In-situ on Farm Agro-biodiversity Conservation in Mid-hills of Indian Central Himalaya

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Central Himalayan region of India is not only a mega plant biodiversity zone but also it has a very rich agro biodiversity coverage embodying landraces and wild ancestors of domesticated plants. In the wake of depleting agro biodiversity base in the region, a study was carried out to investigate the status of *in situ* conservation of these crop plants on-farm in the areas of Tarikhet and Ukhimath Blocks of Kumaon and Garhwal regions in Central Himalayan middle hills. After the pilot survey was conducted to finalize the objective of selecting locations in 2003, a pre-tested standardized technical questionnaire based study was carried out during 2004. The areas covered in this study are less explored and underprivileged almost in the center of the state representing the ecological, agricultural and cultural portraits of both the regions. In between the similarities and dissimilarities in the cropping pattern in both the areas, the richness and intensity of agro biodiversity conservation was comparatively more in Tarikhet as to that of Ukhimath particularly while expressing *in situ* conservation of traditional and coarse grain crops on-farm. Traditional crops and cultivars are still having favor though receiving declined interest due to invasion of HYVs (high yielding varieties), change in agricultural practices, varying lifestyles and food habits. Indian authorities should stronghold the mega-measures for conserving plant genetic wealth in the wake of globally effective and widely accepted efforts of FAO for the conservation of rare, traditional and wild plant genetic resources particularly in the under-privileged areas of the country.

Key Words: Central Himalayas, Diversity distribution, Human sustenance, *In situ* conservation, Plant genetic resources

Introduction

Towards sustaining agro biodiversity and securing food for present and future generations, FAO, (the Food and Agriculture Organization of the United Nations), called upon the international community to attend a 'Plant Summit' in Leipzig in 1996 which culminated in the evolution of FAO Global Plan of Action (FAO 1999 a and b). The efforts of FAO were further strengthened when IT-PGR (The International Treaty on Plant Genetic Resources) was adopted in November 2001 which came into force on 29th June 2004 that initially concurred to manage the agro biodiversity of 35 food crops and 29 forage crops; which reflect 80% of the calorie intake of the world's population (FAO, 2001). Himalayan region stretching through almost eight countries is not only unique in its vastness among other mountain ranges in the world but also it embodies a peculiar ecological configuration, wild genetic resource base and cultural traditions. Since the region is one of the important eight gene centers of wild relatives of cultivated agro biodiversity its conservation is a vital issue (Ives and Messerli 1989; Ramakrishnan *et al.*, 1996; Buch-Hansen, 1997). Besides the treasure of wild relatives of crop plants, a distinctive integrated approach of "Forest-Farm-livestock" in agriculture represented the Indian central Himalayan region in the past. Because of inattention at local, state and national level, the agro biodiversity of traditional crops and their wild relatives faced the threat of extinction in previous years. However, a few efforts (Nautiyal *et al.* 1998 a and b; Maikhuri *et al*; 2001; Maikhuri *et al.*; 2002; Rao *et al.* 2003) have been made to study the prevailing trends on traditional agro biodiversity in farming systems. In view of national ecological perspective, this study was carried to document the *in situ* conservation trends of agro biodiversity in underprivileged and unexplored areas in Tarikhet and Ukhimath Blocks.

Material and Methods

Study Sites

In Uttaranchal, Tarikhet and Ukhimuth blocks of Almora and Rudraprayag districts fall in Kumaon and Garhwal regions respectively. It is around 94.546 ha agricultural land in Tarikhet at an altitude between 1700-1800 msl (meter above sea level) while Ukhimath is situated at an

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altitude between 1300-1500 msl and covering the cultivated area approximately 106.315 ha. Geophysical locations for Tarikhet are approximately between 79º 22′ to 79º 29′ longitude and 29º 33′ to 29º 41′ latitude as well as for Ukhimath are 79º 09′ to 79º 18′ longitude and 30º 30′ to 30º 41′ latitude (Fig. 1).

Strategy

A team of multidisciplinary researchers having specializations in anthropological studies, socio-ethnobotany, socio-economics, agro-ecology, crop production systems, crop protection, plant breeding and plant genetic resources was involved in this investigation before finalizing the pilot survey during 2003. The information on agro biodiversity management and rural development through archival records in institutions were examined to determine the locations suitable for investigation. The areas covered in this study are less explored and underprivileged almost in the center of the state representing the ecological, agricultural and cultural portraits of both Kumaon and Garhwal regions. After the pilot survey, a pre-tested standardized technical questionnaire based study was carried out during 2003 and 2004. These questionnaires gave the common basis of information on the *in situ* conservation of agricultural biological diversity on-farm. Throughout the study, different level of sources like local people, regional experts and local institutions were involved while confirming the information before the synthesis of data.

Sample Selection Criteria

The standardized methodology for sample selection was adopted. From both the blocks, ten percent villages were selected and out of those, fifteen percent populations constituted the lots of samples. A ratio of composition of communities, castes and scheduled tribes was maintained corresponding to their representation in the area. The criteria of sample selection were completely randomized and all parameters like upland and lowland attributes, village demographic features, economic and

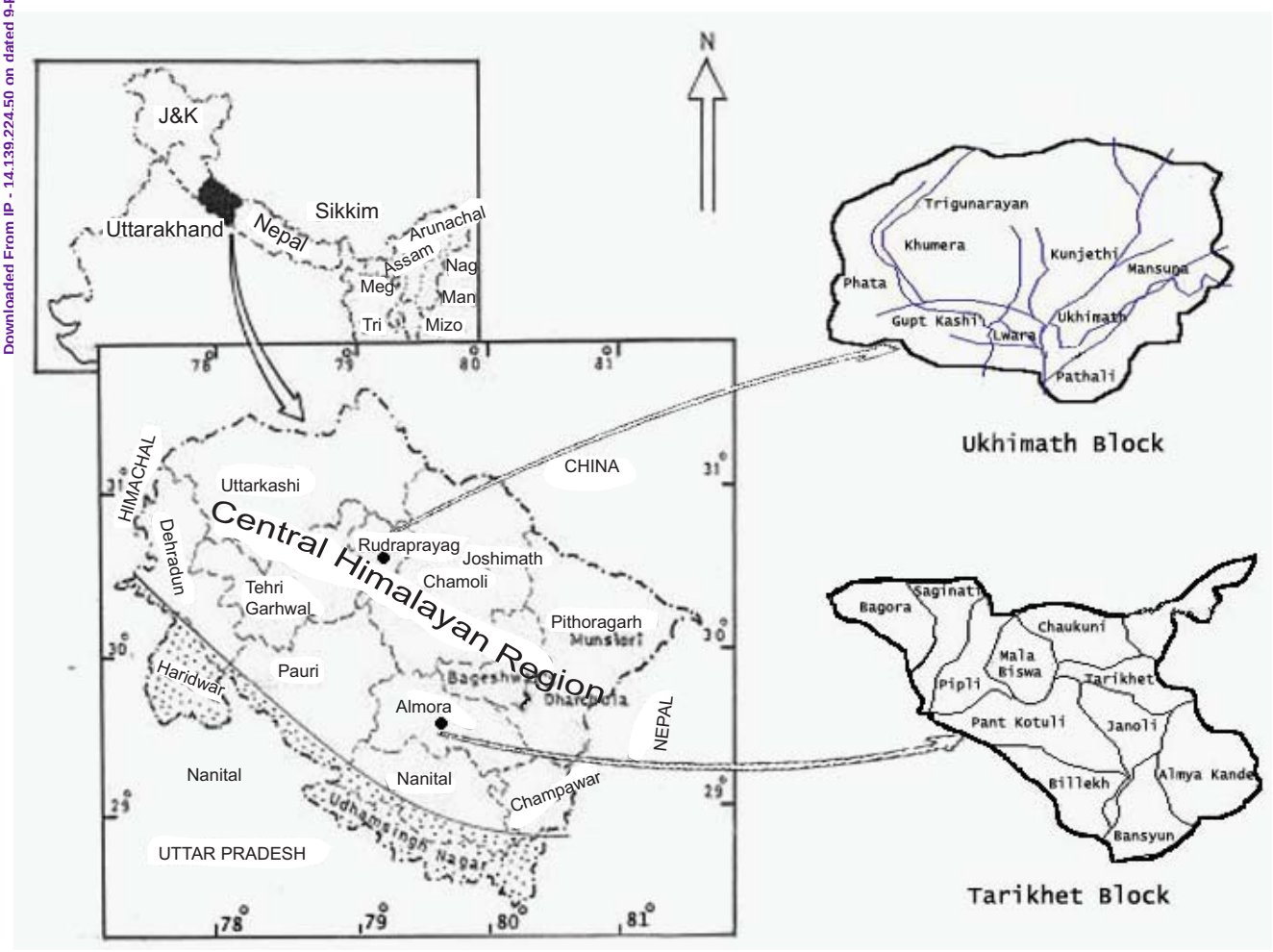


Fig. 1: Location map of the area of study

land holding levels of farmers, land types were equally ratified while recording the observation on agro biodiversity.

Results and Discussion

Depending upon the seasons (October to March-*Rabi* season, April to September-*Kharif* season), the variability in selection of agro biodiversity for cultivation in hills was comparatively a typical in comparison to plain areas in northern parts of the country apart from some base crops like wheat, rice, blackgram and some vegetables common to both areas. In middle hills, traditional crops and cultivars are still having favour though receiving declined interest due to invasion of HYVs (high yielding varieties), change in agricultural practices, varying lifestyles and food habits. The changing agricultural trends in Central Himalayan middle hills due to various factors described earlier (Ramakrishnan *et al.*, 1996, Nautiyal *et al.* 1998 a and b, Maikhuri *et al.*, 2002, Rao *et al.* 2003).

Landscape Orientation

There was not much difference in the landscape orientation in the areas studied under Tarikhet and Ukhimath Blocks except matured stony hills in former as compared to less-matured and muddy hills in Ukhimath areas. The habitat of both the locales (Tarikhet and Ukhimath) encompassed sloppy contoured agricultural fields along with the elevation sides of hills intensively mixed with valleys and also on some locations with grassland steppes amidst pine forests and in open space. The slope of lands was steeper in Tarikhet region as compared to Ukhimath lands. Micro-habitats could easily be recognized among ecosystems. Apart from pines and other moist deciduous forests diversity areas were densely coupled with the MAP (medicinal and aromatic plants) genetic resources like *Valeriana wallichii, Rauwolfia serpentina* etc. characterized with more frequency. At some places in Tarikhet Block, it was a scenario of dry stony hills having appearance of semi cold desert or cold desert in winter. At some locations, the mighty stony wet hills were covered with groups of lower vegetation in Tarikhet having marginal lands for scattered farming. Mostly low lands rich in humus along valleys were suited and occupied with terraced farming. The elevated mountainous locations were having distinct pattern of almost undisturbed biodiversity due to variation in climatic profile. The natural forests in Ukhimath were dominant with trees having broad leaves, a characteristic feature of Garhwal forests, afforded as a major source of nutrient supply to soil. The traditional ecological link of forest-farm-livestock cycle was stronger and functional in Ukhimath as compared to Tarikhet.

Agro Biodiversity On-farm in Tarikhet

We documented total 91 plant species in the area Tarikhet block. Out of these, 23 plants comprise food grains, pulses and oil seeds; vegetable and cash crops aggregates to be 27 while 20 plant species belong to fodder and agro forestry group. The agro biodiversity in fruit accounts to be around 21 species (Table 1). Vegetables and cash crops share major chunk of agro biodiversity that is

Table1. In situ agro-biodiversity conservation on-farm in Tarikhet

Botanical Name of plants	English Name	Local Name	Season of Cultivation
(1)	(2)	(3)	(4)
Food crops			
Amaranthus caudatus	Chaulai	Ram Dana	K
Cajanus cajan	Pigeon pea	Arhar	K
Echinochloa frumentacea	Barnyard Millet	Madira	K
Eleusine coracana	Finger Millet	Mandua	K
Glycine max	Soyabean	Soyabean/ Bhat	K
Macrotyloma uniflorum	Horse gram	Gahat	K
Oryza sativa	*R*ice	Dhan	K
Phaseolus vulgaris	Kidney Bean	Rajmah	K
Sesamum indicum	Sesame	Til	K
Setaria italica	Fox Tail Millet	Koni	K
Sorghum bicolor	Jowar	Jowar	K
Vigna mungo	Blackgram	Urad	K
Vigna radiate	Mung	Green gram	K
Vigna sinensis	Cow pea	Lobiya	K
Zea mays	Maize	Makka	K
Brassica alba	White mustard	Rai (white)	R
Brassica napus	Mustard	Sarso	R
Brassica nigra	Black mustard	Rai (black)	R
Cicer arietinum	Gram	Chana	R
Hordeum vulgare	Barley	Jau	R
Lens culinaris	Lentil	Masoor	R
Triticum aestivum	Wheat	Gehu	R
Vegetables and cash crops			
Colocasia esculenta	Taro	Arvi	K
Cucumis melo	Muskmelon	Kharbooja	K
Cucumis sativus	Cucumber	Khira	K
Cucurbita maxima	Pumpkin	Kaddu	K
Dioscorea alata	Winged yam	Khamalu	K
Hibiscus esculentus	Okra/Lady fingers	Bhindi	K
Luffa cylindrica	sponge gourd	Tori	K
Momordica charantia	Bitter gourd	Karela	K
Solanum melongena	Eggplant	Baigan	K
Spinacia oleracea	Spinach	Palak	K
Allium cepa	Onion	Piyaz	R
Allium sativum	Ginger	Adrakh	R
Brassica botrytis	Cauli flower	Gobhi (phool)	R
Brassica juncea	Leaf mustard	Rai/Sarson	R
Brassica oleracea (capitata)	Cabbage	Gobhi (Patta)	R
Capsicum annum var. *annum*	Capsicum	Shimalaa Mirch	R

(1)	(2)	(3)	(4)
Curcuma domestica	Turmeric	Haldi	R
Daucus carota	Carrot	Gajar	R
Dolichos lablab	Beans	Sem	R
Lagenaria siceraria	Bottle gourd	Lauki	R
Pisum sativum	Pea	Matar	R
Paspalum scrobiculatum	Kodo Millet	Kodon	R
Solanum lycopersicum	Tomato	Tamatar	R
Solanum tuberosum	Potato	Alu	R
Trigonella foenum-graecum	Fenugreek	Methi	R
Zingiber officinale	Ginger	Adrakh	R
Fodder and Agroforestry plants			
Acacia nilotica	Acacia	Babool	Fr
Aesculus indica	Horse Chest nut	Pankor	Ft
Alnus nepalensis	Nepalese Alder	Utis	Fr
Bambusa arundinacea	Bamboo	Bans	Fr
Celtis australis linn	European	Khari hackberry	Fr
Ficus palmate	Wlid fig	Anijir	Fr
Ficus roxburghii	Elephant ear fig tree	Gular	Fr
Gossypium hirsutum	Cotton	Kapaas	Ft
Grewia optiva	Bhimal+	Bhimal	Fr
Melia azedarach	Margosa	Bakain	Fr
Morus alba	Mulbury	Shehtoot	Ft
Pinus roxburghii	Pine	Chir	Ft
Populus androscoggin	Poplar	Poplar	Fr
Prunus cerasoides	Wild himalayan cherry	haya/Paddam	Fr
Quercus leucotrichophora	Oak	Banj	Fr
Rubus ellipticus	Yellow Himalayan	Lalanchu Raspberry	Fr
Sapindus emarginatus	Soapnut	Ritha	Ft
Thuja orientalis	Oriental arborvitae	Morphankhi	Ft
Toona ciliata	Red cedar	Tun	Ft
Ficus spp.	Kheena+		Fr
Fruit plants			
Carica papaya	Papaya	Papeeta	F
Citrus aurantifolia	Lime	Kagzi nibu	F
Citrus limon	Lemon	Bara nimbu	F
Citrus reticulata	Orange	Santara/Narangi	F
Citrus sinensis	Sweet orange	Santara	F
Juglans regia	Walnut	Akhrot	F
Litchi chinensis	Litchi	Litchi	F
Malus sylvestris	Apple	Seb	F
Mangifera indica	Mango	Aam	F
Musa paradisiaca	Banana	Kela	F
Prunus armeniaca	Apricot	Zardalu	F
Prunus domestica	Plum	Alu bukhara	F
Prunus persica	Peach	Aadoo	F
Prunus tomentosa	Cherry	Cherry	F
Psidium guajava	Guava	Amrud	F
Punica granatum	Pomegranate	Anar	F
Pyrus communis	China pear	Nashpati	F
Vitis vinifera	Grapes	Angoor	F

R - Rabi season of cultivation- (October to March)
K - Kahrif season of cultivation- (April to Sertember)
F - Fruit species; Fr - Fodder species; Ft - Forest tree; U - Season of cultivation could not be confirmed; + - English name could not be confirmed

followed by fruit and fodder plants in total agro biodiversity as compared to food grains, pulses and oil seeds (Fig.2). It was almost much similar incidence of agro biodiversity in both the areas investigated, the cultivation of *Cicer arietinum, Brassica alba, Vigna radiata, Sorghum bicolor, Trigonella foenum-graecum* and *Dioscorea alata* though found in Tarikhet was missing in the areas of Ukhimath Block.

The presence of variability among fodder and agro forestry plants as well as fruit tree species was also found to be variable as *Melia azedarach, Bambusa arundanacea, Pinus roxburghii, Prunus cerasoides, Aesculus indica and Sapindus granatum as well as Psidium guajava, Punica granatum, Prunus tomentosa, Punica spp. and Carica papaya* respectively were restricted in Tarikhet areas only.

Figure 4 shows that ginger (*Zingiber officinale)* and cabbage (*Brassica oleracea)* occupied the least agricultural land while wheat figured the highest followed by rice and finger millet, a traditional coarse grain crop; which has prominent place in Uttarakhand agriculture in terms of production following wheat and rice. Nevertheless, Lentil (*Lens culinaris)* occupied comparatively more agricultural land followed by *Cicer arietinum* but the frequency of beans was more.

Agro Biodiversity On-farm in Ukhimath

Figure 3 illustrates that the agro biodiversity profile in Ukhimath had much resemblance to that of Tarikhet except few variations in the frequency of crops and selection criteria of farmers. Eighty plant species were found to be domesticated (Table 2), and in this area of Garhwal region also, vegetables and cash crops comprised the key hunk followed by fodder and agro forestry crops and then fruit trees. However, the agricultural land acquired by crops grown during March to October almost equaled the area coverage by fruit trees that reflect comparatively lesser biodiversity in fruit tree species in Ukhimath as compared to Tarikhet. The endemic agriculture of some tree species like *Psidium guajava, Punica granatum, Punica* spp. (other pomegranate variety locally known as Darim) *Prunus tomentsoa, a*nd *Carica papaya* was detected only in Tarikhet. Correspondingly, the four food crops viz. *Cicer arietinum, Brassica alba, Vigna radiata* and *Sorghum bicolor* were represented only Tarikhet areas but absent in Ukhimath. In vegetables and cash crops, *Vicia faba* and *Coriandrum sativum* were found to be cultivated only in Ukhimath areas. The location specific agro biodiversity incidence was also observed

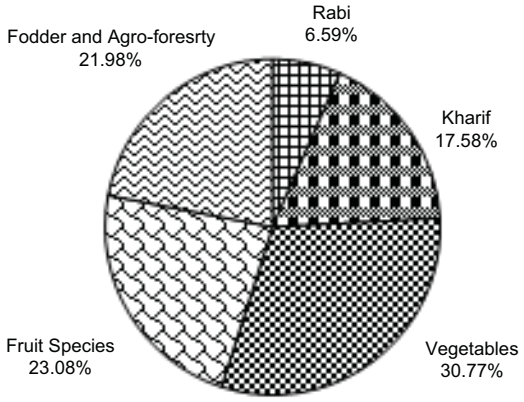


Fig. 2: Percent shares of different species in total agro biodiversity recorded in Tarikhet

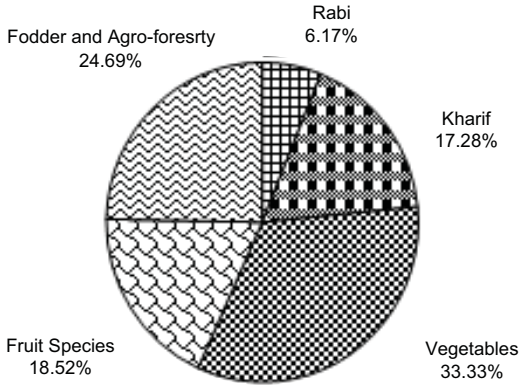


Fig. 3: Percent shares of different species in total agro biodiversity recorded in Ukhimath

Table 2. *In situ* agro biodiversity conservation on-farm in Ukhimath

Botanical name of plants	English name	Local name	Season of cultivation
(1)	(2)	(3)	(4)
Food crops			
Amaranthus caudatus	Chaulai	Ram dana	K
Cajanus cajan	Pigeon pea	Arhar	K
Echinochloa frumentacea	Barnyad Millet	Madira	K
Eleusine coracana	Finger Millet	Mandua	K
Glycine max	Soyabean	Soyabean /Bhat	K
Macrotyloma uniflorum	Horse gram	Gahat	K
Oryza sativa	Rice	Dhan	K
Phaseolus vulgaris	Kidney Bean	Rajmah	K
Sesamum indicum	Sesame	Til	K
Setaria italica	Fox Tail Millet	Koni	K
Vigna radiata	Mung	Green gram	K
Vigna sinensis	Cow pea	Lobiya	K
Zea mays	Maize	Makka	K
Brassica napus	Mustard	Sarso	R
Brassica nigra	Black mustard	Rai (black)	R
Hordeum vulgare	Barley	Jau	R
Lens culinaris	Lentil	Masoor	R
Triticum aestivum	Wheat	Gehu	R
Vegetables and cash crops			
Celocasia esculenta	Taro	Arvi	K
Coriandrum Sativum	Coriander	Dhania	K
Cucumis melo	Muskmelon	Kharbooja	K
Cucumis sativus	Cucumber	Khira	K
Cucurbita maxima	Pumpkin	Kaddu	K
Hibiscus esculentus	Okra/Lady‘s finger	Bhindi	K
Luffa cylindrica	Sponge gourd	Tori	K
Momordica charantia	Bitter Gourd	Karela	K
Solanum melongena	Brinjal	Baigan	K
Spinacia oleracea	Spinach	Palak	K
Vicia faba	Broad bean	Bakla	K
Allium cepa	Onion	Piyaz	R
Allium sativum	Garlic	Lehsun	R
Brassica botrytis	Cauliflower	Gobhi (Phool)	R
Brassica oleracea (capitata)	Cabbage	Gobhi (patta)	R
Capsicum annum var *aanum*	Capsicum	Shimla-Mirch	R
Capsicum annum	Chilli	Mirch	R
Curcuma domestica	Turmeric	Haldi	R
Daucus carota	Carrot	Gajar	R
Dolichos lablab	Beans	Sem	R
Lagenaria siceraria	Bottle gourd	Lauki	R
Pisum sativum	Pea	Matar	R
Raphanus sativus	Radish	Muli	R
Solanum lycopersicum	Tomato	Tamatar	R
Solanum tuberosum	Potato	Alu	R
Zingiber officinale	Ginger	Adrakh	R
Fodder and Agroforestry Plants			
Celtis australis linn	European hackberry	Khari	F
Ficus palmata	Wlid fig	Anjir	F
Ficus roxburghii	Eve’s apron	Timal	F
Ficus subincisa	Chanchri+	Chanchri	F
Fraxinus micrantha	Fraxinus	Angu/Litsia	F
Fraxinus xanthoxyloides	Afgahan Ash	Thelka	F
Gossypium arboreum	Thailand cotton	Kapaas	F
Grewia optiva	Not found	Bhimal	F
Lyonia ovalifolia	Not found	Ayar	F
Morus alba	Mulbury	Shehtoot	F
Quercus leucotricophora	Oak	Banj	F
Quescus floribunda	Moru Oak	Moru	F
Rhododendron arboreum	Rose tree	Burash	F
Salix spp.	willow	Karve	F
Thuja orientalis	Oriental arborvitae	Morphankhi	F
Toona ciliata	Red cedar	Tun	F
Fruit Plants			
Citrus aurantifolia	Lime	Kagzi nibu	F
Citrus limon	Lemon	Bara nibu	F
Citrus reticulata	Orange	Santara/Narangi	F
Citrus sinensis	Sweet orange	Malta	F
Juglans regia	Walnut	Akhrot	F
Litchi chinensis	Litchi	Litchi	F
Malus sylvestris	CrabApple	Seb	F
Mangifera indica	Mango	Aam	F
Musa paradisiaca	Banana	Kela	F
Prunus armeniaca	Apricot	Khubani	F
Prunus domestica	Plum	Alucha	F
Prunus persica	Peach	Aadoo	F
Pyrus communis	Pear	Naspati	F
Vitis vinifera	Grapes	Angoor	F

R - Rabi season of cultivation- (October to March)
K - Kahrif season of cultivation- (April to Sertember)
F - Fruit species; Fr - Fodder species; Ft - Forest tree; U - Season of cultivation could not be confirmed; + - English name could not be confirmed

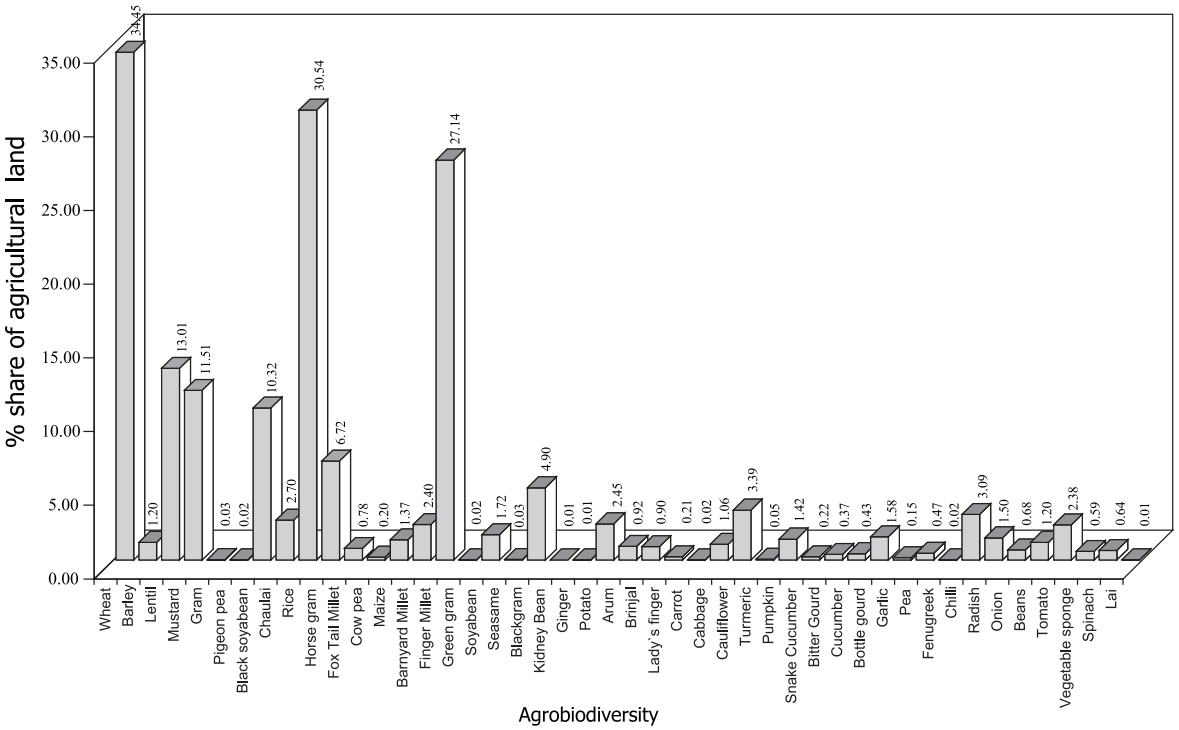


Fig. 4: Percentage incidence of agro biodiversity based on the area covered by agricultural land in Tarikhet

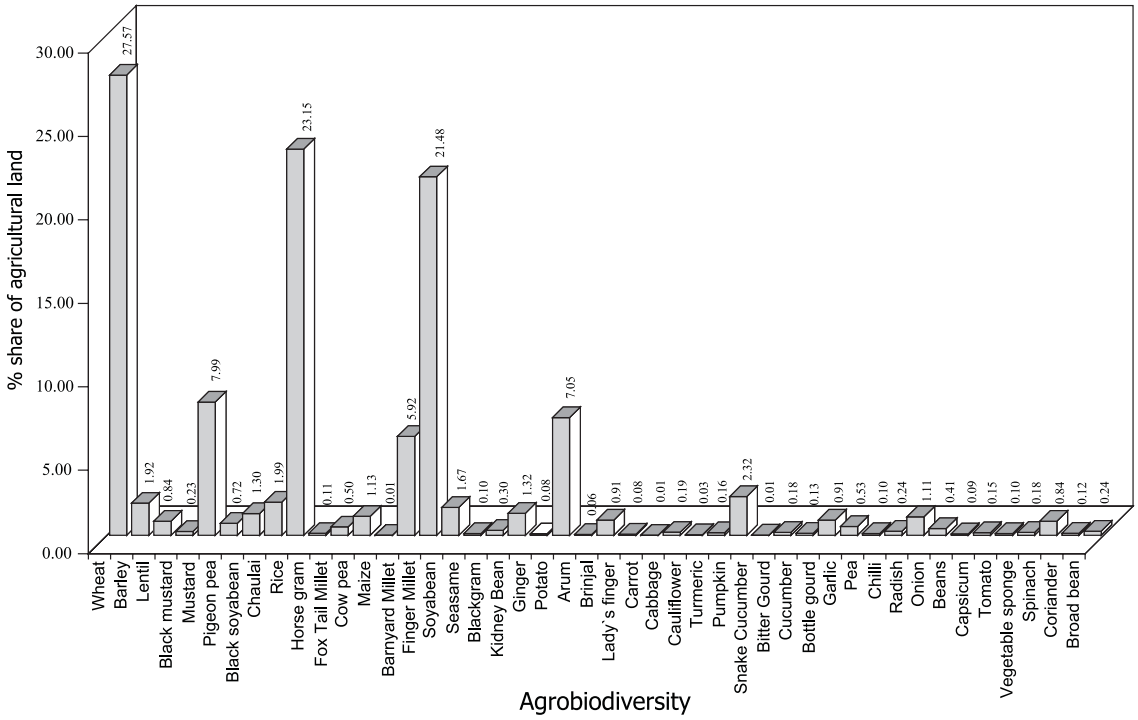
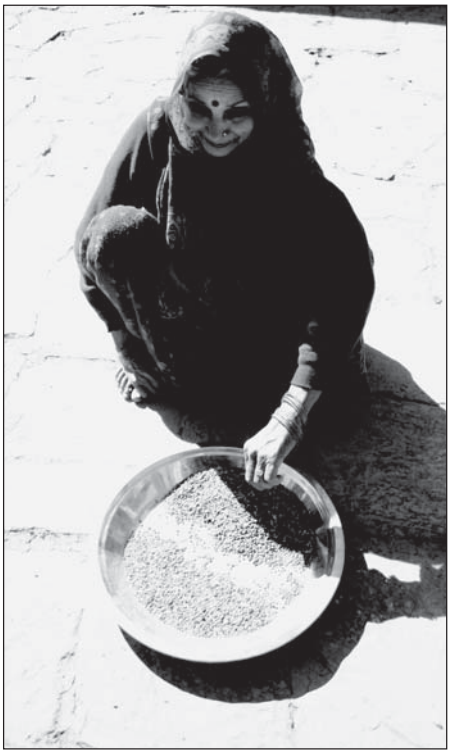
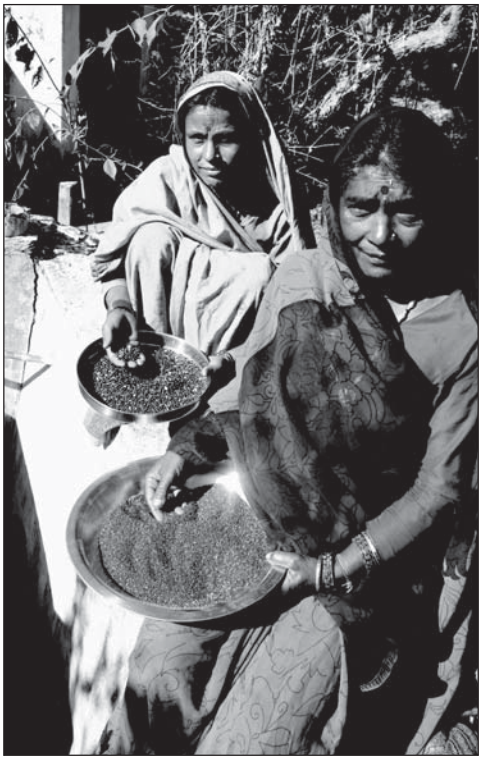


Fig. 5: Percentage incidence of agro biodiversity based on the area covered by agricultural land in Ukhimath

in fodder and agro forestry plant species in Ukhimath where the frequency of these plants was comparatively more in comparison to Tarikhet.

Among food crops, *Triticum aestivum* (wheat) ranked first in terms of cultivation followed by *Oryza sativa* (rice), *E. coracona* (finger millet) and *B. napus* (mustard).





Figs. 6 and 7: Women actively participate in the *in situ* conservation of customary crops like *Macrotyloma uniflorum, Eleusine coracana* and a species of *Glycine max* locally known as *Bhat*

Fig. 8: Natives in Ukhimath conserve agro biodiversity in their kitchen gardens

Conclusions

Albeit the *in situ* conservation trends of genetic resources on-farm in Central Himalayan middle hills has acquired a shift the cultivation of some traditional crops is still maintained. The persistence of crops like *Eleusine coracana, Echinochloa frumentacea, Macrotyloma uniflorum, Dioscorea alata, Colocasia esculenta, Amaranthus caudatus etc.* despite depleting the customary crops in the region reflected the stakeholders' interests in these crops. And the scenario of *in-situ* conservation

of these underprivileged crops on-farm even in unsustainable agricultural systems was much better in the areas of Tarikhet Block as compared to Ukhimath. However, the cropping pattern of vegetables and cash crops was almost similar except some slight variations in both the areas. The absence of agro biodiversity of four food crops in Ukhimath may be due to several factors. A very interesting feature was perceived that the potato (*Solanum tuberosum)* farming was reasonably much significant in Ukhimath to that negligibly found in Tarikhet but this order was reverse in case of Horse gram *(Macrotyloma uniflorum)*. The richness and intensity of agro biodiversity conservation was comparatively more in Tarikhet as to that of Ukhimath particularly while expressing *in situ* conservation of traditional and coarse grain crops on-farm.

So, it is a need of encouragements to crop growers from concerned departments of government, NGOs and other private sectors that deal with the biodiversity conservation and sustainable agriculture to promote cultivation of these wild relatives and landraces rich in energy and nutrition. The farmers in these areas need advancement of understanding related to the complex practices and mechanisms for on farm conservation of crop diversity and their relation with farmers' livelihoods, encouragements for profitable management practices.

In the wake of efforts made by FAO (UN) towards agro biodiversity conservation like Community Biodiversity Development and Conservation Programme (CBDC/IDRC) and Biodiversity Utilization and Conservation in Asia and the Pacific (BUCAP/ NORAGRIC/ MARD) that has been well accredited globally and measures have been strengthened in various parts of the continents stretching across south-east Asia, south Asia to African continent and Latin America. Indian authorities should stronghold the mega-measures for the conservation of rare, traditional and wild genetic resources at the government's sound working policy levels, besides the foreign assistance like pilot project on home gardens to *in-situ* conservation of PGR of CIC Italy, particularly for sensitive agricultural ecosystems in Central Himalayan region.

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