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NOTES ON NEGLECTED AND UNDERUTILIZED CROPS

Pseudocereals and millets: the lost crops of Kashmir

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Abstract The aim of present study was to know about past cultivation of pseudocereals and millets in Kashmir province of Indian state of Jammu and Kashmir. These crops which were cultivated throughout Kashmir in plains as well as in hilly areas are buckwheat species, *Fagopyrum esculentum* and *Fagopyrum tataricum*; amaranth and minor millets, *Setaria italica* and *Panicum miliaceum*. In Kashmir these are now forgotten crops. Few plants of amaranth (*Amaranthus caudatus*) are still grown in almost every kitchen garden in Kashmir. The crop is however not cultivated commercially neither in Kashmir nor in Ladakh or Jammu provinces of the state. Our study has revealed that cultivation of all these crops has been abandoned some five or six decades back throughout Kashmir excepting in few farflung hilly areas in north Kashmir. Currently these crops are also cultivated in Ladakh, but here also their cultivation is dwindling rapidly. The reasons as to why farmers have abandoned these crops and are increasingly losing interest in these biological assets in the areas of their present cultivation have been discussed. There is a need to rescue these threatened crops which have many advantages besides, being nowadays categorized as quality health foods. During our survey in Ladakh province we have collected 30 germplasm accessions of these crops from various locations. These have been deposited in National Seed Gene Bank at NBPGR, New Delhi for conservation and evaluation. The improvement and revival of these lost crops has the potential to diversify agriculture, food system and income of the poor farmers and have the ability to ensure food security and livelihood of the people in this Himalayan state under future adverse climatic conditions.

Keywords Germplasm collection · Kashmir · Ladakh · Millets · Past cultivation · Pseudocereals

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Introduction

Diversity of life is one of the most striking aspects of our planet and humans derive huge benefits from it (Mora et al. 2011). We are astonishingly ignorant about how many species are alive on earth today and even more ignorant about how many we can lose yet still maintain ecosystem services that humanity ultimately depends upon (May 2011). Most essential part of this earth's biodiversity is the plant kingdom. From a variety of plants which can potentially be used for human nutrition, today fewer and fewer species are used. It is estimated that nowadays only 30 crops provide 95 % of human food and energy needs and just 4 of them viz., rice, wheat, maize and potatoes

provide more than 60 %. Agricultural simplification has favoured some crops instead of others on the basis of their comparative advantages for growing in a wider range of habitats, their simple cultivation requirements, easier processing and storability, nutritional properties, taste etc. Large scale farming has disadvantaged growing of some crops used for specific purposes which were less suitable for new technologies and did not produce high yields. During last century and especially during last 50 years, biodiversity in the agricultural landscapes throughout the world has declined to a great extent. The diversity of local and well adapted crops/landraces have been replaced by few crops and a much narrow spectrum of bred cultivars that are often genetically rather similar. Owing to this increasingly fragile agrobiodiversity countless local genetic resources have been lost. However, many of them have been saved and can still be found in some remote areas (Dotlacil et al. 2001), there also the existing genetic diversity is seriously endangered these days. Therefore tapping and conservation of these genetic resources is necessary for sustainable use and for our future prosperity. The diversity in agricultural genetic resources viz., cultivars, landraces, ecotypes, weedy races and wild relatives of crop plants form a gene pool used for improvement of important characters, broadening of genetic base of cultivars and also as a source of new diversity for agriculture (Negri et al. 2009). Crop genetic diversity at species and at varietal (genetic) level increases options and provides insurance against future adverse conditions such as extreme and variable environments and also help combat new pests and diseases, thus ensuring food security.

Agriculture in Kashmir has always been an exceptionally important aspect of people's lives, straddling as it does even today, in the highland and lowland zones, extensive forests and wastes (Hangloo 2008). Kashmir has been an abode to a large number of crops both *Kharif* and *Rabi* although rice being the staple food of the inhabitants has been the principal crop cultivated in Kashmir followed by maize and wheat. Some pseudocereal and minor millet crops were also commonly grown in past, both in the hilly regions as well as in the plains. The cultivation of these crops has now been generally abandoned several decades back. However, these crops are still grown in few remote areas in north Kashmir and in Ladakh province of the state where these crops are also increasingly threatened. The importance of these crops is no less than major cereals, because they produce materials for human consumption from lands and in locations, where other crops would be difficult to grow with same efficiency (Masoodi 2003). In the present scenario of uncertain climatic conditions, their conservation, improvement and revival in the entire region is important for maintaining a wider base of crop diversity for sustainability. The aim of this study was to evaluate farmer knowledge about these crops and their past cultivation in Kashmir province. A survey was conducted in the Ladakh province for collection of germplasm of these crops.

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 640 km from north to south and 480 km from east to west covering an area of 2,22,236 sq km (Singh et al. 2000). Owing to a great heterogeneity in the topography, altitude (300–8,600 m above sea-level) and climate (temperature for example, on an average ranges from −20 to 45 °C), it harbors diverse habitats. Agroclimatically the state is divided into 3 main distinct zones corresponding to 3 provinces:

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

The entire state is constituted by 22 administrative districts, 10 each in Jammu and Kashmir provinces and 2 in Ladakh province. All the 10 districts of Kashmir viz., Anantnag, Bandipore, Baramulla, Budgam, Ganderbal, Kulgam, Kupwara, Pulwama, Shopian and Srinagar and 2 districts of Ladakh viz., Leh and Kargil were covered in the study (Fig. 1).

During last 3 years from 2009 to 2011 several surveys and germplasm collection programmes of various agri-horticultural crops grown in the region were executed by our Research Station. During these exploration and collection trips conducted in the areas

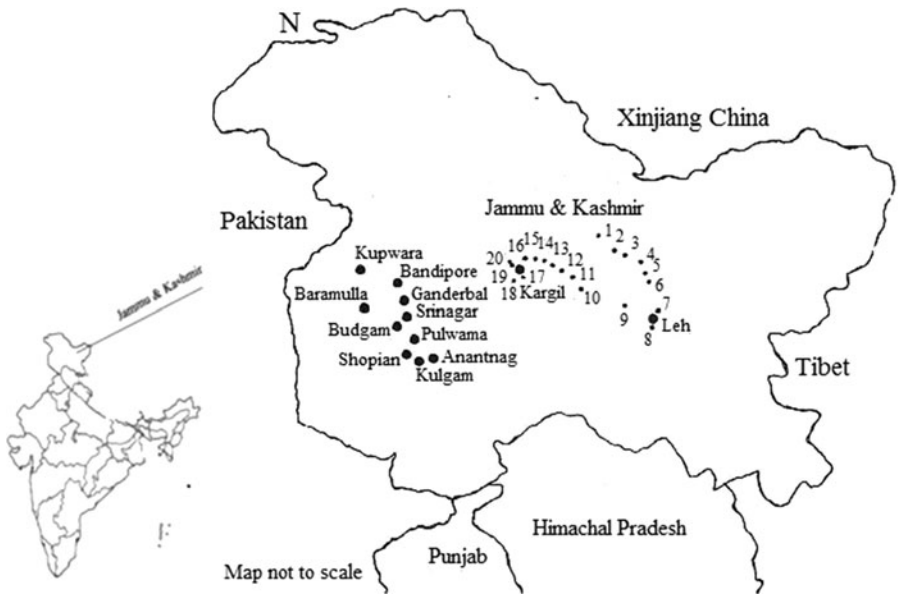

Fig. 1 Map showing study area. Areas labeled from 1 to 20 depict sampling locations mentioned in Table 1

falling in all 10 districts of Kashmir province, farmer knowledge and information about past cultivation of crops including pseudocereals and millets was also recorded. Knowledgeable farmers were interviewed for gathering information about these crops, their farming and utilization. The information thus collected was confirmed from the available literature.

48 villages of Kargil and Leh districts of Ladakh province with an altitudinal variation of 2,743–3,587 m above sea level were surveyed for the collection of germplasm of these crops. Consultations with researchers working in stations of SK University of Science and Technology Kashmir, KVK's and Field Research Laboratory DRDO Leh, besides knowledgeable farmers of the region enabled accurate identification of collection sites. The exploration was conducted in the months of September/October last year keeping in view the period of maturity and harvest of these crops. Local people especially the elderly ones, in every village were interviewed for generating information about local names, farming and utilization pattern of these crops. The indigenous knowledge received from them was recorded in a special notebook. Each field surveyed was mapped by Global Positioning System (GPS) receiver prior to the collection. The collected germplasm was deposited in National Seed Gene Bank at National Bureau of Plant Genetic Resources, New Delhi India.

Results and discussion

Pseudocereals and millets which in past were commonly cultivated throughout Kashmir province of Jammu and Kashmir are:

1. Common Buckwheat (*Fagopyrum esculentum* Moench)
2. Tartary Buckwheat (*Fagopyrum tataricum* (L.) Gaertn.)
3. Amaranth (*Amaranthus caudatus* L.)
4. Foxtail millet (*Setaria italica* (L.) P. Beauv.) and
5. Common millet (*Panicum miliaceum* L.)

Short description

Pseudocereals and millets are generally short duration, fast growing and drought tolerant underutilized crops associated with and strongly adapted to marginal environments with infertile soils than major crops of the world. These have better nutritional qualities and can be grown by simple methods. Whereas pseudocereals include buckwheat and amaranth which are used like cereals but do not belong to the grass family Gramineae, millets refer to a group of annual grasses including common millet and foxtail millet often cultivated as cereals producing small seeded grains.

Fagopyrum esculentum Moench (Family: Polygonaceae) is common sweet buckwheat. It is an erect

Table 1 Germplasm of pseudocereals and minor millets collected from different locations of Ladakh province of Jammu and Kashmir (India)

S. no.	Collection site (district)	Latitude	Longitude	Elevation (m)	Germplasm collected (No. of accessions)
1	Turtuk (Leh)	34°50′	76°49′	2919	*Fagopyrum esculentum* (1)
2	Bodang (Leh)	34°37′	77°10′	2916	*Fagopyrum esculentum* (1)
3	Changmar (Leh)	34°36′	77°16′	2917	*Fagopyrum esculentum* (1)
4	Hunder (Leh)	34°35′	77°27′	2920	*Fagopyrum tataricum* (1)
					Amaranthus caudatus (1)
5	Skampuk (Leh)	34°30′	77°31′	3169	*Amaranthus caudatus* (1)
6	Diskit (Leh)	34°54′	77°55′	3179	*Amaranthus caudatus* (1)
7	Gumpha village (Leh)	34°10′	77°38′	3587	*Amaranthus caudatus* (1)
8	Chochotyakma (Leh)	34°04′	77°35′	3250	*Amaranthus caudatus* (1)
9	Saspool (Leh)	34°14′	77°09′	3093	*Amaranthus caudatus* (1)
10	Domkhar (Leh)	34°23′	76°45′	3050	*Fagopyrum esculentum* (1)
					Setaria italica (1)
11	Achinathang (Leh)	34°30′	76°38′	2890	*Fagopyrum esculentum* (1)
12	Hanuthang (Leh)	34°33′	76°35′	2810	*Setaria italica* (1)
13	Beema (Leh)	34°35′	76°32′	2780	*Setaria italica* (1)
14	Dah (Leh)	34°37′	76°28′	2750	*Amaranthus caudatus* (1)
					Setaria viridis (1)
15	Darchik (Kargil)	34°38′	76°26′	2810	*Setaria italica* (1)
16	Silmoo (Kargil)	34°37′	76°19′	3100	*Amaranthus caudatus* (1)
17	Youkma (Kargil)	34°30′	76°14′	2743	*Amaranthus caudatus* (1)
					Panicum miliaceum (1)
18	Trespone (Kargil)	34°31′	76°12′	2750	*Fagopyrum tataricum* (2)
19	Shilickchey (Kargil)	34°33′	76°11′	2758	*Setaria italica* (5)
20	KakoShilickchey (Kargil)	34°33′	76°11′	2758	*Panicum miliaceum* (1)

annual attaining a height of 60–80 cm. The stem is hollow and angular, with swollen nodes. Leaves are alternate, triangular, acute and 5–10 cm long. Flower clusters and leaves arise from the nodes, both on main stem and branches. Growth habit is indeterminate with flowers opening throughout a long season, so the seed crop does not mature at one time. 5-petaled flowers are dimorphic with either a short or long (3–4 mm) style, arranged in a compound raceme that produces laterally flowered cymose clusters (Quinet et al. 2004). These are fragrant and may be white, pink or red. Fruit is one-seeded, three edged achene measuring 6 mm × 3 mm. Some varieties have distinctly winged seeds. The seed consists of brown or grey colored outer layer or hull, an inner layer, the seed coat proper, and within this the starchy endosperm and the germ.

Fagopyrum tataricum (L.) Gaertn. (Family: Polygonaceae) is bitter buckwheat and is also an annual plant but is taller and coarser than *Fagopyrum esculentum*. Leaves are relatively small, narrow and arrow shaped. Flowers are small, yellowish green and without fragrance. The seed is small, ovoid, conical, brownish, grey or black in colour, with dull irregular faces on each of which is a deep furrow. Kashmir buckwheat (*F. kashmirianum* Munshi), a minor cultivated species of buckwheat described from Kashmir by Munshi (1986) is considered to be morphologically akin to tartary buckwheat (Arora and Engels 1992). According to Ohnishi (1991) *F. esculentum* and *F. tataricum* were derived independently from ancestral wild *F. cymosum*. The plants of *F. cymosum* are tall and stout, leaves are large, long stalked and triangular, stalked white flowers are borne on long recurved terminal and axillary cymes. All the species of *Fagopyrum* named here have been reported from Western Himalayas.

Amaranthus L. (Family: Amaranthaceae) is a cosmopolitan genus of annual or short-lived perennial plants with wide morphological diversity among and within certain species. The genus has few distinguishing characters among its 70 reported species complicating the taxonomy and thus has generally been considered by systematists as a difficult genus (Costea and DeMason 2001). The plants bear catkin-like cymes of densely packed flowers ranging in color from purple and red to green or gold and maturing into large seed-heads with countless small grains. Amaranth is a multi-purpose crop, used as vegetable, grain crop, medicinal plant, forage and as an ornamental. Most of the species of *Amaranthus* are summer annual weeds. The species of amaranth reported from Ladakh, besides *A. caudatus* are *A. graecizans* subsp. s*ylvestris* (Vill.) Brenan and *A. powellii* S. Watson (Klimes and Dickore 2005).

Setaria italica (L.) P. Beauvois (Family: Gramineae) commonly called as foxtail millet("Kakun" in India) is one of the most widely cultivated species of millets. It has the longest history of cultivation among millets, having been grown in China since sometime in 6th millennium BC. It is an annual grass with slender and erect stem growing to a height of 90–150 cm and bends down with weight of seed-heads. Leaves are narrow about 30–45 cm long. The inflorescence is dense, cylindrical and bristly panicle 8–32 cm long often arching towards the tip. There are 1–4 bristles at the base of each spikelet. The seeds are small around 2 mm in diameter and are enclosed in a hard inner glume and its palea. Seed color varies greatly between varieties often creamy white to orange red and even purple.

Panicum miliaceum L. (Family: Gramineae) also called as common millet or proso millet ("Cheena" in India) is an important minor millet grown in India. It is an erect annual grass which tillers profusely. The plants grow up to a height of 45–100 cm. Stem is slender and nodes are distinctly swollen. Leaves are linear and leaf sheath encloses the entire internode. Inflorescence is much branched panicle without bristles, having spikelets at tips of the branches, usually last or the fourth glume encloses a perfect flower which sets grain. Glume and palea are firmly attached to the grain. Seeds are small 2–3 mm and can be cream, yellow, orange-red or brown in color.

Walter Lawrence known for land settlement in Kashmir came here first time in 1889 and visited almost every village of Kashmir. In his book 'The Valley of Kashmir' he has mentioned these autumnal crops being extensively grown throughout Kashmir at that time. The cultivation of these crops has now been abandoned in Kashmir excepting in few remote hilly areas falling in Districts of Bandipore and Kupwara in north Kashmir. Elsewhere in Kashmir these are now forgotten crops. Our study has revealed that elderly farmers in their late sixties and beyond have some knowledge about these crops whereas persons of lesser age group in general are completely ignorant about these biological assets. It appears that cultivation of these crops in Kashmir has been abandoned some five or six decades back. It is believed that pseudocereals and millets in the Himalayas in general have become the victim of new cash crops like peas, potatoes and fruit crops. Wheat and rice have replaced these and many other crops. During the course of our study majority of elderly knowledgeable farmers have attributed the decline in their cultivation, ultimately leading to their abandonment to lower yields, difficult processing, comparatively lower food quality in terms of taste and an increasing access to modern high yielding crop varieties and newer technologies. Modern varieties of rice, wheat and maize suitable for large scale farming have replaced these traditional crops. Infact up to beginning of the second half of twentieth century, agriculture in Kashmir continued to be practiced on traditional lines, subsistence farming was still in vogue and farmers were quite ignorant about scientific methods of cultivation and modern inputs including high yielding varieties (Hangloo 2008).

Buckwheat (local "Trumba") being a short duration crop was considered to be very useful in Kashmir. *Fagopyrum esculentum* (sweet Trumba) and *Fagopyrum tataricum* (bitter Trumba) were commonly cultivated. In plains *F. esculentum* was often grown as substitute for paddy under the conditions of water scarcity whereas, *F. tataricum* being frost tolerant was considered to be important food source in hilly regions. Buckwheat flour was used for the preparation of bread or eaten as porridge. The seeds were also used as feed for poultry and domestic animals especially horses-the main means of transport those days.

Amaranth (local "Ganhar") was frequently sown in rows in cotton fields and on the borders of maize plots. In some high altitude areas of Kashmir valley we have

Fig. 2 Pseudocereals and millets cultivated in Ladakh province of Jammu and Kashmir (India). A Ladakhi woman with a child in a basket tied to her back working in a buckwheat field at Domkhar Leh (**A**); Amaranth growing in a kitchen garden at Dah Leh (**B**); A field of *Setaria italica* at Shilickchey Kargil (**C**) and *Setaria italica* and *Panicum miliaceum* cultivated together at Youkma Kargil (**D**)

seen even nowadays a row of amaranth plants being grown on the borders of maize fields facing open spaces. The role of amaranth as a companion plant serving as trap for many insect pests is now well established. The minute grains of amaranth were parched, ground and taken with milk or water. Roasted grains were also eaten, especially by Hindus during fasting days. Amaranth has been a multipurpose crop also used as a vegetable, medicinal plant, forage and as an ornamental. The crop is not grown for commercial purpose neither in Kashmir nor in Ladakh, but as part of local sustainable agricultural system. It is a tradition to grow few plants of amaranth in almost every kitchen garden of Kashmir and Ladakh (Fig. 2B).

Minor millets—*Setaria italica* (local "Shol" or "Kangni") and *Panicum miliaceum* (local "Ping" or "China") were cultivated throughout Kashmir. *Setaria italica* was more common and was sown as substitute for paddy, when it was apparent from snowless mountain peaks that water availability will not be adequate for cultivation of latter. *Panicum miliaceum* was sown in rainfed drylands. Husked grains of these crops were hard to cook and were eaten as porridge. As the grains of these small millets are well protected in glume encasements, their processing to usable form was not so easy. The hulls were difficult to remove by the conventional milling process. The processing was time consuming and labour intensive,

requiring more time and effort to pound in stone mortars by wooden pestles usually carried out by womenfolk.

In Ladakh province of Jammu and Kashmir, buckwheat species *Fagopyrum esculentum* (local "Dyat", "Chiski", "Ghyas", "Ghyambrus") and *Fagopyrum tataricum* (local "Bru", "Brusuk") as well as minor millets *Setaria italica* (local "Tcha") and *Panicum miliaceum* (local "Tchay tchay") are currently cultivated in different areas. During our survey we have collected 30 accessions of these crops and of *Amaranthus caudatus* (local "Chulai") (Table 1) from various locations (Fig. 1). In Ladakh buckwheat is either used as vegetable (*tait*) or as flour (*tau*). Young leaves and shoots are cooked as spinach. The dehulled groats are cooked as porridge and the flour is used in the preparation of bread, pancakes, biscuits and noodles. Bread made from buckwheat and wheat flour is especially popular. Patients suffering from lung, liver and gastro-intestinal ailments are fed with buckwheat grains especially of *Fagopyrum tataricum*. *Fagopyrum esculentum* is most common species compared to *Fagopyrum tataricum* and is cultivated in relatively plain areas. It is considered to be superior as it yields more flour used for human consumption. *Fagopyrum tataricum* is mostly used as poultry and cattle feed. In many areas we have seen these species are sown in combination. *Fagopyrum tataricum* also grows wild, often escaping from cultivation and is seen as a weed in fields, gardens, ditches and irrigation canals spreading along roads and trails (Klimes and Dickore 2005).

Compared to buckwheat, minor millets are cultivated in a limited area. *Panicum miliaceum* is cultivated less commonly than *Setaria italica*. We have observed diversity in shape and size of seed-heads and seed color in latter (Fig. 3). The groats are ground and the flour is used for bread making. The grains are roasted, dehusked and then grounded into coarse granules and taken as *satu* along with tea. At many places in Kargil these crops are sown together and used as fodder (Fig. 2D). During our survey we have also collected *Setaria viridis* L.—a wild relative of foxtail millet from Dah village growing in association with the latter. *Setaria viridis* is interfertile with *Setaria italica* and has securely been identified as its wild antecedent (Zohary and Hopf 2000). It grows as a weed in fields, gardens and grasslands in North Western Himalayas up to 3,300 m.

Fig. 3 Diversity of seed-head shape and size in *Setaria italica* collected from Ladakh (Jammu & Kashmir)

During the course of our present study we have noted that farmers in Ladakh are losing interest in the cultivation of these traditional crops. Many have revealed that they do not themselves keep the seed of these crops instead buy it from market. This trend may have resulted in the loss of so many valuable farmer varieties of these crops. Infact many elderly farmers recall the quality germplasm of these crops they were once possessing. Throughout Ladakh especially in and around the main towns and in relatively plain areas wheat, pea and mustard cultivation is showing an upward trend. Even wheat, in many areas is now preferred over barley which has been a staple food of Ladakhi's for centuries. High yielding varieties of wheat are increasingly becoming popular in Ladakh. Some farmers in Kargil region have attributed decline in buckwheat cultivation to unusual and untimely rains destroying the crop. Whatever may be the reason, marginalization of these crops can eventually lead to their disappearance from the local sustainable production system. Abandonment of these traditional crops means loss of agrobiodiversity and increased vulnerability to climate (Saxena et al. 2005). This is particularly alarming keeping in view uncertain and harsh climatic conditions and marginal soils of Ladakhi agroecosystem. Broader crop base contribute to agricultural diversification, make better use of marginal lands and changing environments, ensure food security and a more balanced diet, better safeguard of our agro-biodiversity and associated cultural heritage and self reliance of agricultural systems (Sharma et al. 2009). It is thus unfortunate

that the cultivation of these crops is rapidly declining in Ladakh and has altogether been abandoned in Kashmir especially when these crops are now categorized as quality health foods and their demand is increasing day by day. One of the modern society's major worry is the ever increasing number of overweight and obese people and related insurgence of chronic diseases such as heart ailments, hypertension, stroke, diabetes and cancer, promoted by unhealthy diet and sedentary lifestyle. Buckwheat and millets characterized by a high content of bioactive compounds (Protein, beta-glucan and rutin) possessing health beneficial properties hold a great promise (Brunori et al. 2011). As compared to wheat, the content of water insoluble β-glucan is higher in millets, buckwheat and amaranth (Hozova et al. 2007). Glucans are characterized by reduced absorption in the intestines leading to increased viscosity and subsequent delayed gastric emptying and a feeling of fullness. The feeling of gastric fullness help prevent overeating. Buckwheat, amaranth and millets are also gluten free diets, thus used for the treatment of patients suffering from celiac disease prevalent these days (Saturni et al. 2010). Besides human health these crops can serve to improve ecosystem health as well, they can grow with limited water resources and have reduced needs for pesticides and fertilizers and protect soil erosion. Thus, these valuable plant resources need to be conserved preferably in on-farm conservation. International Treaty on Plant Genetic Resources for Food and Agriculture (2004) obliges the signing countries to 'promote or support as appropriate, farmers and local communities efforts to manage and conserve on-farm their plant genetic resources for food and agriculture'. Given the rapid pace of change in the present era, conservation of crop diversity increases options for quick and agile adaptation under future uncertain conditions (Jackson et al. 2010). The revival of these crops can diversify agriculture, food system and income of farmers in Jammu and Kashmir as well.

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