Published in: Agriculture Development Journal 10: 1-22 (2014)

Rice and Buckwheat Genetic Resources in Karnali Zone

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Abstract
Agriculture specially the grain production (rice, buckwheat, etc) is the most priority sector of farmers living in Karnali zone. Knowledge on the existing genetic resources of rice and buckwheat is necessary to set the strategy for increasing the production and productivity. In this paper, we focused on the genetic resources of rice and buckwheat and breeding efforts in these crops for Karnali zone. Farmers are maintaining different genotypes of rice and buckwheat, some of which are very unique eg Jumli Marshi rice and Bhate phapar (Tite buckwheat). Jumli Marshi rice is the most cold tolerant landrace. Tite phapar (Tartary buckwheat) is considered medicinally important. Different national and international exploration missions indicate the richness of valuable gene pools in Karnali zone and their ex-situ conservation. Productivity of existing genotypes of rice and buckwheat is very low. Breeding efforts have not contributed significantly to increase the productivity. Only a few varieties of rice have been released for those areas however, adoption rate is negligible. Varieties with drought and cold tolerance and short duration along with high grain yield are considered suitable for Karnali zone. We recommend breeding the site-specific varieties.

Key words: Breeding effort, buckwheat, Karnali zone, rice

Introduction
Karnali zone lies in the high altitude region of Western Nepal (Table 1, Figure 1). This zone is food deficit and least developed. Cultivated land is limited and most of the agricultural lands are sloppy. Due to high number of livestock, land is fertile but this fertility could not be converted fully in consumable goods. Productivity is low and crop growing period is very short. Snow falls, cold temperature and drought are the major constraints for crop production.

Agriculture is the main source of livelihood. Most of the farmers depend on agribusiness. Crop genetic resources for example, landraces are passed from generation to generation of farmers and are subject to different selection pressures to fit specific farming situations. Karnali zone is remote and technological intervention is low, therefore, it has a unique range of diversity adapted to local conditions (Poudyal et al., 1998). Rice (*Oryza sativa* L.), Tite (tartary buckwheat) and Mithe (common buckwheat) buckwheat (*Fagopyrum* spp) are the major crops grown in all districts of Karnali zone. Other major crops in Karnali zone are maize, Chino (proso millet), barley, naked barley, finger millet, wheat and Kaguno (foxtail millet) (DDC, 2001; KRIDAC, 2002). Richness of rice and buckwheat in Jumla is reported by Poudyal et al. (1998) and Rana et al. (2000). For developing suitable varieties for a particular area, basic information on existing genetic resources, farmers' interest, etc of target area is necessary. The variation in rice and buckwheat should be given priority for developing varieties suitable to the farmers of target areas. Therefore, this study was carried out with the objectives of collecting information about rice and buckwheat germplasm grown in Karnali zone for appropriate resource planning and exploring the potentiality of increasing the productivity of rice and buckwheat.

Materials and Methods
Review
Literature related to rice, buckwheat and Karnali zone were reviewed. Annual reports of District Agriculture Development Office (DADO), Nepal Agricultural Research Council (NARC), findings of in-situ Global Project were the major documents.

Questionnaire Survey
Basic information on existing genetic resources of rice and buckwheat were collected from five districts of Karnali zone by sending the questionnaire. Questionnaire was sent to DADO of Jumla, Humla, Kalikot, Dolpa and Mugu.

Focus Group Discussion
One day farmers training workshop on rice genetic resource management and utilization was organized. Main areas of discussion with farmers were listing of available rice landraces with their liked and disliked traits, problems and importance of Jumli Marshi, etc. Similarly one day farmers training workshop on buckwheat genetic resource management and utilization was organized. Main focus areas of discussion were listing of Tite and Mithe landraces along with importance traits, problems and important of buckwheat, farmers' preferred traits in buckwheat varieties, etc. Discussions were also done with key staff of DADO, Jumla and ARS-NARC, Jumla.

Seed Collections
Available local diversity of rice and buckwheat in Jumla was collected for characterization, evaluation, isozyme survey and ex-situ conservation. Seeds of 6 different landraces of rice were collected consisting of total 37 populations. A total of 28 common and 21 Tartary buckwheat lines were collected from different farmers of Jumla; Hill Crops Research Program, Kavre and Agriculture Botany Division, Khumaltar. Different landraces of rice and buckwheat were found in five districts of Karnali zone, but due to difficulty in going to other districts, collections were restricted to only Jumla district.

Isozyme and Molecular Study
Preliminary study was done for isozyme polymorphism in rice (Jumli Marshi, Fuji 102, Chhommrong, Chandhannath 1, Chandhannath 3) (Joshi and Bimb 2004). Some rice collections of this zone were characterized by RAPD markers (Bimb et al., 2007). Bajracharya et al. (2003a; 2003b) studied Jumla collections of buckwheat using isozymes and rice using SSR markers. RAPD was used to study variation in wild and Tite buckwheat by Bimb et al. (2001a).

Field Experiments
Experimental details were discussed with field staff of Agriculture Research Station (ARS), Jumla. Characterization, collections and evaluation methods and use of field books were discussed and finalized. Selected rice accessions were characterized and evaluated in Agriculture Research Station, Jumla. One set of all these collections were tested for reaction to blast at field level in natural condition including susceptible check in Agriculture Botany Division, Khumaltar. Both Tartary and common buckwheat collected from Jumla were characterized and evaluated in Agriculture Research Station, Jumla. In this experiment genotypes selected from Hill Crops Research Program, Kavre and Agriculture Botany Division, Khumaltar were also included.

Results and Discussion

Status of Rice and Buckwheat in Karnali Zone
Karnali zone is diverse in term of elevation and climate which help to develop and maintain the unique genotypes of rice and buckwheat. Jumla has the highest agriculture land as compare to other districts. Rice and buckwheat are the major crop commodities and contribute significantly to secure farmers' life. Farmers are completely dependent on landraces to grow however few modern varieties of rice are found in limited areas. Informal seed supply was the only system in Jumla and all farmers obtained rice seed from their own village (Baniya et al., 2003). Productivity of these three species (*Orzya sativa, Fagopyrum esculentum* and *F. tataricum*) is very low as compared to yield potential (Table 2). Karnali zone has limited genetic diversity in rice (*Oryza sativa*) but there are great variation at species, landraces and genotypic levels in buckwheat. Five species and subspecies (*Fagopyrum esculentum* ssp *esculentum, F. tataricum* ssp *tataricum, F. tataricum* ssp *potanini, F. tataricum* ssp *annum, F. cymosum* (diploid and tetraploid), *F. gracilipes* and *F. megacarpum*) are found in Karnali zone. Dolpa is the most important for buckwheat diversity in Karnali zone.

Table 1. General information about Karnali zone

District	Headquarter	Total VDC	Area (km^2)	Agriculture land (ha)		Elevation (m)	Climate
				Cultivated	Non cultivated		
Dolpa	Dunai	23	7889	6008	3333	1225-7625	Mild temperate, cool temperate, alpine
Jumla	Khalanga bazaar	30	2531	14743	9314	915-4679	Sub tropical, temperate, alpine
Kalikot	Manma	29	1741	15828	7920	1500-4790	Temperate, cool temperate, alpine
Mugu	Gamgadhi	24	3535	11672	7121	1524-7045	Temperate, cool temperate, alpine
Humla	Simikot	26	5655	6066	3231	1524-7337	Temperate, cool temperate, alpine

Figure 1. Map of Karnali zone

Table 2. Status of rice and buckwheat in Karnali zone

District	Crop	Area (ha)	Production (t)	Productivity (t/ha)	Season	
					Seeding	Harvesting
Mugu	Buckwheat	500	982	1.96	Jestha-Ashad	Bhadra-Kartik
	Rice	1850	4550	2.03	Chaitra-Baisakh	Ashwin-Kartik
Humla	Buckwheat	500	500	1	Jestha-Srawan	Ashwin-Kartik
	Rice	200	316	1.58	Baisakh-Srawan	Ashwin-Marga
Dolpa	Buckwheat	290	300	1.42	Jestha-Ashad	Bhadra-Ashwin
	Rice	180	160	0.88	Chaitra-Baisakh	Ashwin-Kartik
Kalikot	Buckwheat	102	108.62	1.06	Jestha-Srawan	Ashwin-Kartik
	Rice	4474	8858.52	1.98	Chaitra-Baisakh	Ashwin-Kartik
Jumla	Buckwheat	-	-	0.9	Jestha-Ashad	Bhadra-Ashwin
	Rice	1366	2880	2.1	Chaitra-Baisakh	Ashwin-Kartik

National productivity of rice is 2.8 t/ha and of buckwheat is 580 kg/ha. Yield potential of rice is 10.2 t/ha and of buckwheat 3 t/ha. Source: Annual report of DADOs (Mugu, Humla, Dolpa, Kalikot and Jumla).

Environment for Growing Rice and Buckwheat in Karnali Zone

Climate is the major determinant factor for growing crop species or varieties. Due to the cold and snow in winter, this zone is suitable to grow most of the crop species in summer. Crop produced in summer should meet the food demands in winter. Climate during rice and buckwheat growing period is depicted in Figure 2. Temperature is low during grain filling period which may be the important factor of low productivity in that zone. Total biomass production in this zone is also low therefore composting material is not enough. Techniques of biomass production and composting rate are considered important for maintaining soil fertility. Most of the cultivated land is sloppy. Farmers reported that sloppy land is also important to control the frost and snow injury to the crop and to make good aeration in the soil. Buckwheat is grown in areas where other crops cannot be grown. Common buckwheat is summer crop in high hill, autumn crop in mid hill and winter in Tarai. Tartary buckwheat is summer crop in high hill, and autumn and spring crop in mid hill and it is not grown in Tarai (Baniya et al., 2004). Dongol et al. (2004) reported that buckwheat is ranked first in priority by farmers at the places where transport is less accessible, less availability of other food items, little or not intervened by other crops, dryness, unavailability of alternate crops. Farmers' preference has been intensified in high hill areas and westerly region.

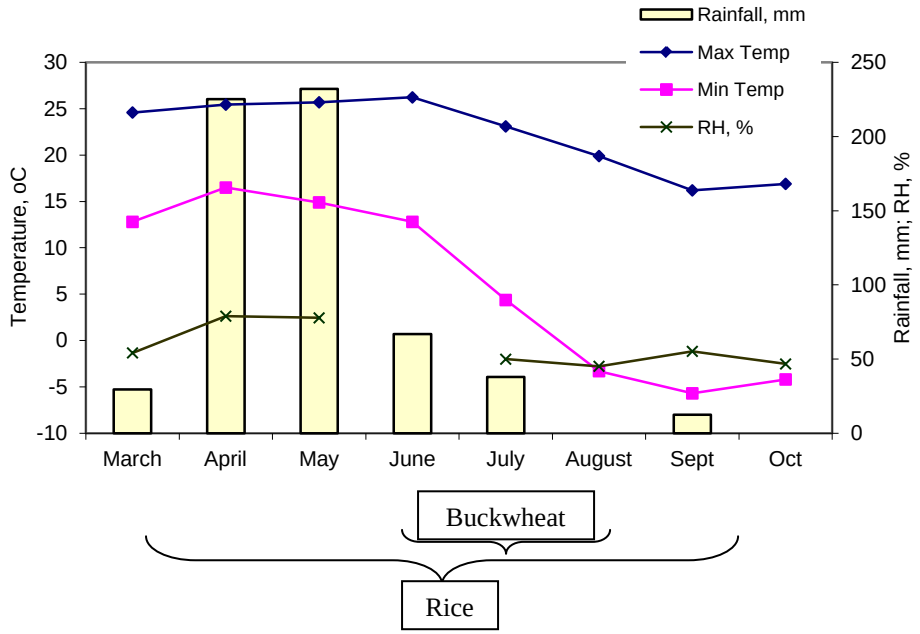

Figure 2. Climatic parameters during rice and buckwheat growing period in Jumla

Unique and Important Features of Rice and Buckwheat

Karnali zone especially due to unique and diverse agro-climate, has unique characteristics in rice and buckwheat. The highest altitude (3050 m) of rice growing area in the world is Chhumchaur, Jumla, Karnali zone. Farmers started cultivation of Jumli Marshi in Chhumchaur in 1954 AD (Bhandari, 1995). Jumli Marshi is the most cold tolerant landrace and it is extensively used as parents at national and international levels. Battalo and Tumalo are other unique rice landraces found in Mugu. Rice seed is always planted in 12 Chaitra (25 March) and harvest starts on 22 October (Shahi and Heu, 1979). Use of sprouting induced rice seeds in the wet bed is also unique technique. Upland rice is also grown in this zone. These cold tolerance rice genetic resources can be grown in Tarai as Hiunde (winter) rice (Joshi, 2004a). Genetic resources of rice, Tartary, common and wild buckwheat from this zone are conserved in country and abroad (IRRI, Japan, Canada, Korea, USA, USSR, Italy, etc) (Upadhyay and Joshi, 2003). Stamp of Jumli Marshi has been issued and this is the first time that the Postal

Department has used agricultural crop in stamp. *Fagopyrum megacarpum* is the only wild species reported from Dolpa in the world. Bhate (Kalo Kishe, Seto Kishe) phapar which is Tite type with less bitterness is found only in Dolpa. Bhate phapar (also called rice tartary buckwheat) which has a non adhering hull allows the use of it as a rice replacement in the staple diet (Campbell, 2003). Other different wild and weedy buckwheat are also found in this zone. The region seems to be potential place for housing frost and cold tolerance buckwheat landraces.

Ex-situ Conservation of Rice and Buckwheat Accessions from Karnali Zone

Rice is grown from 60 m to 3050 m altitude and buckwheat from 60 m to 4200 m altitude in Nepal. Due to the great variation in altitude of growing these species, diverse genotypes have been developed and maintained on-farm and some are conserved ex-situ. Seeds of rice, Tartary and common buckwheat were kept ex-situ for medium term conservation in Khumaltar. Agriculture Botany Division has 90 accessions of rice consisting of 53 different landraces (Table 3) collected from Karnali zone. These were collected by ABD, IBPGR and NRRP in the past years. The biggest number of collections was from Humla (47) followed by Mugu (18). Ten accessions of common buckwheat and 17 accessions of Tartary buckwheat were collected and conserved ex-situ from different districts of Karnali zone (Table 4). The highest collections of common and Tartary buckwheat were from Humla (5) and Mugu (7) respectively.

Table 3. Details of collection of different rice landraces from Karnali zone

SN	Landrace	District	Altitude, m	Accessions, n	Collection year	Collecting institute
1.	Basmati	Humla	1350, 1640, 1665, 1850	4	1985	IBPGR/ABD
2.	Bhertalo dhan	Humla	1850	1	1985	IBPGR/ABD
3.	Bhuwa dhan	Humla	1860, 1970, 2220, 2335	5	1985, 1991	IBPGR/ABD
4.	Dhatulo dhan	Humla	1850	1	1985	IBPGR/ABD
5.	Dogro dhan	Humla	2220, 2400	2	1985, 1991	IBPGR/ABD
6.	Dokor dhan	Humla	2100	2	1985	IBPGR/ABD
7.	Jhuldhan	Humla	1350	1	1985	IBPGR/ABD
8.	Kalo marsi	Humla	2100, 2300, 2350, 2420, 2600	7	1985	IBPGR/ABD
9.	Katikiya dhan	Humla	1350	1	1985	IBPGR/ABD
10.	Khachucha dhan	Humla	2350	1	1985	IBPGR/ABD
11.	Khachya dhokro	Humla	1850	1	1985	IBPGR/ABD
12.	Khetala dhan	Humla	2120, 2220	3	1985	IBPGR/ABD
13.	Lasadro dhan	Humla	1740	3	1985	IBPGR/ABD
14.	Maina pokhari dhan	Humla	1350	1	1985	IBPGR/ABD
15.	Mal marse	Humla	2240	2	1985	IBPGR/ABD
16.	Nakhine dhan	Humla	1350	1	1985	IBPGR/ABD
17.	Nan dhan	Humla	1730	1	1985	IBPGR/ABD
18.	Nauro dhan	Humla	1970	1	1985	IBPGR/ABD
19.	Ratanpur dhan	Humla	1350, 1850	2	1985	IBPGR/ABD
20.	Rato katike dhan	Humla	1360	1	1985	IBPGR/ABD
21.	Rumsero dhan	Humla	1820	1	1985	IBPGR/ABD
22.	Seto dhan	Humla	1360, 1850, 1970	3	1985	IBPGR/ABD
23.	Seto marse	Humla	2100	1	1985	IBPGR/ABD
24.	Thapachine dhan	Humla	1665	1	1985	IBPGR/ABD
25.	Barakoti dhan	Jumla	2530, 2713	2	1991	ABD
26.	Jadan marsi	Jumla	NA	1	NA	NRRP
27.	Kalo maheli	Jumla	NA	1	NA	NRRP
28.	Kalo marsi	Jumla	2393, 2603,2713	7	1991	NRRP, ABD
29.	Kalo seto marse	Jumla	2550	1	1991	ABD
30.	Marsi	Jumla	NA	1	NA	NRRP
31.	Meheli	Jumla	NA	1	NA	NRRP

SN	Landrace	District	Altitude, m	Accessions, n	Collection year	Collecting institute
32.	Rato marsi	Jumla	NA	1	NA	NRRP
33.	Seti marsi dhan	Jumla	2390	2	1991	ABD, NRRP
34.	Dadhime dhan	Kalikot	1980	1	1991	ABD
35.	Darma/Chimathe dhan	Kalikot	1792	1	1991	ABD
36.	Ghaiya dhan	Kalikot	1609	1	1991	ABD
37.	Gumki dotelo dhan	Kalikot	1768	1	1991	ABD
38.	Jhose dhan	Kalikot	1609, 1268	2	1991	ABD
39.	Koglya dhan	Kalikot	1268, 1585	2	1991	ABD
40.	Tirthbhog dhan	Kalikot	1268	1	1991	ABD
41.	Bhuwa dhan	Mugu	2020	1	1985	IBPGR/ABD
42.	Boya dhan	Mugu	2000	1	1985	IBPGR/ABD
43.	Dhan	Mugu	1960, 2035	2	1991	ABD
44.	Dhaudo dhan	Mugu	1780	1	1985	IBPGR/ABD
45.	Dhokro dhan	Mugu	2350	1	1985	IBPGR/ABD
46.	Ghaiya dhan	Mugu	2380	1	1985	IBPGR/ABD
47.	Juga dhan	Mugu	2350	1	1985	IBPGR/ABD
48.	Jumli dhan	Mugu	2020	1	1985	IBPGR/ABD
49.	Kalo marsi	Mugu	2350, 2380, 2600	4	1985	IBPGR/ABD
50.	Lotan sarau	Mugu	2080	2	1985	IBPGR/ABD
51.	Marsi dhan	Mugu	1870	1	1985	IBPGR/ABD
52.	Pakhe ghaiya	Mugu	1960	1	1991	ABD
53.	Seto dhan	Mugu	2030	1	1985	IBPGR/ABD

Table 4. Details of collection of buckwheat landraces from Karnali zone

SN	Local name	District	Altitude, m	Accessions, n	Collected year	Collecting institute
Common buckwheat						
1	Mithe phapar	Dolpa	2520	1	1986	JAPAN/ABD
2	Mithe phapar	Humla	1860, 2230, 2840	4	1985	JAPAN/ABD
3	Guliyo phapar	Humla	2335	1	1991	ABD
4	Bharule phapar	Jumla	2530	2	1991	ABD
5	Mithe phapar	Kalikot	1768	1	1991	ABD
6	Mithe phapar	Mugu	1960	1	1991	ABD
Tartary buckwheat						
1	Goriya tite phapar	Dolpa	3090	1	1989	JAPAN/ABD
2	Tite phapar	Dolpa	2960, 3070	4	1989	JAPAN/ABD
3	Tite phapar	Humla	2335, 2400	3	1987	JAPAN/ABD
4	Tite phapar	Jumla	2390, 2393, 2500, 2603, 2896, 3160	6	1989, 1991	JAPAN/ABD
5	Bharuley phapar	Jumla	2697	1	1991	ABD
6	Tite phapar	Kalikot	1792	1	1991	ABD
7	Tite phapar	Mugu	2652	1	1991	ABD

Breeding Efforts for Rice and Buckwheat

Agriculture Research Station, Jumla was established in 1971 to conduct on-station and on-farm research for Karnali zone. Since its inception, researches are being carried out in rice and buckwheat to generate, develop and transfer appropriate technologies. Different trials for example, advancement and selection of segregating material, observation nursery, initial evaluation trial, coordinated varietal trial, farmers field trail, Jumla selection varietal trial, varietal display, participatory varietal selection, etc are being conducted for rice and buckwheat improvement (ARS, 2006; Biswokarma et al., 2001).

Rice research is usually coordinated with Agriculture Botany Division, Khumaltar and buckwheat research with Hill Crops Research Program, Kavre. Through these research organizations, different genotypes of rice originated in Nepal, IRRI, India, Japan, China, Korea, Taiwan, etc (Joshi, 2004b), and different genotypes of buckwheat both Tartary and common originated in Nepal, Canada, USSR, Japan, China, Poland, South Africa, Brazil, Mongolia, India, Sweden, etc (Baniya, 2001) have been characterized, evaluated and exposed to the farmers of Karnali zone.

Rice farming is considered as the prestigious crop in the hill and mountain and farmers prefer to grow rice even in a small piece of land whenever it is possible to grow. Rice is not only the staple food for the Nepalese people but also a dependable source of cattle feed all the year round. About 29% rice area lies in hill and mountain (NRRP, 1997). But these areas have limited or no access to transportation which hamper in the technology dissemination and input availability. Major problems in rice crop of these areas are neck blast, foot rot disease, cold injury and hailstorm at maturity stage (Shahi and Hue, 1979; Bhandari, 1995). Due to the monogenic nature of cold tolerance in rice (Shahi and Khush 1985), it will be easy to develop the cold tolerant varieties. Most of the improved cultivars are based on the exotic genotypes, which indicate the exclusion of cold tolerance local genotypes in breeding program, however Jumli Marshi was used to develop the Khumal-8 and Manjushree-2 (Joshi, 2004c). Stability analysis of rice genotypes indicated that varieties that were developed using Jumli Marshi as one of the parent, are site specific (Joshi et al., 2003a). Most of the recommended varieties for mid and high hills are japonica type (Joshi and Bimb, 2004). Cold tolerant rice genotypes, NR10288-015J-15J-7 and NR10293 were developed using Jumli Marshi as one of the parents and are most stable as well as adapted in cold stress environment (Bista and Joshi, 2004).

Rice varietal research work in Nepal had been started from 1950s by collection and evaluation of local germplasm and introduction of exotic rice cultivars (NRRP, 1997). Some of the introduced cultivars were well adopted in valley condition and released for cultivation. But most of the high yielding exotic varieties could not become popular in the high hill because of short plant height, cold susceptibility, threshing problems, etc. Systematic rice breeding work for hill and mountain started from 1975 utilizing local germplasm in breeding program at Agriculture Botany Division, Khumaltar. Most of the basic breeding works are done in Khumaltar for that Karnali zone. There are 21 improved rice cultivars (16 for mid hill and 5 for mountain) (Table 5), 1500 landraces and 6 wild species and relatives of rice in mid and high hills of Nepal. Based on the analysis of 20 improved cultivars, Taiwan, Philippines, India and Nepal are the origin countries for these cultivars. In Nepal 8 cultivars were bred and developed using local landraces and exotic genotypes for mid and high hill areas. A total of 47 ancestors originated in 12 different countries were used to develop these 20 cultivars (Joshi, 2004c). The highest number of ancestors was from India and Taiwan.

Buckwheat improvement work began in a systematic way after the establishment of National Hill Crops Research Program in 1986. Research is limited to characterization and evaluation of indigenous and exotic genotypes. Some molecular works have also been initiated to assess the genetic diversity in buckwheat. Common buckwheat is a self incompatible species with out-crossing characteristics and therefore, crop improvement program similar to out crossing species eg maize can be used. However Tartary buckwheat crop improvement programs can be handled as other self pollinating crops. Joshi (2004d) identified three genotypes GF-212, Sample-6-1 and Sample-7 as superior genotypes which were well adapted to all environment and stable.

Table 5. Rice varieties released for hill and mountain and their origin and parentage

SN	Variety	Parentage	Origin	Year of release	Yield, t/ha	Recommended domain
1.	Tainan-1	Tsai-Yuanchung/Dee-Geo-Woo-gen	Taiwan	1967	6.6	Warm temperate
2.	Chainan-2	Cluamohu/Shiniri-Aikoku/Taicdhung 65	Taiwan	1967	7.8	Warm temperate
3.	Chainung-242	Hsingchio 4/Taichung 150//Taipe 17/T 45	Taiwan	1967	7.3	Warm temperate

SN	Variety	Parentage	Origin	Year of release	Yield, t/ha	Recommended domain
4.	Taichung-176	Tsai-Yuanchung/Dee-Geo-Woo-gen	Taiwan	1967	7.9	Warm temperate
5.	Himali	Cica 4/Kalu	IRRI	1982	6.4	Warm temperate
6.	Kanchan	CR 126-42-5/IR 2061-21-3	IRRI	1982	7.6	Warm temperate
7.	Khumal-3	China 1039/IR580	India	1983	6.5	Warm temperate,
8.	Khumal-2	Jarneli/Kn-LD-361-DLK-2-8	Nepal	1987	5.6	Warm temperate
9.	Khumal-4	IR 28/ Pokhreli Masino	Nepal	1987	6.3	Warm temperate
10.	Khumal-7	Chaina 1039 DEF MUT/Kn 18-361-1-8-6-10	IRRI	1990	7.0	Warm temperate
11.	Khumal-9	K 28-76-D-1/Kn18-214-1-4-3	IRRI	1990	6.7	Warm temperate
12.	Khumal-5	Pokhreli Masino/KA-1B-361-BLK-2-8	Nepal	1990	6.7	Warm temperate
13.	Khumal-6	IR 13146-45-2-3/IR7492-18-6-1-1-3-3	IRRI	1999	7.8	Warm temperate
14.	Khumal-11	Akudaka/Barkat	Nepal	2002	10.0	Warm temperate
15.	Manjushree-2	Fuji 102/NR10157 (Jumli Marsi/IR 9129-159-3//kn-lb-361-1-8-6-3)	Nepal	2002	8.3	Kathmandu valley and similar areas
16.	Khumal-8	Jumli Marsi/IR-36	Nepal	2006	8-9	Sub-tropical- warm temperate
17.	Palung-2	BG 94-2/Pokhreli Masino	Nepal	1987	6.1	Cool temperate
18.	Chhomrong Dhan	Selection from Ghandruk Local	Nepal	1991	4.2	Cool temperate (1300-2000 m)
19.	Machhapuchhre 3	Fuji 102/Chhomroong Dhan	Nepal	1996	5.0	Cool temperate (1300-2000 m)
20.	Chandannath-3	Selection from Yunlen-1	China	2002	6.0	Jumla valley (2300 m) & similar areas
21.	Chandannath-1	Selection from Jingling 78-102	China	2002	6.0	Jumla valley, similar areas

Existing Landraces and Varieties of Rice and Buckwheat

Most of the VDCs of all five districts have rice and Tartary and common buckwheat genetic recourses (Table 7). Different landraces of these three species are available and they are being maintained on-farm in different areas of Karnali zone (Table 8). These landraces have their unique characteristics that meet the diverse needs of diverse farmers (Table 9 and 10). Farmers prefer Jumli Marshi because; it is very tasty, *andilo* (content feeling after consumption), cold tolerant and early maturity. However, Jumli Marshi need more water and fertilizers and it is blast susceptible. Modern varieties of rice are also being grown in some districts.

Buckwheat cultivation is very easy and can be grown in marginalized soil and adverse environments. Field and storage pests are negligible in buckwheat crops and seeds. However, farmers reported many problems in buckwheat cultivation. These problems are bitter taste, lodging in high fertile soil, difficult to dehusk and grind, storage problem for Barule phapar, low grain yield of common buckwheat, shattering and marketing problems, damage of crops easily by rainfall, limited food items made from buckwheat, causing of joint or leg problems (Jhamjhamaune) after having more leaf, etc. Its food items are tasty with nutritious and medicinal value. Two species of buckwheat are under cultivation. Among these two species, Tartary has different local names but common buckwheat is commonly called Mithe Phapar in most of the locations (Upadhyay and Joshi, 2003). Average diversity is higher in common buckwheat than in Tartary (Joshi and Baniya, 2006). In Jumla where species diversity is higher, food culture is also rich as compared to Mustang and Manag (Rijal et al., 2001).

We collected the existing rice and buckwheat genetic resources from Jumla. Seeds of 6 different landraces of rice were collected consisting of total 37 populations (Table 11). A total of 28 Mithe and 21 Tite buckwheat genotypes were collected from different farmers of Jumla, Hill Crops Research

Program, Kavre and Agriculture Botany Division, Khumaltar (Table 12). Genetic diversity is very rich in Dolpa and every family grows Tartary buckwheat (Vaidya et al., 1998). Wild (*Fagopyrum cymosum* and *F. megacarpum* etc) and weedy forms of Tartary buckwheat are found in Dolpa and other districts of Karnali zone (Nakayama et al., 2001). Loss of landraces in Jumla is reported by Joshi et al., (2005). Genetic erosion may also be in other districts. Based on the morphological data and value in term of area and number of growers, diversity status of rice and buckwheat landraces of Jumla (NARC, LIBIRD and IPGRI, 2005) is determined and they are kept in red listing categories (Joshi et al., 2004) which is very important for giving priority to conserve ex-situ.

Table 7. Number of VDCs growing rice and buckwheat

SN	District	Total VDC	Number of VDC growing			
			Rice	Mithe	Tite	Wild
1	Dolpa	23	10	17	23	14
2	Jumla	30	27	30	30	30
3	Kalikot	29	23	5	6	0
4	Mugu	24	-	-	-	-
5	Humla	26	-	-	-	-

Table 8. Rice and buckwheat landraces and varieties being grown in Karnali zone

SN	District	Landraces/ varieties		Main crops
		Rice	Buckwheat	
1	Dolpa	Chommrong, Lumle-1, Jinling, Yunlen, Chandhannath-1, Local	Mithe phapar, Local Chuchche, Local Lekhari, Bhate, ACC# 2223, Dalle, Kalo	Maize, rice, wheat, finger millet, naked barley, barley, buckwheat, chino
2	Jumla	Seto Marshi, Rato Marshi, Kalo Marshi, Jumli Marshi, Jumli Marshi Mehele, Jumli Marshi Dadime, Chandhannath 1, Chandhannath 3, Ghaiya	Mithe phapar, Chuchche, Barule, Takule, Tilkunde, Tote, Ghode, Tite phapar	Rice, barley, wheat, buckwheat, finger millet
3	Humla	-	-	Naked barley, wheat, barley, buckwheat, rice, chino
4	Kalikot	Chommrong, Palung, Khumal-4, Khumal-5, Khumal-6, Khumal-7, Khumal-9, Chandhannath-1, Tirthapoke, Tarijiule, Chimathekalo	Tite phapar, Mithe phapar	Naked barley, finger millet, buckwheat
5	Mugu	-	-	Wheat, barley, naked barley, chino, kaguno, rice, buckwheat

Table 9. Rice varieties with preferred and non preferred traits of farmers

SN	Variety	Morphology	Liked traits	Disliked traits
1	Jumli Marshi Rato	Dwarf plant, dense grain in panicle	Tasty, easy to mill	Low straw yield, blast susceptible, need more water
2	Jumli Marshi Seto	Tall plant, red grain after matured	Tasty, fast cooking and need low water for cooking	Low yield, shattering
3	Jumli Marshi Kalo	Medium size plant, black and large grain, white seed,	Easy milling and threshing, tasty, andilo, cold tolerance, rice good for heart patients,	Need more water to cultivate, lodging, weed problems, blast

SN	Variety	Morphology	Liked traits	Disliked traits
		reddish plant	good market value, straw good for livestock, low storage pests	susceptible, low grain yield
4	Dadime	Small plant, small size grain, red grain, red seed	High yield, early maturity, wind can't shatter the grains, straw good for livestock	Difficult to thresh, need more water, more storage pests, grain color not good for eating
5	Ghaiya	Low tillering, round and bold grain	Need less water and fertilizer, drought resistance, blast resistance	Not tasty, low yield
6	Chandhannath 1	Short plant, black small grain	High yield, need low water, lodging resistance, hail stone resistance (hail stone can't damage grain), tasty, low disease problems, good straw for livestock	Low straw yield, difficult to thresh, grain color not good for eating
7	Chandhannath 3	Tall plant, long panicle, yellow grain, white seed, long grain	Less tasty than Kalo Marshi, high straw yield, easy to harvest, low diseases problems, need low water, cold tolerance	Need more fertilizers, difficult to thresh, late maturity, storage pests problems, difficult to mill, crop can be damaged if there are more water in the field

Table 10. Landraces of buckwheat with prefer and non prefer traits of farmers

SN	Variety	Morphology	Liked traits	Disliked traits
1	Mithe Phapar	Red stem and leaf, white flower, tall plant, shiny black triangular seed, large seed	Tasty, thin husk, lodging resistance, good ringata disease	Low grain yield, straw not good for livestock
2	Barule	Medium size leaf and plant, seed not pointed	High yield, short duration variety, leaf useful for vegetables, more branching, more flour yield, no need of intercultural operations, useful for livestock, good for pregnant livestock especially in case of Sal najarne problem	Bitter, flour come out if rainfall occur after maturity, difficult to grind, if eat more, can create swelling and jamjamaune problems
3	Chuchche	Long triangular seed, tall plant, triangular leaf, low branching	Low cost of intercultural operations, leaf are useful for fresh and dry vegetables, high yield, early maturity, useful for cough, jaundice, diabetes, low weed problems, useful for sick animals and during bleeding	Bitter, cause headache if eat more, if leaf eat before monsoon cause jamjamaune, turn eye yellow and swell body if eat more, no seed set in case of high moisture and fertile soil, lodging problem in fertile soil

Table 11. Rice accessions collected from different farmers of Jumla and evaluated in ARS, Jumla

SN	Landrace	Population, n	Collection sites in Jumla
1	Jumli Marshi	5	Chumchaur, Patarasi, Dillichaur, Raralihi, Chandhannath
2	Rato Marshi	11	Malika Bota, Rara Lihi, Thapa, Badki, Narakot, Birat, Tamti, Kanka Sundari, Daku, Lamra
3	Dadime	6	Mahabai Patar Khola, Kalika Khetu, Kudari, Pandab Gupha, Mallika Danta, Rara Lihi
4	Mehele	5	Kalika Khetu, Rara Lihi, Ghode Mahadev, Mallika Danta, Hanku
5	Kalo Marshi	9	Talium, Dhapa, Depalgau, Mahat, Hanku, Kudari, Patarasi, Chumchaur
6	Seto Marshi	1	Lamra

Table 12. Buckwheat accessions collected from different farmers of Jumla and from Kavre and Khumaltar evaluated in ARS, Jumla

SN	Landrace	Population, n	Source
Common buckwheat			
1	Mithe Phapar	11	Jumla (Kudari, Lamra, Rara Lihi, Tato Pani, Hanku, Kudari, Mallika Danta, Ghode Mahadev)
2	ACC# 481, CBBP-03, GF-5099, ACC# 6529, ACC# 5274, GF-5289, ACC# 2244, GF-5063, GF-5283	1 from each line	Kavre
11	ACC# 2228, COLL# 7529, IR-13, ACC#6575, AIBL-D, ACC# 6273, ACC# 22-7-1, DHANKUTTA, ACC# 9251, MY-10-2, LOCAL SWEET, COLL# PL-21, ACC# 1012, ACC# LOCAL SWEET, PL-30, ACC# 7519, KHUMAL, GF-5251	1 from each line	Khumaltar
Tartary buckwheat			
1	Barule	32	Kudari, Wadki, Ghuthichaur, Patarkhola, Lamra, Chumchaur, Rara Lihi, Hanku, Dhapa, Mallikadhanta, Bumramadichaur, Patmara, Kalikakhetu, Talium, Patrasi, Sanigau, Tatopani, Ghodemahadev, Pandavghupha
2	Chuchche	23	Kalikakhetu, Hanku, Narakot, Rara Lihi, Bumramadichaur, Chumchaur, Birat, Talium, Badki, Patmara, Dhapa, Lamra, Sanigau, Tatopani, Kudari, Kawasowti, Lama, Depalgau, Chandhannath, Malikabota
3	Tite phapar	7	Talium, Patrasi, Tamti, Kankasundari, Mallikadnata, Mahat,
4	MY-2-27-1, GF-5283, SAMPLE# 6-1, SAMPLE# 8, ACC# 2223, ACC#2227	1 from each line	Kavre
10	ACC# 7529, ACC# 2201-2, BHATE PHAPAR, ACC# 6485, MY-2-33-1, ACC# 2236, KLE-IR-13-6-106, LOCAL BITTER, KAVRE BITTER, GF-5251, MY-2-27-1, ACC# 15170, S-1	1 from each line	Khumaltar

Farmers' Perception on Medicinal Value of Rice and Buckwheat

Farmers are familiar with the genotypes of rice and buckwheat for their medicinal value. Jumli Marshi is considered to have medicinal and nutritious values. Tartary buckwheat is recognized as very useful for treatment and control of human and livestock diseases. Fresh leaf, dried leaf, seed husk and flour are used for this purpose. Tartary buckwheat is eaten during cold season to generate heat in the body. Some of the medicinal importance of rice and buckwheat (Sharma, 2001; Vaidya et al., 1998; Rijal et al., 2001) are given below.

- Jumli Marshi Kalo is good for heart patients.
- Paste of tartary buckwheat is applied in cold, wound, fire burn, cough, eye problem, jaundice and fever.
- Fresh flour is swallowed with warm water for fever and also useful for dandruff treatment and stopping hair dropping.
- Hot lagar is eaten in cold, gastric and indigestion.
- Drained green water of bitter buckwheat flour after dipping over night is used for epilepsy.
- Tender leaves, twigs of wild buckwheat are used for dysentery, pneumonia and cholera.
- Tartary buckwheat as food is useful for stomach problem.
- It is used to reduce the effect of poison.
- Flour paste is useful in pimples and skin scratches.
- It is useful in case of sudden stop of stool and urine, bleeding during the birth of baby, gum bleeding and swelling.
- Soaked flour is useful for internal worms etc.

Genetic Variation

Preliminary study showed the isozyme polymorphism in rice (Jumli Marshi, Fuji-102, Chhommrong, Chandhannath-1, Chandhannath-3) (Figure 3). RAPD markers also revealed the genetic variation among the collections of rice from Karnali zone (Figure 4). SSR markers showed very little genetic variation among landraces of Jumla and landrace names adopted by farmers are inconsistent indicators of genetic identity (Bajracharya et al., 2003a). Different biotechnological tools have been tried to increase the productivity of cultivated buckwheat species (Joshi and Bimb, 2001). Allozyme study in Tartary buckwheat of Jumla exhibited on-farm diversity (Bajracharya et al., 2003b). Within populations of wild buckwheat, eco-geographical variation was observed dividing the population into mid western, western and central regions by RAPD study (Bimb et al., 2001a). However RAPD could not explain the variation due to geographical distance in Tartary buckwheat (Bimb et al., 2001b). Limited DNA markers have been developed in buckwheat and some markers designed to use DNA sequences of common buckwheat can be used for tartary buckwheat (Joshi et al., 2006). This diversity information is very useful for management and utilization of these genetic resources.

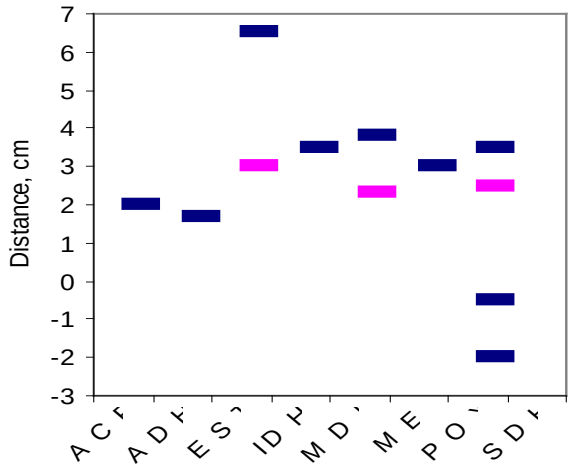

Figure 3. Isozyme profiles of Chhommrong rice cultivar

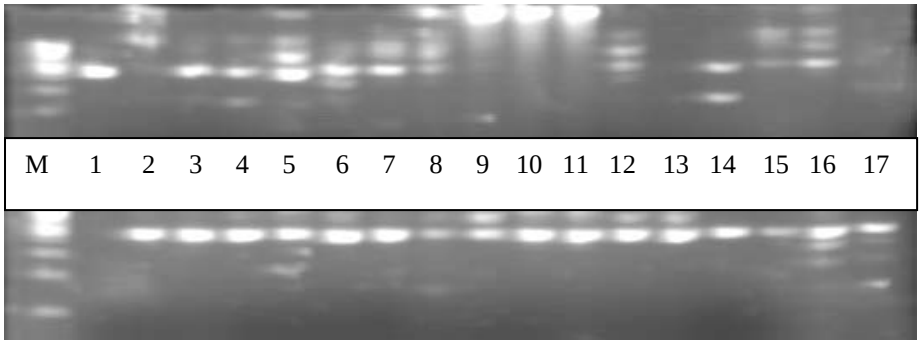

Figure 4. RAPD polymorphism of different rice genotypes with primer 141 (M, marker; **Sample above:** 1, Kali Marshi; 2, Ghaiya dhan; 3, Dhokro dhan; 4, Maine Pokhreli; 5, Lekali dhan; 6, Hanse; 7, Pale dhan; 8, Bageri dhan; 9, Jethobor; 10, Pokhara Masino; 11, Chananchur; 12, Lalshar; 13, NR10315-145-2-3; 14, NR10286-6-3-2-2; 15, Manjushree-2 ; 16, NR10375-20-1-2; 17, Khumal 11. **Sample below**: 1, NR10353-8-2-1; 2, NR28518-3-2-3-1; 3, NR10276-15-2-3-3-2; 4, NR10414-25-2; 5, NR10414-34-2-3; 6, Taichung-176; 7, Jumli White; 8, Chandhannath-1; 9, Chandhannath-3; 10, NR10276-9-3-3-3-2; 11, NR10285-29-3-1; 12, Sabitri; 13, IR-24; 14, A57-115-8; 15, CO 39; 16, Masuli;17, Check3 from Jumla, 2 from Humla and 3 Mugu)

Characterization and Evaluation of Jumla Collections

Out of 37, 14 rice collections were characterized and evaluated at population levels in Agriculture Research Station, Jumla. Only the traits of six genotypes are given in Table 9. Some of these were promising. Blast experiment including all 37 collections showed that all the tested genotypes were susceptible to blast in Khumaltar.

Table 13. Performance of Jumla rice collections

SN	Landrace	Maturity day	Plant height	Yield, t/ha	Blast reaction
1	Jumli Marshi Mehele	194	80	3.3	Field resistance
2	Jumli Marshi Darime HBP	159	83	3.5	Field resistance
3	Jumli Marshi Darime KBR	194	86	3.7	Field resistance
4	Kalo Marshi	196	76	3.5	Field resistance
5	Jumli Marshi	194	89	4.2	Field resistance
6	Rato Marshi	196	70	4.5	Field resistance

* Capital letter after landrace name is farmer name in short who provided the seeds.

Buckwheat is very short duration crop and it can be grown in diverse environments. Tartary is suitable to high altitude and it can tolerate frost. Due to rainfall during flowering period of common buckwheat, most of the genotypes showed poor performance. However five lines did well. Performances of five and 13 lines of common and Tartary respectively are given in Table 10. Most of the Tartary buckwheat did well. Maturity days, plant height and other yield components trait are important for indirect selection of genotypes. Maturity days had a significant positive correlation with plant height and grain yield (Joshi, 2005). Pandey et al. (2003) studied two landraces of Tartary buckwheat, Barule and Chuchche at population level and found more variability in Chuchche. Bainya et al. (2001) studied buckwheat collections from Dolpa and Jumla in different locations and result were inconsistent. Due to the bitterness in Tartary buckwheat, farmers preferred common buckwheat. Farmers soaked the flour of Tartary buckwheat for 5 hours before actual cooking to reduce the bitterness. Bitterness increases as altitude decreases (Subedi et al., 2001). Jumla Tite was preferred across the agro ecosystems mainly for higher yield but despite low yield of Bhate from Dolpa, it was liked by Mustang and Kaski farmers for its bold grain, loose husk and low bitterness (Subedi et al., 2001).

Table 14. Performance of Jumla buckwheat collections

SN	Landrace	Maturity day	Plant height	Yield, kg/ha
Common buckwheat				
1	Mithe phapar UKH	66	78	700
2	Mithe phapar AB	73	67	300
3	Mithe phapar HBR	71	72	601
4	Mithe phapar DKU	66	54	863
5	Mithe phapar PSR	66	56	495
Tartary buckwheat				
1	Barule JR	74	56	696
2	Chuchche BC	76	45	600
3	Chuchche DB	78	46	537
4	Barule KU	106	49	616
5	Barule LBA	106	50	700
6	Chuchche MBD	96	49	500
7	Tite phapar NK	77	42	500
8	Barule UR	79	46	500
9	Chuchche NDA	66	51	550
10	Barule GBB	96	69	500
11	Tite phapar PU	96	42	593
12	Chuchche SD	76	45	844
13	Barule KB	78	63	1430

* Capital letter after landrace name is farmer name in short who provided the seeds.

Conclusions

Farmers are maintaining diverse landraces of rice and Tartary and common buckwheat by growing them in diverse environments. Contribution may be significant in food security if some genetic improvement can be done on these three species for Karnali zone. Some of these landraces are medicinally important and very nutritious; however, they are under risk of genetic erosion due to the low productivity. Rice and buckwheat genetic resources are being lost from Karnali zone and existing landraces are not competitive. Therefore conservation efforts should be initiated making landraces more competitive. Sustainable use of these valuable landraces is necessary for continuity of important genes. Landraces from other districts except from Jumla are less studied. Potential of genetic resources available in Dolpa, Humla, Kalikot and Mugu should be explored. In addition to landrace improvement, new varieties with disease resistance, cold tolerance and short growing period should be introduced to increase the option of varietal choices. Agriculture Research Station, Jumla does not represent the upper part of Karnali zone for evaluating genotypes. Therefore genotypes doing well on-station may not perform well in other areas of Karnali zone. Breeding works for Karnali zone should be carried out in Jumla.

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