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SHORT COMMUNICATION

Collecting Plant Genetic Resources from South-eastern Ladakh, India

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For the first time, systematic germplasm collection trip was conducted across south-eastern Ladakh during September 2018. A total of 76 accessions belonging to 21 species including 44 accessions of wild germplasm were collected from the altitude of 3,400-5,300 meters above mean sea level. Good variability in hull-less barley, and wheat wild relatives namely *Elymus nutans* Griseb. and *Leymus secalinus* (Georgi) Tzvelev was augmented from this tract for the first time. Germplasm of *Chenopodium karoi* (Murr) Aellen was collected for the first time in India. The commonly occurring *Elymus nutans* is replaced by *E. schrenkianus* (Fisch. & C.A.Mey.) Tzvelev in altitudes above 4,700 m while *E. repens* (L.) Gould was found upto 4,300 m, which was otherwise known only below 3,000 m. This communication briefly discusses on the germplasm collected/observed and future exploration scope from this remote area.

Key Words: Cold-arid Himalaya, Crop wild relatives, Germplasm collection, Leh district, Purple barley

South-eastern part of Union Territory of Ladakh encompasses three (out of eight) tehsils of Leh district, namely, Nyoma, Kharu and Durbuk. This remote part of Ladakh shares borders with China (Tibet) in the east, Kargil district in the west, and Lahaul and Spiti district of Himachal Pradesh in the south. Broadly falling under Trans-Himalayan biogeographic zone as well as cold-arid agroclimatic zone, this region is significant for the occurrence of crop wild relatives belonging to the genera *Allium*, *Avena*, *Carum*, *Cicer*, *Elymus*, *Eremopyrum, Hordeum* and *Prunus* (Arora and Nayar, 1984). However, this part of Ladakh has not been systematically explored for plant genetic resources collection, as evident by the meagre germplasm holdings (<10 accessions) from this vast stretch of ecologically fragile area, swayed by the vagaries of climate change. Keeping this in view, an expedition for collecting germplasm of agri-horticultural crops and their wild relatives was undertaken during September 2018.

Tehsils of Nyoma, Kharu and Durbuk together comprise of 39 villages with a total population of around 25,000 (population density 3/km^2); majority of them embracing Buddhism. Upper region (>4,500 m) has permaforst climate, while lower region is slightly warmer with intense solar radiation. Rainfall is scanty, most of the precipitation is obtained through snow. Soil is mostly of rocks and sands. Landscape is arid desert-like with low temperatures leading to sparse vegetation. Nevertheless, afforestation with multipurpose tree species such as willows and poplars is common along roadsides, river banks and near oasis. Source of irrigation for crops is snow-melt *nallahs*, *kuhls* and streams. Usually spring wheat (in areas below 3,500 m) and barley are the staple crops in the areas. Common fruit trees include apple, apricot and walnut. Livestocks such as pashmina goats, sheep, cattle, horses and yaks are reared here.

Random sampling was followed while collecting germplasm in the field as well as from farm store, whereas, in case of wild germplasm, small samples from adjoining areas were often bulked. The germplasm of wild species was collected from roadsides, field margins, grasslands, salty marshes, sand dunes, screes and rock crevices. Passport data sheet was filled in as per standard format (Moss and Guarino, 1995) at each collection

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site. The collected germplasm and important herbarium voucher specimens were deposited in the National Gene Bank (NGB) and the National Herbarium of Cultivated Plants (NHCP), ICAR-NBPGR, New Delhi, respectively.

Explored areas are located at latitudes between 32°56'220" and 33°43'737" N, longitudes between 77°35'615" and 78°38'641" E, and altitudes between 3,400 and 5,300 m amsl. A total of 76 germplasm accessions (21 taxa) had been collected from 28 collection sites (Fig. 1). This includes 32 accessions of crops and 44 of crop wild relatives (Table 1). Barring barley and rapeseed, all the germplasm were augmented for the first time from this area.

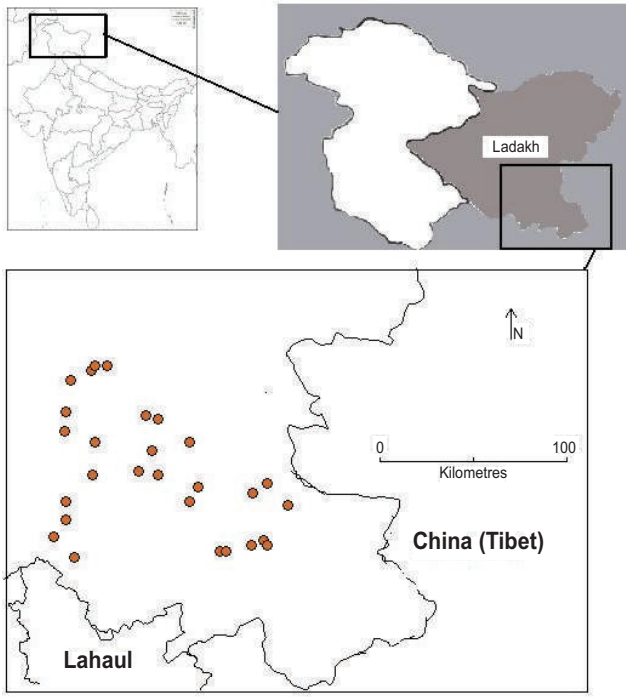

Fig. 1. Location of explored area in Ladakh, India (collection sites indicated)

In general, barley is the staple food crop of native people and is being cultivated in altitudes upto 4,400 m amsl. It is relished in the form of "*satu*". Cultivated barleys are of naked grain-type (i.e. hull-less barley); amber, black/grey and purple grain colours were present (Fig. 2A), with the preponderance of black colour. Tibetan purple barley is sparingly cultivated along with normal barley without any distinction (Fig. 2B). Normally lemma and palea of its spikelets become purple due to anthocyanin pigments, however, a variant of purple barley with green lemma awn (PRVJ-91) was also collected from Rango village. Although local people didn't distinguish grain colour variation relating to utility, literature search revealed that, in Tibet, purple barley is preferred for extracting alcoholic beverage '*chang*' owing to distinct flavour and colour (Tashi *et al*., 2012). Choo *et al*. (2005) reported that purple barley had a lower *Fusarium* head blight incidence than normal barley under high disease incidence conditions. Two-rowed barley was rarely found in Sumdo and Rango villages, where it seemed to be an accidental admixture in barley/oats crops, and matures two weeks later than naked barley. Upto 3,800 m amsl, stripe/yellow rust incidence was noticed in barley; above this altitude, incidence was not discernible; therefore, germplasm from higher altitudes, needs to be studied whether the observed field tolerance/resistance is innate or merely due to prevailing harsh weather conditions.

Only at Liktse village (3,500 m), wheat cultivation was observed, and red and amber grain types were collected; above the altitude of 3,600 m, wheat crop is replaced by barley. Both stripe/yellow and leaf rust were prevalently found in wheat crop. Rapeseed, field pea, lentil, buckwheat, potato and oats (as fodder) are the only few choices of other crops cultivated. In fieldpea, black (locally called *kalamattar*) as well as mottled brown seed types were collected. Mountain spinach, carrot, sweet chard/mangel and coriander were found only under homestead cultivation. Squashes such as zucchini (*Cucurbita pepo* L.) and scallop squash (*C. pepo* L. subsp. *ovifera* (L.) D.S. Decker) were rarely found in home gardens.

Among the wild germplasm, wild relatives of wheat and barley, i.e. *Elymus* spp. (21 acc.) and *Leymus secalinus* were predominant in the collection. *Elymus nutans* is the most common species found in field boundaries, unattended fields, ungrazed sites, roadsides and also in mountain slopes across the altitudes surveyed. *Elymus dahuricus* Turcz. ex Griseb. is rarely observed in field boundaries, orchards and roadsides. *Elymus himalayanus* (Nevski) Tzvelev is specifically common in tract between Sarchu and Pang. *Elymus longearistatus* (Boiss). Tzvelev is habitat-specific and is occasional along roadsides and hillslopes. A niche-specific species, *Elymus schrenkianus*, was found occurring gregariously in altitudes above 4,700 m amsl (Fig. 2E), replacing *E. nutans*. In Sarchu (4,100 m) and Tsaga (4,300 m), authors found *E. repens*, a rhizomatous self-incompatible species inhabiting disturbed habitats, which is the

Table 1. Germplasm collected from south-eastern Ladakh, India

Sl. No.	Species	Acc.	Remarks
Cereals		**18**	
1.	*Avena sativa* L.	3	Exclusively grown as fodder
2.	*Hordeum vulgare* L.	11	Grain colour variation noticed
3.	*Triticum aestivum* L.	4	Red and amber grain types observed
Pseudocereals		2	
4.	*Fagopyrum esculentum* Moench	1	Informed by locals as non-traditional crop
5.	*Fagopyrum tataricum* (L.) Gaertn.	1	Of rare cultivation
Grain legumes		4	
6.	*Lens culinaris* Medik.	1	Found only in Tsaga village
7.	*Pisum sativum* L. var. *arvense* (L.) Poir.	3	Characterised by pink flowers
Oilseeds		5	
8.	*Brassica napus* L.	5	Commonly cultivated as pure crop
Vegetables		**2**	
9.	*Artiplex hortensis* L.	1	Green plant type preferred
10.	*Daucus carota* L.	1	---
Spices		**1**	
11.	*Coriandrum sativum* L.	1	Small-sized seeds; highly fragrant
Crop wild relatives		**44**	
12.	*Allium przewalskianum* Regel	5	Occurs in wider ecological conditions - rocky crevices, meadows, disturbed habitats
13.	*Carum carvi* L.	4	Abundant in areas east of Nyoma
14.	*Chenopodium karoi* (Murr) Aellen	1	Big sized seeds; of potential use in chenopod improvement
15.	*Elymus dahuricus* Turcz.	2	Exhibits late spike maturity
16.	*Elymus himalayanus* (Nevski) Tzvelev	2	Characterized by thin, easily breakable rachis and straight long lemma awn
17.	*Elymus longearistatus* (Boiss.) Tzvelev	1	Has disarticulate rachis
18.	*Elymus nutans* Griseb.	10	Variability with respect to to plant stature, pigmentation, spike density and length, number of spikelets/ node, and awn length and colour
17.	*Elymus schrenkianus* (Fisch. & C.A.Mey.) Tzvelev	4	Niche-specific elegant species, characterised by pigmented robust spikes
18.	*Elymus* spp.	2	Identity of two entities yet-to-be established
19.	*Fagopyrum tataricum* (L.) Gaertn. subsp. *potaninii* Batalin	1	Ruderal type, characterised by short stature, seeds small with undulate/protruded margin
20.	*Leymus secalinus* (Georgi) Tzvelev	11	Variability with respect to pigmentation, number of spikelets/ node and plant stature
21.	*Setaria viridis* (L.) P.Beauv.	1	Common field weed; variation with respect to pigmentation

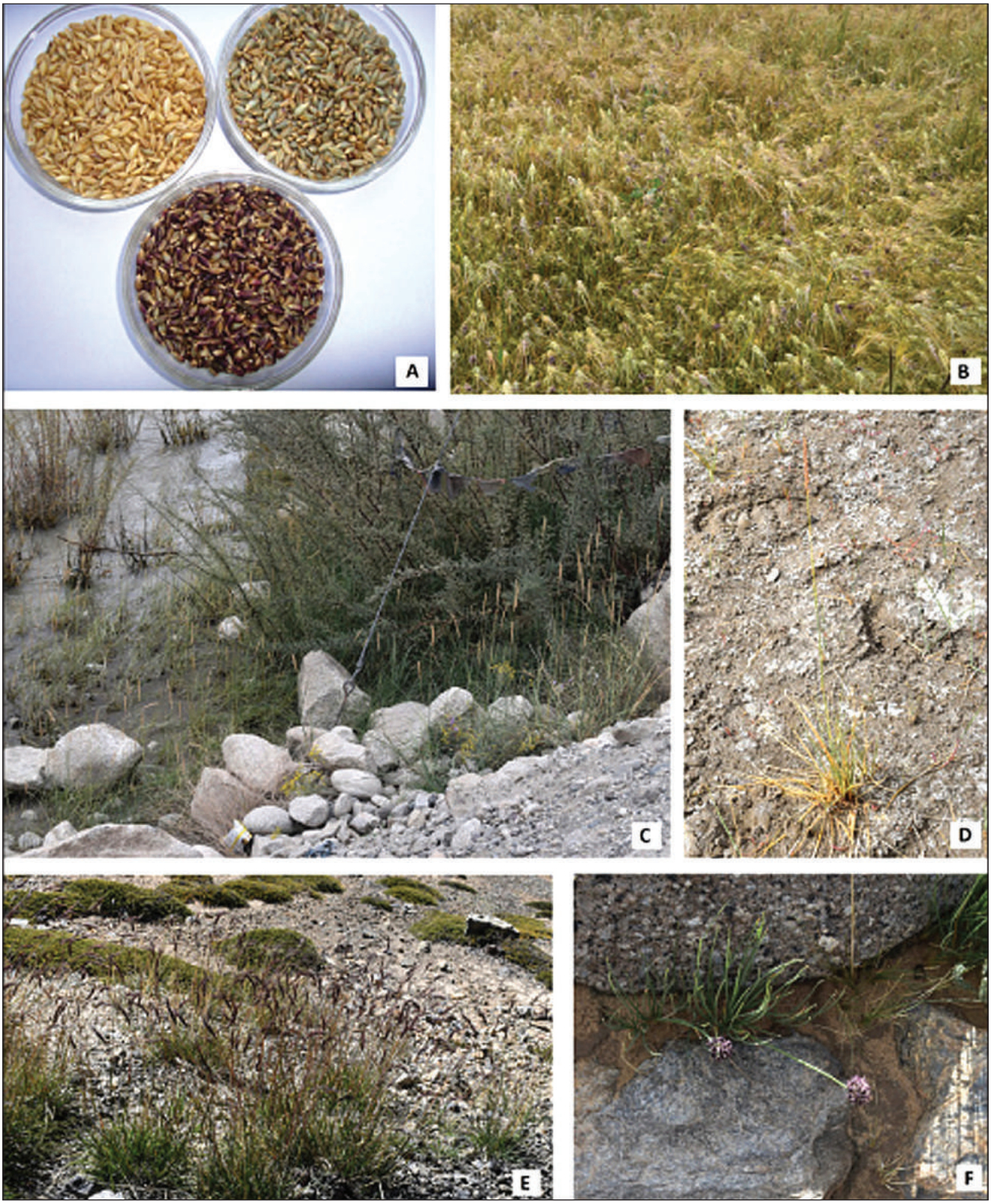

Fig. 2. A. Normal (amber), black/grey and purple grain colours in naked barley accessions collected; B. Both black/grey and purple barley grown together at Nyoma; C & D. *Leymus secalinus* naturally growing in waterlogging condition (left) and over saline encrustations (right); E & F. Natural habitat of *Elymus schrenkianus* (in Pang area) and *Allium przewalskianum* (near Tsokar Lake), respectively.

highest ever-recorded altitude for this species (generally <3,000 m, vide Pradheep *et al*., 2019). *Elymus mutabilis* (Drobow) Tzvelev was rarely observed in flowering stage at Sumdo, showing the tendency of late spike maturity (25 days) in comparison to the collected *Elymus* species.

Adaptation of *Leymus secalinus* (Georgi) Tzvelev to diverse ecological conditions such as waterlogging (Fig. 2C), saline sites (Fig. 2D), sandy as well as boulder-prone (scree) areas, hillslopes and as field weed indicate astounding plasticity. This species was found as dominant vegetation in plant community especially in the sandy areas east of Nyoma (like Loma, Muth, Rango, Dungti, Tsaga, Chushul), where delayed spike maturity (for 15-20 days) was noticed. Spikelet sterility has been observed in half of the collections, as this was reported to be a rhizomatous self-sterile species (Parmer and Sagar, 1963). The slender-spiked one (PRVJ-97), rarely found from Polokonga Pass, matches with var. *tenuis* L.B.Cai. Though widespread ecological adaptations are exhibited by this species, aphid (*Sitobion* sp.) incidence was noticed in some localities.

Other wild germplasm collections include caraway (*Carum carvi* L.), *Allium przewalskianum* Regel (locally called *kotse*; its crushed and dried leaf paste is added to traditional food, *thupka* Fig. 2F), *Fagopyrum tataricum* (L.) Gaertn. subsp. *potaninii* Batalin (progenitor of tartary buckwheat, as a rare field weed) and *Chenopodium karoi* (a common field weed; collected for the first time). Collected wild germplasm warrants detailed taxonomic studies and characterization, that would pave way for germplasm utilization especially in abiotic stress tolerance breeding programmes, besides spotting of new taxa or new distribution records to the country.

Further, explored region represents moderate level of genetic diversity in turnip, radish, apricot, seabuckthorn, *Beta vulgaris* L. (sweet chard/mangel), *Setaria viridis* (L.) P. Beauv., *Amaranthus retroflexus* L., *Chenopodium* spp., wild *Brassicae*, minor fruits (*Rubus*, *Ribes*, etc.) and wild edible plants, which may be targeted for germplasm collecting in the near future. As the choice of crops is limited in this harsh terrain, winter wheat (in snow-line area) and cereal oats in poor and marginal soils could be introduced as alternative crops to enhance the livelihood of local people. Moreover, glasshouse cultivation of vegetables such as broccoli and lettuce may be worth-considering. Future explorations can be focused on far-flung areas bordering Tibet (China) like Anlay, Demchok, Hunli, Koyul and Tsomomiri, which could not be visited during this trip.

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