

Exploration, collection and conservation of multicrop germplasm from Kishtwar district of Jammu and Kashmir, India

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Abstract

Systematic exploration and germplasm collection trips were conducted across Kishtwar district of Jammu and Kashmir state covering Chatroo valley, Padder valley and Kishtwar main including areas of Dachan, Surror, Sarthal, Bhonjwa and Drabshala during 2013, 2015 and 2018. A total of 113 germplasm accessions belonging to 29 species of crops and wild relatives from as many as 40 collection sites were collected at altitudes ranging from 1340-2670 m. Several areas in Sarthal, Bhonjwa, Dachan and Gulabgarh Padder were first time explored. Crop group wise accessions collected are pulses (39) mostly common beans, cereals (30) mostly maize, vegetables and spices (25), pseudocereals and millets (16), besides one accession each of *Glycine max*, *Solanum pseudocapsicum* and *Nicotiana tabacum*. The germplasm has been conserved in National Gene Bank (NGB), New Delhi. This study highlights information on the germplasm collected/observed and threats leading to biodiversity loss/genetic erosion in the highly fragile region of Kishtwar.

Keywords: Conservation, Exploration, Germplasm collection, Kishtwar, Plant genetic resources

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INTRODUCTION

Kishtwar, popularly known as the “Land of Sapphire and Saffron” is an extremely mountainous region with very steep slopes having total forest area of 58394 hectares rich in forest products. Vegetation and climate in the area can broadly be categorized into sub-tropical, temperate and alpine with wide diversity of fauna and flora. This valuable biodiversity however is being increasingly threatened nowadays. In general, biodiversity in the Himalayas including its distribution and survival has been adversely affected by climate change and increased anthropogenic pressure (Shrestha *et al.*, 2012, Yue *et al.*, 2013). The diversity of several important crops including cereals, pseudocereals, millets, pulses etc. likewise, is threatened by rapid urbanization and habitat erosion as well as unpredictable and extreme climatic events including increasing frequency of drought, rising temperatures and flooding. Crop diversity in farmer’s field is diminishing fast and the wild relatives or ‘wild cousins’ of our food crops continue to

disappear in their natural habitats. Replacement of local varieties/landraces of crops also leads to this genetic erosion. In largely mountainous and fragile place of Kishtwar, biodiversity in general and in agricultural fields during last few years has increasingly become vulnerable by developmental activities like construction of roads and hydroelectric power projects. Half a dozen hydroelectric power projects in the district have lead to displacement of several villages. While the threats to these resources are growing, the efforts to conserve crop genetic diversity are insufficient in the region. There are countless inaccessible pockets in the remote areas where traditional crops and local varieties/landraces are still being cultivated by the farmers. Therefore, concerted and intensive efforts are required for collection and conservation of available crop genetic diversity in the region. Besides, traditional knowledge associated with the use of old varieties/landraces is rapidly vanishing. Hence, exploration, collection and conservation of available crop genetic diversity in

the region is a much better option to safeguard diversity at risk. The present study reports on collection expeditions carried out in the years 2013, 2015 and 2018 in different areas of Kishtwar primarily to capture crop genetic variability and conserve the representative germplasm in National Gene Bank for future use.

MATERIALS AND METHODS

Description of the study area: Kishtwar in Jammu province of north western Indian Himalayan state of Jammu and Kashmir lies at 32°53' and 34°21'N latitude and 75°1' and 76° 47'E longitude with an average altitude of 1638 m is the third least populous district after Kargil and Leh having a total geographical area of 1,644 sq km. The district is flanked by lofty Himalayas (Pir Panjal range) from all sides and the entire tract is extremely mountainous, bearing very steep slopes pierced by deep valleys like Marwah-Wadwan valley, Padder valley and Chatroo valley. The area is practically devoid of any flat ground except Kishtwar plateau and Atholi plateau in Padder valley and is bounded by Kargil district in the North, Northeast and East, Himachal Pradesh in the South and Anantnag, Ramban and Doda districts in the West (Fig. 1). River Chenab is the major river of the district. Famous Synthan pass (3,784 m) links Anantnag with Kishtwar. Kishtwar High Altitude National Park situated in the North of Kishtwar between 33°20'-34°40' North latitude and 75 ° 40'-76 ° 10' East longitudes is spread over an area of 425 sq. kms harboring 35 villages. The area being rural in nature has agriculture based economy. Agriculture is the main source of livelihood in the district as in the rest of the state. It is mostly a mono cropped zone with low production and productivity. Suitable hill sides are cultivated after having them terraced into fields. The major crops grown in the district are maize, paddy, wheat, barley, pulses particularly common beans and vegetables. The main fresh fruit produced in the district includes apple, apricot, plum, pear and peach and dry fruits produced include mostly walnuts. Saffron is also grown at some places. Soil is spodosolic, undulating and prone to erosion. The monsoon hardly reaches here and it is due to low average annual precipitation (36.04 inches/year) that the area has been declared drought prone consequently making it insufficient in food grain production; particularly the Marwah-Wadwan area which remains cut off for 5-6 months in a year due to snowfall in winter.

Germplasm collection: During the years 2013, 2015 and 2018, systematic expeditions were conducted across Kishtwar district covering Chatroo valley, Padder valley and Kishtwar main including areas of Dachan, Surror, Sarthal, Bhonjwa and Drabshala. Prior to that information on region's flora, agriculture and results from previous collect-



Fig. 1. Map of Jammu & Kashmir state of India. The study area of Kishtwar district is marked in color.

ing missions were gathered and analyzed with the specific aim of better planning of these explorations. The main sources of germplasm samples of cultivated crops were farmer's fields or the threshing yards/farm stores in case the crop had already been harvested. In general, random sampling was followed for field collection and farm stored material whereas small samples were bulked in case of wild species. In a few cases samples were also collected from seed sellers, which made it possible to find out and collect old traditional material. The germplasm of wild species was collected from roadsides, on the sides of farmer's fields and from rock crevices. At each collecting site a passport data sheet was filled in as per standard format (Moss and Guarino, 1995) using data from a hand-held GPS system that included latitude, longitude and altitude of the place of collection. Data were collected through informed consent semi-structured interviews and questionnaires on technical information from each person from whom germplasm samples were collected in the areas surveyed. Each collection was assigned a unique collector number. The collected material was deposited in the NGB (National Gene Bank) for long term conservation.

RESULTS AND DISCUSSION

A total of 113 germplasm accessions belonging to 29 species of crops and wild relatives from as many as 40 collection sites across Kishtwar situated between 33°07'-33°34' N latitude and 75°33'-76°11' E longitude at an altitude ranging from 1340-2670 m were collected during exploration and germplasm collection programmes in 2013, 2015 and 2018 (Table 1). Following are the crop group wise germplasm collections:

Cereals: Maize is the most common cereal crop cultivated throughout Kishtwar and a key source of food, fodder and livelihood of people. The crop is generally grown under rainfed conditions either singly or intercropped with pulses particularly common beans. Traditional varieties/landraces of

Table 1. Plant Genetic Resources collected from Kishtwar district of Jammu & Kashmir, India.

S.N.	Crop species (No. of collections)	Common name	Local name	Collection sites
1	<i>Phaseolus vulgaris</i> (31)	French bean	Rajma	Drabshala Surror, Salana, Kankoot Surror, Dhara Surror, Angara Sarthal, Galigadh Sarthal, Gorna Sarthal, Bidha, Thakraie, Massu Padder, Narhal Padder, Galhar Naghseni, Danghdooro Dachan, Pinradi, Naghni Bhonjwa, Marmulla Chatroo, Bamalpora Gurinal Chatroo, Sigdi Bata
2	<i>Vigna radiata</i> (01)	Green gram	Moong	Chingam Chatroo
3	<i>Vigna mungo</i> (03)	Black Gram	Mash	Salana Drabshala, Pochal
4	<i>Vigna unguiculata</i> (01)	Cowpea	Rongi	Gorna Sarthal
5	<i>Lens culinaris</i> (02)	Lentil	Masur	Gorna Sarthal, Pochal
6	<i>Macrotyloma uniflorum</i> (01)	Horse Gram	Kulth	Gorna Sarthal
7	<i>Coriandrum sativum</i> (06)	Coriander	Dhaniwal/ Dhania	Passerkoot Chatroo, Padyarana Naghsani, Karthaie Padder, Bhandera, Thathri, Prem Nagar
8	<i>Trigonella foenum-graecum</i> (03)	Fenugreek	Meethi	Chingam Chatroo, Bhandera, Gorna Sarthal
9	<i>Bunium persicum</i> (02)	Black cumin	Zeera	Karthaie Padder
10	<i>Elymus semicostatus</i> (06)	Wildrye		Synthan Maidan, Watsir Chingam, Narian, Lower Naghni, Lower Galhar Naghsani, Lower Bumalpora Gurinal Chatroo
11	<i>Fagopyrum dibotrys</i> (02)	Wild Buck-wheat	Dhrav/ Mukti	Galigadh Sarthal, Naghni Bhonjwa
12	<i>Fagopyrum esculentum</i> (02)	Buckwheat		Narhal Padder, Galhar Naghseni
13	<i>Zea mays</i> (15)	Maize	Kukdi/ Maka	Bidha, Galigadh Sarthal, Gorna Sarthal, Aghral Devi Mandir Sarthal, Ikhala, Naghni Bhonjwa, Salana Drabshalla, Massu Padder, Kundal Padder, Marmulla Chatroo, Bumalpora Gurinal Chatroo
14	<i>Lycopersicon esculentum</i> (03)	Tomato	Tamatar	Galigadh Sarthal, Naghni Bhonjwa, Massu Padder
15	<i>Cucumis sativus</i> (03)	Cucumber	Kheera	Gorna Sarthal, Massu Padder, Marmulla Chatroo
16	<i>Capsicum annum</i> (03)	Chilli	Mirch	Gorna Sarthal, Naghni Bhonjwa, Massu Padder
17	<i>Hordeum vulgare</i> (04)	Barley	Jau/Grim	Aghral Devi Mandir Sarthal, Danghdooro Dachan, Salana Drabshalla, Galhar Naghsani
18	<i>Cucurbita pepo</i> (02)	Pumpkin		Aghral Devi Mandir Sarthal, Naghni Bhonjwa
19	<i>Chenopodium album</i> (03)	Chenopod	Ba-jarbangh	Aghral Devi Mandir Sarthal, Massu Padder, Narhal Padder
20	<i>Amaranthus hypochondriacus</i> (03)	Amaranth	Ganhar/ Babri	Aghral Devi Mandir Sarthal, Narhal Padder
21	<i>Glycine max</i> (01)	Soybean		Lower Aghral Devi Mandir Sarthal
21	<i>Solanum pseudocapsicum</i> (01)	Jerusalem Cherry	Amluk	Shalimar
23	<i>Oryza sativa</i> (05)	Paddy	Dhan/Lal Dhan	Ikhala, Naghni Bhonjwa, Massu Padder, Bumalpora Gurinal Chatroo
24	<i>Nicotiana tabacum</i> (01)	Tobacco	Desi tamakoo	Naghni Bhonjwa
25	<i>Eleusine coracana</i> (03)	Finger millet	Mandua/ Kudroo	Bidha, Karthaie Padder, Massu Padder
26	<i>Setaria italica</i> (01)	Foxtail millet	Sallan	Massu Padder
27	<i>Panicum miliaceum</i> (01)	Proso millet	Cheena	Narhal Padder
28	<i>Setaria viridis</i> (01)			Marmulla Chatroo
29	<i>Allium sativum</i> (03)	Garlic	Lahsun	Karthaie Padder, Thathri, Prem Nagar

maize are still popular in the farmer's fields throughout the state owing to their better grain quality in terms of taste, better fodder quality, wider adaptability to local conditions, resistance to draught, cold, insects and pests, early maturity and low input requirement. 15 diverse accessions of this crop have been collected during the course of present study from various parts of Kishtwar often with smaller cobs showing variations in grain size and color of yellow, orange or white. White maize has been found to be more common in this region of the state. In an earlier study we have reported protein content of 13.6% and 15.2% in two maize genotypes collected from Kishtwar with corresponding oil content of 3.47% and 4.02% respectively (Sultan et al., 2018). Maize thus seems to be an important source of nutrition for local people. In the north western Indian Himalayan state Jammu and Kashmir, maize is second most important crop after rice and is a staple food of tribal population (Najeeb et al., 2012). At many places in Kishtwar maize and paddy are cultivated side by side in characteristic terraced fields (Fig. 2) but cultivation of paddy is less common than that of maize. Five accessions of paddy including famous red rice landrace 'Lal Dhan' have been collected. This awned landrace was found to be cultivated by a single farmer in Massu village of Padder. Red rice awned landrace locally known as 'Zag' has also been collected from a field at Bumalpora Gurinal in Chatroo. Four accessions of another cereal *Hordeum vulgare* cultivated occasionally in some areas of Kishtwar were also collected. Unlike naked barley cultivation and consumption in Ladakh province of the state, the barley cultivated in Kishtwar hills is always hulled and is frequently used by local people during religious ceremonies. We have not been able to collect wheat from Chatroo valley, Padder valley and Kishtwar main including areas of Dachan, Surror, Sarthal, Bhonjwa and Drabshala during the course of our present study.

Pseudocereals: Two accessions each of *Fagopyrum esculentum* and *Fagopyrum dibotrys* and three accessions each of *Chenopodium album* and *Amaranthus hypochondriacus* were collected during the course of present study. *Fagopyrum dibotrys* grows wild on slopes, as a weed in maize fields or in kitchen gardens at many places especially in Padder and Sarthal areas (Fig. 2). According to local people its young tender leaves are sometimes used as a vegetable having sour taste. *Chenopodium album* has first time been seen by authors to be cultivated in the state of Jammu and Kashmir. Out of three accessions, one was collected from farmer's field and second from farmer store in Padder area whereas third one has been collected from wild growing in a maize field in Sarthal area. Three accessions of *Amaranthus hypochondriacus* have been collected from maize

fields in Sarthal and Padder areas. The amaranth having red colored inflorescences was found to be grown on maize field bunds whereas one accession with greenish inflorescence has been collected from within the field.

Millets: Minor millets found to be cultivated in Kishtwar especially in Padder valley *Eleusine coracana*, *Setaria italica* and *Panicum miliaceum*. Three accessions of *Eleusine coracana* which seems to be cultivated more commonly compared to other two millets were collected. One accession of a primitive type of *Setaria italica* cultivated on a small patch of land by a single farmer in Massu padder (Fig. 2) was also collected. Locally called as 'Sallan' according to the farmer is tasty when consumed as 'sattu' after roasting. One accession of *Panicum miliaceum*, the third minor millet was collected which among the three is rarely cultivated in the region. Farmers are increasingly losing interest in these crops now and according to locals there cultivation has now drastically declined. In Ladakh, *Setaria italica* is more commonly cultivated than *Eleusine coracana* and that during last few decades, the cultivation there also has significantly declined (Sultan and Omvir, 2013). One accession of *Setaria viridis*, the wild cousin of *Setaria italica* was also collected from the area.

Grain legumes: Common bean (*Phaseolus vulgaris*) is the important and most common grain legume cultivated in the entire area mostly intercropped with maize and we have collected 31 diverse accessions from different areas. Variability was collected in seed size, shape and color. In the state of Jammu and Kashmir, common beans are often named according to the area of their production for example, famous Shopian rajma, Gurez rajma, Badherwah rajma, Kishtwar rajma, Poonch rajma etc. Same trend is followed within Kishtwar district also with Warwan rajma, Dachan rajma, Padder rajma, Keshwan rajma etc. named after the respective areas of their production within the district. Of particular interest is our collection of 'Keshwan rajma' produced in and around rough hilly terrains of Keshwan area. This short duration genotype with brownish cuboid seeds has an average seed length, seed width and 100-seed weight of 12.5 mm, 8.0 mm and 36.8 g respectively (Sultan et al., 2014) and is believed to be very tasty by locals. Besides common beans other grain legume germplasm collected from the area include *Vigna unguiculata*, *Vigna radiata*, *Vigna mungo*, *Lens culinaris* and *Macrotyloma uniflorum*. These pulses are cultivated occasionally but not as frequently as common beans. One accession of another grain legume soybean (*Glycine max*) was also collected from Farmer's field. Limited numbers of heavy pod bearing plants were characteristically grown at the rim of a field near village Aghral Devi Mandir Sarthal.

Vegetables and spices: Good quantities of differ-



Fig. 2. From top left to right: **A** - Characteristic terraced fields in hill district of Kishtwar (Jammu & Kashmir) with mixed farming of maize, paddy and pulses; **B** - a field of Finger millet (*Eleusine coracana*) in Bidha; **C** - a small field of primitive type of Fox-tail millet (*Setaria italica*) locally called as 'Sallan' in Massu Padder; **D** - buckwheat species, *Fagopyrum dibotrys* growing wild along roadside in Sarthal area; **E** - local cucumber collected from Gorna in Sarthal area and **F** - edible creeping cucumber (*Solena heterophylla*) growing wild in Nagni area of Bhonjwa Kishtwar.

ent kinds of vegetables are produced in Kishtwar especially in Sarthal area. Inspire of introduction of high yielding varieties of vegetables in the district, traditional landraces are still very popular owing to their good taste. During the present study three (03) accessions each of *Lycopersicon esculentum*, *Cucumis sativus*, *Trigonella foenum-graecum*, *Allium sativum* and *Capsicum annum* have been collected mostly from Sarthal areas. Six (06) accessions of *Coriandrum sativum* and two (02) each of *Cucurbita pepo* and *Bunium persicum* were also collected. Good variability has been collected in *Coriandrum sativum*, the seeds vary greatly in shape, size and aroma. The two accessions of *Bunium persicum* have been collected from Padder area where it grows wild on hill slopes. Locally called as 'Zoor' or 'Kala zeera', its seeds are used as spice and condiment. It is collected by the local people and sold in the market thus, playing an important role in income generation for most of the families. However, over last few years there has been a drastic decline in its production and this valuable plant genetic re-

source is now highly endangered. Overharvesting over the years may be one of the main reasons for its decreasing populations.

Other crops: One accession each of *Nicotiana tabacum* and *Solanum pseudocapsicum* have also been collected during the study. *Nicotiana tabacum* has been collected from Nagnhi Bhonjwa where it was found growing as a roadside weed. According to locals this 'Desi tamakoo' was cultivated in the past for domestic use and now its cultivation has been almost stopped. *Solanum pseudocapsicum* was collected from roadside near Shalimar area where few unusually quite bigger plants of about 4 - 6 feet tall with heavy fruit bearing were seen growing. Otherwise smaller plants of this wild *Solanum* can be seen growing on hill slopes at several places in the area. Locally called as 'Amluk', its ripe berries in past were used as 'Chutney' by many people. However, due to its intense and sharp smell it has not been so popular as revealed by many locals.

The main source of livelihood of the people of Kishtwar is agriculture as around 90% of the population is rural and directly or indirectly involved with the agriculture and allied sectors. A total of 25872 hectares area of the District is under food and non food crops out of which about half of the area is under high yielding varieties of different crops (DS&EO, 2017). Further, a total of 8889 hectare area is under major horticulture crops which comprise 4227 hectares under fresh fruits and 4662 hectares under dry fruits. The main fresh fruit produced in the district includes apple, apricot, plum par and peach and dry fruits produced chiefly include walnut and almond. Saffron is also cultivated at few places in the district on an area of roughly 120 hectares.

The forests are mostly comprised of deodar, fir and pine trees. Entire area is very rich in a range of medicinal plants and some wild fruits. Wild edible plants of *Allium roylei*, *Bunium persicum*, *Corylus jacquemontii*, *Crataegus songarica*, *Elaeagnus umbellata*, *Ficus palmata*, *Morus serrata*, *Pinus gerardiana*, *Prunus armeniaca*, *Prunus cornuta*, *Punica granatum*, *Pyrus paschia*, *Rubus* sp., *Viburnum grandiflorum*, *Zizyphus oxyphylla* etc. can be seen growing at different places. During the course of present study we have noted wild edible creeping cucumber species namely *Solena heterophylla* growing abundantly in Nagni area of Bhonjwa Kishtwar (Fig. 2). The locals especially children fondly eat its ripe reddish fruits. Good populations of *Perilla frutescence* growing along roadside have also been seen by the authors growing in the area. Unfortunately this valuable biodiversity including that in agricultural fields is increasingly been threatened nowadays. Construction of network of roads has lead to habitat loss. Inaccessible pockets in the district known for

cultivation of countless landraces are being connected by the roads and high yielding varieties are fast spreading replacing traditional varieties. With the introduction of exotic seeds and plants, alien species of weeds and pests are making their way into this once untouched neat and clean hilly area with serene environment. We have seen several populations of alien species of *Xanthium spinosum* around agricultural fields in Gulabgarh area of Padder valley. Such invasive alien species pose a significant threat to the biodiversity in general and in agricultural fields. Species which are listed to be of immediate cause of concern in the Kishtwar district include *Parthenium hysterophorus*, *Xanthium spinosum*, *Cirsium arvense*, *Anthemis cotula* (Bhutyal *et al.*, 2014). Half a dozen hydroelectric power projects are functioning in the district and many more are coming up. Several villages have been dislocated and prime agricultural land has been inundated. The collection and conservation of available plant genetic resources from the region thus becomes inevitable.

Conclusion

The collected 113 multicroop germplasm accessions belonging to 29 species of crops and wild relatives from as many as 40 collection sites across Kishtwar have been conserved at National Gene Bank (NGB), ICAR-NBPGR New Delhi under long term conservation. Genetic diversity forms the core of initial material for the improvement of the characteristics of crops either by farmers, plant breeders or molecular methods. Genetic resources support the maintenance of biological diversity, promote sustainable agricultural production and contribute to the sustainable development and diversification of agricultural production. The plant genetic diversity allows crops and varieties to adapt to ever changing conditions and to overcome the constraints caused by biotic and abiotic stresses. In future, with the help of advanced molecular biological methods, it will be possible to detect in the conserved material the values unknown so far, which can be used for the breeding of new disease resistant or otherwise value added varieties.

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