On-farm Management of Rice Varieties in Kumaon Himalayas of Uttarakhand

PS Mehta, KS Negi, AK Trivedi and SN Ojha
National Bureau of Plant Genetic Resources (NBPGR), Regional Station Bhowali-263132, Niglat, Distt. Nainital, Uttarakhand

In heterogenous agro-ecosystems, local farming communities used to grow different cultivars adaptable in different eco-niches. They are the managers of crop diversity as well as custodians of the important genetic wealth. The Himalayan highlands are important centre of crop diversity due to high ecological heterogeinity and socio-cultural integrations. Rice crop genetic diversity managed by the local farm households in Kumaon Himalaya of Uttarakhand state has been documented in the present study. Farmers management and on-farm conservation of existing rice varieties were studied in detail. Farmers variety selection criteria, seed flow, exchange and traditional storage techniques, which are the important processes involved in on-farm management were also studied in greater detail. This study examines and discusses the processes of seed and variety selection, adaptation in different agro-ecosystem in respect of management of crop diversity for subsistence needs.

Key Words: On-farm management of rice, Uttarakhand, Primitive cultivars, Kumaon Himalaya

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Introduction

Rice (*Oryza sativa* L.) is one of the major crop of kharif season in Uttarakhand. It is the single most important food crop and 90% of it is grown and consumed in Asia (Khush and Brar, 2005). It is well known that rice emerged as staple food in South-East Asia that proliferated and subsequently dominated the world food bowl along with other food crops (Paroda, 2004). Rice contributes 26% in the world's food production (FAO, 1996). In Kumaon Himalayas it is grown since time immemorial. Before green revolution era, the total cultivation of rice was dependent on traditional local cultivars. The old traditional rice cultivars were very well known in the Gazetteer of Himalayan provinces (Atkinson, 1882). After green revolution, many rice varieties were developed by various regional, national and international organizations, but these high yielding varieties (HYVs) were suitable to irrigated areas only. In Kumaon Himalaya only 15% cultivable land is irrigated. In rainfed cultivation, mostly traditional cultivars are grown by the farm households. These local cultivars are very much suitable to the agro-climatic conditions and eco-niches. Despite the spread of many improved varieties, several local named varieties are still grown in the region because of their well adaptability (Bisht *et al*., 2006). Farming communities in the Kumaon Himalaya are completely dependent on local cultivars and seed system, which are suitable for their environmental, socio-economic and ethnic requirements. These local varieties are managed by the local farmers in different agro eco-niches. Farmers management of diversity refers to the cultivation of a diverse set of more or less specialized crop population. These population are named and recognized as units by the farmers. These are known as farmers varieties as opposed to the improved varieties.

Today there is a world wide concern over the loss of crop diversity. A particular concern is the substitution of a diverse set of genetically variable crop landraces by a few genetically uniform modern varieties (Brush, 1991; Harlan, 1992; Hawkes, 1983; National Research Council, 1983; Plucknett *et al*., 1987). The need to conserve the wide array of diversity has been recognized as very important for many decades. It has resulted in to the creation of gene banks around the world *i.e.*, *ex-situ* conservation (Hawkes, 1983; Plucknett *et al*., 1987). Lately, on-farm (*in-situ*) conservation and management has been advocated as a complementary method to *ex-situ* conservation (Altieri and Merrick, 1987; Brush, 1991; IPGRI, 1993; Old Field and Alcorn, 1987).

On-farm conservation of plant genetic resources can be defined as the continued cultivation and management of a diverse set of crop populations by farmers in the agro-ecosystem, where a crop has evolved. It is a dynamic and is aimed at maintaining the evolutionary processes that continue to shape the diversity.

In Kumaon Himalayas, farmers have developed and nurtured crop diversity and this process is still continue amongst the farmers, in spite of socio-economic and technological changes. For conservation and management of diversity, the process of seed selection, flow of seed material and local storage methods are the major components involved. The present study aimed at documentation of the local rice cultivars grown by the

farm households in Kumaon Himalaya is undertaken. The results are described in the light of farmers management of rice varieties for sustainable livelihood in this Himalayan region.

Materials and Methods

Data on rice genetic resources were collected from primary sources with the help of planned structural and unstructured interview schedules/questionnaires at individual household levels during 2007 and 2008 cropping seasons. Sample households were randomly selected from all the 33 development blocks of five districts of Kumaon Himalaya of Uttarakhand state. Three to four villages were selected from each development block representing the distinct agro ecological niches. In each selected village 5% households were randomly selected for interview. For randomization, lottery system was adopted. Thus a total of 363 farm households were interviewed for documentation of rice varieties grown by them. The district wise details of development blocks and number of villages surveyed and respondent farmers are presented in Table 1.

During the survey of the region, a non-participant observation method was also used while recording the information of rice cultivars.

Using participatory rural appraisal (PRA), information was obtained on the erosion and shift in cultivar diversity and changes. The information for current status was validated by taking observations in the fields of the farmers for the cultivars diversity grown by them. Respondent households were also asked to fill a questionnaire for extracting their knowledge on rice cultivars and diversity available under on-farm management. Local seed exchange systems, selection methods and storage techniques were also studied in greater details. All possible care was also taken to avoid the duplicacy of varieties by comparing information provided by different farm households and social groups.

Table 1. Districts, number of development blocks, villages and households surveyed for collection of data of rice diversity

District	Number of development blocks	Number of villages surveyed for the study	Number of households sampled
Almora	11	40	112
Bageshwar	4	16	58
Champawat	4	17	39
Nainital	7	21	63
Pithoragarh	8	29	91
Total	33	123	363

Information obtained was authenticated from knowledgeable elderly farmers particularly from women folks, who are considered as the manager of crop diversity in the area surveyed.

Results and Discussion

The cropping system in Kumaon Himalaya is built around two major seasons, *Kharif* (April to October) and *Rabi* (October to April). Rice is the major crop of *Kharif* season. It is grown in both conditions irrigated as well as rainfed. In the hills, practice of mixed cropping is very common, however rice is grown as mono crop. There are three different agro-ecosystems-rainfed locally known as *uprao*, irrigated locally known as *talao* or *sera* and marshy land locally called *simar* or *gazar*. Rice is grown in all the three agro-ecosystems in the entire hill region. A detailed inventory of local farmer named rice cultivars grown in different agro-ecosystem of Kumaon Himalaya is presented in Table 2. A total of 131 traditional and improved /HYVs have been documented in the present study, of which 73 are categorized as rainfed, 29 as irrigated and 29 as common. Common cultivars are also suitable for marshy areas (simar). Most of the cultivars 73 are grown under rainfed conditions. None of the improved varieties are cultivated in rainfed areas in the entire Kumaon region. In irrigated agro-ecosystem, there are 29 traditional cultivars grown by the farmers as against 10 improved cultivars. In earlier studies a total of 117 cultivars have been documented, of which 74 were categorized as rare, and 43 as common. Most of the cultivars were recorded in rainfed agro-ecosystems (Bisht *et al.*, 2007). In an ancient document the Gazetteer of North-Western provinces, a total of 48 traditional cultivars of rice were mentioned in Kumaon Himalayas (Atkinson, 1882). The present study reveals larger number of cultivars under cultivation in the region. It is mention worthy that the cultivars mentioned more than 100 years back are still under cultivation in the region. The study revealed that the rainfed (*upraon*) cultivation is a reservoir of traditional rice cultivars. Farmers have identified and selected the cultivars for different eco-niches, which atleast produce some yield in spite of adverse climatic conditions. That's why a large number of cultivars grown in the rainfed ecosystem. Local farming communities have maintained and conserved them for centuries. They have also acquired a good traditional knowledge in respect of these different varieties.

In irrigated agro-eco system 29 traditional local named varieties are grown as against 10 improved

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Table 2. Rice cultivars grown and managed by the local farmers of Kumaon Himalaya in various agro-ecosystems

Agro-ecosystem(s)	Traditional cultivars	Improved cultivars
Rainfed agro-eco system (*upraon* cultivation)	*Dhurbasmati, Boran, Paktauli, Akadi, Kirmiti, Banpas, Roti, Sontu, Jhumaria, Musmad, Hat, Makhur, Jawan, Masur, Telhat, Syont, Jungledhan, Jhadua, Nanbasmati, Thulbasmati, Ud, Parange, Jhakui, Bakul, Pingau kaludhan, Dangazai, Ram-Sita, Bakudhan, Dan naulia, Nauldudh, Giddha, Bamkua, Phamkua, Timilia Goldhan, Maildhan, Batasu, Gadai, Choria, Thai, Ram manua, Roti, Tawali, Sirmodia, Uskal, Lumadia, Ghesu, Timasia, Gadalu, Bhadgar, Sudia, Bhuria, Janoli, Madgar, Hayal Nalu, Jhusia, Matiya, Chamaria, Lahangi, Jungloi, Dotiyali, Dhank, Rokhiyal, Khardudh, Tilasi, Pokhiya, Lal jaria Jhini, Bagesaria*	—
Irrigated agro-ecosystem *(Talaon* or *Sera cultivation)*	*Jiruli, Rajmati, Kapkoti, Dal badal, Rajula, Lali, Chhoti, bakul, Jamai, Jorhat, katyuri, katisal, Anjan, Siyud Kalajamali, Kashmiri, Jamali, Askotia Jyoli, Binduli, Parvati, Ramgarhi, Lohin, Sunkhar, Rajdhan, Sita, Musia, Lumadia, Pandudha*	Govind, China-4, Saket, Taichun, Native-8, IR-8, Indrasan, IR-24, VL-206, Pant-11
Common (grown in both rainfed and irrigated egro-eco-system) (suitable for *Simar* or *Gazar* cultivation)	*Thapachini, Dudh, Joliya, Gazai, Laldhan, Nandhani, Simanjari, Suntola, Sanwdhan, Ratdhan, Silkdhan, Patauli, Gazai, Kavdhan, Chhotia, Khazia, Chinbhuri, Basmati, Kalparia, Kalthuni, Sal Gadalu, Janoli, Pyolia, Ghini, Kalajaria, Jhusia kala, Jhusia safed, Ponthia*	Anjani, Mangraj

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varieties. Although 15% of the cultivable land under irrigation in Kumaon Himalaya and rest is under rainfed (Bisht *et al*., 2007). Approximately 69% of the cultivable irrigated area is occupied by 12 high yielding varieties (Table 3).

Local cultivars, which are categorized as common are found very widely adapted in the region as they are suitable for both conditions rainfed as well as irrigated. An average 71.67% rice cultivation is occupied by traditional cultivars as against 28.33% by HYVs in the entire Kumaon Himalaya (Table 3).

Rainfed agro-ecosystem is completely dominated by traditional cultivars, whereas 84% of rice cultivation is marshy areas is dominated by these local cultivars. It is interesting to note that all the traditional cultivars under cultivation in the region are farmer named,

Table 3. Occupancy of rice cultivation area by different types of cultivars in different agro-ecosystems

Agro-ecosystem	Occupancy of area under traditional cultivars (%)	Occupancy of area under improved cultivars (HYVs) %
Rainfed agro-ecosystem	100.00	0.00
Irrigated agro-ecosystem	31.00	69.00
Marshy agro-ecosystem	84.00	16.00
Average	71.67	28.33

particularly in rice, based on certain characteristic features (Mehta *et al*., 2008). Farmers varieties including crop populations, which farmers have identified and named as units (Lando and Mak, 1994). The large diversity of rice is managed by farmers as an adaptable strategy to cope with heterogeneous and uncertain ecological, socio-economic environment including different soil types (Das and Das, 2004).

In Kumaon Himalayas, farm holdings are marginal to small. These small pieces of fields are scattered over the entire village land and different eco-niches, which compels farmers to grow different cultivars for different type of eco-niches and soil types. As a strategy to produce atleast for their subsistence needs, farmers grow more number of varieties. The present study reveals that at different altitude levels, the number of varieties also differ. Rice is grown up to 2,200 msl in the hills. In the lower altitudinal areas, mostly irrigated land is used to grown improved varieties and in the higher reaches (above 2,000 msl) a limited number of varieties, which are adaptable in the cold climate are grown. Middle hills (between 1,001-2,000 msl), where both types of land (irrigated and rainfed) is found available for cultivation is found as the reservoir of a large number of varieties. Maximum an average of 19 varieties were found between 1,500-2,000 msl altitude followed by an average of 18.40 varieties between 1,001-1,500 msl. The largest number of varieties *i.e.*, 53 are grown in the villages situated between 1,501-2,000 msl in district Pithoragarh and followed by 45 varieties in the villages of district Almora situated between 1,001-1,550 msl (Table 4).

The study also reveals that the individual farm households grow and maintain atleast one or more rice landraces ranging between 1-9. Individual farm households grow and maintain an average of 3.08 different cultivars in Kumaon Himalayas. The highest average number of rice cultivars are maintained per household in district

Bageshwar (4.19) followed by Champawat (3.28), Pithoragarh (3.12), Almora (2.59) and Nainital (2.25) Table 5.

Since the topography, geographical situations, altitudes, micro-eco-niches, availability of irrigation water vary from district to district, which attributes the variation in the number of cultivars under cultivation. In the region, heterogeinity of topography, altitude, water regeme, environment, temperature, soil types etc. were observed to be very high. This heterogeneity has created a large number of micro-eco niches, which in turn are responsible for creation of a large number of local landraces/primitive cultivars to suit varied environments (Mehta *et al.,* 2008). As the HYVs are adaptable to a wide environment, they do not cater to the needs of the various micro-eco-niches prevailing in the region. Perhaps that is why a large number of farm households prefer to grow traditional cultivars inspite of introduction of HYVs.

Selection of varieties is also an important task of the farmers. Farmers use multiple criteria to select the varieties of their choice. The selection criteria is influenced by different socio-economic, geographical and technological factors, *viz.*, performance of the variety with respect to agro-ecological conditions, uses of the output and input requirements. In hill farming system, use of input is very limited, seeds and farm yard manures are used as inputs. Assured yield, good straw quality, drought tolerance, quality of rice, etc. are the major selection criteria adopted by the farmers in this region. Farmers have identified and selected the rice varieties for different agro-ecosystems on the basis of their trials and observation. The varieties grown in rainfed areas are considered as drought tolerant (Table 2). Like wise the cultivars *Thapachini, Joliya* and *Chotia* are found good yielding. However, *Jamai, Thapachini* and *Bakua* are considered good in taste. Hill agriculture is interlinked with animal husbandry, hence fodder is also an important byproduct of crop yield. *Thapachini* and *Uskar* are good straw yielding varieties (Mehta *et al.,* 2008). Generally good straw yielding cultivars are selected by the farming communities for cultivation in their fields. These varieties are under cultivation in Uttarakhand since time immemorial. Thus, the fact is that farmers have multiple criteria to select what varieties to plant as well as where, when and how to do it has been well established and reflect their concerns (Bellon, 1991; Brush *et al.,* 1981; Brush, 1992; Lando and Mak, 1994; Lambert, 1985; Sperling *et al.,* 1993).

Seed Flow and Exchange

The exchange of seed material is common historical pattern all over the world that currently continues, particularly with the introduction of modern varieties. Several studies have documented the flow of seed of different varieties among small famers (Cromwell, 1990; Dennis, 1987; Loutte, 1994; Sperling *et al.,* 1993). These flows can happen within a village, a region, a country or even countries. It is evident from the survey that there was no formal system of seed exchange in the region, which was the limiting factor for continuous survival and on-farm management of local cultivars especially those grown by marginal farmers. However, the seed flow and exchange of varieties by using barter system is practiced in the region. Exchange of seed material with in a village is observed very larger in comparison to out side of villages. Farmers preserve the seed material from their own harvest to be sown in the next cropping season. In Kumaon Himalayas, 79% of the seed material is arranged by the local farming communities from their own harvest, 16.2% seed material is collected from the neighbouring farmers, relative and friends. Only 4.8% seed material is procured from government or non-government seed agencies. It includes improved varieties developed by different research and development organizations (Table 5).

It was also observed in the study area that sometimes a married daughter carried the seed material from parental house to her-in-laws house and vise-versa. Similarly some service personnel like military men collect the

Table 4. Number of rice varieties grown by the farmers in different altitudinal gradients in Kumaon Himalaya

S.No.	Altitudinal gradients msl	Districts					Average number of varieties
		Almora	Bageshwar	Champawat	Nainital	Pithoragarh	
1	Up to 500	—	—	—	9	—	9.00
2	501-1000	28	—	—	11	03	14.00
3	1001-1500	45	16	10	9	12	18.40
4	1501-2000	11	10	18	03	53	19.00
5	Above 2001	—	17	04	—	08	9.67

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Table 5. Average rice varieties grown and maintained per households in different districts of Kumaon Himalayas

S.No.	District	Range	Average rice varieties grown and maintained by per household
1	Almora	1-9	2.59
2	Bageshwar	1-6	4.19
3	Champawat	1-6	3.28
4	Nainital	1-4	2.25
5	Pithoragarh	1-9	3.12
	Average varieties/household	3.08	

seed material from very far-flung areas. These varieties were known after the place or state of their collection. *Punjabi, Kashmiri, Kapkoti, Askoti, Ramgarhi, Jorhat* etc. are the cultivars introduced in the region and are performing well here since long. Introduction of these cultivars had enriched the rice diversity of the region and are flourishing very well in this Himalayan highland.

Seed Storage and Conservation System

Farmers, on the basis of performance and preference select the seed material of various varieties to be stored for the next cropping season. Generally each and every cultivar were selected for seed purposes. Selection of panicles for seed were done by old and experienced women folk from healthy crops fields. In order to ensure good germination only healthy and shining seeds were selected and harvested separately. The seed material was sun dried very carefully. Before storing, the moisture content of the seeds were tested by crushing them with teeth. By virtue of their age old knowledge of the viability of grains, healthy grains were selected and stored every season, thereby enhancing the genetic potential of the crop to with stand biotic and abiotic stresses (Ravishankar and Selvam 1998). To protect the seed material from insects, cow dung or oak wood ashes are mixed with seed material before putting them in the storage bins. For safe and secure storage, the leaves and rhizomes of Bach (*Acorus calamus*), Timur (*Zanthoxylum armatum*), Bakayan (*Melia azadirachta*), Turmeric (*Curcuma longa*) were added in the dried seed material. These plant materials emit, a pungent smell, which act as repellant to insects. Storage of each cultivar was done separately to facilitate their identification and collection from specific fields. Generally seeds were stored in the containers, wooden bins and bamboo/*ringal* made bins. Bamboo/*ringal* made bins were plastered with mud, cow dung, mustard cake, and cow urine. Before putting the seeds in the storage containers or bins, they were sun dried carefully. After putting the seed material in the storage containers/bins, they were made airtight by covering the mouth with straw and cloth plastered with cow dung, mud and cow urine. Such storage systems have served farmers as their own seed banks from centuries. An urgent need was felt to strengthen at the village level for *in-situ* (on-farm) conservation of crop diversity (Swaminathan, 1998). Traditional seed storage system and repositories conserve the genes, which are very conveniently adaptable in various agro-eco-niches of this Himalayan region.

Table 5. Sources of seed material of local farmers of Kumaon Himalaya

S.No.	Source of material	Percentage of seed material (%)
1	Harvest from their own fields	79.00
2	Exchange of seed material from neighbours, relatives and friends	16.20
3	Procurement of seed material from government and non-government agencies	4.80

The present study is an evidence from the detailed documentation of rice cultivars in Kumaon Himalaya. This information collected from the house hold levels or farmers plots may not be an appropriate measurement to analyze the diversity, but indicates a vast wealth of rice diversity available in the region. In this Himalayan region, it is observed that out side forces influencing cropping system and diversity are negligible. Local agro-eco-systems, mico-eco-niches, climatic conditions, soil types etc. are the various attributes, which compels farmer to adopt more and more different cultivars adaptable to different situations. Agriculture for subsistence is completely dependent on local cultivars. These cultivars are managed by local farming communities inhabiting in various agro-eco niches. Such types of agro-eco-niches are suitable for on-farm conservation of crop varieties. The region as a whole may acts as a reservoir of rice cultivars possesses various characteristic features.

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