Rice Gene Pool for Tarai and Inner Tarai Areas of Nepal

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ABSTRACT

Knowledge on crop gene pool helps to develop varieties, to know the potential sources for breeding materials and to develop strategy for sustainable use and conservation. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool, existing landraces and wild species. The objective of this research was to study the diversity of rice gene pool present in the Nepalese improved rice cultivars and landraces adapted to Tarai and Inner Tarai (<1000 m). Pedigrees of 28 Nepalese rice cultivars were examined and surveyed the literature for distribution of landraces and wild relatives of rice. Crosses among *indica* rice gene pool are more common and use of *japonica* and *nivara* species were less common. There are 28 improved rice cultivars, >500 landraces, and 6 wild species and relatives of rice adapted to Tarai and Inner Tarai. Eight countries are the origins for 28 cultivars. In Nepal 4 cultivars were bred and developed using a local landrace and exotic genotypes. A total of 35 ancestors originated in 11 different countries were used to develop these 28 cultivars. Highest number of ancestors was from India. Use of ancestors of both *sativa* and *nivara* species having *indica* and japonica types indicated the collection of wide gene pool. Most of the ancestors were *sativa* (60.00%) and *indica* (65.71%). Genetic erosion is observed in rice diversity therefore, *in situ*, on farm and *ex situ* conservations are necessary for maintaining the genetic variation. Utilization of local landraces in breeding program may be the good way of genetic resources conservation. Gene pool from these landraces along with international gene pool could make towards success in developing high yielding cultivars with wide adaptability and/or site specific. In this study, cultivars and landraces surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity is very useful for further rice improvement and should be conserved both *ex situ* and *in situ*.

Key words: Ancestor, Landrace, Nepalese rice cultivar, Rice gene pool, Tarai and Inner Tarai

INTRODUCTION

Rice is a staple food crop and plays an important role in Nepal's economy. Different kinds of landraces and wild rice in Nepal are reported by Mallick (1981/82), Sherchand et al (1998), Joshi et al (1998), Shrestha and Upadhyay (1999), Rana et al (2000a, 2000b, 2000c), Adhikari et al (1995) and Gupta et al (2000). About 2000 rice landraces are reported in Nepal growing from 60 to 3050 m altitude (Mallick 1981/82). Rice samples of 500 years ago are found at Simraungardh, Bara (Mallick 1981/82) which support the statement that Nepal is one of the centers of rice diversity. During mid 1960s the yield potential of semi dwarf high yielding varieties initiated a scope for raising rice production in the country. Several exotic varieties were obtained through IRRI and Taiwan (NRRP 1997a). Rice research was initiated in 1951 (Mallick 1981/82) and National Rice Improvement Program was established in 1972 at Parwanipur to organize the research and development works on rice as a commodity crop. So far there are 48 improved rice cultivars recommended for cultivation. Among them 28 are recommended for Tarai, Inner Tarai and Foot Hills of Nepal.

Genetic diversity is necessary to derive different transgenic segregants suitable for different agro-ecology and to meet the needs of farmers. The main source of the diversity for development of modern varieties is the traditional varieties that have been grown and selected for generations by rice farmers. All modern varieties can be traced back to landraces. Both the potential for long term genetic gain and the reduction of genetic vulnerability may depend on the genetic diversity present in the genetic base of the crop. The amount of genetic diversity presents depends on the number and diversity of the original ancestors involved in the creation of a germplasm pool, existing landraces and wild rice and their relatives. The level of genetic variation present in gene pools of most important crops has been analyzed by studying the pedigree relationship between cultivars. Kinship coefficients estimation of cultivars of oat (Souza and Sorrells 1989), soybean (Cox et al 1985a), wheat (Joshi et al 2004), winter wheat (Cox et al 1985b), rice (Dilday 1990) and barley (Martin et al 1991) has shown that a restricted number of ancestral genotypes account for a large proportion of the variation present in released cultivars. The pedigrees of IRRI varieties upto 1994 have been traced back to 40 landraces from 12 different countries (de Leon and Carpena 1995). Diversity of rice considering ancestors of cultivars, wild relatives and landraces should be assessed for effective conservation and utilization of rice gene pool. Information on cultivars diversity based on pedigrees is useful for risk assessment on concern cultivar. Equally, such types of analysis explain how the breeders are able to capture genetic diversity in a cultivar. Therefore study was focused here on landraces and wild rice diversity and its distribution in Nepal and countries from where genes were introduced through improved cultivars in Nepal particularly in Tarai and Inner Tarai areas.

METHODOLOGY

In this study basically diversity on landraces in terms of their name, improved cultivars in terms of their ancestors and origin and wild rice in terms of species distribution were assessed. Literature related to rice exploration, improved cultivars recommended for Tarai and Inner Tarai and Nepalese landraces adapted to Tarai and Inner Tarai and wild rice and their relatives were reviewed. Three sites, National Rice Research Program (NRRP), Haridnath; Regional Agriculture Research Station, Parwanipur, and Plant Genetic Resources (PGR) Unit, Khumaltar were visited. PGR Unit has collected and conserved many rice landraces. Rice genotypes available in Nepal were categorized under four groups 1. Landraces, 2. Improved cultivars, 3. Ancestors of these cultivars and 4. Wild rice and their relatives. Unique and endangered rice landraces were compiled. Based on collection data, landraces and wild species distribution were indicated in Nepal map. Landrace diversity based on different name was compiled with respect to districts. It is assumed to estimate the landrace richness that rice landrace is different if the name given by farmer was different. Frequency of rice accessions collected from different districts and conserved in PGR Unit was computed. Altogether 28 cultivars had been released for Tarai and Inner Tarai and Foot Hills in Nepal from 1959 to 2002. Here in this study the pedigrees of these 28 cultivars were examined. Study shows that most of the cultivars were introduced either from IRRI or India. The pedigrees of these rice cultivars were traced back to their ancestors that had no known relationship with each other. One example of the cultivar back to ancestors is given in Figure 1. The source of improved cultivars, their pedigree and release dates were Mallick (1981/82), IRRI (1970, 1987, 2000a, 2000b), NRRP (1992, 1997a), NRRP (1997b) and IRRI (GEU). Origin of ancestors, their group and species were identified. Diversity was studied on improved cultivars based on their origin, types and number of ancestors and ancestors' types. Countries from where the genes introduced in Nepal were located in world map based on the origin of ancestors of Nepalese improved rice cultivars.

RESULTS AND DISCUSSION

The land in Nepal has the largest variations in altitude in the world. Three types of land *Bari*, *Khet* and flat and fertile with good soil depths produce rice indicating the diverse rice genotypes adopted to different production environments. Rice is grown mainly as *Barkhe* crop sown in June/July and harvested in Sept/Oct. It is also grown as *Hiunde* (winter rice popularly known as Boro rice) and Chaite dhan. Due to the varied agroecological diversity of the country, it is possible to plant same cultivar in *Barkhe*, *Hiunde* and *Chaite* seasons. Nepal posses many diversity in rice however, under the CGIAR system Nepal received a lot of rice genotypes. Landraces are diverse in maturity period, photoperiodism, growing seasons, adaptation to different cropping systems and cultural practices and dormancy. Rice can be observed in the field all year round somewhere in Nepal.

Exploration and collection

Ten international exploration missions have targeted cultivated and wild rice species in Nepal (Upadhyay and Joshi 2003). Forty exploration programs were carried out in different parts of Nepal to collect different crops species by international organizations from 1937 to 2000. The countries/ organizations involved in exploration missions are Germany, Japan, UK, IRRI, FAO, IBPGR and USAID. A total of 1550 different rice varieties from Nepal have been collected from altitude of 60-3050 m and conserved at IRRI, Philippines (Shrestha and Vaughan 1989). National organizations mainly by Agriculture Botany Division (ABD), Khumaltar had explored different crop species 22 times in different parts of Nepal. They have targeted 7 times to rice both cultivated and wild from 1981 to 2000 (Gupta et al 2000). There are 615 landraces, which are differed by name collected from Tarai and Inner Tarai and conserved in ABD. These are collected from different altitude ranging from 65 to 1000 m. There may be many landraces that are genetically same but differed only by name or vise versa. These need to verify. ABD has 2963 accessions of rice landraces and 144 accessions of wild rice collected from all over the country (Gupta et al 2000). These are conserved ex situ at medium term storage facility in Khumaltar.

Landrace gene pool

ABD has representative rice landraces from 73 districts of Nepal (Table 1). Highest number of rice accessions among the 33 Tarai and Inner Tarai districts was collected from Sunsari (3.88% of total accessions) followed by Dhanusha (3.37%), Parsa and Bara. Collection sites of 197 accessions were not known. Sunsari, Dhanusha, Parsa and Bara may be the focal area in term of rice landraces diversity in Tarai and Inner Tarai. Lumle Agriculture Research Station (LARS) and NRRP, Hardinath have also maintained some landraces and ABD has 1608 accessions of rice adapted to Tarai and Inner Tarai. There may be duplicate accessions in these three places. Removing duplicate accessions and adding new one should be made continuously. Extensive survey and duplication study of accessions could help to control genetic erosion and conservation cost. Many of these landraces are still grown by farmers. These landraces have a wide range of natural adaptation to withstand varied abiotic and biotic conditions. In addition, these landraces have high tillering ability, withstand severe drought stress, have good quality grains and adapted to marginalized areas.

Table 1. Total rice accessions and frequency collected from different districts of Tarai and Inner Tarai of Nepal and conserved *ex situ*

SN	District	Accession, n	%	SN	District	Accession, n	%

A. Tarai and Inner Tarai districts				**B. Districts fall in both ecoregions**			
1	Banke	58	1.96	22	Arghakhanchi	28	0.94
2	Bara	84	2.83	23	Dandeldhura	33	1.11
3	Bardiya	12	0.4	24	Dhankuta	72	2.43
4	Chitwan	16	0.54	25	Doti	39	1.32
5	Dang	36	1.21	26	Ilam	56	1.89
6	Dhanusha	74	2.5	27	Makwanpur	22	0.74
7	Jhapa	100	3.37	28	Palpa	18	0.61
8	Kailali	23	0.78	29	Pyuthan	13	0.44
9	Kanchanpur	44	1.48	30	Sallyan	21	0.71
10	Kapilvastu	40	1.35	31	Sindhuli	20	0.67
11	Mahottary	74	2.5	32	Surkhet	31	1.05
12	Nawalparasi	28	0.94	33	Tanahun	74	2.5
13	Parsa	85	2.87		Sub total	427	14.41
14	Rautahat	74	2.5	**C. Mid and high hill districts**		1158	39.04
15	Rupandehi	38	1.28		Unknown	197	6.65
16	Saptari	62	2.09		Total	2963	100
17	Sarlahi	36	1.21				
18	Siraha	82	2.77				
19	Sunsari	115	3.88				
20	Udaypur	50	1.69				
21	Morang	50	1.69				
	Sub total	1181	39.84				

Source: Gupta et al 2000.

Nepal has many locally adapted rice genotypes but only one has been used or improved for developing Nepalese Tarai and Inner Tarai rice cultivar. Trends of using local landraces are now increasing which help to check genetic erosion (B Chaudhary, Personal communication). Due to agro ecological differences Nepalese genotypes may contain unique genes (Table 2). These genes if conserved properly could be enough to fulfill rice grain demand in Nepal for next century. Diverse ethnic groups have great knowledge about the genotypes possessing unique characters. The possibility of starting a three lines heterosis breeding using local landraces was reported (Joshi et al 2003b). Among the 14 rice genotypes tested for their ability to restore fertility and maintain sterility, two landraces (Kature and Ratodhan) are restorers and other two (Deharadune and Chiunde) are maintainers (Joshi 2000a). Great potential of exploiting heterosis is possible using landraces and improved cultivars (Joshi 2000b, Joshi and Subedi 2001, Joshi 2003b). A set of 183 landraces were characterized and evaluated over space and time (1998-2000) (Sharma et al 2001). There was wide variation in maturity. Landraces were comparable with the improved cultivars. There is a possibility of breeding for new levels of grain yield and other economical characters using these landraces. Blast resistance was widely available in these landraces. More important genotypes should be identified and developed a strategy to use them. These genotypes may have potential role in developing suitable varieties and/or increasing national production. Clear advantages were indicated in using locally adapted parents and selection in the target environment compared to introduction from international nurseries, which usually perform poorly (Sthapit 1992). Characterization, evaluation and utilization of these landraces in breeding program by LARS, NRRP and ABD could certainly enhance the rice gene pool conservation. Landraces were mostly collected from western and eastern Nepal (Figure 2). The distribution pattern of rice could help to locate diverse rice areas and to implement in situ and on farm conservation and exploration program. This pattern suggests that there are diverse rice landraces adapted to different environments. Characterization and improvement of these landraces are necessary for long-term conservation and utilization. Due to the expansion of modern varieties these landraces are under threats of extinction. In addition, some of the landraces are under threat or extinct (Table 3) due to natural and human factors. Chang (1984) estimated more than 100,000 rice cultivars existed in Asia earlier in the 20th century. But with the advent of modern, high yielding varieties and intensive cultivation, a small number of productive and relatively uniform cultivars now dominate commercial production (Chang 1994).

Table 2. Some of the unique rice genetic resources cultivated in Tarai, Inner Tarai, mid and high hills of Nepal

SN	Genotype	Uniqueness
1	Amaghauj	Multiple spikelets per node
2	Anati or Anadi	Festival rice/ sticky rice/ medicinal value
3	Bhati, Silhat	Deep water rice
4	Chainon 2, Taichung 176	Japonica type
5	Chhommrong dhan, Jumli marshi	Cold tolerance rice, *andilo*
6	Ekle rice	Zn deficiency tolerance
7	Gamadi, Sathi	Panicle matured within flag leaf, early rice
8	Ghayia	Upland rice
9	Gurdi	Lodging susceptible
10	IR 8, Jaya	Indica type
11	Jarneli, Kathe Gurdi	Drought tolerance, secure grain yielder
12	Jhinuwa	Good eating quality
13	Kalanimak	Photo period sensitive
14	Khera	God preferred landrace
15	Laila Majnu or Jhodi dhan	Two grains in a lemma and palea
16	Lalka basmati	Improtant for party
17	Mansara, Mutmur, Anga	Adopted to very marginalized land
18	Nal tumme	Shade loving rice
19	Nakhisaro, Sathi, Laltenger	Pest resistance
20	Pahele	Vitamin A content landrace (?)
21	Pakhe Masino, Radha-4, Taichung, Lahure Sahila, Gori Sahila, Makar Kandhu	Hiunde (winter) rice
22	Parwanipur 1	Ratoon rice
23	Patle dhan	Good for pregnant women
24	Samundaphinj	Swampy land rice
25	Sokan dhan, Bageri	Resistance to BB and GLH‡
26	Wild rice	Festival rice/ perenniality gene

Hiunde rice (seeding at December and harvesting at May) has been cultivated since 35 years ago at Taruwa VDC, Nawalparasi. This rice was extensively cultivated after 2042 BS (1984) in these areas. Farmer of this area, Khadka Narayan Mahato has more knowledge on Hiunde rice. BB, Bacterial blight. GLH, Green leaf hopper.
Sources: Mallick (1981/82), NRRP (1997), Rijal (1998), Upadhyay and Joshi (2003).

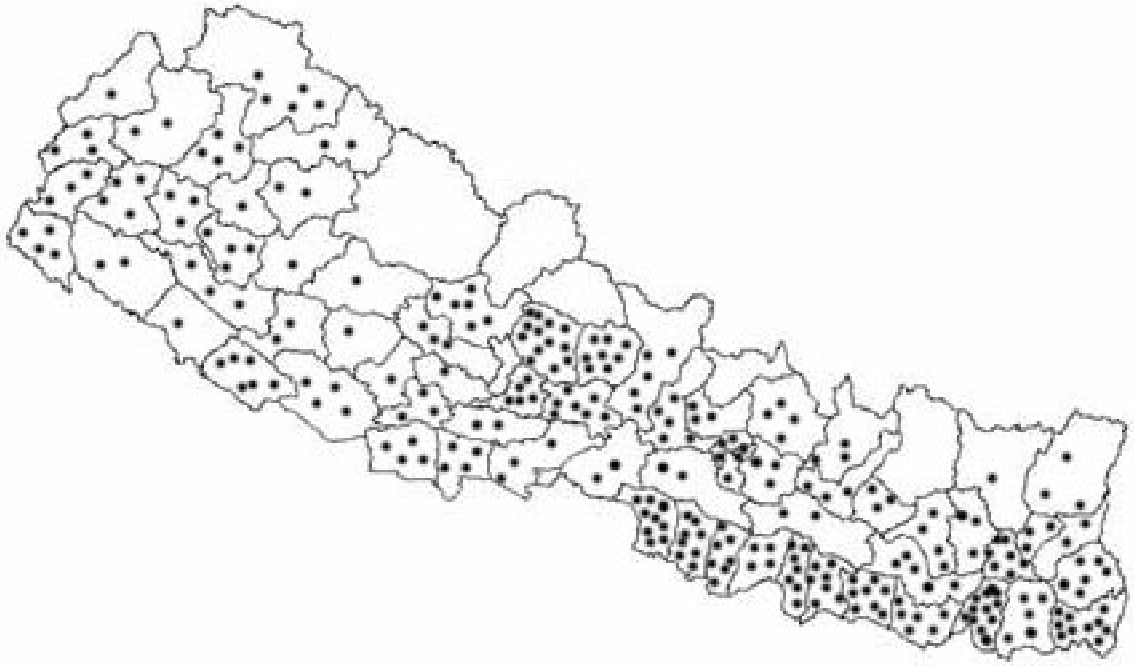

Figure 2. Distribution of rice diversity (more the number of dots more the diversity).

Table 3. Endangered and lost rice landraces in Tarai, Inner Tarai, mid and high hills of Nepal†

Endangered (48)	Lost (105)
Tauli, Thapachinia, Marsi, Mansara, Siraunla, Masind, Nathani, Khalte Kolo, Biramphool, Samundaphinj, Jhinuwa, Bayarni, Ramani, Pahenle Ghaiya, Bichare, Basmati, Dudhe Marange, Pakhe Masino, Sindhuli, Pakhe Sali, Jabaka, Charinangre, Pakhe Jhinuwa, Basaune Jhinuwa, Pahenle, jhinuwa, Gudura, Bardari, Battisara, Pokhreli Jhinuwa, Pagate Jhinuwa, Phente silange, Lalka Basmati, Soka, Sarho, Satraj, Lajhi, Rango, Gajargul, Ratrani, Katuash, Latongad, Masura, Dudhisaro, Lalka Kartik, Ghuthani, Anadi, Khera, Mansari and Anga	Lahure Sahila, Gori Sahila, Makar Kandhu, Timaha, Darmali, Germani, Koili, Budho thakale, Ghote, Salidhan, Jhauri, Bhamger, Lalka Pharam, Lajhi, Lohasaran, Parewa Pankha, Handiphul, Karma, Golabachhi, Dudhi Kariya, Bachhi, Devsar, Dudhraj, Sikhichanda, Galphuli Dutha, Rjana, Madhukari, Habsa, Ratin, Bansbarcli, Kanakjira, Ramjamai, Ratan, Tulasiprasad, Mahajogi, Ramini Katika, Sankharika, Sokan, Baramphusi, Ghiukumari, Anandi, Manshara, Satraj, Barkhabahadur, Pokhraj, Sankharika, Gondan, Maturi, Bhulani, Kuriya, Surkamiti, Satraj, Najhi, Golarato, Rajala, Megadoot, Dudhraj, Maturi, Parweapankhe, Kariyakamod, Gaddar, Kanajira, Babadudhi, Bhulani, Barkha Bahadur, Nakhi, Karma, Rati, Horinlduri, Gokulchanda, Maturi, Jhali, Gangaur, Dhudi, Katausi, Tulsi Prasad, Kanakjira, Gokulchan, Sukhichand, Pakhar, Bansnareli, Karma, Silan, Akhidudhi, Jhabri, Jajagaur, Satawa, Bangaluwa, Dudhisaro, Borch Bahadur, Mutari, Amaghaur, Barbasaru, Jhali, Mashura, Gokhul, Handa, Kudiya, Ramjamai, Kasturi, Dudha Kariya, Satariya, Changol, Golabati, Madhusar, Manshari

† not exhaustive. This information is mostly from western development region.

Sources: Upadhyay 1995, Rijal et al 1998, Joshi et al 1998, Sherchan et al 1998, Rana et al 2000c.

Improved rice gene pool

Twenty-eight improved rice varieties suitable to Tarai, Inner Tarai and Foot Hills of Nepal (Table 4a, 4b) are real efforts of researchers to be released during the period from 1959 to 2002. More numbers of crosses involving many parental lines in cultivars like Sabitri, Laxmi and Chaite 4 indicate the effort of scientists to collect value genes in single genotype. Use of different landraces in crossing program is a good strategy to increase yield (Joshi 2004). Six cultivars were released in 1987. The earliest released cultivar is China 45 in 1959. Shuttling of generation lines during winter season is also possible in Nepal, which helps to develop more rice cultivars within short period of time.

Table 4a. Improved rice varieties recommended for Tarai, Inner Tarai and foot hills of Nepal in *Barkhe* season

SN	Variety	Abb	Pedigree	Parentage	Year released
1	Barkhe-2	BKH2	B441b-126-3/2/2001	C4-63GB/B531b -TK39	1987
2	Durga	DGA	IET 2938	Jaya//IR8/Latisail	1979
3	Ghaiya-2	GHA2	MW 10	MTU15/Waikakku	1987
4	IR20	IR20	IR 532E-576	IR 262-24-3/TKM6	1972
5	IR22	IR22	IR 579-160-2	IR 8/Tadukan	1972
6	IR8	IR8	IR 8-288-3	Peta/DGWG	1968
7	Janaki	JNK	BG 90-2	Peta*3/TN1//Remadja	1979
8	Jaya	JAYA	-	TN1/T141	1973
9	Khajura-2	KAJ2	PAU41-262	RP72/Mutant65	1987
10	Makwanpur-1	MKN	BG 400-1	Ob678/IR20//H4	1987
11	Masuli	MAS	Mahsuri	Mayang Ebos 80*2/Taichung 65	1973
12	Radha Krishna-9	RA9	NR 15016-24-1-3	IR 42/Masuli	1991
13	Radha-11	RA11	TCA 80-4	Local selection	1995
14	Radha-12	RA12	OR 142-99	TNI/T141//Annapurna	1995
15	Radha-4	RA4	IR 8423-156-2-2-1	BG 34-8/IR 2071-625-1	1995
16	Radha-7	RA7	NR 15013-40-1-1	Janaki/Masuli	1991
17	Rampur Masuli	RAMSULI	-	Lal Nakanda/IR30	1999
18	Sabitri	SAB	IR 2071-124-6-4	IR 1561-228-1/IR 1737//CR 94-13	1979

Source: NRRPa 1997.

Table 4b. Improved rice varieties recommended for *Chaite* season or first rice crop in the double rice cropped areas of Nepal (Recommended to Tarai and Inner Tarai)

SN	Variety	Abb	Pedigree	Parentage	Year released
1	Bindeswari	BND	IET 1444	TN 1/Co29	1981
2	China-45	CH45	China 45	Selection at CRRI	1959
3	Chaite-2	CHT2	IR7151-1260-3-3	BG34-8/IR2061-522-6-9	1987
4	Chaite-4	CHT4	IR9729-67-3	BG34-8/IR28//IR2071-625-1-252	1987
5	Chaite-6	CHT6	NR 274-7-3-3-1	NR6-5-46-50/IR28	1991
6	Chandina	CND	IR532-1-176	Peta* 3/TN1//TKM6	1978
7	IR24	IR24	IR661-1-140-3	IR8/// Century Patna/SLO//Sigadis	1975
8	Laxmi	LAXMI	IR2061-628-1-6-4-3	IR833-6-2-1-1//IR1561-149-1/IR1737	1979
9	Malika	MALI	Mala/J15 (IR272)	CP/SLO*2//Sigadis	1982
10	Parwanipur-1	PWP1	IR400-29-2-73	Peta* 4/TN1	1973

Source: NRRPa 1997.

A total of 35 ancestors originated in 11 different countries were used to develop 28 rice cultivars (Table 5). Eight countries are the origins for 28 cultivars (Figure 3). These genes were mainly from Asian countries (Figure 4). Maximum ancestors were from India followed by Taiwan and Indonesia. Involvement of ancestors from 11 countries indicates the introduction of genes adapted to different geographic locations. A single landrace of each of seven countries (Figure 4) have been used in developing rice cultivars probably because of having value genes with them. Evidence shows that breeders can develop best varieties by reshuffling the genes from these wide collections. In Nepal 4 cultivars had been originated. Use of ancestors of both *indica and japonica* groups of *sativa* and *nivara* species indicated the collection of wide gene pools. Relatively more ancestors originated in more different countries were used for Nepalese wheat cultivars and mid and high hill rice cultivars development (Joshi and Mudwari 2003, Joshi 2003a) than Tarai and Inner Tarai rice cultivars. Evidence suggests that some modern varieties have a narrow genetic background. Lin (1991) has shown a narrow genetic background of japonica varieties released in Taiwan between 1940 to 1987. Dilday (1990) documented similar pattern for US rice cultivars. Concerns were raised about the narrow genetic diversity present among IRRI varieties (Hargrove 1979, Hargrove et al 1980, Chang 1994). All semidwarf cultivars have the *sd1* gene for short plant stature. Most semidwarf cultivars derived from IR8 and other early IRRI releases carry the cytoplasm of Cina. All *indica* type rice hybrids in China share the *sdl* gene and the wild abortive (WA) source of cytolasmic male sterility (Chang 1994).

Table 5. Ancestors used for developing Nepalese rice cultivars for *Chaite* and *Barkhe* Season for Tarai, Inner Tarai and foot hills of Nepal

SN	Ancestor	Abb	Origin	Abb	Group	Species
1	ANNAPURNA	ANNA	?	?	?	?
2	B531B-TK39	B531B	?	?	?	?
3	C4-63-GB	C4	?	?	?	?
4	CENTURY PATNA	CP	USA	USA	INDICA	SATIVA
5	CHINA-45	CH45	CHINA	CHN	?	SATIVA
6	CINA	CINA	CHINA	CHN	?	SATIVA
7	CO-18	CO18	INDIA	IND	INDICA	SATIVA
8	CO-29	CO29	INDIA	IND	INDICA	SATIVA
9	DEE-GEO-WOO-GEN	DGWG	TAIWAN	TWN	INDICA	SATIVA
10	GEB-24	GEB24	INDIA	IND	INDICA	SATIVA
11	GP-15	GP15	?	?	?	?
12	H4	H4	CEYLON	CLN	INDICA	SATIVA
13	H501	H501	CEYLON	CLN	INDICA	?
14	LALNAKANDA	LKD	INDIA	IND	INDICA	?
15	LATISAIL	LAS	PAKISTAN	PAK	INDICA	SATIVA
16	MAS	MAS	INDONESIA	IDO	INDICA	?
17	MAYANG EBOS-80	ME80	MALAYSIA	MAL	INDICA	SATIVA
18	MTU15	MTU15	INDIA	IND	INDICA	SATIVA
19	MUTANT-65	MTNT 65	?	?	?	?
20	SHANKARA	SKR	NEPAL	NPL	INDICA	SATIVA
21	O. NIVARA	ON	?	?	?	NIVARA
22	OB678	OB678	SRILANKA	SRI	?	?
23	PP	PP	?	?	?	?
24	PTB 18	PTB 18	INDIA	IND	INDICA	?
25	PTB 21	PTB 21	INDIA	IND	INDICA	?
26	REMADJA	REM	INDONESIA	IDO	INDICA	SATIVA
27	RP72	RP72	INDIA	IND	INDICA	SATIVA
28	SIGADIS	SGO	INDONESIA	IDO	INDICA	SATIVA
29	SLO	SLO	INDIA	IND	INDICA	SATIVA
30	T141	T141	INDIA	IND	INDICA	SATIVA
31	TADUKAN	TDKN	PHILIPPINES	PHL	INDICA	SATIVA
32	TAICHUNG NATIVE1	TN1	TAIWAN	TWN	INDICA	SATIVA
33	TAICHUNG-65	T65	TAIWAN	TWN	JAPONICA	SATIVA
34	TCA-80-4	TCA80	INDIA	IND	INDICA	SATIVA
35	WAIKAKKU	WKU	?	?	?	?

? Not known

Use of 35 ancestors from 11 different countries for tropical and sub tropical rice cultivars represent the great diversity in built in 28 Nepalese rice cultivars. The origins of 8 ancestors are not known. Ancestors were with different groups eg *indica* (65.71%) and japonica (2.86%). Groups and species of 31.43% and 37.14% ancestors respectively are not known. There were 60.00% sativa and 2.86% *nivara* ancestors species (Figure 5). Such diversity in species, origin and groups of ancestors have certainly enriched Nepalese rice biodiversity.

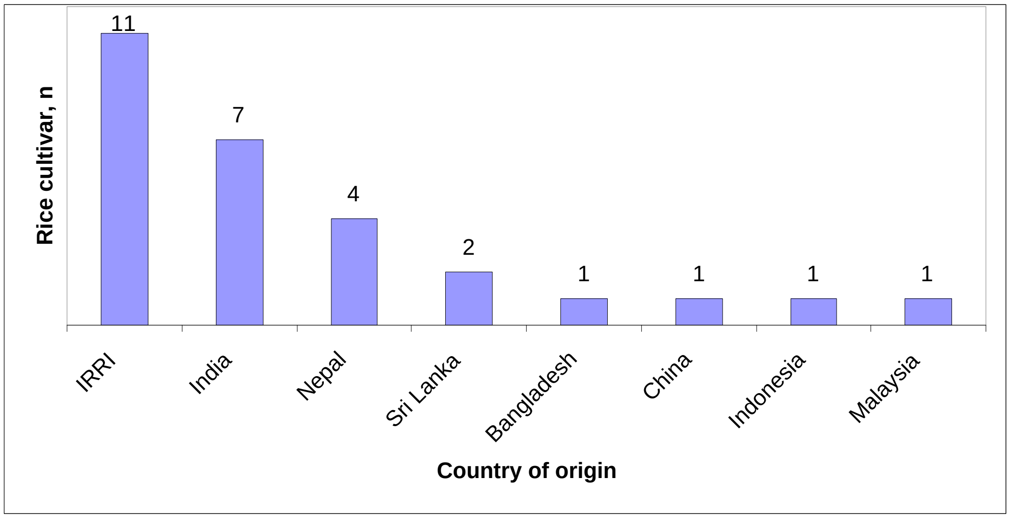

Figure 3. Countries of origin of 28 Tarai and Inner Tarai improved rice cultivars in Nepal.

Figure 4. Countries where the ancestors of Nepalese improved rice cultivars recommended for Tarai, Inner Tarai and foot hills were originated. Origins of 8 ancestors are not known.

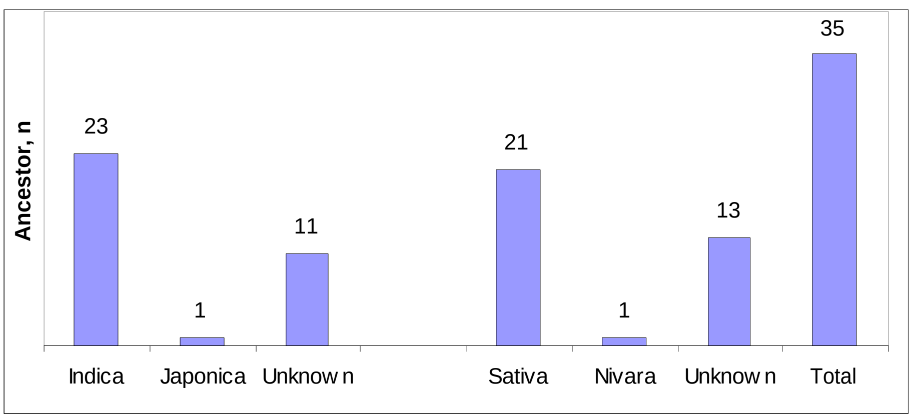

Figure 5. Ancestors' group used to develop Nepalese rice cultivars for Tarai and Inner Tarai.

Wild rice gene pool

Nepal being the center of diversity of rice, harbor the wild rice and its relatives in addition to diverse forms of landraces. Four wild rice species, *Oryza nivara*, *O. rufipogan*, *O. granulata* and *O. officinalis* are found in different areas of Nepal (Figure 6). Some of these areas are Ghodagodhi tal, Ajigara tal, Lothar, Jhapa, Illam, Sundarpur, Surkhet, Nijgada, Janakpur, Nepalgungj, Bara, Dang, Kapilbastu, Rupendehi, Birendranagar, Kaski, Palpa, Banke, Bardiya, Kancanpur etc (Table 6). Weedy rice, *O. sativa* f. *spontanea* is found in rice field across the country. *Hygrooryza aristata* and *Leersia hexandra* are other two species in related genera found in Nepal. These species are adapted to different ecological conditions in terms of altitude and water requirements, and distributed across the Tarai and mid hill. *O. rufipogan*, one of the natural parents of the present day cultivated rice is reported to have found in the northern most limit and the highest altitude in Nepal in the world (Shrestha and Upadhyay 1999). This extraordinary biological diversity in Nepal is due to geological, geographical and cultural factors. Very little attention has been given to wild rice diversity in Nepal. Nepal was considered as area of potentially new and useful genes for rice breeders (Shrestha and Upadhyay 1999). Wild species represent a rich pool of diversity particularly for their ability to withstand pests and diseases (Jackson 1995). Since wild germplasm is a valuable source for improving rice productivity and durability, explorations on those wild relatives are suggested followed by their proper characterization and utilization in the breeding program.

Table 6. Wild rice and wild relatives of rice found in different districts of Nepal

SN	Wild /relative	Local name	Districts†
1	*Oryza nivara* Sharma et Shastry	Tinna, Jhara	**Banke, Kapilbastu, Lumbini, Bardiya, Kailali, Kanchanpur,** Kaski, **Dang, Rupandehi**
2	*O. rufipogon* Griff. (*O. perennis* Moench.)	Nabo ghans, Anga, Salidhan	**Banke, Kapilbastu, Kailali, Kanchanpur,** Surkhet, Kaski, Palpa, **Rupendehi, Dang**
3	*O. granulata* Nees et Arn. ex Watt.	Ban dhan, Jangali dhan, Sitarani dhan	**Chitwan, Jhapa,** Ilam, Makawanpur
4	*O. officinalis* Wall ex Watt.	-	**Kancahnpur, Bara, Janakpur**
5	*O. sativa* f. *spontanea* (weedy rice)	Navo, Thima, Jara	Most of the rice growing districts, **Rupandehi, Kapilbastu, Banke, Bardiya, Kanchanpur,** Lamjung
6	*Hygroryza aristata*	-	Kaski, **Kailali**, Kathmandu
7	*Leersia hexandra*	-	Kaski, Lamjung, Kathmandu

† Bold districts lie in Tarai and Inner Tarai of Nepal.
Sources: Shrestha and Updhyaya 1999, Sthapit 1999.

Figure 6. Distribution of wild rice and related species in Nepal.

Contributions of Nepalese PGR at national and international level have not been well documented. A total of 48 improved rice cultivars certainly have significant contributions at National economy. There are many more rice genotypes that have potential to make the Nepal difference. National and international organizations have explored and collected many rice genotypes from different parts of Nepal but their value and uses are very little known.

Despite high yielding attributes of improved cultivars compared to those of local types improved varieties were found to be susceptible to diseases and lodging (Shrestha 1976). There are many examples of improved varieties gaining popularity within a short period of time but later become susceptible to biotic stresses. Such trend was not reported in landraces. In this study, cultivars surveyed represent a wide range of variation for different areas of origin and adaptation. This genetic diversity may be useful for further rice improvement. The results of this study may help in the selection of the most diverse cultivars and greatly expand genetic variation for rice improvement. Cultivated landraces of *indica* and *japonica* type, wild rice and wild relatives of rice are found in Nepal. Gene pool from these landraces along with international gene pool could make to success in developing high yielding cultivars with wide adaptability. Developing cultivars possessing desired period of maturity, height and yield is seemed possible using this gene pool. However, modern varieties have been replacing the landraces and improved old varieties resulted in the genetic erosion. Therefore, in situ, on farm and ex situ conservations are necessary for maintaining the genetic variation. Government, semi governmental and private agencies should take action to conserve and utilize rice genetic diversity present in Nepal.

There is need of identifying least cost *in situ* and *ex situ* conservation for rice landraces and wild rice gene pools and policy instruments most suitable for supporting conservation of this gene pool (D. Gauchan, personal communication). Participatory varietal selection (PVS) methodology has been selected to increase diversity in addition to increase the adoption rate of variety (Joshi et al 2003a). A prerequisite of conservation is genetic assessment of rice populations in the area that are likely to constitute rare, unique and distinctive genetic resources. Based on available information and genetic analysis, prediction of the future value of these genetic resources is needed in the extent to which they have high genetic value in improving yield potential and sustaining future rice productivity in the changing pest endemics, climate change and changes in market demand. We don't have favorable policy and legal for the protection of wild rice habitats. Molecular study is necessary to assess the diversity among ancestors (if possible) and cultivars derived from these ancestors. For effective conservation least cost methodologies for *in situ*, on farm and ex situ systems should be developed. Utilization of local landraces should be the first priority to conserve them in addition to increase the yield. Crossing program should be designed based on pedigrees information and local landraces. Potentiality of native genotypes should be made available. Varieties developed using local landraces will perform and adapt better than others. Duplicate accessions of ABD and LARS should be removed and gene bank must be updated through regular exploration program. To release cultivar, ancestors and number of crosses for that cultivar should be considered. For the conservation of wide gene pool, site-specific trial rather than coordinated trial is recommended. Conservation work be initiated after genetic assessment of rice populations in the area that are likely to constitute rare, unique and distinctive resources. Specific technological options (plant breeding, biotechnology) for utilization of genes and appropriate economics instruments for providing incentives to community are suggested for conservation and utilization of rice diversity. For recommendation of any varieties microenvironment effects be considered. For Nepalese agro biodiversity conservation and utilization, plant breeding work should get first priority. Nepal has still many traditional farming systems. Based on the locality needs, these systems should be improved through participatory approach for overall plant genetic resources management.

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