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FOSRIN

Food Security through Ricebean Research in India and Nepal

Report 1: Distribution of ricebean in India and Nepal

Report on the distribution of ricebean in India and Nepal

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Executive summary

This document contains information on the distribution and diversity of ricebean (*Vigna umbellata*) germplasm in India and Nepal, drawn from the literature, interviews with farmers and scientists, germplasm collection expeditions and field visits. It was produced by a team lead by Mr Resham Gautam of the Nepalese NGO Local Initiatives in Biodiversity, Research and Development (LI-BIRD), including project staff from each of the Indian and Nepalese partners as well as from the UK.

Ricebean is an underutilised grain legume cultivated in hill areas of India and Nepal, often as an intercrop. Of the *Vigna* species, it is most closely related to Adzuki bean (*V. angularis*). The original centre of domestication is thought to be Indo China, and it is derived from a wild form *V. umbellata* var *gracilis* with which it is cross fertile. The wild types occur in natural and disturbed habitats and forest clearings, and are indeterminate, photoperiod-sensitive, freely-branching, twining or trailing plants with small seeds. Many ricebean landraces are similar in form to the wild types.

Ricebean is adapted to subhumid regions and in general yields between 200 and 300 kg ha^{-1}. It grows on a wide range of soil types including acid soils and is largely resistant to pests and diseases. It is drought tolerant and will also tolerate some degree of waterlogging. It is a good source of protein and contains high levels of essential amino acids, essential fatty acids, vitamins and minerals. Despite these advantages it is little exploited, and has great potential for improvement.

Germplasm is held at the World Vegetable Center in Taiwan, as well as with the NBPGR in New Delhi and NARC in Kathmandu: NBPGR has the most comprehensive collection with over 1700 accessions.

In Nepal ricebean grows in the rainfed uplands in marginal areas, particularly on drier east and south-facing slopes. It is most common between 700 and 1400 m asl, but is also found between 300 and 600 m asl and up to 2400 m asl in Humla, a high-hill district. No information is available from the literature, but the NARC PGR unit has collected germplasm for a number of years in several national and international collection and exploration missions, and has a collection of 149 accessions from 29 districts. In addition, FOSRIN collected 156 accessions from 16 districts in 2006. According to information from District Agricultural Development Offices (DADOs), of 75 districts, twelve were growing more than 90 ha of ricebean, with the greatest area in Tanahun. In contrast, in sixty districts less than 40 ha were being grown. The ricebean area was greater in the west of Nepal than elsewhere, and most was grown in the hills. Despite the very high diversity, farmers classified varieties according to maturity time, seed colour and grain size, and three main groups could be identified based upon time to maturity. Field visits were made to validate the information, and these identified small "pocket" areas in which ricebean was grown. The number of pocket areas in a district largely corresponded to the total area reported to be under the crop in that district. In general, ricebean was grown as an intercrop with maize, but at the lower altitudes it was also grown on rice bunds. It is almost always grown as a summer crop.

In India ricebean is grown mainly in the NW (Himachal Pradesh and Uttaranchal) and NE (Assam Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura) hills, as well as in western India in Madhya Pradesh and Chhatishgarh. The wild forms are widespread from Kerala in the south through the Eastern and Western Ghats to the Himalayas, and show great variability, particularly in the NE. Germplasm collection has been conducted by NBPGR and other agencies since

the 1970s, and a great many accessions collected: NBPGR has in excess of 1700. Like Nepal, these accessions show great variability. In addition, research on the crop has been carried out under the All-India Coordinated Research Network on Underutilized Crops, with evaluations carried out at a range of locations both in the hills and in the plains. This has included some crop improvement work. In addition, FOSRIN staff collected 89 accessions from thirteen districts in the NE, NW and W of India in 2006.

Ricebean distribution was assessed in different states, and found to be highest in the NE states, medium in the NW and west, and low in the south and east of the country and the NW plains (Punjab and Haryana), although the crop was reported to some extent in all states except Rajasthan. However, within states distribution was uneven, with ricebean often found mainly in the higher and more marginal areas.

Despite the existence of improved varieties in India, normally a mixture of landraces is grown. Farmers use seed colour and grain size to classify their landraces, as well as maturity period and growth habit. The crop has a range of different names in different areas. It is generally grown as a summer crop in the NW, but in the NE it is grown in both summer and winter. Intercropping is common in the NW and sole cropping as a component of he local shifting cultivation system in the NE, but in central and other regions both sole and mixed cropping is carried out.

The report notes the potential for breeding to improve the crop and so encourage its wider use. It recommends that existing germplasm is catalogued accurately, and made available for breeders for the benefit of farmers in both India and Nepal in both countries, although steps need to be taken to standardise varietal nomenclature. A comprehensive list of references is given, as well as a list of the genotypes identified from the literature in India.

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The cover photograph shows a typical ricebean growing area near Gulmi in the middle hills in the Western Development Region of Nepal.

Photo: Professor John Witcombe.

1. Introduction

Ricebean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi, previously *Phaseolus calcaratus*) is an annual vine legume which is little known, little researched and little exploited. It is regarded as a minor food and fodder crop and is often grown as intercrop or mixed crop with maize (*Zea mays*), sorghum (*Sorghum bicolor*) and cowpea (*V. unguiculata*) as well as a sole crop in uplands on a very limited area. Like the other Asiatic *Vigna* species, ricebean is a fairly short-lived warm-season annual. Grown mainly as a dried pulse, it is also important as a fodder, a green manure and a vegetable. Ricebean is most widely grown as an intercrop, particularly of maize, throughout Indo-China and extending into southern China, India and Bangladesh. In the past it was widely grown as lowland crop on residual soil water after the harvest of long-season rice, but it has been displaced to a great extent where shorter duration rice varieties are grown. Ricebean grows well on a range of soils. It establishes rapidly and has the potential to produce large amounts of nutritious animal fodder and high quality grain.

1.1 Taxonomy

The cultivated Asiatic *Vigna* species belong to the sub-genus *Ceratotropis*, a fairly distinct and homogeneous group, largely restricted to Asia, which has a chromosome number of $2n = 22$ (except *V. glabrescens*, $2n = 44$). There are seven cultivated species within the sub-genus (Table 1.1), as well as a number of wild species. *V. glabrescens* is an amphidiploid that may have arisen from a natural cross between *V. mungo* and one of the others in the sub-genus, probably *V. umbellata* but possibly *V. angularis*. Artificial crosses have also been made between *V. mungo* and *V. umbellata* to produce improved mung bean varieties (e.g. Singh *et al*, 2006)

Table 1.1: Cultivated Asian species of *Vigna* (in order of economic importance), their 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

There are three more or less secondary gene pools within the group: ricebean is closer to *V. angularis* (Adzuki bean) than to the other species, being in the Angulares group (Kaga *et al*, 1996, Tomooka *et al*, 2003).

1.2 Origin and distribution

Ricebean's distribution pattern indicates great adaptive polymorphism for diverse environments, with its distribution ranging from humid tropical to sub-tropical, to sub-temperate climate. The presumed centre of domestication is Indo-China. It is thought to be derived from the wild form *V. umbellata* var *gracilis*, with which it is cross-fertile, and which is distributed from Southern China through the north of Vietnam, Laos and Thailand into Myanmar and India (Tomooka *et al*, 1991). Studies of the genetic and eco-geographical relationships among the wild relatives of *Vigna* species were made by Saravanakumar et al (2001).

1.3 Wild types

The wild forms of ricebean occur in the ground cover in both natural and disturbed habitats, and in forest clearings. They are typically fine-stemmed, freely-branching and small-leaved plants with either a twining or a trailing habit, showing photoperiod sensitivity and indeterminate growth, with sporadic and asynchronous flowering, strongly dihescent pods and small hard seeds. In many areas, landraces which retain many of these characteristics persist, in particular with regard to daylight sensitivity, growth habit and hard seeds. There is a high degree of introgression between wild and cultivated forms, and Bisht *et al* (2005) noted that within-species variation within ricebean was higher than in related species.
In 39 accessions of the wild type the means and range of selected traits are shown below, as well as the those of five Indian cultigens (Table 1.2). Particularly noteworthy is the wide range in days to flowering and maturity, numbers of pods and seed size.

Table 1.2: Mean, range and coefficient of variation for important quantitative traits of cultivated and wild forms 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 (?)	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

Within the wild types, Bisht *et al* (2005) noted particular variation between populations for pubescence, bud size, numbers of flowers per raceme and pods per peduncle, and seed size and weight. There was also variation in days to flowering and maturity, number of pod-bearing clusters and pods per plant, seed size and yield. A population from the NW Himalayas were less robust, having thinner leaflets and shorter pods, and were considered to be more adapted to situations of abiotic stress, particularly drought.

1.4 Adaptation and agronomy

In a comprehensive review of the grain legumes of the lowland tropics, Rachie & Roberts (1974) classed ricebean as adapted to subhumid regions with 1000 – 1500 mm precipitation (along with French beans [*Phaseolus vulgaris*], soybeans [*Glycine max*], and jack and sword beans [*Canavalia* species), although they noted acknowledged other factors than rainfall were also involved in adaptation, for example rainfall pattern, moisture distribution, temperatures, cloud cover and relative humidity, soil characteristics, pests and diseases. They also noted the importance of human needs in assessing adaptation – for example taste, the need for a particular use, or market price. They suggested that average yields were between 200 and 300 kg ha^{-1}, although with the potential for 1200 kg ha^{-1}, that the crop would grow on a range of soils, and was resistant to pests and diseases. It would mature in as little as 60 days, and although performing well under humid conditions, was also tolerant to drought (Chatterjee & Mukherjee, 1979; Mukherjee *et al*, 1980; NAS 1979) and high temperatures. It is tolerant to some degree of waterlogging, although the young plants appear to be susceptible (de Carvallho & Veira, 1996). Ricebean is also known to be tolerant to acidic soils (e.g. Dwivedi, 1996). Shattering is a problem in comparison with other grain legumes, and can be particularly serious under conditions of frequent wetting and drying.

Ricebean plays an important role in human, animal and soil health improvement. All varieties seem to be good sources of protein, essential amino acids, essential fatty acids and minerals (Mohan & Janardhanan, 1994), and the dried seeds make an excellent addition to a cereal-based diet.

So far little has been done to exploit the potential of the crop: there are several features that need attention from breeders before it could be widely adopted. Most varieties are highly photoperiod sensitive, and so when grown in the subtropics are late flowering and show strong vegetative growth. Their twining habit makes them very suitable for use as intercrops with such species as maize, sorghum and possibly some of the minor millet species, which can provide support, but also makes them difficult to harvest. Many of the current varieties are susceptible to shattering, and show high levels of hard seededness. Some crop improvement work has been carried out on ricebean in India, but not in Nepal. However, the use of ricebean as a green manure crop was studied in a series of field experiments in Nepal, and this revealed that it is one of the best legumes for the purpose due to high biomass production over a short period of time, is easy to incorporate into the soil, and decomposes rapidly.

1.5 Germplasm collections

The World Vegetable Centre (formerly the Asian Vegetable Research and Development Center) based in Taiwan has 197 accessions of ricebean, including 8 genotypes from Nepal and 24 from India. However, there is little or no passport data (World Vegetable Center, 2007), other than for a Nepalese genotype (given the name Mogimass), collected at 2000 m in Bajura district. The Indian genotypes IC 7588, IC 8229, EC 18771, and IC 7506 are noted as being less sensitive to photoperiod, but no other information is given. In India, the National Bureau of Plant Genetic Resources (NBPGR) contains over 1700 accessions from a variety of Asian countries (NBPGR, 2007). As well as this, there is a collection held at the Indian Institute for Pulses Research, and the NBPGR station at Bhowali, Uttar Pradesh, also maintain a collection of over 300 genotypes (Negi *et al*, 1996). In Nepal, the Plant Genetic Resources Unit of the NARC maintains a collection of some 300 accessions from various parts of the country.

No systematic study has been done to document ricebean distribution, diversity, use or value in either India or Nepal. The objective of this work, therefore, which was led by Partner 8, the Nepalese NGO Local Initiatives for Biodiversity, Research and Development (LI-BIRD) was to describe the extent of ricebean diversity and its distribution in India and Nepal. The other participating partners were CSKHPKV, Palampur, Himachal Pradesh, Assam Agricultural University (AAU), Jorhat, Assam, and Gramin Vikas Trust (GVT).

2. Methodology

No information on the crop is available in Nepal, and there is little on its distribution in India. Therefore, we collected information on ricebean from several sources using various methodologies (Table 2.1). These included staff consultation within organisations and outside, literature searches, and germplasm collection followed by confirmatory field visits.

Table 2.1: Methodologies adopted for the process

Steps	Method/approaches	Outcomes
Consultation with staff of: *Nepal* LI-BIRD District Agriculture Development Office (DADO) *India* CSKHPKV, Palampur (Himachal Pradesh) AAU Jorhat (Assam) GVT Vivekanand Parvatiya Krishi Anusandhan Shala, Almora, Uttaranchal College of Forestry & Hill Agriculture (GB Pant University of Agriculture & Technology) Ranichauri, Uttaranchal State Agriculture Departments	Individual contact	Collection of preliminary information on ricebean crops based on existing knowledge
Literature search and review	Study of: Regional Agriculture Directorate and DADO profiles National Agriculture Technology Project reports All India Coordinated Research Network on Under-utilized Crops ICAR Ad-hoc Project reports NBPGR Publications CABI Abstracts, journal articles	Identify crop status at some of the districts as reported in the literature
Information collection from NARC PGR unit Consultation with commodity programme and other scientists with knowledge on ricebean diversity and distribution in Nepal	Telephone contact, e-mail Study information about the germplasm collected by PGR unit	Listing some potential districts and sites
Germplasm collection from different districts for on-farm evaluation	Mobilization of local organisations in Nepal, on-farm evaluation of collected germplasm Survey of areas for germplasm collection in India by project staff	Diversity assessed, farmers preferred traits analysed, potential landraces for further improvement identified
Field visit to selected districts to update information provided by DADOs and assess the landrace diversity in Nepal	Identification of districts with large areas of ricebean, discussion with DADOs, identification of pocket areas, field visits, discussion with farmers	Identification of pocket areas of ricebean, diversity assessed in the pocket areas

3. Results

3.1 Nepal

In Nepal, ricebean is commonly cultivated as an intercrop with maize, on bunds or as a sole crop, and is considered to be a minor food crop. It is generally grown on rainfed uplands of marginal agricultural areas of the country. Intercropping with maize is very common, particularly in south-facing *Bari* (unirrigated terrace risers) lands in the middle hills.

3.1.1. Information from the literature

There is no information on either the wild forms of ricebean or on the distribution of the crop in Nepal. There are no formally-released varieties of ricebean, and a formal supply system for the crop does not exist.

3.1.2 Germplasm collection at the NARC Plant Genetic Resources unit

The NARC PGR unit initiated germplasm collection on a number of crops in 1976, and has a few ricebean accessions from various parts of the country: most areas are now represented. The collection is made up of accession from 29 districts, representing the area from the Eastern to the Far Western development regions of Nepal (Table 3.1.1), although most are from the Eastern and Central development regions. The information helps to identify potential areas of the crop in the regions from which it was collected.

Table 3.1.1: Summary of ricebean accessions collected by the NARC PGR unit.

District	Location	No. of accessions	Diversity
Eastern Development Region			
Bhojpur	Ranibas	7	*Seto, Kalo, Rato, Baghe, Naga masyang*
Dhankuta	Khaireni, Pakhribas, Muga, Phalete, Simle, Salle, Sehargaun	20	*Seto, Rato masyang, Ghore mas, Tthulo Rate ghore*
Illam	Saprang, Balangaun, Barbhaniya, Phidim, Kolbang, Lalikhark, Kakse, Amle, Palotar, Ttinkhope, Phidim,	20	*Banmara masyang, Rato masyang, Masyang, Seto masyang*
Jhapa	Kumarkhod	1	*Masyang*
Khotang	Murket	1	
Okhaldhunga	Rampurtar, Taluwa	2	*Masyang/Dhade mas*
Panchthar	Naugin, Yannam	3	*Masyang*
Taplejung	Dokhu, Liukhim	3	*Rato masang, Masyang*
Terahathum	Sakranti	1	*Rato ghore*
Sub total		58	
Central development region			
Bhaktapur	Sirutar	1	*Masyang*
Kavre	Dhulikhel, Banepa	17	*Masyang*
Lalitpur		1	*Masyang*
Nuwakot	Kalika, Trishuli, Bhairabi, Gerkutar, Chaurali	10	*Chhirbire, pahelo, Rato, Dhadekalo masyang, Dhaderato masyang*
Sub total		29	
Western development region			
Arghakhanchhi	Dhikura	4	*Khaire masyang, Dhawanse masyang, Dhani masyang, Jhilange*
Baglung	Githapata, Ramrekha	2	*Syaltung*

Table 3.1.1 (Continued)

District	Location	No. of accessions	Diversity
Gorkha	Manakamana, Gorakhkali, Muchhock, Khairbot, Nareswor	6	*Masyang*
Gulmi	Ruru	3	*Pinyaloanhelo masyang, Rato masyang, Thulo pinyalopanhelo masyang, Jhilinge*
Lamjung	Dudhpokhari, Bichaur, Gauda, Gaunshahar	5	*Masyang, Thulo masyang, Gurans*
Myagdi	Kirakhar, Ramrekha	2	*Syaltung*
Syanjya	Arukhrka	1	*Masyang*
Tanahun	Shyamgha, Dorphirdi	2	*Masyang*
Sub total		25	
Mid-western development region			
Dang	Bangaun, Sishaniya, Purandhara, Gobardiha, Deukhuri	5	*Khaira masyang, Chhirbire masyang, Seto, Jhilange masyang, Jhilange seto masyang, Gurans*
Humla	Ripa, Jaira, Lali	4	*Gurans, Masyang*
Kalikot	Khandachakra, Tadi	3	*Silti*
Mugu	Tauatuma, Nigale, Pina	3	*Gurans*
Pyuthan	Belbas, Dharmabati	3	*Chirbiremasyang*
Sub total		18	
Far-western development region			
Baitadi	Saprang, Baitadi, Bhatkanda, Ranga junaune	74	*Gurans, Masyang Grusu*
Bajhang	Hemantawada, Bhatekhola	2	*Gurans, Masyang*
Bajura	Thalthale, Murti, Martadi, Dhumkane, Dogdi, Atichand	68	*Ghoremas, Rangale mas, Seto masyang, Masyang*
Sub total		17	
Unknown -sites	Geta	2	*Gurans*
Total 29 districts		**136**	

Source: PGR unit, Agriculture Botany Division, NARC, Khumaltar

3.1.3 Germplasm collection for on-farm evaluation by the project

In 2006, ricebean germplasm was collected from a total of sixteen districts. This was done by mobilizing two local organizations, the SUPPORT Foundation (a local NGO working in the Far-western part of Nepal) and the Rapti Agriculture Graduates Society (RAS)-Nepal (a local network of agricultural graduates in the Mid-western region). These two NGOs collected germplasm from eight and three districts of the Far- and Mid-western regions respectively. In addition, LI-BIRD and CAZS-NR (working with NARC) collected samples from another five districts in the Western and Central regions. In total, 156 landrace accessions were collected from 153 households in sixteen districts (Table 3.1.2)

Table 3.1.2: Districts and organizations involved in ricebean landrace collection in 2006

Name of district	No. of accessions	Collected by
Achham, Bajura, Baitadi, Bajhang, Dadeldhura, Doti, Darchula, Surkhet,	71	SUPPORT Foundation
Gulmi, Kaski, Palpa	48	LI-BIRD
Kavre, Nuwakot	17	CAZS-NR/NARC
Dang, Salyan, Pyuthan	20	RAS-Nepal
Total	**156**	

3.1. 4 Distribution of ricebean in Nepal

According to the DADO information, Tahanun has the highest area growing ricebean (378 ha, or 7% of the total legume growing areas in the district) followed by Ramechhap (300 ha, 9%), Palpa (269 ha, 11%) and then Baglung (265 ha, 24%). This indicates that the main areas of ricebean in Nepal are in the hills. The total area under ricebean is greater in the Western Development Region than in other parts of the country (Table 3.1.3), although there is no documentation available for several districts (this does not imply however that no ricebean is grown there).

Table 3.1.3. Area under ricebean by districts (ha)

District	Area (ha)	District	Area (ha)	District	Area (ha)
Eastern Development Region					
Bhojpur	13	Okhaldhunga	10	Solukhumbu	3
Dhankuta	10	Panchthar	8	Sunsari	1
Illam	8	Sankhuwasabha	12	Taplejung	7
Jhapa	0.5	Sapteari	Not documented	Terahathum	10
Khotang	15	Siraha	Not documented	Udayapur	10
Morang	2				
Total	**109.5**				
Central Development Region					
Bara	Not documented	Kavre	80	Ramechhap	300
Bhaktapur	Not documented	Lalitpur	Not documented	Rasuwa	Not documented
Chitwan	22	Mahottari	Not documented	Rautahat	Not documented
Dhading	31	Makawan-pur	30	Saptari	Not documented
Dhanusa	Not documented	Nuwakot	105	Sindhuli	267
Dolakha	70	Parsa	Not documented	Sindhupalchowk	120
Kathmandu	Not documented				
Total	**1025**				
Western Development Region					
Arghakhan chhi	150	Lamjung	115	Palpa	269
Baglung	265	Manag	Not documented	Parbat	20
Gorkha	11	Mustang	Not documented	Rupendhi	Not documented
Gulmi	130	Myagdi	12	Syanjya	250
Kapilbastu	Not documented	Nawalparasi	Not documented	Tanahun	378
Kaski	36				
Total	**1636**				
Mid-Western Development Region					
Banke	Not documented	Humla	Not documented	Pyuthan	21
Bardia	Not documented	Jajarkot	152	Rolpa	15
Dailekh	15	Jumla	Not documented	Rukum	
Dang	105	Kalikot		Salyan	30
Dolpa	Not documented	Mugu	Not documented	Surkhet	
Total	**338**				
Far-Western Development Region					
Achham	35	Bajura	50	Doti	5
Baitadi	25	Dadeldhura	4	Kailali	Not documented
Bajhang	50	Darchula	Not documented	Kanchanpur	Not documented
Total	**169**				
Nepal total	**at least 3277.5**				

Source: District Agriculture Development Offices, 2006/07

Based on Table 3.1.3, we grouped the 75 districts into three categories (Table 3.1.4). The first category (low) represents all those *terai*[1] and high hill and mountain districts with less than 40 ha area occupied by ricebean. The second category (medium) is those districts with between 40 and 90 ha area growing ricebean – all three of these are hill districts. Finally (high), there are twelve districts growing more than 90 ha of ricebean (Figure 3.1.1).

Table 3.1.4. Districts classified by area of ricebean grown. The figure in parenthesis is the number of districts (total districts = 75)

Category	Index	Districts
<40 ha	Low	Makawanpur, Pyuthan, Kaski, Dhading, Chitwan, Parbat, Salyan, Gorkha, Illam, Terahathum, Achham, Doti, Dadeldhura, Baitadi, Rolpa, remaining *Terai* and high mountain districts (60)
40-90 ha	Medium	Bajura, Bajhang, Dolakha (3)
>90 ha	High	Ramechhap, Tanahun, Lamjung, Palpa, Gulmi, Baglung, Dang, Nuwakot, Sindhupalchhok, Syanjya, Sindhuli, Arghakhanchi (12)

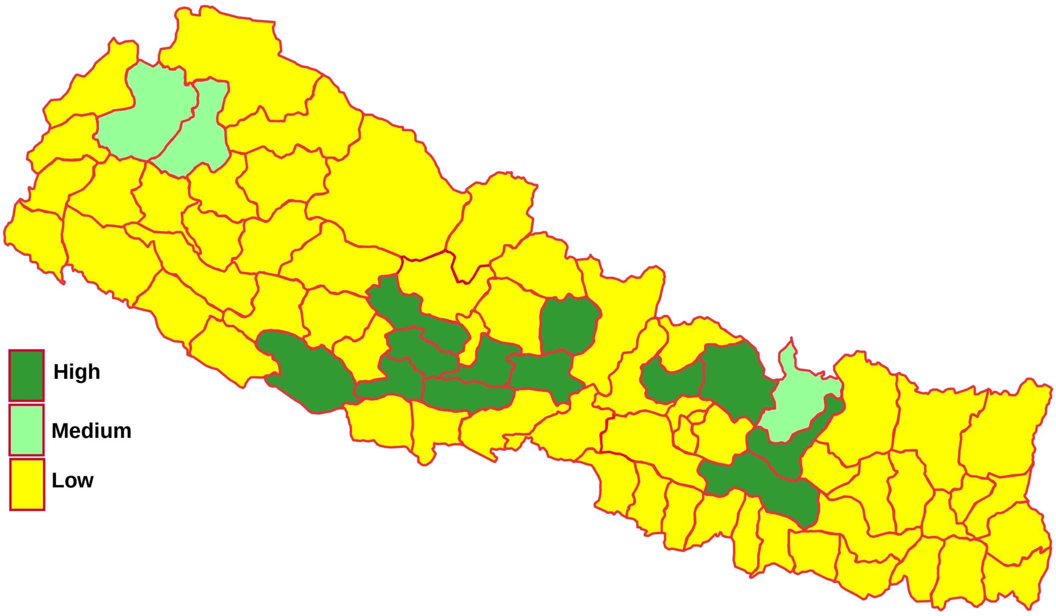

Figure 3.1.1: Ricebean crop distribution in Nepal (by area coverage)

3.1.5 Diversity of ricebean landraces

Based upon their own descriptors, farmers have recognised that there is very high diversity among ricebean landraces. Days to maturity, seed coat colour and grain size are the major traits used by farmers to identify and name the various landraces (Table 3.1.5).

3.1.6 Field visit to validate and assess ricebean diversity

The project team visited the high, medium and low districts identified from Table 3.1.4 to assess ricebean diversity and distribution. Discussions were held with DADO staff to identify

[1] The *Terai*, *Tarai* or *Madhesh* (Nepali:मधेश), or "moist land" is a 20 to 30 km wide band of flat and fertile land stretching from the east to the west of the country adjacent to India. It occupies about 17% of the total land and is home to almost 50% of the total population of Nepal.

potential VDCs [2] and small areas of ricebean in each district. We then organized a joint field visit to some of the areas to validate the information, assess diversity and collect germplasm. The diversity of ricebean landraces given to us by the farmers is presented in Table 3.1.6.

Table 3.1.5. Diversity of ricebean landraces in various parts of 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*

Table 3.1.6. Ricebean pocket areas and major diversity in various districts of Nepal

District	Small areas/VDCs	Major diversity	Local name
Western Development Region			
Tanahun	Ambu, Chhimkeshowri, Deurali, Dharampani, Chhipchhipe, Baidi, Kota, Virkot, Gajkot, Kinhu, Raipur, Firfire	*Kalo sano, seto sano, Chhirkemirke thulo, Chhirkemirke sano*	*Masyang*
Baglung	Paiyu Thunthap, Rangkhani, Sarkuwa, Jaidi, Chhisti, Narayansthan, Tityang, Siyana, Bhakunde, Resha, Biyu, Hatiya, Harichaur	*Chhirkemirke (sano), sano seto , Kalo sano, Khairo thulo, Rato sano*	*Siltung/Saltung/ Ratamas*
Gulmi	Darar Devisthan, Simichaur, Dubichaur, Birbas, Gaudakot, Hardineta, Baletaxar, Amorarbathok, Kharjyang, Digam, Ruru	*Bhadure, Rato, Seto, Chhirkemirke, Thulo pinyalo*	*Jhilinge*
Kaski	Hansapur, Nirmalpokhari, Kristi, Lahachowk, Parche, Lwangghalel	*Kalo sano, Chhirkemirke sano, Chhirkemirke thulo, Kalo thulo, Rato, Seto sano, Seto thulo, thulo pinyalo*	*Masyang*
Central			
Ramech-hap	Sukajor, Okhreni, Sunarpani, Himganga, Rampur, Ramechhap, Bhaluajor, Pakarbas, Makathum	*Chhirkemirke thulo (Bage), Rato, Seto sano, Kalo, Pahelo*	*Masyang*
Sindhuli	Bitijor, Bhuwaneshwori, Tinkanya, Ranichuri, Kapilakot, Dadigurase, Kamalamai Municipality	*Chhirkemirke, Seto, Khairo, Kalo*	*Masyang*
Dolakha	Sahare, Melung, Jafe, Chyama, Dadakharka, Bhedpu, Bhirkot	*Chhirkemirke, Seto, Khairo, Rato*	*Masyang*
Nuwakot	Not available	*Chhikemirke, Pahelo, Rato, Kalo*	*Masyang*
Mid-western			
Dang	Chailahi, Sishaniya, Tulsipur, Sonpur, Halwar	*Khairo, Seto, Chhirkemirke*	*Siltung, Jhilinge*
Surkhet	Uttarganga	*Chhikemirke thulo, Seto thulo*	*Siltung*

[2] VDC – Village Development Committee, the smallest political unit in Nepal

Table 3.1.6 (Continued)

District	Small areas/VDCs	Major diversity	Local name
Far-western			
Bajhang	Sunkuda, Deulekh, Shali	*Seto, Khairo,*	*Ghoremas, Gurans*
Bajura	Kada, Maltikode	*Seto, Khairo*	*Gurans*
Eastern			
Bhojpur	Not available	*Seto, Kalo, Rato, Chhikemirke (Bage)*	*Masyang*
Dhankuta	Not available	*Seto, Rato, Chhirkemirke*	*Ghoremas*

3.1.7 Production domains

In all parts of Nepal, ricebean is grown as a summer crop, and particularly across the *terai*, inner *terai* and the midhills it is very much a subsistence crop. Ricebean can be grown in a range of soil and climatic conditions from the east to the west of Nepal due to its wide adaptation. The crop is more common in the Western development region than in other parts of Nepal, and is best adapted to drought-prone east and south facing slopes in the range of 700-1400 masl. However, some landraces are being found at lower altitudes, between 300 and 600 masl. Ricebean is most often found in gravel mixed red to black soil. Intercropping with maize in uplands is the dominant cropping pattern in most of the areas where it is grown, but in some parts of the country it is also grown on rice bunds, particularly in the plains.

The crop is valued as food by poor people, in particular by those living in food deficit dry areas. It is has great potential as a crop for utilizing uncultivated marginal land, conserving biodiversity as well as contributing to the food and nutritional security of poor farmers, but for this to happen it is essential that consumer-preferred ricebean landraces or varieties should be identified.

3.2 India

In NW India mixed cropping of ricebean with maize is very common, particularly in the mid-hill areas of Himachal Pradesh and Uttaranchal. Very often, ricebean landraces as well as soybean, cowpea and horsegram (*Macrotyloma uniflorum*) and in some areas blackgram are commonly mixed with maize. In the NE it is grown as a sole crop, while in central and other lower parts of India it is grown either as a sole crop or mixed with maize, sorghum or cowpea. In western India particularly in Madhya Pradesh and Chhatishgarh, it is usually grown on bunds of the rice (*Oryza sativa*) fields.

In the NE of India, pigeonpea (*Cajanus cajan*), pea (*Pisum sativum*), ricebean, rajmash or kidney bean (Common bean, *Phaseolus vulgaris*), greengram, blackgram and lentil (*Lens culinaris*) have all been identified as suitable pulse crops. Ricebean is a very important pulse for the *kharif* (summer) season and is an integral component of the local *Jhum* (shifting cultivation) system.

3.2.1 Information from the literature

In India, the crop is mainly found in the Western and Eastern *Ghats* and the NE Himalayas, including Assam, Meghalaya, Mizoram and Manipur (Jain & Mehra, 1978) but is also grown in the sub-temperate western Himalaya in the Uttaranchal and Himachal Pradesh hills. Arora (1988) noted rich diversity in cultigens in the NE region and Eastern Himalayas, in particular, in the Assam plains and adjacent hill areas, and in N Bengal and Sikkim, and it is possible that introgression and folk selection have played a dominant role in the creation of ricebean's rich genetic variability and also in the evolution of present day landraces. Local ricebean landraces still exist in villages but the area under the crop in India is considerably declining each year. There are a number of reasons for this, including non-synchronous maturity, non availability of higher yielding varieties, and a problem of blister beetle (*Mylabris* spp.), one of the few serious pests to affect this crop.

The wild forms are widespread from Kerala through the Western and Eastern Ghats to the NW Himalayas and the NE (Bisht *et al*, 2005; Jain & Mehra, 1978) up to about 1500 m, with the main botanical source for the species being the humid tropical region of the western Ghats (Arora & Chandel, 1972). There is great variability in wild forms in the NE region[3], as well as sporadically in the Western Himalayas and the Eastern and Western Ghats (Arora, 1992).

3.2.2 Plant exploration and germplasm collection (NBPGR)

In India, germplasm collection was initiated by NBPGR, New Delhi during the 1960s, particularly from the north-eastern region (Thomas & Mathur, 1991), and NBPGR maintains the world base collection of ricebean germplasm (IBPGR, 1989). Between 1970 and 1976, Arora & Mehra (1978) sampled many crops including ricebean from fields, gardens and markets in north-east India (Assam, Meghalaya, Mizoram, Manipur and Arunachal Pradesh). Later, Arora *et al* (1980) evaluated over 300 collections of ricebean from the tribal-dominated mountains in the east and northeast between 1970 and 1979. They noted variation in a number of pod-related characters. Collections with high 100-seed weight were found in Assam and Meghalaya and comparatively early types were obtained from Assam. Collections from Meghalaya, Bihar and Assam had a particularly high protein content (>23%). Further collection was carried out in 1978 by Chandal (1981) in the Simla and Bilaspur hills and the Kulu-Manali region of Himachal Pradesh. Other collecting expeditions have been made by NBPGR as well as by scientific staff of the State Agriculture Universities and Research Institutes.

Table 3.2.1. Initial germplasm collection assembled at NBPGR, New Delhi

State/ region	**Indigenous collection**	**Exotic collection**	**Miscellaneous**
Assam	12		
Meghalaya	55		
Mizoram	35	120	16
Manipur	108		
Tripura	1		
Arunachal Pradesh	6		
Bihar	33		
Orissa	40		
North Bengal	50		
Sikkim	42		
Khasi hills, Himachal hills and Western Ghats	12		
Total germplasm	394	120	16
Total diversity collected		**530**	

Over 500 indigenous and exotic accessions were grown and evaluated at NBPGR during the 1970s (Chandel *et al*, 1988): a wide range of genetic variation was found and a number of promising accessions were identified. The most promising genotypes in the indigenous collections were IC-17656, IC-16706, IC-16710, IC-16751, IC-16771, IC-16772 and IC-14667 from the Northeastern and the Peninsular regions. Promising exotic introductions were

[3] The NE Region of India comprises eight states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, a distinct geographical entity with similar agroenvironments.

from PNG, Indonesia and other material received from USDA. The entire germplasm collection held at NBPGR, both indigenous and exotic accessions, was evaluated (Table 3.2.1) and analysis of the inter-regional diversity for a range of morphological attributes revealed rich variability within Indian germplasm (Chandel *et al* 1988).

Sarma *et al* (1991) evaluated 19 lines collected from Meghalaya and Mizoram under rainfed conditions on terraces. They found high broad sense heritabilities for 100-seed weight, days to maturity and pod length. Seed yield was strongly correlated with plant height, number of branches and number of pods per plant, and, at the genotype level, also with number of seeds per pod and days to 50% flowering. A number of the lines had a yield potential in excess of one t ha^{-1}, although there were highly significant genotype x year interactions for most traits. Sarma *et al* (2002) collected ricebean germplasm in Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and West Bengal, India during 1999-2002 and presented data on its characterisation.

3.2.3 Ricebean research in the All- India Coordinated Research Network on Underutilized Crops:

Table 3.2.2: Evaluation of ricebean entries in the Indian hills under the All-India Co-ordinated Research Network on Underutilized Crops

Genotypes	Plant height (cm)	Days to flowering	Mean maturity duration (days)	Mean 100 seed weight (g)	Mean grain yield (kg ha^{-1})
2005-06					
IVT					
BRS-1	111.6	72. 6	126.7	6.36	1054
Totru local	57.6	58.5	77.7	4.42	279
VRB-1	109.6	69.3	123.8	6.48	1178
VRB-2	81.8	75.2	129.6	4.60	591
PRR-1 (C)	102.0	70.1	125.6	5.69	1045
PRR-2 (C)	109.7	72.7	126.7	6.64	1054
RBL-1 (C)	114.8	74.4	132.7	6.93	788
RBL-6 (C)	116.0	75.4	133.2	6.53	867
2006-07					
IVT					
LRB005	124.8	72.8	125.3	6.12	935
LRB009	126.6	74.3	125.3	6.57	747
LRB010	1298.0	72.4	125.3	6.73	983
LRB013	128.3	74.5	125.0	6.40	976
LRB022	124.9	75.7	125.9	6.20	1204
LRB023	143.9	75.4	127.5	7.18	896
LRB035-1	125.3	74.1	127.7	6.29	732
RBL309	132.9	73.1	125.7	7.04	752
RBL334	126.9	70.1	122.4	7.19	843
RBL463	131.7	68.9	128.1	6.77	902
RBS16	129.5	83.0	138.2	9.25	376
AVT					
VRR-1	126.5	65.9	117.1	6.93	852
PRR-1 (C)	119.9	67.1	118.8	6.18	843
PRR-2 (C)	116.6	66.1	116.7	6.56	1017
RBL-1 (C)	133.7	68.7	122.5	6.55	844
RBL-6 (C)	131.0	69.7	125.7	6.58	763

In this project, evaluation of ricebean genotypes is being undertaken at a number of different locations in India. Initially, genotypes are tested in Initial Varietal Trials (IVT) and thereafter promising genotypes are further evaluated in Advanced Varietal Trials at different locations. The testing sites in the Northwestern Hills are Almora, Bhowali, Ranichauri (Uttrachal) and

Palampur (Himachal Pradesh). In the plains, testing is carried out at Ambikapur (Chhattisgarh), Bangalore (Karnataka), Bhubaneswar (Orissa), Faizabad (Uttar Pradesh), Hisar (Haryana), Ludhiana (Punjab), Mettupalayam (Tamilnadu), Rahuri (Maharashtra), Ranchi (Jharkhand) and S.K. Nagar (Gujarat). The performance of some of the entries tested in the Northwestern hills during 2005-06 and 2006-07 is listed below (Table 3.2.2).

3.2.4 Crop improvement work in India

Large G x E interactions are a problem in improvement work for the crop (Dobhal & Gautam, 1994; Gyanendra Singh *et al*, 1998;Shukla et al, 2003), but there is a great deal of variability within the species for a wide range of traits, including yield components and phenology (Borah *et al*, 2001; Chandal *et al*, 1988; Mal & Joshi, 1991; Sarma *et al*, 1991; Singh *et al*, 1997). Heritability appears to be good for 100-grain weight, seedling height, grain yield, days to flowering and maturity, and number and dry weight of nodules (Borah *et al*, 2001; Devi & Singh, 2006; Gyanendra Singh *et al*, 1992). Grain yield is correlated with number of pods per plant and number of seeds per pod, total biomass, and the number and dry weight of nodules per plant (Borah *et al*, 2001Gyanendra Singh *et al*, 1992;), and also with number of branches, clusters, pod length and 100-seed weight (Borah *et al*, 2001). Height may be positively (Borah *et al*, 2001) or negatively (Singh *et al*, 1997) correlated with yield, and there appears to be a negative correlation between days to maturity and yield (Singh *et al*, 1997) which points to the possibility of developing early maturing types without yield reductions.

Identification of germplasm in India is complicated by a tendency to rename varieties when they are used at a new institution. Hybridization at NBPGR between an early variety from China, a bold seeded variety from Mysore, India, and a yellow seeded variety from Nepal led to the development of several promising lines combining earliness and high yield (Mal & Joshi, 1991). One, C × M12 P3 was capable of producing up to 2.5 t ha^{-1} grain yield and held promise for cultivation in the hills. A variety RBL-1 was developed at PAU, Ludhiana through single progeny selection and released for Punjab state, and RBL-6 has also been released (Mal *et al*, 1996). Other introductions which gave consistently superior performance in north India conditions included EC-93452, EC-101887, PI-247685 and PI-247693. The variety Konkan rice bean-1 (RB-10, possibly the same as KRB-1), a fodder type cultivar, was developed by single plant selection through multi-environment testing in Maharashtra (Thaware *et al*, 2005). The varieties BRS-1, BRS-2 (bred at the NBPGR Research Station, Bhowali, Uttrachand) and Naini have been released for hill land. Another variety, Bidhan (K-1) has also been released nationally (Shukla *et al*, 2003). There is a report in the literature of extra-early varieties (38 – 40 days earlier to mature than normal genotypes) being developed at Hisar, Haryana (Gupta *et al*, 2002) but there appears to be no other information on these.

Mutation breeding using gamma radiation in three cultigens from Manipur (RBM-6, RBM-13 and RBM-31), produced two dwarf mutants from RBM-6 (less than 50% of the height of the parent), and an early maturing mutant (120 vs 154 d) of RBM-13 in the M_2 generation (Devi & Singh, 2006). Highly induced variability was seen for clusters, pods and grain yield.

Gyanendra Singh *et al* (1998) identified stable genotypes as RCRB1-301 and EC-18585 for days to flowering, RBL-2, RBL-35 and RCRB1-301 for days to maturity and IC-16807, S-10 and EC-18585 for plant height, and Dobhal & Gautam (1994) identified RB-49 and RB-40 as the most stable and highest yielding of eleven genotypes.

Singh *et al* (1999) identified combinations of parents for various breeding objectives: RBM-1 x RBM-10 for shorter height, early flowering and greater number of seeds per pod, RBM-10 x RBM-17 for increased number of primary branches per plant, RBM-11 x RBM-17 for a higher number of pods per plant and seed yield per plant, and RBM-31 x RBM-17 for greater pod length and seed weight.

A list of the around 100 genotypes identified in India is given in the appendix – it is however highly likely that some of the designations refer to the same genotype, and the vast majority of these are likely to be landraces.

3.2.5 Germplasm collection in FOSRIN

Exploratory visits were made by project staff to ricebean growing areas in Himachal Pradesh (HP), Assam, Manipur, Nagaland, Arunachal Pradesh and Madhya Pradesh in order to collect germplasm (Table 3.2.3). The material collected is summarised in Table 3.2.4.

Table 3.2.3: Districts in which ricebean germplasm was collected in India, 2006 - 2007

Districts	Accessions collected	Collecting agency
NE Region: Tirap, Mokochung, Tuli, East Imphal, Karbi Anglong	25	AAU
Himachal Pradesh: Solan, Bilaspur, Kangra, Mandi	48	CSKHPKV
Madhaya Pradesh: Jhabua, Barwani, Dhar, Mandla	16	GVT

During exploration, passport data (name and addresses of the farmers, plant type, seed colour and size and average yield in the region) were collected.

Table 3.2.4: Germplasm collection in India, 2006 - 2007

Landrace	Seed colour	Seed size	Landrace	Seed colour	Seed size	Landrace	Seed colour	Seed size
Himachal Pradesh								
Chibroo 1	Greenish	Medium	Darin C 1	Greenish	Small	Dasehra1	Greenish	Medium
Chibroo 2	Blood red	-do-	Darin C 2	Light brown	Medium	Dasehra2	Blood red	-do-
Chibroo 3	Brown	-do-	Darin C 3	Greenish	Small	Dasehra3	Light brown	-do-
Chibroo 4	Greenish	-do-	Darin C 4	Dark brown	Small	Dasehra4	Greyish	-do-
Chibroo 5	Grayish	-do-	Darin D 1	Dark brown	Medium	DhabanA 1	Brown	Small
Darin A 1	Greenish	-do-	Arki 1	Greenish	-do-	DhabanA 2	Greenish	Small
Darin A 2	Blood red	-do-	Arki 2	Blood red	-do-	DhabanA 3	Brownish	Medium
Darin A 3	Light brown	-do-	Arki 3	Dark red	-do-	DhabanA 4	Light green	Small
Darin A 4	Brown	-do-	Trilokpur 1	Greenish	-do-	DhabanA 5	Blackish green	Bold
Darin A 5	Light brown	-do-	Trilokpur 2	Blood red	-do-	DhabanB 1	Blackish green	Medium
Darin A 6	Dark brown	-do-	Trilokpur 3	Greyish	-do-	DhabanB 2	Greyish	-do-
Darin B 1	Greenish	Small	Trilokpur 4	Brown	-do-	Palampur 1	Greyish	Bold
Darin B 2	Brown	Medium	Nagrota 1	Dark greyish	Bold	Palampur 2	Black	-do-
Darin B 3	Greenish	-do-	Nagrota 2	Light greenish	-do-	Palampur 3	Light brown	-do-
Darin B 4	Blood red	-do-	Nagrota 3	Greyish black	Medium	Palampur 4	Dark brown	-do-
Darin B 5	Light brown	-do-	Nagrota 4	Light brown	-do-			
Madhaya Pradesh								
Jhabua 1	Light yellow	Medium	Barwani-1	Brown	Medium	Dhar-1	Brown	Small
Jhabua 2	Brown	Small	Barwani-2	Light brown	Medium	Dhar-2	Yellow	Medium
Jhabua 3	Yellow	Bold	Barwani-3	Yellow	Small	Mandla-1	Yellow	Small
Jhabua 4	Grey	Medium	Barwani-4	Brown	Bold	Mandla-2	Yellow	Bold
Jhabua 5	Brown	Bold	Barwani-5	Variegated	Medium			
Jhabua 6	Yellow	Small	Barwani-6	Black	Bold			
AAU Jorhat								
JCR-06-1	Blackish	Bold	JCR-07-5	Yellowish	Small	JCR-07-14	Wine red	Medium
JCR-06-2	Blackish brown	Bold	JCR-07-6	Reddish brown to yellowish brown	Medium	JCR-07-15	Greenish yellow	Medium
JCR-06-3	Blackish	Medium	JCR-07-7	Light yellow	Bold	JCR-07-16	Black smoky	Bold
JCR-06-4	Blackish	Bold	JCR-07-8	Blackish	Bold	JCR-07-17	Yellowish brown	Bold

Table 3.2.4 (Continued)

Landrace	Seed colour	Seed size	Landrace	Seed colour	Seed size	Landrace	Seed colour	Seed size
JCR-06-5	Reddish brown	Bold	JCR-07-9	Wine red	Bold	JCR-07-18	Reddish brown	Bold
JCR-07-1	Yellowish	Medium	JCR-07-10	Black smoky	Bold	JCR-07-19	Black smoky	Bold
JCR-07-2	Yellowish brown	Medium	JCR-07-11	Black smoky	Medium	JCR-07-20	Yellowish	Bold
JCR-07-3	Blackish	Medium	JCR-07-12	Yellowish	Medium			
JCR-07-4	Yellowish green	Medium	JCR-07-13	Blackish	Medium			

3.2.6 Distribution of ricebean in India

Although ricebean is not reported as a separate species in either the Statistical Abstract of India, or in the statistics from individual States, an attempt has been made to show its distribution through India based upon the literature and other methods noted in Table 2.1. The national distribution is shown in Table 3.2.5 and Figure 3.2.1.

Table 3.2.5: States reported to be growing ricebean in India

Spread of the crop	States with the crop reported
High	Assam, Meghalaya, Manipur, Nagaland, Mizorum, parts of Arunachal Pradesh, hill regions of North Bengal, Sikkim and Orissa
Medium	Himachal Pradesh, Uttranchal, Chattisgarh, Jharkhand, Madhya Pradesh
Low	Kerala, Tamil Nadu, Gujrat, Punjab, Maharashtra, Haryana, Jammu & Kashmir , Karnataka , Andhra Pradesh, Andaman and Nicobar Islands

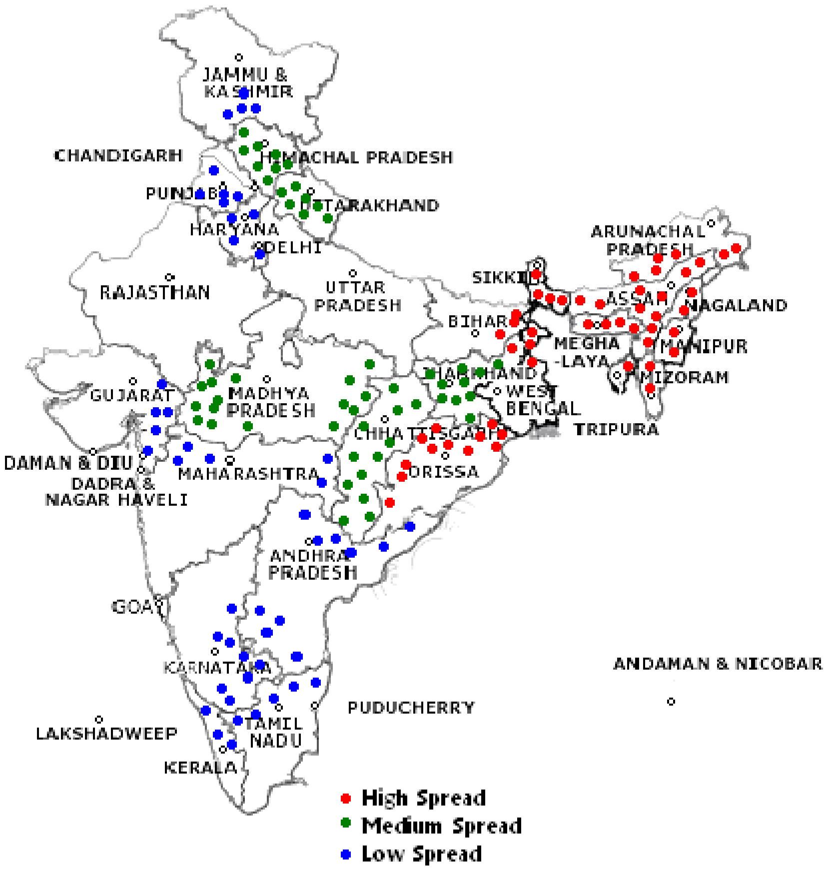

Fig 3.2.1: Ricebean distribution in India

3.2.6.1 Northwestern Himalaya

According to the survey conducted in the project, and from information collected from the various sources noted in Table 2.1, ricebean is mainly confined to the mid and low hills of Himachal Pradesh. It is also grown to some extent in Uttrakhand and Jammu and Kashmir, as well as in Punjab and Haryana. In HP it is grown particularly in Mandi, Bilaspur, Solan and Sirmour districts, as a mixed crop with maize. It is grown to a lesser extent in Kangra and Hamirpur districts, and only small areas are found in the high hills in Shimla and Chamba districts (Table 3.2.6, Figure 3.2.2). Areas within districts in HP are shown in Table 3.2.7.

In Uttranchal, ricebean is grown as a mixed crop with maize, and occupies 10% of the total pulse growing area in the state. Its cultivation is mainly concentrated in Tihari and Garhwal areas and the area grown declines through the Kumaon hills towards Almora and Nainital.

Table 3.2.6: Districts with high, medium and low areas of ricebean in NW India

Category	Districts
Himachal Pradesh	
High coverage	Solan, Mandi, Sirmour, Bilaspur
Medium coverage	Hamirpur, Kangra
Low coverage	Chamba, Shimla
Uttaranchal	
High coverage	Tihari, Garwhal
Medium coverage	Kumaon
Low coverage	Nainital, Almora

From the sparse information available, it appears that the crop is rarely cultivated in Punjab, Haryana and Jammu and Kashmir. Although RBL-1, developed at PAU, Ludhiana has been released for that Punjab, there is very little ricebean cultivated in these States.

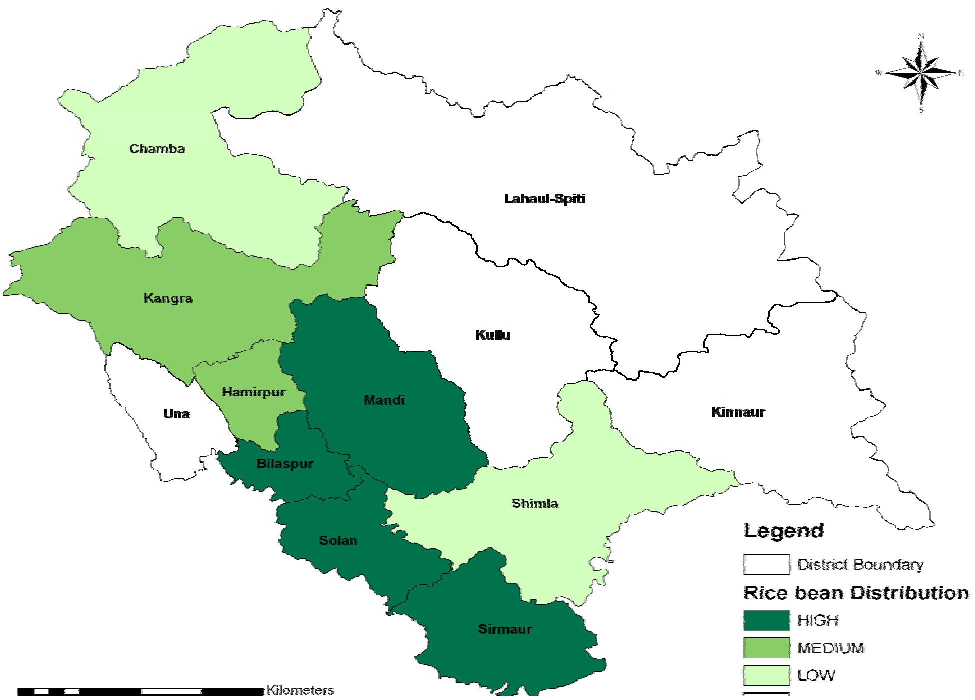

Fig 3.2.2. Ricebean distribution in Himachal Pradesh (India)

Table 3.2.7. Areas of ricebean cultivation in different districts of Himachal Pradesh (India)

District	Areas grown
Mandi	Sarkaghat; Baldwara; Triphalghat; Rewalsar – Leda – Desehra; Halyatar Belt; Kotli; Joginder Nagar –Padhar- Darang Belt; Dhawan - Baggi Belt
Bilaspur	Kuthera - Ghumarwin-Berthin Belt; Jandhoota; Chandpur- Bilaspur Belt
Sirmour	Naina Tikkar - Sarahan Belt; Pachhad; Paonta Sahib – Saton - Shelai Belt
Kangra	Panchrukhi; Jawali area; Khudian; Trilokpur
Solan	Arki; Bhararighat –Piplughat - Daralaghat Belt
Hamirpur	Awah Devi; Barsar
Shimla	Rampur – Sarahan Belt
Chamba	Salooni

3.2.6.2 Northeastern region and other parts of the country

In the NE region, ricebean is grown predominantly under rainfed conditions in mixed farming systems, under shifting cultivation (*Jhum*), or in kitchen gardens and backyards, particularly in Assam, Meghalaya, Manipur, Mizoram, Arunachal Pradesh and Nagaland, in the hilly regions of north Bengal and Sikkim. It is also grown in the eastern peninsular tract – parts of Madhya Pradesh and Chhatishgarh, and sporadically in Gujarat, Karnataka, and Andhra Pradesh. There are no reports of ricebean cultivation in Rajasthan. There is one report (Gangwar & Jayan, 1986) of ricebean being introduced to the Andaman and Nicobar Islands, although it is not know if it is still cultivated there.

As a result of its high fodder production potential (up to 35 t ha^{-1}), ricebean is now attracting attention as a leguminous fodder crop in Kerala, Orissa and West Bengal. As a fodder crop ricebean is sown in February-March or July-August and harvested either when the crop attains maximum vegetative growth or at flowering.

In addition, experimental work on ricebean has been carried out all over India, from Haryana (Khabiruddin *et al*, 2002; Lokesh *et al*, 2005a, 2005b) to West Bengal (e.g. Chakrabarti & Bhattacharya 2005a, 2005b), and south to Maharashtra (e.g. Patil & Jadhav, 2006a, 2006b; Thaware *et al*, 2005) and Karnataka (e.g. Rudragouda & Angadi, 2002)

3.2.7 Diversity of ricebean landraces

Considerable diversity is present in the local landraces, and a mixture of these is normally grown. The diversity has been noted by farmers (Tables 3.2.8 & 3.2.9), based upon their own descriptors (generally seed coat colour and grain size), as well as in formal studies.

Table 3.2.8: Farmers' descriptors for the identification of landraces in India

Character	Variability
Growing habit	Semi spreading
Maturity	Non-synchronous: early (< 95 days); medium 95 – 120 days; late > 120 days
Length of pods	4-7 cm
No. of grain per pod	4 - 10
Grain colour	Creamish yellow; creamish green; brown; light brown; chocolate; greyish mottled; maroon; black
Seed size	Small (100 seed weight = 3-5g) Medium (100 seed weight = 6-8g) Bold (100 seed weight > 8g

Ricebean has been variously referred to in English as redbean, climbing mountain bean, Mambi bean and oriental bean. In Hindi, it is called '*Sutari*', and in the hills of Himachal Pradesh and Uttaranchal is popularly known as *Rajmoong, Naurangi, Satrangi, Moth* (not to be confuse with *V. aconitifolia*), *Haramah* and *Paharimah*. In eastern India it is known by different names in different areas, for example *Bejiamah* (Assam), *Nagamah* (Arunachal Pradesh), *Bete* (Mizoram), *Jami* and *Agukzungken* (Nagaland) and *Chak hawai* (Manipur).

3.2.8 Production domains of ricebean

In all parts of the Northwestern Himalaya ricebean is grown as a *Kharif* (summer) crop during June and harvested in October-November. The crop has an advantage over other pulses in that it is free from the common pests and diseases of these crops, although in recent years blister beetle (*Mylabris spp*) and *Anthracnose* have appeared in high rainfall environments on heavy soils, and these are becoming a major threat to ricebean. This crop can withstand heavy rains but is susceptible to waterlogging. Ricebean is best suited to the low and mid hills of the Northwestern Indian Himalaya, representing subtropical to sub-temperate climatic conditions, a region in which mixed cropping with maize is the dominant cropping pattern.

Table 3.2.9: Variability of Indian ricebean landraces based upon farmers description

Name of the state/ landraces	Distinguishing traits	Positive traits	Negative traits
Manipur			
Angoubi	Seed bold and white	Good cooking quality	
Arangbi	Seed bold, black & white	Good taste	
Arangbi macha	Seed small, black & white	Not good as above	Trailing habit
Nagaland			
Tanakla	Seed small /bold, black	Good taste	
Temusingla	Seed small /bold, white	Good taste	
Teremla	Seed bold, wine red	Good taste	
Assam			
Thengbon	Seed bold, black	Good taste	
Thengbouso	Seed small, yellow	Good taste	
Madhaya Pradesh			
Mathia	Small seed, brown, medium maturity	Good taste	
Himachal Pradesh			
Mixture of landraces	Small, bold seed/ black, white	Good taste	

In the Northeastern region of India it is grown in both *kharif* and *rabi* (the winter season), generally as a sole crop. In the central and other regions of India it is generally grown either as a sole crop or mixed with maize, sorghum or cowpea. In eastern Madhya Pradesh and Chhatishgarh regions it is mainly grown on the bunds of the rice fields.

4. Conclusions

Clearly ricebean is a potentially valuable multipurpose (grain, fodder and green manure) crop for farmers in the marginal hill areas of Nepal and northern India, as well as in third countries with similar environments. In both India and Nepal ricebean is a rainfed crop found particularly in hill areas, and is most common under intercropping, although some sole crops are grown. It would be valuable if future germplasm collection expeditions were to use GPS to map the location of their accessions.

The large range of diversity available in both countries suggests that there is excellent potential for breeding to improve the crop for a number of the traits desired by farmers, and so to promote its use more widely. The classification by farmers in both countries in terms of preferred traits (time to maturity, grain size and colour, growth habit) should be particularly useful in identifying genotypes for use as parents in breeding programmes.

It is essential that the existing germplasm is catalogued accurately, and that it is made available for plant breeders in both India and Nepal for the benefit of farmers in both countries. The molecular analysis being undertaken in FOSRIN should enable the landraces to be identified accurately, and prevent resources being wasted on duplicate material – as a corollary to this steps need to be taken to standardise varietal nomenclature, in particular in India.

In view of the volume of work that has been carried out in India already, and the large number of institutions apparently working on the crop, it would add considerable value to the work of FOSRIN if it were possible for ricebean scientists from India and elsewhere to attend the final workshop.

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Appendix 1: Indian ricebean cultivars and cultigens identified from the literature

Name	Origin	Area tested	Comments	Reference
Bidhan-1		West Bengal	Response to S and salinity.	Mandal et al, 2002
Bidhan-1		West Bengal	Effect of lime on forage yield and quality on an oxisol	Mandal et al, 2001
Bidhan-1 (K-1)		Bihar (Ranchi), Orissa (Bhubaneswar), West Bengal (Kalyani)	Released nationally	Shukla et al, 2003
K-1		West Bangal	Response to P and effect on next wheat crop	Patra, 2001
KHRB1		Karnataka (Dharwad)	Agronomic trial	Rudragouda et al, 2005
KHRB-1		Karnataka (Dharwad)	Forage trial	Rudragouda & Angadi, 2002
KHRB-3		Haryana (Hisar)	High methionine	Khabiruddin et al, 2002
KRB-1		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-2		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-2		Bihar (Ranchi), Orissa (Bhubaneswar), West Bengal (Kalyani)	Well adapted	Shukla et al, 2003
KRB-3		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-4		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-5		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-5		Bihar (Ranchi), Orissa (Bhubaneswar), West Bengal (Kalyani)	Adapted to better environments	Shukla et al, 2003
KRB-6		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-7		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b

Name	Origin	Area tested	Comments	Reference
KRB-8		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-9		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-10		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-12		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-13		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-13		Bihar (Ranchi), Orissa (Bhubaneswar), West Bengal (Kalyani)	Adapted to poorer environments	Shukla et al, 2003
KRB-14		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-16		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
KRB-18		West Bengal	Genetic variability Forage + yield characters	Chakrabarti & Bhattacharya 2005a Chakrabarti & Bhattacharya 2005b
L-1		Karnataka (Bangalore)	LD50 from mutagens	Prakash & Shambhulingappa, 2000
LRB-31-5		Maharashtra	Inoculation with rhizobia N fixing ability	Patil & Jadhav, 2006a Patil & Jadhav, 2006b
PDRB-1		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RB-4		New Delhi	Effect of intercropping and insecticide	Satyanarayana et al, 2001
RB-6		Maharashtra	Fodder type	Thaware et al, 2005
RB-10 (Konkan rice bean 1)	Maharashtra selection	Maharashtra	Fodder type, released in Maharashtra	Thaware et al, 2005
RB-32			Antinutrients	Saharan et al, 2002
RB 58		Haryana	Crossed with mung bean	Singh et al, 2006
RBH-10		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-1	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-1		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)

Name	Origin	Area tested	Comments	Reference
RBL-1		Haryana (Hisar)	High sugar, low starch	Khabiruddin et al, 2002
RBL-1		Bihar (Ranchi)	Intercropping with teosinte	Choubey et al, 2000
RBL-1 + 14 others	PAU Ludhiana	Orissa	Pod borer resistant	Mandal, 2005
RBL-10	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-13	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-2	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-2		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-3		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-4	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-5	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-6	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-6	PAU Ludhiana	Karnataka (Dharwad)	Agronomic trial	Rudragouda et al, 2005
RBL-6		Karnataka (Dharwad)	Forage trial	Rudragouda & Angadi, 2002
RBL-6		Orissa (Bhubaneswar)	Response to row spacing and P	Khanda et al, 2001
RBL-6		Haryana (Hisar)	Seed yield components Genotypic divergence Path coefficient analysis, morphology and quality Correlation of morphology and quality	Lokesh et al, 2005a Lokesh et al, 2005b Lokesh et al, 2003a Lokesh et al, 2003b
RBL-7	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-9		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-20		Haryana (Hisar)	High sugar	Khabiruddin et al, 2002
RBL-23	PAU Ludhiana		Nutritional evaluation. Low protein, S-amino acids and tryptophan	Sadana et al, 2006
RBL-33-1		Haryana (Hisar)	High protein	Khabiruddin et al, 2002
RBL-35	PAU Ludhiana		Nutritional evaluation. High protein and amino acid content	Sadana et al, 2006
RBL-35			Crossed with mungbean	Sidhu & Satija, 2003
RBL-35		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-35		Haryana (Hisar)	High protein, best quality overall	Khabiruddin et al, 2002
RBL-37	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-40	PAU Ludhiana		Nutritional evaluation	Sadana et al, 2006
RBL-50		Haryana (Hisar)	High methionine, high starch	Khabiruddin et al, 2002
RBL-50		Karnataka (Bangalore)	LD50 from mutagens	Prakash & Shambhulingappa, 2000
RBL-52		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-70		Bihar (Ranchi)	Effect of row spacing on yield	Srivastava & Srivastava (2003)
RBL-99		Haryana (Hisar)	High protein	Khabiruddin et al, 2002
RBL-141			Crossed with mungbean	Sidhu & Satija, 2003
RBL-167			Crossed with mungbean	Sidhu & Satija, 2003

Name	**Origin**	**Area tested**	**Comments**	**Reference**
RBL-202		Haryana (Hisar)	High methionine	Khabiruddin et al, 2002
SRBS-43		Orissa (Bhubaneswar)	Yield and nutrient uptake response to N and P	Khanda et al, 1999
SRBS-50		Haryana (Hisar)	High protein	Khabiruddin et al, 2002
SRBS 113		Orissa	Pod borer resistant	Mandal, 2005
SRBS-368		Maharashtra (Tirupati)	Double cropping potential	Lakshmi & Murthy, 2001
V1 (KS-7 x BC-15)		West Bengal	Seed production	Mukherjee et al, 2004
V2 (KR-33 x KS-7		West Bengal	Seed production	Mukherjee et al, 2004
V3)KR-21 x KS-6)		West Bengal	Seed production	Mukherjee et al, 2004
V4 (KR-13 x BC-15)		West Bengal	Seed production	Mukherjee et al, 2004