characterising it for suitability to cropping systems
    - match farmer-preferred varieties to diverse seasons, environments and markets
  - Using genetic, agronomic, and socio-economic approaches firmly based on client-orientated principles:
    - To identify genotypes and parents for breeding programmes suitable for integrating ricebean into rice- and maize-based cropping systems in WNE India and Nepal.

Specific objectives: 1

- Analyze supply-chain for stages and linkages where product value of improved ricebean is potentially lost or quality information may be compromised or lost
- To assess genetic diversity and indigenous knowledge on ricebean in Nepal and India
  - To assess genetic diversity and uses of ricebean using indigenous knowledge
  - To characterise germplasm diversity using molecular marker techniques
  - To characterise germplasm for phenological traits and suitability for a range of diverse environments and cropping systems using participatory approaches

Specific objectives: 2

- To assess the potential impact of enhanced pulse availability on local human nutrition
- To develop a Market-based Legumes Traits Value-Index (MLTVI) that allows breeders to assess ex ante the value of new legumes in terms of their monetary value to consumers
- To develop innovative and efficient marketing methods for high quality, protein-rich products from the crops to increase market accessibility, product value and promote export value
- To develop policies to support and promote equitable access to such protein-rich foods, building sustainable medium and long term food security

Specific objectives: 3

- To ensure effective integration of results, hypotheses and germplasm, and their wide dissemination to stakeholders and other interested parties
- To ensure dialogue between participating institutions, research teams, other projects, participating communities and governments
- To strengthen sustainably the research capability of the Asia Partner Country institutes involved in the project

Work packages

- To develop innovative and efficient marketing methods for high quality, protein-rich products from the crops to increase market accessibility, product value and promote export value.
- To develop policies to support and promote equitable access to such protein-rich foods, building sustainable medium and long term food security.
- To assess genetic diversity and uses of ricebean using indigenous knowledge of the crop

Work packages

- To characterise germplasm diversity using molecular marker techniques
- To characterise the germplasm for phenological traits and suitability for a range of diverse environments and cropping systems
- To assess the potential impact of enhanced pulse availability on local human nutrition.

Deliverables

- D1.1 Empirically estimated hedonic demand function for legumes
- D1.2 Legumes Trait Value Index for guiding ricebean breeding
- D1.3 Strategy for introducing ricebean into the legumes supply-chain
- D1.4 Final report (thesis) on ricebean marketing
- D1.5 Article on ricebean marketing in a research journal
- D2.1 National distribution of ricebean described and published
- D2.2 Analysis of local knowledge of rice bean diversity and uses from selected study areas published

Deliverables

- D2.3 Analysis of ricebean diversity published in a research journal
- D3.1 Polymorphic markers identified and published
- D3.2 Diversity in Nepal and India on the basis of molecular markers described and published
- D3.3 Diversity estimates using agromporphological and molecular markers in relation to biophysical and socio-economic variables described and published

Deliverables

- D4.1 Quantitative and qualitative data on performance and acceptability of genotypes analysed and published
- D4.2 Quantitative and qualitative data on farmers preferences analysed, compared with results of WP1 and published
- D5.1 Diet and food preparation documented and published
- D5.2Nutrient content analysed, documented and published
- D5.3 Analysis of health and nutrition impact published

Ricebean

- Fairly short-lived warm-season annual legume
  - Minor food and fodder crop
- Grown mainly as a dried pulse
  - Also important as fodder, green manure and vegetable.

Ricebean

- Most widely intercropped, particularly with maize, (also sorghum and cowpea) in Indo-China, southern China, India and Bangladesh.
  - Also sole crop in uplands on a very limited area
- Was widely grown as a lowland crop on residual soil water after harvest of long-season rice
  - Largely displaced now shorter duration rice varieties grown

Taxonomy

- Sub-genus *Ceratotropis*
  - fairly distinct and homogeneous group
  - largely restricted to Asia
  - $2n = 22$ (except *V. glabrescens*, $2n = 44$).
- 7 cultivated species, and several wild ones.
- *V. glabrescens* is an amphidiploid that may have arisen from a natural cross between *V. mungo* and one of the others, probably *V. umbellata* but possibly *V. angularis*.
  - Artificial crosses between *V. mungo* and *V. umbellata* to produce improved mung bean varieties
- 3 more or less secondary gene pools
  - ricebean closer to *V. angularis* (Adzuki bean) than to the other species, being in the Angulares group.

Cultivated Asian *Vigna* (in order of economic importance), probable wild progenitors, and centres of domestication (after Lawn, 1995)

Species	Common name	Wild progenitor	Centre of domestication
V. radiata	Mungbean, green gram	Var. *sublobata*	India
V. mungo	Black gram, urd bean	Var. *silvestris*	India
V. angularis	Adzuki bean	Var. *nipponensis*	NE Asia
V. umbellata	Ricebean	Var. *gracilis?*	SE Asia
V. aconitifolia	Moth bean, mat bean	-	S Asia
V. trilobata	Pillipesara bean, jungle bean	-	S Asia
V. glabrescens		*V. radiata* x *V. umbellata(?)* *V. reflexo-pilosa*	SE Asia

Origin and distribution

- Distribution indicates great adaptive polymorphism for diverse environments
  - Humid tropical to sub-tropical, to sub-temperate
- Presumed centre of domestication northern Thailand and Myanmar
  - Derived, probably in a single domestication event, from wild *V. umbellata* var *gracilis*
    - Cross-fertile
    - Distributed from S China through N Vietnam, Laos and Thailand into Myanmar and India

Distribution

- Also found outside Asia
  - Introduced by the Arabs into Egypt, the eastern coast of Africa and the Indian Ocean islands
- Cultivated to a more limited extent in
  - Fiji, USA, Brazil, Australia, SW Asia, tropical Africa and America
  - In tropical Africa grown in West Africa, East Africa and the Indian Ocean islands
    - Less frequently in Central and southern Africa.

Wild types

- Wild forms occur in ground cover in natural and disturbed habitats, and forest clearings
- Typically fine-stemmed, freely-branching and small-leaved
  - Twining or trailing habit
  - Photoperiod sensitivity
  - Indeterminate growth
  - Sporadic and asynchronous flowering
  - Strongly dihescent pods
  - Small hard seeds.
- In many areas, landraces with these characteristics persist
  - Especially daylight sensitivity, growth habit and hard seeds.
- High introgression between wild and cultivated forms
  - Within-species variation higher than in related species.

Mean, range and CV for quantitative traits of cultivated (5) and wild forms (39) of *V. umbellata* (After Bisht *et al*, 2005)

Trait		*V. umbellata*	*V. umbellata* var. *gracilis*
Height (m)	Mean	1.92	2.51
	Range	1.92 – 1.93	1.20 – 3.00
	CV (%)	28.3	17.5
Days to flowering	Mean	73.5	149
	Range	52 – 123	59 – 175
	CV (%)	28.3	18.7
Days to maturity	Mean	95	165
	Range	85 – 150	75 – 195
	CV (%)	16.2	17.3
Pods per plant	Mean	51.1	67.5
	Range	38.2 – 136.0	0.63 – 376.7
	CV (%)	18.0	120.4
100-seed weight (g)	Mean	5.28	0.85
	Range	4.89 – 6.68	0.40 – 1.30
	CV (%)	18.8	32.9
Seed size (mm)	Mean	18.7	6.64
	Range	10.5 – 32.0	5.11 – 10.46
	CV (%)	15.1	38.7
Yield per plant (g)	Mean	7.84	5.76
	Range	6.78 – 9.90	0.22 – 27.35
	CV (%)	10.8	280.2

Wild types

- Within wild types, particular variation for pubescence, bud size, flowers / raceme, pods / peduncle, and seed size and weight.
  - Also days to flowering and maturity, number of pod-bearing clusters and pods / plant, seed size and yield.
- Population from NW Himalayas less robust
  - Thinner leaflets and shorter pods
  - Thought more adapted to abiotic stress, particularly drought

Potential

- Grows well on many soils.
  - Establishes rapidly
- Excellent bruchid resistance
  - Can be crossed with e.g. mung bean to introduce this
- Potential to produce large amounts of nutritious fodder and high quality grain
- Greatest yield potential of all *Vigna* spp
- Most potential to be successful if introduced to Africa

Production constraints

- Small and fragmented land holdings, declining productivity
- Grown on residual fertility and moisture and in marginal and exhausted soils
- Highly photoperiod sensitive
- Late flowering, strong vegetative growth
- Twining habit
  - Needs staking or intercropping with maize or sorghum
- Hard to harvest
  - Susceptible to shattering
- High level of hard-seededness

Trade

- Little ricebean production enters international trade
  - Japan the main importer
- Main exporters Thailand, Myanmar and China.
- Madagascar also exports some
  - average annual export in 1998–2000 estimated at 1100 t (PROTA, 2006)

Germplasm collection

- Germplasm held at the World Vegetable Center in Taiwan
- NBPGR in New Delhi
  - The most comprehensive collection
  - > 1700 accessions
- China (Institute of Crop Germplasm Resources (CAAS), Beijing; > 1300 accessions)
- NARC in Kathmandu

Diversity in Nepal

- Very high landrace diversity
  - Named on maturity period, grain size and grain colour
- Most prefer bold (large) seeded varieties
  - But these mature late
  - Farmers have to forgo the next crop in the cycle.

Diversity of ricebean landraces in Nepal

Maturity group	Diversity	Local name
Early (<130 days)	Light green (small)	*Bhadaure seto*
	Brown (small)	*Bhadaure khairo*
Medium (130-140 days)	Grey mottled (medium)	*Chhirkemirke masang*
	Light green (medium)	*Seto masang*
	Yellowish white (medium)	*Seto masang*
	Black (medium)	*Kalo masang*
	Purple red (medium)	*Rato masang*
	Red (medium)	*Rato masang*
	Brown (medium)	*Khairo masang*
Late (>140 days)	Grey mottled (bold)	*Thulo Chhirkemirke*
	Yellowish white (bold)	*Thulo seto*
	Light green (medium)	*Mailo seto*
	Black (bold)	*Kalo thulo*
	Yellow (bold)	*Thulo pinyalo*

Diversity and cropping, India

- Despite improved varieties in India, normally a mixture of landraces is grown.
  - Seed colour and grain size used to classify
    - Also maturity period and growth habit.
- Range of names in different areas.
- Generally a summer crop in NW
  - In NE grown in both summer and winter
- Intercropping is common in NW
  - Sole cropping as a component of shifting cultivation NE
  - Both sole and mixed cropping in central and other regions

Potential

- Good potential for breeding
  - Improve the crop and encourage wider use
- Existing germplasm should be:
  - Catalogued accurately
  - Made available for breeders for the benefit of farmers in both India and Nepal
- Need to standardise varietal nomenclature

Molecular work

Identification of polymorphic makers

- No modern plant breeding despite very high phenotypic diversity
- Stratified sample selected to cover range of diversity
- 27 genotypes from Nepal, sampled on
  - Diversity in local names
  - Geographical origin
  - Agro-environment
  - Growth habit
  - Seed traits
- Also bold-seeded check and adzuki bean check

Summary of SSR diversity values for ricebean accessions and all samples

Diversity parameters	Ricebeans	All accessions including adzuki bean
Accessions considered	27	29
SSR primers screened	109	109
Primers amplified	49	49
Monomorphic primers	19	14
Polymorphic primers	30	35
% polymorphic primers	61	71
Total alleles (bands) observed	85	93
Alleles /primer	1.7	1.9
Total polymorphic alleles (bands)	63	79
Alleles/polymorphic primer	2.1	2.3
% polymorphic alleles (bands)	74	85
Polymorphic information content (PIC)	0.26	0.24

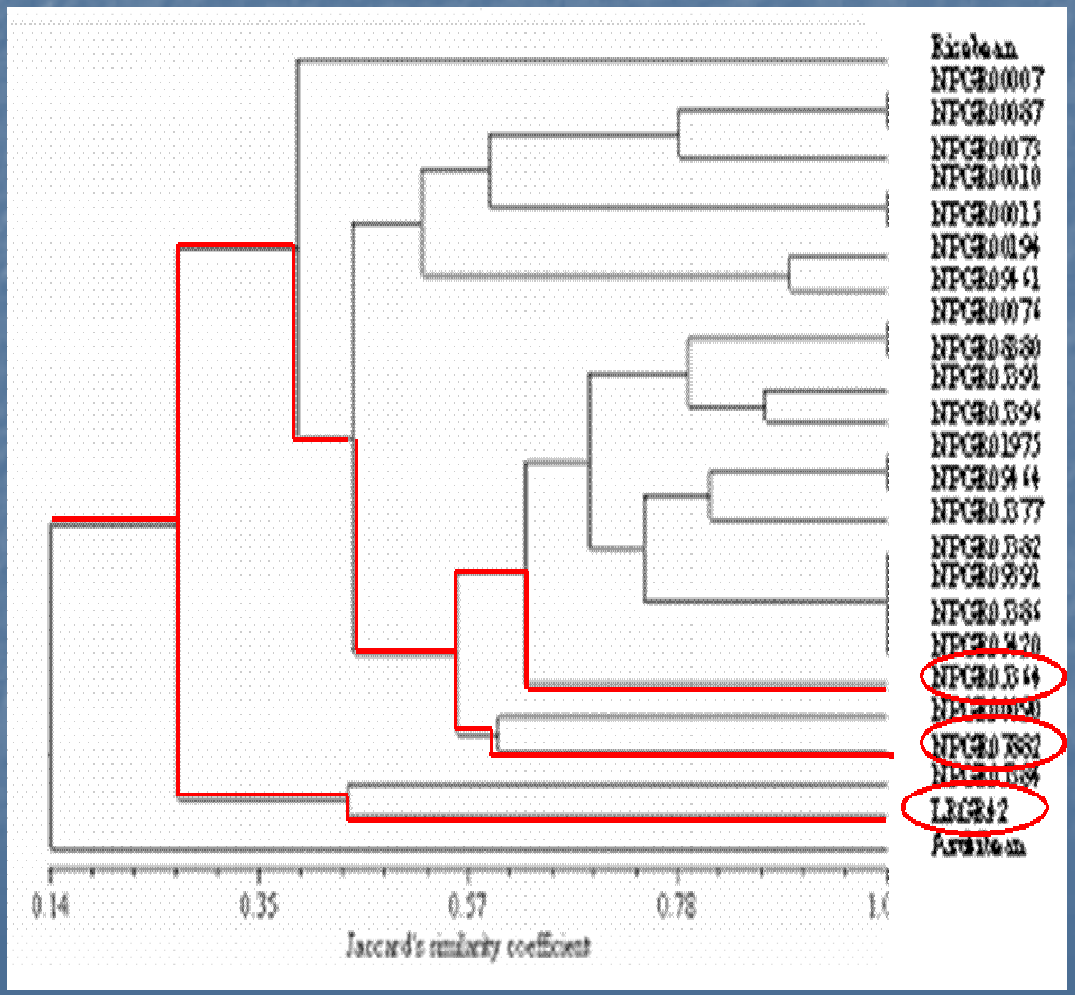
- Eleven primers contained AG repeats
  - 1 had AAG repeats and another GT(AT)AG repeats.
  - Belonged to linkage groups 1, 2, 3, 6, 8, 10 and 11 of the ricebean genome
  - Explained variation at DNA level between
    - ricebean accessions
    - ricebean and adzuki bean

Molecular diversity

- Ricebean accessions diverse, but less than expected
- Dendrograms constructed based on UPGMA analysis
  - Compare groupings and identify primers best describing diversity.

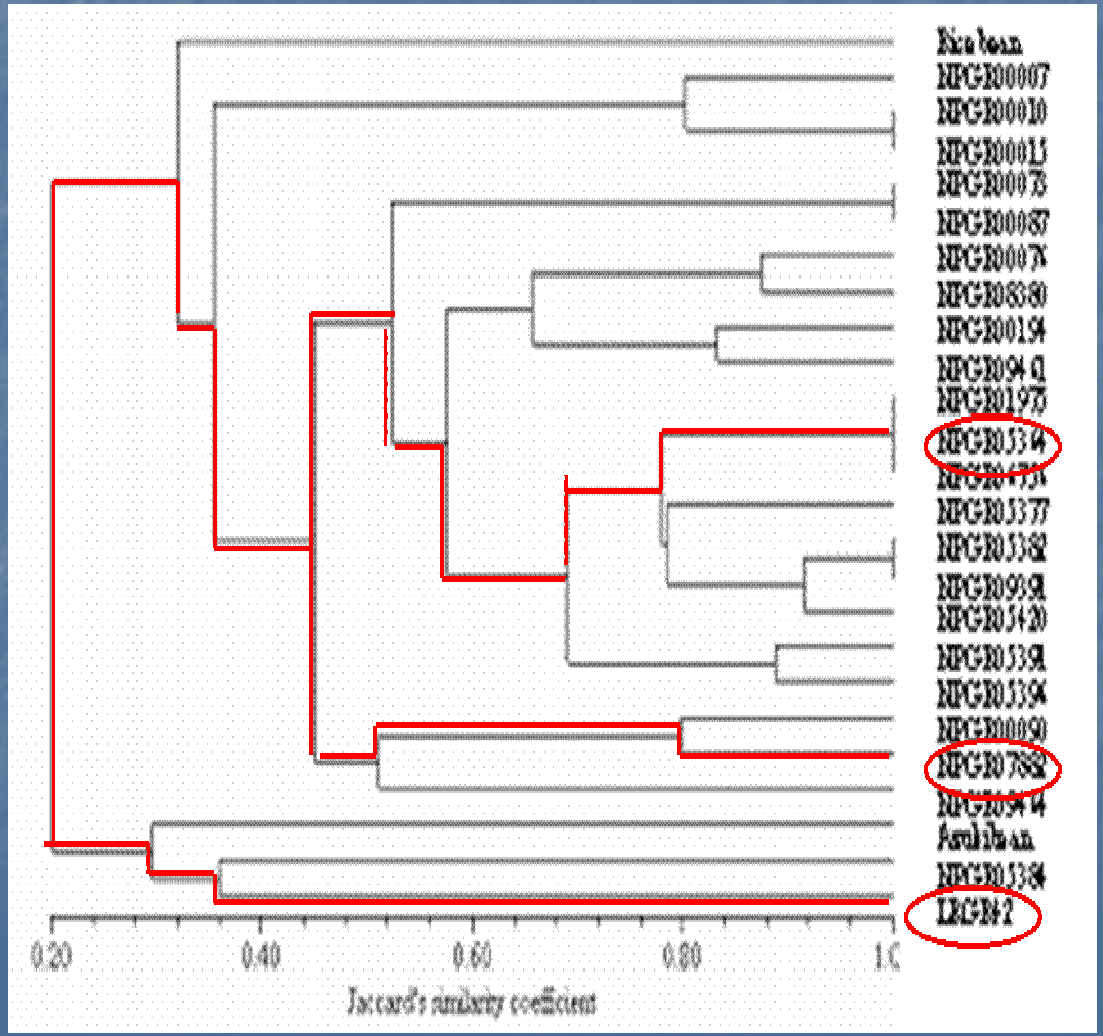
Molecular diversity

- 3 accessions from mid to high-hills in far west clustered close to adzuki bean when grouped using 8 polymorphic primers with > 3 bands per primer
  - indeterminate growth habit



Molecular diversity

- 2 also close when clustering used the 13 polymorphic primers with PIC > average.



Next……

- Identified primers used to assess molecular marker diversity in landraces selected for good performance in field trials


Diets and nutrition

Diets

- **Nutritional value in many respects impacted by different methods of food preparation.**

Effect of soaking and sprouting on mineral availability, derived from Saharan *et al* (2001)

Mean values	Ca mg/100g		Fe mg/100g		P mg/100g	
	Total	% available	Total	% available	Total	% available
Raw bean	311.7	59.8	6.6	37.9	257.1	33.4
Soaked 12 hours	303.0	62.1	6.4	39.3	255.0	37.7
Sprouted 24 hours	299.2	67.5	6.4	41.5	255.8	38.8

Diets

- Common, low cost, pre-cooking and cooking procedures considerably reduce
  - Anti-nutritional factors like phytic acid, tannin and trypsin inhibitor
  - Indigestible saccharides
- Effects of overnight soaking, sprouting, de-hulling and pressure cooking all tend to reduce anti-nutritional factors
  - Make important micronutrients more bio-available and beans more digestive.

Diets

- Field evidence of widespread use of pressure cookers for common preparations of ricebean
  - Leads to widespread neglect of soaking and sprouting

Preparations of pulses recorded in baseline study of dietary survey.

Method of preparation, %	Gulmi	Dolakha	Assam	HP
Boiling	10	0.5	66	1.0
Soaking	0	0	0	0.5
Pressure cooking	14	0.5	1.5	92.5
Frying	0	2	0.5	0.5
Combination	76	97	31	5.5

Diets

- The most common preparation of ricebean in India and Nepal is *dhal* with rice, wheat or maize, and various vegetables in addition to dairy produce.
  - Also served as e.g.
    - mixed bean sprout soup
    - ricebean stuffed items
    - grinding soaked ricebean to paste to make various shapes of deep fried nuggets
    - In Madagascar flour of dried germinated ricebean seeds included in complementary foods for children

Diets

- Many recipes are existing local ones
  - Field demonstrations show that ricebean is a versatile raw material which can substitute other pulses in popular local recipes
- So ricebean has potentials when it comes to value added products
  - These can be produced at a local market place and tea-shop level.

Diets

- Field evidence also showed large variations in the diets in different sites
  - in terms of staple composition (balance between rice, maize and wheat)
  - and in consumption of different grain pulses.
- In the 4 areas surveyed, ricebean was the 6th most common grain pulse

Nutritional value

Different food groups' share of protein supply, %.

	Nepal		India	
	1969-71	2001-03	1969-71	2001-2003
Cereals	71	66	52	56
Pulses	9	6	19	11
Meat and dairy	11	9	10	16

Source: FAO (2009)

Protein content according to various authors

- Reviewed literature, supplemented by analysis of selected nutrients.
- Several favourable characteristics compared to other pulses.
  - Protein content in normal range
    - High digestibility
    - very favourable amino acid composition for human consumption.

Authors	Crude protein %
Malhotra *et al*, 1988	17.5 - 23.1
Mohan & Janardhan, 1994	21.9 - 26.1
Saikia *et al*, 1999	16.9 - 18.0
Rodriguez & Mendoza, 1991	17.3 - 21.4
Saharan *et al*, 2002	18.2 ± 0.2
Duke, 1981	20.9
FAO, 1982	18.5
Chandel *et al*, 1978	14.0-24.0
Kaur & Kapoor, 1992	17.2 – 18.5
Overall range	14.0-26.1

Nutritional value

- No toxins or allergenic compounds
  - enzyme inhibitors low compared to most pulses
- Content of other antinutrients e.g. phytate also moderate compared to other pulses
  - levels reduced by common cooking methods.
- Less flatulence producing saccharides than many other pulses
- Ricebean has local cultural roles
  - Generally none that restrict its use.

Possible pharmaceutical use

- Protein concentrates from seeds have *in-vivo* anti-hypercholesterolaemic effects in hamsters.
- Peptide isolated from seeds shows strong antifungal activity
  - *Botrytis cinerea*, *Fusarium oxysporum*, *Rhizoctonia solani* & *Mycosphaerella arachidicola*.
- Mitogenic and anti-HIV-1 reverse transcriptase activity.

Source: Prota