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Weedy diversity of subsistence agriculture and their traditional uses in cold arid region of India

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In Ladakh, a cold arid region, subsistence agriculture has been in practice and is associated with livestock rearing in very small-scale stone-built terrace farming. Due to poor resources, public distribution systems, import/mutual exchange of plant materials and higher labour cost, high-altitude default organic farming has become a complex activity where weeds have become a recurrent problem. Moreover, they have become an integral part of fodder resources under small-scale stone-built terraced farming in barren ecosystems for enriching straw with supplementary weedy stuff. As a result, cropped areas suffer severe weed pressure as it requires 4-5 weedings under high-altitude solar radiation. An intensive survey revealed that the majority of weeds constituted of Amaranthaceae, Asteraceae, Poaceae and Fabaceae families, and they varied attitudinally. In this region, weeds are the major associated plant species, limiting the performance of crops in terms of seed quality and yields significantly. Hence, weed menace is overlooked in crops that impact the invasive weedy species to move upward to high altitudes under climate change. Conversely, people across this region have identified many of the weedy species for their day-to-day consumption as green leafy vegetables and for medicinal uses under the harsh climate of the cold arid region. This article describes the weedy species identified in crops and their utilization under low-land holding subsistence agriculture.

Keywords: Cold arid region, Ladakh, Subsistence agriculture, Weedy diversity, Weed utilization
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Recently, the Ladakh region has been recognized by the Government of India as a Union Territory. This is located at and above 9,800 feet and is a land-locked region surrounded by China to the East, Himachal Pradesh to the South, Jammu and Kashmir and Gilgit-Baltistan to the West and the Southwest of Karakoram range in North[1] and the Indus river supports Ladakh agriculture. In this region, agriculture and livestock rearing are the main livelihood options for rural people with a reported area of 45167 hectares, of which only 10,542 hectares (23%) have been brought under agricultural practice. On an average, the majority of farmers of the region possess only between 0.5 and 2 hectares and are inclined towards the cash crops more often, including staple crops for their livelihood[2]. Scanty precipitation and the river systems are two of the major land features that limit the possibility of small-scale farming activities, therefore, farming practices have adapted to this severe environment where families mostly rely on subsistence agriculture and crops such as wheat, barley and potato cultivated on stone-built terraces[3]. In last 6-7 years only, there was a 50% to 80% deficit in annual precipitation in Ladakh between 2013 and 2017 and 2016 was a year of record low rain[4]. Under such conditions, the present practice of farming makes biotic factors match the pace of abiotic changes and altogether impacts the crop productivity significantly. Food security measures have always been neglected at every level for mountain livelihoods, and traditional systems have been continuing since many decades also in the region[5]. Conversely, in the recent past, imports have encouraged biological invasion, which is one of the most important mechanisms that pose serious threats to the conservation of native ecosystems worldwide[6]. Amongst the biotic factors, weeds have been identified as a major menace in crops/vegetables as compared to other pests and still continue being an integral part of the vegetation, causing 30%-50% reduction in crop yields, which is also apparently evident from the naked eyes, thus enriching the soil weed seed bank in the cultivated fields. A rapid warming in Himalayas has been observed increasing

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the plant upper distributional limits and species being adapted to warmer climate[7]. Under this phenomenon, exotic plant species such as invasive weedy species that have moved to upper altitudes and have significant establishment and adaptation are now posing a serious threat in a Northern pocket of the cold arid desert.

The expansion of invasive weedy species has been predicted towards upper and lower elevations by 2050 and it has also been calculated that invasive alien plant species might expand upward by 981 m and downward by 359 m in the beginning of 2070 and hence, the elevation range would expand from "622 m-2865 m" to "448 m-3547 m"[8]. However, despite receiving training, resource-poor farmers are still unable to use the technologies properly and continue to be dependent on age-old practices. The measures designed to meet the needs of the Ladakhi farming community remain half-baked and social promises are cut short by shoddy implementation. As a result of the hasty and unsatisfactory execution of agricultural practices in a mono-cropped short season, crop fields are built up with an enormous weed seed bank and crops face weed menace directly and indirectly. In view of the above, an intensive survey was carried out in six villages of varying altitudes to understand the weed diversity and their mode of occurrence and recurrence in cropped and non-cropped areas.

Methodology

Keeping the above features of Ladakhi subsistence agriculture in mind, a bio-geographical survey was carried out by Regional Research Station, ICAR-Central Arid Zone Research Institute (CAZRI), Leh, during 2013-18 at different villages of Leh district, namely, Saboo (77° 34' 48" E, 34° 0' 12" N), Stakmo (77^0 42' 21.56" E, 34° 01' 36.90" N), Nang (77° 45' 06.34" E,34° 02' 35.6" N), Umla (77° 23' 57" E, 34° 14' 12.33" N), Phey (77° 27' 56.99" E, 34° 08' 0.6" N) and Stakna, (77° 41' 06.33" E, 33° 59' 44.06" N). The survey was also made to understand the weedy diversity, mode of dissemination, weed pressure, weed seed bank build-up and the constraints thereon. Discussions were also held for recognizing the weeds and their impact on crops and their yields in identified villages by interacting with local staff and older and experienced farmers, particularly farm women who were associated with vegetable growing and weeding operations, which could address the seriousness of the weed problem and number of weedings being performed at different intervals at villages with varying altitudes due to high solar radiation and on-spot observation of the method adopted by the villagers. The extent and characteristics of associated grassy and broad-leaved weeds were observed in different crops of above villages. Being a cold arid region, wide diurnal and seasonal fluctuations in temperature with -40°C in winter and +35°C in summer are observed. In general, the region has a short, mild summer with a mono-cropped short growing season (end of April to third week of September) to long cold winter (October to first week of April). Annual precipitation is extremely low due to rain shadow effect caused by the Karakoram ranges on one side and the mighty Greater Himalayas and Zanskar ranges on the other side. Precipitation is about 50-70 mm, with July and August being the rainiest months and the average rainy days in these months being two each. Precipitation is very low and mainly in the form of snow. The air is very dry, and relative humidity ranges from 6% to 24%. Due to high elevation and low humidity, the radiation level is very high[9] and potential evapo-transpiration is to the order of 700-800 mm per year. The soil of these villages is gravelly and sandy-to-sandy loam in texture and medium-to-medium high in organic matter with a pH of 7.85 EC and poor water holding capacity. More than 90% soils are low in phosphorous and high in potassium[10].

Results and Discussion

A benchmark survey was carried out in identified villages (Fig. 1) and recorded in areas with similar soil representing gravelly and sandy-to-sandy loam in texture and medium-to-medium high in organic

Fig. 1 — Villages of varied altitudes of Leh district for exploring weedy diversity

matter to understand the variability in weedy species of cropped and non-cropped areas and few of the species varied attitudinally. With such a soil type, weeds are the major beneficiaries, making the best utilization of available resources such as starter doses of fertilizers and manures, plentiful light, space, soil and moisture, thereby rendering crop plants devoid of moisture mainly under arid environment. During the survey, experienced and older farmers informed that the growing period varies according to the location and altitude, ranging from 80 to 150 days and weeds are an integral part of crops undertaken as livestock, which is an important alternate livelihood option for a region such as Ladakh where villages are remotely located and support each other for exchanging germplasm, seeds and for nutritional security.

Weed Diversity Assumption (WDA)

WDA aimed at exploring the plant species actually imposing competition with crops till a critical period is attained during the growth of crops/fodders/grasslands and the intensity/degree of crop-weed competition amongst the plant communities for resources and impact on growth parameters and yield attributes. It was recorded that wild (weedy) species immediately respond to the diurnal changes in temperature and available moisture taking place from April to May and interfere with crop plants. Ladakh's subsistence agricultural system is one of the Globally Important Agricultural Heritage Systems identified[11] as unique on its own for conservation of natural resources, management practices, sources of fertility, and use of weeds as fodder. The intensity of weedy species at two altitudes was recorded (Table 1). Location-specific scientific interventions such as organic control of weeds in conjugation with possible pre-emergence herbicides integrated with their own traditional practices were evaluated as per the requirement of resource poor constrained farming community of remotely located villages under Buddhist culture.

These inputs would directly or indirectly address the impact of weedy diversity and increased weed seed banks on crop weed competition and yields of crops. The WDA revealed the novel prediction about how weedy diversity impacts crops yields under

Table 1 — Altitudinal behavior of important weedy species when infestation is more

Weeds/ Altitude	3200 m MSL Saboo, Umla, Stakmo, Nang				2900 m MSL Phey, Spituk, Chushot, Thiksey				Crops
	Presence	Intensity	Height (cm)	Losses caused (%)	Presence	intensity	Height (cm)	Losses caused (%)	
Chenopodium album	√	L-M	50-70	10-12	√	M-H	50-120	12-15	Vg
Chenopodium carinata	√	VH	20-30	10-12	√	H	30-40	12-15	Vg
*Chenodpodium botrys**	√	L*	10-30	5-8	√	VL	-	-	Vg
Agropyron repens	√	H	20-35	10-18	√	L-M	20-45	5-10	B,W,P,O, Vg
Phragmites australis#	-	-	-	-	√	VH**	100-300	40-50	S, Br
Malwa neglecta	√	L	30-55	5-10	√	H	40-120	20-30	Vg
Avena sativa	√	VL	30-55	5-6	√	M-H	40-68	10-12	W
*Cirsium arvense****	-	-	-	-	√	H*	25-100	20-30	S,Vg
Setaria viridis	√	L	5-8	-	√	M-H	8-15	-	Vg
Convolvulus arvensis	√	L	20-40	5-8	√	M	20-40	8-10	W,B
Ambrosia artemisiifolia	√	L	20-45	5-8	√	M-H	35-55	8-10	Vg,S
Artemisia sp	√	L	20-35	5-6	√	M-H	40-110	8-12	Vg,S
Clematis sp.***	-	-	-	-	√	L	±100	-	SBT
Stellaria media	-	-	-	-	√	L	70-80	5-8	P
Festuca sp****	√	VL	50-120	-	√	L-M	75-130	-	Br
Stephenomeria sp.**	-	-	-	-	√	L	15-20	-	Br
Cascuta sp.**	-	-	-	-	√	L-M	40-60	20-30	A
*Peganum harmala***	-	-	-	-	√	L	30-40	-	Br
*Cardaria draba***	-	-	-	-	√	M	50-70	-	Br

* Scattered in barren lands; **Location specific; *** only on and around Sea buckthorn, ****Bunds
L-Low, M-Medium, H-High, VH-Very High
Intensity- VL (2-10/ m^2); L (30-50/m^2); M (50-80/m^2); H (80-120/m^2); VH (120 & above/m^2)
River and lower altitude side;* Scattered in barren lands; **Location specific; *** only on and around Sea buckthorn, ****Bunds
L-Low, M-Medium, H-High, VH-Very High
Intensity- VL (2-10/ m^2); L (30-50/m^2); M (50-80/m^2); H (80-120/m^2); VH (120 & above/m^2)
S-Staple crops, B-Barley, W-wheat, P-Potato, O-Onion, A-Alfalfa, Br-Barren, Vg-Vegetables, SBT-Sea buckthorn

controlled and non-controlled phases and yield loss due to weed–crop competition (i.e., the impact on yield per unit weed density) under given soil resource and will also determine the extent to which weed–crop competition weakens the crops and calculate critical periods.

We aimed to test the hypothesis that increased tourism, upward distribution of plant species and farmers' negligence were associated with the establishment of the invasion of exotic grasses/herbs in cropped and non-cropped areas and high grasslands of cold arid regions under the impact of abiotic processes Few weedy species are slowly becoming accepted as leafy vegetables on the mountain due to locked periods, although environmentally damaging weeds are ignored. It can be pointed out that this weedy species influenced the local biodiversity significantly, especially in staple crops, but not at a regional rate, thus confirming the hypothesis that most of the weedy species are more related to specific local environmental conditions of the crop. Our hypothesis revealed that in last 3 decades, the increasing cultivation of confined crops, regional mutual exchange of seed resources, public distribution system (PDS) of imported hybrids and grains have led to the weedy invasion under subsistence agriculture cultivation with frequent applications of non-decomposed manures under a fixed trend of common management practices, and these practices have filtered weed species.

Basis of weed problem

It is clear from the observations and Fig. 2a that the famers, particularly farm women, focus more on vegetables and alfalfa (75%) as compared to staples (25%) as wheat flour is distributed at very cheap rate under PDS. Vegetables for traditional consumption and alfalfa for livestock during the 7-month harsh winter supports them as compared to wheat and barley. This negligence overlooks the intercultural operations in staple crops and encourages more weed seed banks which profusely emerge in the next season and drastically reduce the crop yield by nearly 50% (Fig. 2b). Weedings are only performed for vegetables that support them, and straw yield mixed with weed dry matter is considered more important for livestock feeding for another 7 months of harsh winter. The survey showed different modes of weed dissemination, as shown in Fig. 2c.

Status of farming

Traditional methods of crop production system are still in trend under subsistence agriculture as any experiment may keep them devoid for one season and

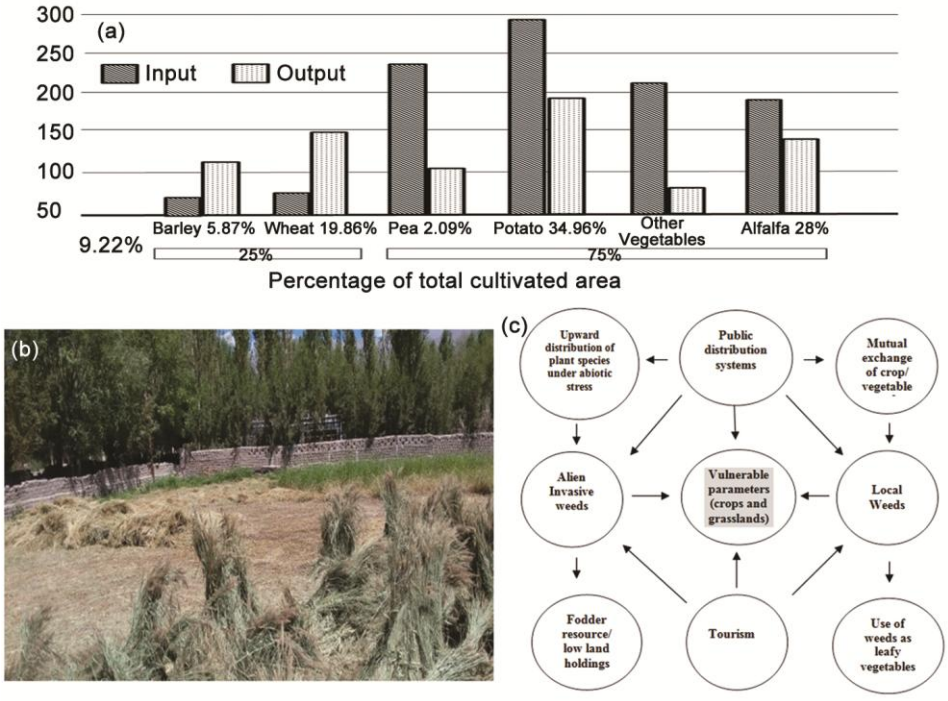

Fig. 2 — (a) Energy budget for different crops in village Saboo (unit in each case= value X 10^5 k cal/ha /year), (b) Intensity of weed problem and their ration ratio of Wheat (30%) and *Phragmites* weed and (c) Diagram showing major weed dissemination through various modes

taking risk costs them a lot. So, the farming community believes that exchange of seeds and only improved crop seeds especially designed for cold arid conditions have importance for winter season also. It has been observed that the weed dissemination occurs with various modes (Fig. 2c) recorded in the Ladakh region and PDS might be the major source for interception of unidentified weed seeds with grains. As a result of this, the cropped areas have been under severe weedy pressure. Furthermore, higher seeding on small land holdings with no intercultural operations and less monitoring have led to the build-up of weed seed banks which are impacted by the sudden change in temperature from April to May and flourish in staple crops and non-cropped areas. Traditional farming has been in practice since many decades. The following are the major constraints of developing more weed population in cropped and pastoral manors:

- not everyone has the same capacity to adapt to the changing climate
- poor communities are more vulnerable, in particular those in extremely high altitude as they tend to have more limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies
- PDS leads to a decline in interest in barley/wheat cultivation and other intercultural operations
- people's lack of interest due to new avenues of employments like tourism, army and government jobs, and booming construction activities
- villages are remotely and deeply located valleys to each other where traditional farming practices with constrained resources still dominate
- reduction in crop productivity by 30%-60% due to weeds and other pests with high labour cost
- prone to natural disaster and depleting natural resources
- reduced and un-decomposed manure application in cropped lands by 60%-75%
- negative impact of absence of forest cover and other vegetation, resulting in soil erosion on sloping land by about 30%
- reduced livestock size and productivity by 60%
- less technical knowhow, out-migration and lack of interest
- lower interest due to remoteness, poor marketability, and isolation
- increased vulnerability to soil erosion and flash flood
- reduced crop, vegetables, fruits and fodder production
- erratic/negligible precipitation

During the survey, it was found that the major weeds of the crop fields constituted mainly of Amaranthaceae, Asteraceae, Poaceae and Fabaceae families in cropped areas. Livestock is allowed for grazing after the sowing is completed. The temperature range of the cold arid region does not allow farm yard manure to decompose or partially decompose because of which many weed seeds are recovered intact in manure and pose a serious threat to crop fields in addition to the already existing weed seed banks and contribute to a large, resulting weedier invasion. Weeds with small, hard seeds such as *Chenopodium album* and *Amaranthus* pass easily through most animals and remain to start weedy invasion[12]. These two weeds in the cold arid region have been recorded at all studied altitudes. It is a known fact that geographical features, altitude, ecology, topography and climatic conditions are primarily responsible in making the Himalayan region a rich repository in biodiversity, especially in plant life[13]. Under the Himalayan medicinal plant range, farmers state many weedy plants of Ladakh region having an imperative role in traditional uses in the region such as for consumption and treating common ailments. The weedy diversity of Ladakh has been mentioned in Table 2.

During the survey, in almost all villages located in valleys and plains, most of the weedy species are common. These have been recorded in different crops. In wheat and barley, the dominant weeds were *Amaranthus* spp., *Avena sativa, Bidens biternata, Chenopodium album, Chenopodium carinata, Cirsium arvense, Convolvulus arvensis, Datura stramonium, Digitaria ischaemum, Hardeum vulgare, Medicago luplina, Medicago sativa, Melilotus officinalis, Polypogon monspeliensis, Setaria viridis, Stellaria media, Trifolium repens, Polygonum convolvulus* (wild buckwheat), and *Lolium* species (Fig. 3). In pea, *Amaranthus* spp, *Bidens biternata, Chenopodium album, Convolvulus arvensis. Conyza canadensis, Datura stramonium, Daucus carota, Digitaria ischaemum, Lactuca sativa, Medicago luplina, Medicago sativa, Melilotus officinalis, Setaria viridis, Trifolium repens, Polygonum convolvulus (*wild buckwheat*)* and *Lolium* species were recorded. In potato, dominance of *Amaranthus* spp., *Chenopodium album, Convolvulus arvensis.*

Datura stramonium, Digitaria ischaemum, Medicago luplina, Medicago sativa, Melilotus officinalis, Polypogon monspeliensis, Setaria viridis, Trifolium repens and *Lolium* sp. was noted. The presence of such weeds in these crops resulted in 30%-40% crop yield losses and has attracted various insects and diseases on the crop plants. Table 1 shows the intensity of occurrence of weeds at different altitudes and their presence and level of infestation (Fig. 3). It is also clear from this table that the intensity level of infestation of the same weed species is on the medium-to-higher side in case of lower altitudes as compared to higher altitudes. The village-wise diversity of weeds was recorded. In villages like Saboo, Umla, Stakmo, and Nang at an altitude of 3200 msl, weeds such as *Chenopodium album, C. carinatum>Agropyron repens> Convolvulus arvensis>Polygonum convolvulus (*wild buckwheat*) >Malwa neglecta>Amaranthus* spp. *>Melilotus officinalis>Setaria viridis> Stellaria media >Avena sativa >Bidens biternata>Digitaria ischaemum, >Hardeum vulgare>Medicago* spp. and *Lolium* species dominated in wheat-barley, pea and potato crops. Phey, Spituk and Thiksey at an altitude of 2900 msl on the river side had weeds such as *Phragmites australis>Chenopodium album >Malwa neglecta>Convolvulus arvensis>Setaria viridis>Cirsium arvense>Fectusa* sp[14].

In case of non-cultivated land, vegetation along the river belt was dominated by *Phragmites australis>Cirsium arvense>Festuca sp* (preferred pasture grass), along with *Ambrosia artemisiifolia, and Clematis* sp. around sea buckthorn vegetation. These species dominated in the order shown as per the density recorded per metre square. Other non-cropped road-sided weeds included *Datura stramonium, Conyza canadensis, Setaria viridis, Cardaria draba,* (height of C*ardaria* reduces as altitude increases)**,** *Cardaria* spp., *Peganum harmala, Capparis spinosa* (pockets of hills). The detailed list of weedy diversity has been mentioned in Table 2.

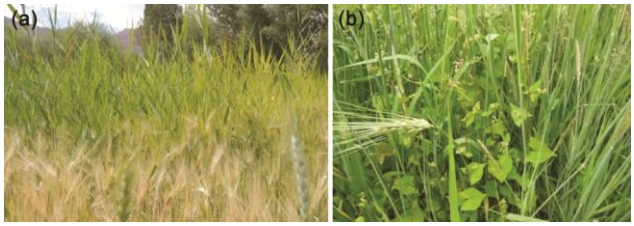

Fig. 3 — Weed infestation in wheat in Leh

Table 2 — Families, weeds, vernacular names and their traditional uses

Family	Name of weeds	Vernacular name	Recorded in	Possible traditional uses*
Poaceae	*Digitaria sanguinalis* (L.) *Scop.*	-	Crop fields	Fodder resource
	Digitaria ishcemum	rTsa	Crop fields	Fodder resource
	Avena fatua	Kasam (Nubra)	Crop fields	Grains are grinded for making roti, when not harvested makes a good fodder
	Cenchrus ciliaris	-	Pasture and wetlands	Fodder resource. Whole plant. *Cenchrus ciliaris* is reported to be lactagogue, kidney pains, tumors, sores and wounds[15]
	Festuca rubra L.	Lchipkyang	Crop fields	Fodder resource
	Poa annua L.	-	Crop fields, pasture and wetlands	Fodder resource
	Poa pratensis L.	Lchipkyang	Pasture	Fodder resource
	Festuca gaulca	Chipkyang	Crop fields	Fodder resource and straw basket for carrying vegetables to Market
	Phragmites australis Adans.	Dambu	Crop fields, pasture, sea buckthorn area, forest	Fodder resource
	Bromus spp.	-	Pasture, road sides	-
	Trisetum spicatum L.	Spang	Irrigation channels, around pond and water bodies	To reduce seepage losses, collected for fodder or grazed by cattle
	Setaria viridis	Ljamak	Crops, irrigation channels, culverts	Collected for fodder or grazed by cattle
	Setaria glauca (L.) P. *Beauv*	Norbo-rtsey	Crop field, irrigation channels, culverts	Collected for fodder or grazed by cattle
	Agropyron repens	Rampa	Crop fields	

(*Contd.*)

Table 2 — Families, weeds, vernacular names and their traditional uses (*Contd*.)

Family	Name of weeds	Vernacular name	Recorded in	Possible traditional uses*
Leguminosae	*Medicago sativa* L.	Yarkhan Oal	Crop fields, orchards, agroforestry systems	Most important forage legume
	Medicago falcate L.	Oal		
	Medicago media L.	Oal		
	Medicago lupulina	-	Crop fields and waterlogged condition	Most important forage legume
	Vicia monantha	-	Crop fields and vegetable garden	
	Melilotus officinalis	-	Crop fields and waterlogged condition	As pasture or livestock feed and used as a phytoremediation—phytodegradation plant for treatment of soils contaminated with dioxins[16], in the chemical industry, dicoumarol is extracted from the plant to produce rodenticides[17]
	Trifolium repens	Oal chun	-	Most important forage legume of the temperate zones[18]
	Lotus corniculatus L.	-	Crop fields and waterlogged condition	A double-flowered variety is grown as an ornamental plant. It is regularly included as a component of wildflower mixes in Europe. commonly planted along roadsides for erosion control or pastures for forage and then spreads into natural areas, high quality forage[19]
	Astragalus spp. L.	Landekaon	Pasture	Main use to boost the body's immune system
	Lathyrus aphaca L.	rSanma, Shiche	Crop fields	Collected for fodder or grazed by cattle
	Lathyrus humilis L.	rSanma		
Cyperaceae	*Carex* spp. L.	-	Pasture	Collected for fodder or the animals are left around to graze.
	Cyperus spp. *L*.	-	-	
	Kobresia spp. C.B. Clarke	*Spoto*	Pasture	It is an important forage in Changthang due to its nutritious features
Polygonaceae	*Rumex patientia* L.	*Shoma*	Culverts and irrigation channel	Medicinal uses
	Fagopyrum tataricum Mill.	*Tayat*	Crop fields	It not only has medicinal value but also possesses rich nutritional value
	Polygonum convolvulus		Crop fields	Seeds are ground into a powder and used when mixed with cereals for nutritional value
	Fagopyrum esculentum Mill.	*Tao*	Crop fields	Leaves are collected, cleaned and cut into pieces, boiled with grinded barley prepared as stew, also mixed in buttermilk served with *paba*. Leaves with fried with onion and served with rice and roti, leaves are cooked as vegetables

(*Contd*.)

Table 2 — Families, weeds, vernacular names and their traditional uses (*Contd*.)

Family	Name of weeds	Vernacular name	Recorded in	Possible traditional uses*
Chenopodiaceae	*Chenopodium album* L.	*Nynue, Negue*	Crop fields, vegetable garden, bunds	Leaves are used as leafy vegetable, taken with Paba, Tangtur is prepared
	Chenopodium botrys L.			-
	Chenopodium carinata			Collected for fodder or for grazing
	Chenopodium glaucum			
Convolvulaceae	*Convolvulus arvensis*	*Tuk-tuk/ Ratrcho*	Crop fields and bunds	Seeds are eaten raw or fried with onion or boiled and taken.
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	*Shepherd's purse*	Vegetable garden	Used for culinary purposes, especially in Asian cuisine
	Lepidium latifolium L.	*Payak rTsawa*, Shang-rtso	Vegetable garden	Leaves are collected to remove bitterness it is boiled for 10 min and then fried with onion or tomato served with rice, paba or roti
Astraceae	*Artemisia* spp L.	*Burtse,* Khamppa	Alfalfa fodder fields, wetland	Leaves are boiled and taken as antimicrobial and intestinal worm. Leaf decoction is given during stomach or intestinal complaints.
	Sonchus oleraceus	-	Fodder area	-
	Stephanomeria panciflora	-	Crop fields, pasture	-
	Cirsium arvense	*Ljangtser*	Crop fields, pasture, culverts, roadside	Tender leaves are eaten by cows and goat/ sheep
	Cirsium verutum	*Ljangtser nakpo*		
	Galinsoga ciliate	-	Vegetable garden	-
	Conyza sp (L.) *Cronquist*	-	-	Whole plants, and its oil works as a diuretic, and prevents bleeding, for diarrhea, excessive menstruation. Haemorrhoids, other disorders and bronchial complaints. Externally used for eczema and ringworm[15]
	Bidens pilosa	*Chaja, Saja, Soljaa*	Vegetable garden	Fresh leaves are utilized for 'Ladakhi tea'
	Lactuca dissecta L.	-	-	Leaf paste is used for skin diseases.
	Picris hieracioides L.	-	Wetland and irrigation channel	-
	Taraxacum spp. L.	-	Pasture	-
	Ambrosia artemisiifolia L.	*Khamchu/ Khamppa*	Crop fields, fodder areas	-
	Echinops spp.	*Jangtser nakpo*	Barren lands	Medicinal uses
Rosaceae	*Potentilla fruticosa* L.	*Toma*	Pasture	Roots have edible properties but also utilized as medicinal for diarrhoea patients and as good astringent.
	Potentilla anserina			
Solanaceae	*Datura stramonium*	-	Road sides	-
	Physochlaina praealta	*Langtang*	Pasture and highlands	-
Malvaceae	*Malva neglecta*	*Halo*	Crop fields and irrigation channel	Plant parts are utilized for soothing irritated tissues and reducing inflammation, used for bronchitis, coughs, throat-infections. Asthma, emphysema and gastritis[15]
Onagraceae	*Cuscuta approximata*	-	Alfalfa crop	-
Papaveraceae	*Corydalis flabellata*	-	Highlands	-
Lamiaceae	*Nepata laevigata*	Jatukpa	Non-cropped and bunds	Used as medicine (leaves decoction) during Pneumonia

(*Contd*.)

Table 2 — Families, weeds, vernacular names and their traditional uses (*Contd.*)

Family	Name of weeds	Vernacular name	Recorded in	Possible traditional uses*
Fabaceae	*Vicia sativa*	Yughpo	Crop fields	Collected for fodder, leguminous (nitrogen fixing) locals consider to increase soil fertility
	Trigonella spp (Linn)			Dried plants are used as a remedy for pain and insufficient lactation. Internally for late onset diabetes, poor digestion, gastric inflammation, digestive disorder, tuberculosis. It is not recommended during pregnancy[15]
Caryophyllaceae	*Stellaria monosperma*	Sinche	Pea and other crop fields	Collected for fodder or grazed by cattle
Paperveraceae	*Corydalis sp*	Highlands	Ralchat-nakpo	Purple/ blue flowers are collected for decoration
Amaranthaceae	*Axyris hybrida*	highlands	-	-
Caryophyllaceae	*Stellaria media*	-	Pea and other crops in Khaltse block	*Stellaria media* is fit to be eaten as nutrition and leaves are used in salads[20]
Ranunculaceae	*Clematis* spp	*dByi-mong dkar/ nag-po, Gakgic, bIchho*	Seabuckthorn and non-cropped situation in Thiksey block, Stakna village, Saboo, Durbuk roadside	There are two species of Clematis such as *Clematis orienatalis* and *C. tibetana*, are the creeping weeds over sea buckthorn shrub, but has not been reported to cause economical losses of this shrub. However, it has been utilized as decoction of branches against indigestion, recorded in interview with the farming community of Thiksey, Leh. Its utilization has also been reported at Sikkim fir inflammatory uses[21]
Aquatic weeds				
Polygonaceae	*Rumex crispus*	-	Aquatic body	Food (soups, sauces and salads)[22,23]
Potamogetonaceae	*Zannichellia palustris*	-	Aquatic body	-
Polygonaceae	*Polygonum affine*	-	Aquatic body	-
Juncaginaceae	*Troglochin* sp.	-	In aquatic bodies adjoining to Grassland	-
Poaceae	*Catabrosa aquatica*	-	Wetland	-
Orobanchaceae	*Pedicularis longiflora*	-	In wetland and aquatic bodies adjoining to Grassland	-
Plantaginaceae	*Hippuris vulgaris*	-	Culverts and aquatic bodies	-
Paperveraceae	*Corydalis* sp.	Ralchat-nakpo	High altitude and near grasslands and other landforms	Purple/ blue flowers are collected for decoration[24]
Zygohpyllaceae (Nitrariaceae)	*Peganum harmala*	Baltishukpa	Road sides	Seeds are exposed to heat and ground for fine powder and taken alone or smoked with tobacco[25]

* Discussion with old farmers, farm-women, people and Wangmoa and Garkoti (2016)

Table 3 — Effect of organic weed management on weeds and yield of potato in Stakmo

Treatments	Weed density (No.m^{-2})		Weed dry weight (g.m^{-2})		WCE (%) 60 DAS	Tuber yield (t.ha^{-1})	Weed index (%)
	30 DAS	60 DAS	30 DAS	60 DAS			
No control	8.8 (76.67)	9.39 (88)	3.91 (15.23)	4.8 (23)	-	5.70	72.43
Hand hoeing (30 DAS)	5.04 (26.3)	5.74 (33)	2.89 (8.33)	3.39 (11.67)	49.26	19.13	11.65
Black mulch	4.9 (24)	6.25 (39)	3.20 (10.2)	3.6 (13.06)	43.21	21.65	-
Metribuzin 500 g a.i. /ha	4.6 (21.33)	5.57 (31)	3.3 (10.9)	3.67 (13.67)	40.56	18.81	13.13
Earthing-up at 30 DAS	3.3 (11)	3.89 (15)	2.7 (7.2)	2.78 (7.83)	65.95	18.89	12.76
CD (P-0.05)	1.24	0.17	1.12	0.746	-	3.77	-

Impact of weeds on crop yield

Potato is one of the life line crops of the Ladakh region where tuber yield drastically reduces by 72% if weeds are not controlled as compared to other organic weed management practices which are generally not adopted (Table 3). If undertaken, this could enhance yield by 3-4 times over the no-control only either by using black mulch or earthing up.

Infiltration of invasive species in grasslands of Changthang range

In grasslands, native species without weedy species build up 278 to 620 kg/m^2 of fresh above-ground biomass. Although entry of invasive weeds like *Cirsium arvense* (native to South-Eastern Europe and the Eastern Mediterranean and entered due to tourism) in Changthang pastoral systems has been observed by investigators and local populaces[13]. Its fast spread started affecting the aboveground biomass significantly. Invasive *Cirsium arvense* (locally known as *Ljangtser*) has threatened the natural areas by reducing biodiversity and altering ecosystem functions, and it has also entered and impacted the greater yield reduction in cropped areas as well by reducing crop and livestock productivity indirectly. Amongst Changthang (Ladakh) grasses, spiny leaves of Canadian thistle are unpalatable to livestock; therefore, the forage productivity of pasture and rangeland is reducing due to its infestation. The native vegetation is *Kobresia* spp. (dominant cyperaceae), *Carex* spp, *Leontopodium pusillum, Astragalus strictus, Triglochin* spp., *Puccinellia* spp., *Glaux maritima*. *Thalictrum alpinum, Potentilla saundersiana, Aster flaccidus, Primula walshii* and *Pedicularis* spp. *Lancea tibetica, Lagotis brachystachya, Potentilla bifurca, Persicaria glacialis* and *Lasiocarpum densiflorum*. Amongst the above, *Carex* spp. has been mentioned as dominating unpalatable coarse grass and is an indicator of depletion of grasslands[1].

Conclusions

In Ladakh's cold arid region, subsistence agriculture, which is in practice since its evolution, and livestock rearing are the main livelihood options for rural people in very small-scale, stone-built terrace farming. Due to remotely located villages in valleys, poor resources and higher labour cost, farming itself is a major complex activity. Furthermore, weeds are the major menace and are not taken seriously as they can be more vegetation biomass for livestock in a barren and harsh ecosystem. As a result of which, weed seed banks rise and other weedy species are added and develop association in cropped areas every year due to import/mutual exchange of new crop/vegetable seeds/plant materials. Weed dissemination through various modes like PDS, mutual exchange, and use as leafy vegetables/fodder resources, and ignorance towards weeding and strict monitoring encourage weed seed bank and impact cropped areas and pastures. Crops suffer tremendous weedy pressure, and there are certain weedy species which Ladakhi farmers find difficulty to eradicate. Due to higher solar radiation and short season at higher altitude, a recurrent problem of weed emergence has been observed, and this requires 4-5 weedings till the crop can fully occupy the spaces, weeds cause enough crop growth losses and result in significant yield reduction. In non-cropped areas, weeds and invasive species are mostly confined to the wetlands or surviving with available moisture abundantly with full potency. In addition, upward movement of invasive species due to climate change has been observed. Knowledge of weeds and their menace would allow farmers to plan suitable

combating strategies during critical periods for crop-weed competition in cropped areas, which is a major consideration in the Leh region. Conversely, in a barren ecosystem, many of the weedy species are turned traditionally either for edible or medicinal purposes.

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Conflict of Interest

There is no conflict amongst the authors as it is evidence-based learning and collection of traditional knowledge from the farming community and old people involved, although nothing confidential.

Author(s) contribution

Conceptualization of work, classification and identification of weeds with data analysis, review of literature, interventions and original drafting and discussion were done by MSR. Laying out of experiments and data collection on weeds and crops was done by SL. Collection of samples and data on traditional knowledge on weeds was done by ND. Background and data on budgeting was done by JCT.

References

1 Jina P S, Ladakh: The Land and the People, Indus Publishing, ISBN 978-81-7387-057-6, 1998.

2 LAHDC, Statistical Hand Book, 2016-17, Series 38.

3 Wilson N, Cold, High and Dry: Traditional Agriculture in Ladakh, February 6, 2009, https://www.permaculturenews.org/2009/02/06/cold-high-and-dry-traditional-agriculture-in-ladakh.

4 Joshi H, Climate change impacts agriculture in Ladakh: a multimedia report, *India Climate Dialogur* (2018) Aug 13, 2018.

5 Dame, J & Nüsser M, Food security in high mountain regions: agricultural production and the impact of food subsidies in Ladakh, Northern India, *Food Sec,* 3 (2011) 179–194.

6 Shaheen, H, Batool, A, GillaniG, S. F, Dar, M E, Habib, T & Shamshad A, Diversity and Distribution of Invasive Plant Species in Suburban Vegetation of Kashmir Himalayas, *Pol J Environ Stud* 28, (4) (2019) 1-11.

7 Dolezal, J, Dvorsky M, Kopecky M, Liancourt P, Hiiesalu I, *et al.*, Vegetation dynamics at the upper elevational limit of vascular plants in Himalaya, *Sci Rep*, 6 (2016) 24881.

8 Thapa S, Chitale V, Rijal S J, Bisht N & Shrestha B B, Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya, *PLoS ONE*, 13 (4) (2018) e0195752. https://doi.org/ 10.1371/journal.pone.0195752.

9 Shafiq M U, Bhat M S, Rasool R, Ahmed P, Singh H & Hassan H, Variability of precipitation regime in Ladakh region of India from 1901-2000, *J Climatol Weather Forecasting*, 4 (2) (2016) 165.

10 Acharya S, Singh N, Katiyar A K, Maurya S B & Shrivastava R B, *Extension Bulletin No. 24*, 2012.

11 FAO. Conservation and Adaptive Management of Globally Important Agricultural Heritage Systems (GIAHS)-PIMS 2050. Terminal Report, Project Symbol: UNTS/GLO/002/GEF Project ID: 137561, Food and Agriculture Organization of the United Nations Rome, Italy. (2008) 37 pp

12 https://clackswcd-wpengine.netdna-ssl.com/wp-content/uploads/ weeds.pdf

13 Ghosh M, Top 5 medicinal plants in Himalayan region and their medicinal benefits, *dream Wonderlust*, 1 (2) (2013).

14 Raghuvanshi M S, Mishra A K, Tewari J C, S Landol, Singh Lakhan & Bhatt R K, Canadian Thistle enters Changthang: Major threat to ancient pasture. Paper presented in National symposium on Sustaining Agricultural Productivity in Arid Ecosystems: Challenges and Opportunities, held at RRS, ICAR-CAZRI, Leh (2015) 257.

15 Gulshan A B, Dasti A A, Hussain S, Atta M I & Amin-ud-Din M, Indigenous uses of medicinal plants in rural areas of Dera Ghazi Khan, Punjab, Pakistan, *ARPN J Agric & Biol. Sci*, 7 (9) (2012) 750-762.

16 Sandia National Labs, SSFL Report (2012) 10.

17 Schipper I A, Sweet clover poisoning, In: Beef Cattle Handbook. North Dakota State University. BCH-3415 (1999) 2.

18 Elgersma A & Hassink J, Effects of white clover (*Trifolium repens* L.) on plant and soil nitrogen and soil organic matter in mixtures with perennial ryegrass (*Lolium perenne* L.), *Plant and Soil*, 197 (1997) 177-186.

19 Wilhelm G & Rericha, Book - Flora of the Chicago region: A floristic and ecological synthesis, *Indiana Acad Sci*, (2017) 1392 pp.

20 https://en.wikipedia.org/wiki/Stellaria_media

21 Singh B, Brahma M, & Gurung J, An investigation of traditional uses and anti-inflammatory property of *Clematis buchanaiana* De Candolle and *Trpistra nutans* Wall. Ex Lindl.: native ethnomedicinal plants from Sikkim, India, *Indian J Tradit Know*, 19 (4) (2020) 719-727.

22 Alfawaz M A, Chemical composition of hummayd (*Rumex vesicarius*) grown in Saudi Arabia, *J Food Compost Anal*, 19 (2006) 552-555.

23 Polat R, Selvi S, Cakilcioglu U, Acar M, Investigation of ethnobotanical aspect of wild sold in Bingöl (Turkey) local markets, *Biol Divers Conserv*, 5 (2012) 155-161.

24 Wangmoa, S & Garkoti, S C, Traditional Use of Weeds of Ladakh region of Jammu and Kashmir State India, *J Ethnobiol Tradit Med Photon*, 126 (2016) 1148-1159.

25 Navchoo I A, Buth G M, Ethnobotany of Ladakh, India: Beverages, Narcotics, Foods, *Econ Bot*, 44 (1999) 318-332.