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GERMPLASM COLLECTION FROM LAST REMNANTS OF RICE LANDRACE GENETIC DIVERSITY IN HIGH ALTITUDE AREAS OF KASHMIR HIMALAYAS

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Abstract

The aim of the present study was to know about past and present cultivation and status of rice landraces in Kashmir province of Indian Himalayan state of Jammu and Kashmir. Tremendous genetic diversity has existed in past in paddy fields throughout Kashmir especially in remote high altitude areas and more than 4 dozen named landraces have been recorded in the literature. Elderly farmers in their sixties and beyond still fondly remember these landraces and often recall quality attributes in many of these genetic resources. Most of the landraces have now disappeared from the local production system and only few are presently being cultivated and that too in a very small area. The reasons as to why farmers lost interest in these genetic resources and why few landraces are still popular in farmer fields have been discussed. Our study has revealed that variability in paddy fields has now been drastically reduced to few high altitude areas where also it is seriously endangered. We argue that collection of well adapted traditional varieties from these 'last remnants of rice genetic diversity' in Kashmir is an important task especially under prevailing uncertain social and climatic conditions to ensure a sustainable environment. 32 germplasm accessions of some landraces have been collected during our survey in these areas. These have been deposited in National Seed Gene Bank at NBPGR, New Delhi for conservation and characterization.

Keywords: *genetic diversity; germplasm collection; Kashmir; landraces; rice.*

Introduction

Rice is a major source of staple food world over. About 80% of world rice production comes from the cultivation of Asian rice (*Oryza sativa* L.) which is believed to have originated in South and Southeast Asia and is now cultivated worldwide whereas African rice (*Oryza glaberrima* Steud.) was domesticated in parts of West Africa and remains locally important in some farming systems there. Thousands of years of selection through natural and human-assisted processes has resulted in a tremendously broad range of genetic diversity in rice as reflected in more than 140, 000 primitive varieties (landraces) and improved varieties in *Oryza sativa* existing today. The amount of genetic variability of a species is essential for its survival and adaptation in different environments. The diversity in agricultural genetic resources viz., cultivars, landraces, ecotypes, weedy races and wild relatives of crop plants form a gene pool

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used for improvement of important characters, broadening of genetic base of cultivars and also a source of new diversity for agriculture [1]. Traditional varieties are a repository of genetic diversity and according to Lanteri and Barcaccia [2], landraces have the higher genetic variability among different groups of germplasm, as well as better environmental adaptation, and are an irreplaceable source of highly co-adapted genotypes. As a natural source of genes for disease and insect tolerance, these materials have also a high potential to increase the genetic basis of elite rice lines and cultivars. Narrow genetic base is traditionally pointed out as the main reason for the stagnation of genetic gains of rice breeding programmes, and for the increase of pest and disease susceptibilities in modern rice cultivars [3, 4]. However, as the grain yield potential of landraces is often low are unable to supply the population-driven consumption needs of modern times. During last century and especially during last five or six decades the diversity of well adapted landraces have been replaced by a much narrow spectrum of high yielding bred cultivars that are often genetically very similar. Throughout the world countless valuable landraces have been lost. Still small farmers in Asia and Africa continue to grow hundreds of different traditional varieties for specific traits such as aroma and cooking quality and for particular agro-ecological adaptations.

Genetic diversity available in rice in India is quite impressive and local landraces/primitive cultivars play an important role in maintaining this diversity [5]. The crop is cultivated in almost all the Indian states under a remarkably wide range of agro-climatic conditions and ecological situations. Although semi-dwarf rice now occupy most of the cultivated areas in India, yet ancestral varieties can still be found in almost all upland marginal areas [6]. Considerable rice landrace diversity exists in Indian Himalayas [7-10]. Selection made by various ethnic groups inhabiting different altitudes and climatic conditions in the Himalayan region practicing different forms of cultivation and diverse culture and traditions has contributed to the diversity of rice crop in this region [6]. The Himalayan region of India thus represents a valuable centre of genetic diversity of rice crop. In the state of Jammu and Kashmir agriculture is mainstay of more than 80% of the population and rice is staple food crop. The state is rich in rice culture from the ancient times and a number of landraces and traditional varieties grown earlier have been replaced by modern high yielding varieties. Walter Lawrence, the British land settlement commissioner first time came here in 1889 and visited almost every village of Kashmir. In his book “The Valley of Kashmir” he recorded that rice in Kashmir are infinite in variety and that he found 53 different varieties of rice cultivated at a single place. He also makes a mention of countless shades of green seen in the paddy fields which according to him during flowering presented a most brilliant collection of ‘art’ colors. Considerably high genetic erosion especially during second half of last century has resulted in loss of this variability to a great extent. Still one can see some variability in paddy fields in few remote high altitude areas of Kashmir. Here also existing genetic diversity is seriously endangered. It has been reported that majority of the rice landraces in Jammu and Kashmir and adjoining Himalayan states of India have reached on the verge of extinction and may disappear from farmers field in next 5 or 10 years or even faster [10]. The present study was therefore undertaken to collect and conserve available rice genetic diversity from the ‘last remnants of variability’ in high altitude areas of Kashmir besides evaluating local farmer knowledge about these genetic resources.

Materials and Methods

Jammu and Kashmir (33°17′-37°20′ N latitude and 73°25′-80°30′ E longitude) within India is phytogeographically most complex North-Western Himalayan state located in the far north of the country sharing international boundaries with Pakistan in the west, Chinese autonomous region of Xinjiang in the north and Tibet in the north-east. It extends to over 640km from north to south and 480km from east to west covering an area of 2, 22, 236km^2 [11]. Owing to a great heterogeneity in the topography, altitude (300-8600m above sea-level) and climate (temperature for example, on an average ranges from -20°C to 45°C), it harbors diverse habitats. Agro climatically the state is divided into three main distinct zones corresponding to three provinces:

1. Cold-arid zone of Ladakh
2. Alpine-temperate zone of Kashmir
3. Sub-tropical zone of Jammu

The entire state is constituted by 22 administrative districts, 10 each in Kashmir and Jammu provinces and two in Ladakh province. Rice is cultivated in the two provinces of Kashmir and Jammu but not in Ladakh. During last four years from 2009-2012 several surveys and germplasm collection programmes of various crops grown in the region were executed by our Research Station. During these exploration and collection trips conducted in the areas falling in all 10 districts of Kashmir province (Fig. 1), farmer knowledge and information about past cultivation of crops including rice landraces was also recorded. Knowledgeable farmers were interviewed for gathering information about number of landraces cultivated in past, their qualities, associated traditional knowledge and reasons for discarding these landraces. The information thus collected was confirmed from the available literature.

Fig. 1. Map of Jammu & Kashmir state of India –
10 districts of Kashmir province covered in the study have been labeled

During the months of September and October last year an exploration and germplasm collection programme of rice landraces in high altitude areas of Kashmir falling in the districts of Anantnag, Baramulla, Budgam and Kulgam was conducted by our Research Station in collaboration with Directorate of Rice Research, Hyderabad, India. Germplasm samples were collected mostly from the field and sometimes from farmer's store. The techniques for collection and passport data documentation followed technical guidelines as per Moss and Guarino [12]. Each accession was assigned a specific collector number at the time of collection. The fields surveyed were mapped by Global Positioning System (GPS) receiver prior to the collection. Local people especially the elderly ones, in every village were interviewed for generating information about local names, unique features and other relevant information. Visual observations like husk color, seed coat color, grain type and awning were also recorded. The indigenous knowledge received from them was recorded in a special notebook. For each accession a representative sample of single populations by collecting seed from several individual plants was prepared. The collected germplasm was shared between collecting partners and one set was deposited in National Gene Bank at National Bureau of Plant Genetic Resources, New Delhi India for conservation and characterization.

Results and Discussion

Landraces and traditional varieties of rice have been utilized by inhabitants in Kashmir since hundreds of years and therefore hold a special position in the cultural landscape heritage of the region. However, unfortunately for many reasons the genetic diversity of rice has considerably decreased in Kashmir in the last five or six decades. During the course of our present study we have noted that elderly farmers throughout Kashmir fondly remember these landraces and their quality attributes. The names of rice landraces which have been collected by us in interviews with local farmers are presented in Table 1.

Table 1. Rice landraces collected from local farmers

Ambir Khan	Jamna Siri	Mush Kandi	Shahie
Aziz Beoul	Kamad	Mushuq Budij	Sater
Baber	Kamal Dar	Niver	Shalle Zag
Bal Kaun	Kathwur	Nune Beoul	Shuner
Barkat	Kawa Kuder	Prenie Babe	Siga
Begum	Khar Koot	Qadir Beig	Tcheri Bara
Bote Baber	Khet Gud	Qamroz	Tilla Zag
Brez	Kiri Rusi	Rahim Bara	Wat Zag
Cirka	Khuch	Ranji	Wuzul Kred
Drangi Bara	Lar Beoul	Rehman Bhati	Yemberzal
Geaw Zeer	Majeth	Resham	Zaged
Gulzag	Mirzag	Shalle Keau	Zagir
Jala Kred	Mehvan	Safed Brez	Zagi Tal

Most of these names are found in the literature. Elderly farmers in their sixties and beyond have some knowledge about these landraces whereas younger generation is generally ignorant about these genetic resources. Information provided by farmers during our survey suggests that some of these landraces such as Mushuq Budij, Baber, Begum, Gulzag, Kamad, Lar Beoul, Niver and Zaged were more common than others. Characteristics of these landraces as told by farmers and confirmed from previous literature are presented in Table 2.

Table 2. Characteristics of the rice landraces

Aromatic	Bold seeded	Early maturing	Good swelling ability	High yielding	Non-sticky	Sticky	Sweet and nourishing
Aziz Beoul	Aziz Beoul	Baber	Baber	Baber	Baber	Kamad	Baber
Baber	Barkat	Brez	Barkat	Bal Kaun		Nune Beoul	Gul Zag
Lar Beoul	Bote Baber	Majeth	Kathwur	Begum			Niver
Mush Kandi	Kamad	Niver		Kathwur			
Mushuq Budij	Kathwur	Qadir Beigh		Mehvan			
Qadir Beigh	Khuch			Nune Beoul			
Safed Brez	Lar Beoul			Yemberzal			
Shahie	Rehman Bhati						
	Shahie						
	Tilla Zag						

Regarding the maximum number of grains per panicle, most important are Baber, Kathwur, Mehvan, Nune Beoul.

Threshing of these landraces according to farmers was generally difficult, more cumbersome in red rice cultivars. During our survey we have seen threshing carried out by machines in some remote areas. The cultivation of majority of these landraces which were particularly adapted to local environments and requirements has now been abandoned. However, few landraces for example, Mushuq Budij, Kamad and some Zag varieties due to their unique characteristics and special use are still popular and cultivated at small scale especially in high altitude areas of Kashmir. These landraces are still maintained for social, ecological and economic values. Zag rice (‘Zag’ meaning red) with fish curry has always been relished by Kashmiri people.

Red rices Niver and Zag cultivars were often cultivated in high altitude areas as these varieties were hardier than white rices and withstood the chill of cold weather and were more tolerant to cold water from mountains entering first into the fields there. Besides, spiky glumes of red rices gave some protection to the crop against some wild beasts prevalent in these areas.

Two systems of paddy cultivation have been practiced in Kashmir, broadcast system and nursery system. Up to the late nineteenth century and even early twentieth century all lands were sown using broadcast system [13]. Broadcast system locally called as *wotur* is risky and labor intensive was preferably practiced because of its best outturns per acre. In present times nursery system is followed throughout Kashmir excepting in few high altitude areas where terraced lands are still sown as *wotur*. In nursery system pre-sprouted seeds are first sown in moist carefully puddled patch of land and after five to six weeks the seedlings at four to five leaf stage are then transplanted in well irrigated bullock puddled fields. For sprouting, the seed is packed in gunny bags and soaked in water for 2-3 days and after draining excess water the gunny bags filled with wet seed are transferred to warm places such as cowsheds or are covered with foliage of plants until sprouting occurs. However, farmers in Uri area of Kashmir during our survey have revealed that they do not use sprouted seeds instead sow dry seeds in the moist nursery plot in which greenery appears just after twelve days of sowing. This practice is followed because Uri is warmest zone in Kashmir. Mostly in Kashmir transplantation of seedlings is completed preferably up to June 21st of the year and crop is harvested in October or November. Crop duration increases when we move from lower to higher elevations. Because of extreme climatic conditions rice is thus grown once in a year. Average yield of rice in Indian hill states like that of Jammu and Kashmir is about 1.1 tons per hectare compared to average national yield of 1.9 tons per hectare. Major productivity constraints are low temperature, rice

blast and very short span of cropping season. Cold snap at flowering period results in spikelet sterility. In Kashmir region the temperature remains generally low, varying from -10°C during winter to 30°C during summer with a yearly average of 13°C. Lack of short duration varieties and those with cold tolerance complicate the situation. In a quest for increasing yields farmers even in high altitude areas have abandoned their generally low yielding and blast susceptible but generally cold tolerant traditional varieties and started cultivating modern high yielding and comparatively short duration varieties and might have harvested good yields sometimes under favorable climates. However improved modern varieties have not stood the test of time. Under the prevailing uncertain weather conditions we have seen complete crop failures in many high altitude areas in absence of reliable varieties and the poor farmers always seem to be very much concerned about that.

Presently in comparatively plain lowlands predominantly uniform high yielding varieties are cultivated. As we move up to the higher altitudes the variability in paddy fields increases and awned Zag rices become prevalent. The areas surveyed by us were once known for tremendous genetic diversity in paddy fields and many landraces mostly of red rices were cultivated here. An elderly farmer in Khag area of Kashmir has revealed that just a decade back he identified 70 different types of paddies in fields there. Considerable genetic erosion over the years has resulted in loss of this variability. Our study has revealed that variability has been reduced to a very small area in few high altitude areas and here also the existing genetic diversity is seriously endangered (Fig. 2).

Fig. 2. Genetic diversity in paddy fields is highly endangered in these "last remnants of variability" in high altitude areas of Kashmir

Therefore, we believe collections from these 'last remnants of rice genetic diversity' in Kashmir are significant. Native landraces represent a rich stock of exploitable genetic resources used as basic raw material by plant breeders to develop disease resistant, cold tolerant, low input and short duration modern varieties as one might expect them to have a high proportion of locally common alleles of adaptive significance. The conservation of old and local rice cultivars should thus, be seen as an important task to ensure sustainable environment. Collection guarantees the rice genetic variability preservation for the future, as source of genes of potential

agricultural interest. A total of 32 accessions of different rice landraces were collected by us from different high altitude areas of Kashmir in our present study (Table 3). Variability was observed in these accessions in plant height grain type, awning and husk colour (Fig. 3). Tallest plants were observed in landrace 'Kathwur' while those of 'Shalla Keau' are dwarf often remaining hidden by surrounding paddy plants of other cultivars in a mixture. Most of these accessions were with awn which varied in length.

Fig. 3. Genetic diversity of rice landraces collected from high altitude areas of Kashmir

Up to the beginning of the second half of twentieth century, agriculture in Kashmir continued to be practiced on traditional lines and the state had been deficient in food crops even in politically and climatically normal years. With the advent of high yielding rice varieties there has been fast replacement of traditional cultivars. Loss of rice genetic diversity in Kashmir can be related not only to adoption of modern varieties but also to the loss of farming systems especially in high altitude areas of rich genetic diversity. In these areas there has been a gradual shift from rice to other crops particularly apple and other horticultural crops. Area under apple cultivation for example, in the region has shown an increasing trend from 1970s.

Aromatic rice yielding 'Mushuq Budij' is most popular landrace cultivated by many farmers in Kashmir. Next in importance is landrace 'Kamad' which is believed to be cold tolerant and not suitable for higher temperatures. Farmers often rotate this landrace with other rice cultivars in order to obtain a good yields. As landraces are known to have low input requirements farmers throughout Kashmir have revealed that application of nitrogen fertilizers and herbicides to them results in crop failure. However phosphorus fertilizers at the rate of 80 kg./acre are applied for a good crop. Weeding is done manually. Maturity period of these landraces according to farmers ranges from 130 to 145 days. Normally a good crop of landrace 'Mushuq Budij' gives a yield of 16 quintals/acre (1 quintal = 100kg.). One quintal rice of this landrace currently sells at a price of 15000 Rs. (280 US Dollars) whereas cost of same quantity of rice obtained from improved modern varieties is 2500 Rs. (46 US dollars).

Table 3. Germplasm of rice landraces/local varieties collected from high altitude areas of Kashmir (India)

Place of collection (District)	Elevation (m)	Latitude	Longitude	Landraces collected (No. of accessions)
1. Yarisuther (Budgam)	1804	33° 52'	74° 42'	Zag (3)
2. Nunar (Budgam)	1885	33° 53'	74° 41'	Mushuq Budij (1)
3. Gurweath (Budgam)	1834	33° 48'	74° 40'	Barkat (2)
4. Khurd Gurweath (Budgam)	1828	33° 48'	74° 40'	Telezag (1) Mirzag (1)
5. Nasarpora Khag (Budgam)	1840	33° 58'	74° 31'	Rahim Bara (1)
6. Lassipora Khag (Budgam)	1995	33° 56'	74° 33'	Drangi Bara (2)
7. Batpora Drang (Budgam)	1952	33° 59'	74° 32'	Zag (1)
8. Sonapah Beerwah (Budgam)	1860	33° 55'	74° 34'	Kathwur (1)
9. Sail Beerwah (Budgam)	1858	33° 54'	74° 34'	Zag (1)
10. Yarikhah Beerwah (Budgam)	2013	33° 49'	74° 34'	Kawa Kuder (1)
11. Jabla Uri (Baramulla)	1512	34° 09'	73° 58'	Zag (1) Baber (1)
12. Salamabad Uri (Baramulla)	1510	34°10'	73° 59'	Cirka (1)
13. Khreti Iqbalpora (Anantnag)	2136	33° 37'	75° 22'	Jamna Siri (1)
14. Sagam Kokernag (Anantnag)	1697	33° 41'	75° 21'	Mushuq Budij (1) Kamad (1)
15. Lamoo Kokernag (Anantnag)	2136	33° 37'	75° 22'	Zag (2)
16. Chagund Verinag (Anantnag)	1969	33° 32'	75° 14'	Shala Zag (1)
17. Qamar Verinag (Anantnag)	2047	33° 34'	75° 15'	Jamna Siri (2)
18. Ghawas Verinag (Anantnag)	2050	33° 34'	75° 15'	Shalla Keau (2)
19. Chohan Verinag (Anantnag)	2058	33° 35'	75° 16'	Kawa Kuder (2)
20. Reshipora Verinag (Anantnag)	2049	33° 33'	75° 15'	Zag (1)
21. Waltengo Qazigund (Kulgam)	1886	33° 31'	75° 07'	Zag (1)

Disease and insect resistance are other important characteristics observed in some landraces as told by farmers. Now very rare landrace 'Baber' is believed to be insect and disease resistant. In remote Uri area of Baramulla district of Kashmir we have noted heavy damage caused by grasshoppers in some paddy fields sown with modern varieties whereas this landrace collected from same fields was completely unaffected by the insect. It has been reported that both nymph and adult grasshoppers damage rice crop by feeding on leaves and when found in greater numbers can feed even on midrib and cause extensive defoliations [14]. During our survey we have also noted that age old tradition of sowing soya bean (*Glysine max*) on paddy field bunds is still followed in some high altitude areas of Kashmir whereas this practice is seldom seen now in lowlands. This practice is supposed to give some protection to paddy field bunds besides yielding few kilograms of seed for household use. Roasted soya bean seeds have been a popular snack of Kashmiris especially during harsh winters.

Taking note of heavy loss of locally adapted rice genetic diversity, the State Agricultural University (SKUAST) has now started stimulating small farmers in some of the high altitude areas to keep cultivating landraces of 'Mushuq Budij' and 'Kamad' by establishing monetary subsidies. In fact, International Treaty on Plant Genetic Resources for Food and Agriculture [15] obliges the signing countries to 'promote or support as appropriate, farmers and local community's efforts to manage and conserve on-farm their plant genetic resources for food and agriculture'. On farm conservation of landraces is useful to preserve the evolutionary process which generates new genotypes under natural conditions [16]. Therefore, farmers rightly need to be encouraged for on farm conservation of not just two but many landraces in areas under cultivation of modern varieties and incorporation of modern varieties in areas under landrace

cultivation. The incorporation of modern rice cultivars in landrace cultivation areas and the selection carried out by small farmers are the most probable factors responsible for increasing landraces' genetic variability [17]. Genetic diversity is the foundation of sustainability because it provides raw material for adaptation, evolution and survival of species and individuals especially under changed environmental, disease and social conditions [18].

Conclusions

In past tremendous genetic diversity existed in paddy fields in Kashmir especially in high altitude areas and more than 4 dozen named landraces were cultivated some more commonly than others. Most of these landraces have now disappeared. Few landraces are still popular owing to their unique features yielding bold grained, sweet, nourishing, aromatic rice and fetching much more revenue in the market than modern varieties. The diversity has been drastically reduced to a very small area in few high altitude areas. 32 germplasm accessions of some landraces from these 'last remnants of rice genetic diversity in Kashmir' were collected and deposited in National Seed Gene Bank at NBPGR, New Delhi for conservation and characterization. These germplasm collections assume importance especially under prevailing uncertain climatic conditions.

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