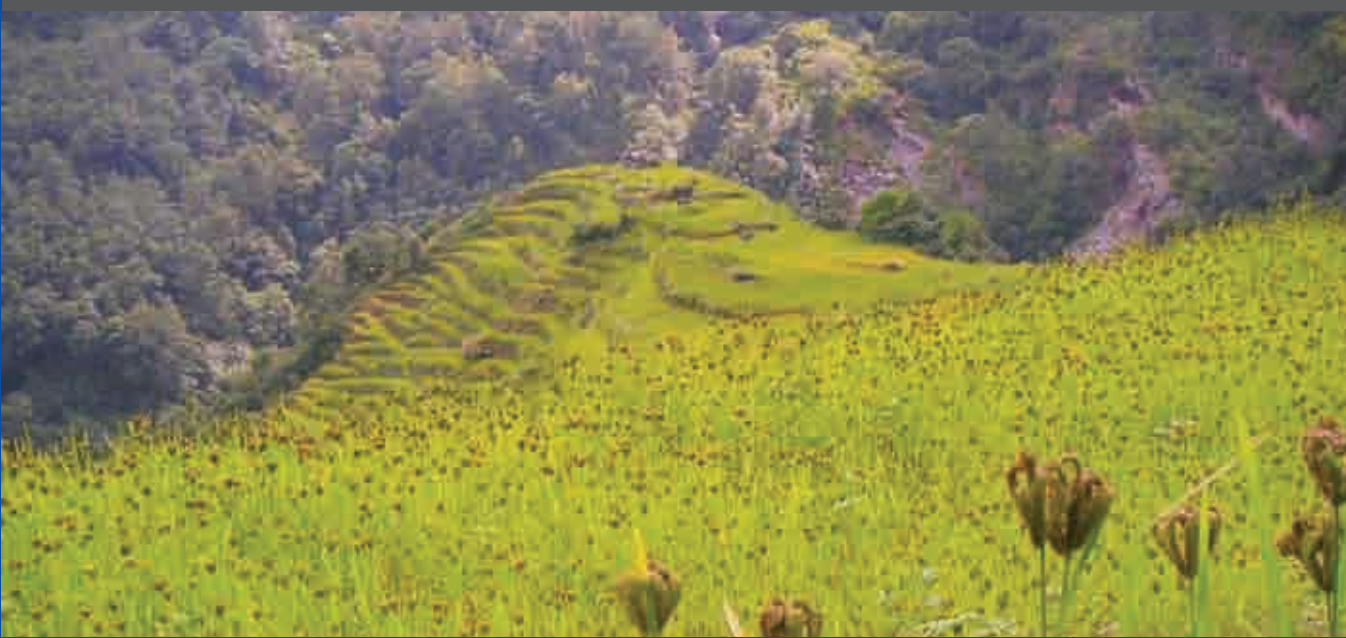
MILLETS IN THE INDIAN HIMALAYA

B Venkatesh Bhat, A Arunachalam, Dinesh Kumar, Vilas A Tonapi and Trilochan Mohapatra



Indian Council of Agricultural Research
Ministry of Agriculture & Farmers' Welfare, Government of India, New Delhi

Source: North East Network from Facebook

Millets in the Indian Himalaya

Indian Council of Agricultural Research

Ministry of Agriculture & Farmers' Welfare, Govt. of India
Krishi Bhawan, New Delhi

Citation:
Bhat, B.V., Arunachalam, A, Kumar, D, Tonapi, V.A. and T. Mohapatra (2019), Millets in the Indian Himalaya, Indian Council of Agricultural Research, New Delhi. 84p.

Year of Publication : 2019

ISBN : 81-89335-89-8

Compiled and Edited by:
B Venkatesh Bhat, A Arunachalam, Dinesh Kumar, Vilas A Tonapi and Trilochan Mohapatra

Published by:
ICAR-Indian Institute of Millets Research (IIMR), Hyderabad
Indian Council of Agricultural Research (ICAR)
Ministry of Agricultrue & Farmers' Welfare,
Government of India
Krishi Bhawan, New Delhi

Printed at:
Balajiscan Private Limited
11-2-1145, Beside Mata's Temple, Nampally, Hyderabad – 500001, Telangana, INDIA.
Cell: 9248007736/37; e-mail: bsplpress@gmail.com website: www.balajiscan.com

त्रिलोचन महापात्र, पीएच.डी.
सचिव एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE AND FARMERS WELFARE
KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

The Indian Himalayan Region spreads across ten states and is endowed with rich bio-diversity of plants, animals, and microorganisms due to their various ecological locations and altitudinal variation within a short distance. The Himalayan highlands are important centres of crop plant diversity due to high ecological heterogeneity and high local socio-cultural integrations. About 85 % of the Himalayan populace is directly or indirectly dependent on traditionally practiced integrated hill agriculture, animal husbandry, agro-forestry and forestry for livelihood. Millets form an integral part of subsistence agriculture in Himalayan region predominated by small farmers. Millets are used for food and beverages though their use for fodder and bird feed are insignificant. Finger millet is the major and versatile millet in these areas followed by foxtail millet. Barnyard millet is confined mostly to Uttarakhand while bajra and jowar are cultivated in few districts of Jammu & Kashmir and Himachal Pradesh. Proso millet is grown in few packets in few Himalayan states. The pattern of millet consumption varies across states and has remained similar or reduced over time. In Arunachal Pradesh for instance, the cultural utility of millets is high, whereas communities in Assam and Tripura don't include millets. Traditional fermented foods and beverages occupy special place in Himalayas across North-Eastern states of India particularly in Arunachal Pradesh due to their nutritive value, taste, health aspects, social, ritual and cultural importance. Among ingredients of traditional beverages, starter cultures are source of yeast cells which is responsible for conversion of carbohydrate into ethanol.

Since centuries, the millets have provided food and nutritional security to the populations in the disadvantaged geographical regions. Agronomic advantages e.g. highly adapted to low rainfall conditions, able to withstand fairly long dry spells, recover fast after delayed rain, make them good contingent crops. Millets are highly resilient in adapting to different ecological conditions; ideal crops for climate change and contingency plantings. Being C4 plants these are more environment friendly with high water use efficiency and low input requirement, but equally responsive to high input management. In addition to

these agronomic advantages, millets can offer other benefits in ecological, nutritional, and socioeconomic areas. Besides being farmer-friendly, the unique nutritional properties of millets, i.e., high fiber, quality protein & mineral composition, being called as “nutricereals”. Generation of higher demand for the dryland crops like millets will significantly increase the farmers’ income. Millets are climate resilient crops and can adapt to wide ranges of climatic conditions. They can be grown in marginal soil conditions with minimal requirement for irrigation water. But consumption of millets in the country has come down significantly due do several demand led reasons. Establishment of sustainable value chains and creation of demand for millets across Himalayan states and in millet growing states of India will help the farmers in getting better price and market for their produce. Proper value addition measures can be taken up at farm level to overcome these problems which will boost the millets cultivation nationwide and therefore will positively impact the farmers’ income.

Millets crops now stand at a critical juncture. Keeping in view the present situation, there is a need to reorient millet R&D programmes both structurally and functionally as millets as a group stand distinctly as climate smart crops which have a significant role to play in the climate change scenario and also as crops which are highly drought tolerant and can usher in food, feed, fodder, nutritional and livelihood security to all in dryland ecosystems as “MIRACLE NUTRI-CEREALS” providing nutritional and health security to all, which in fact is the need of the hour. In addition, it is apt time to critically evaluate their role in the conservation of bio-diversity, human and animal nutrition, industrial uses and therapeutic diets in the form of functional foods. This publication from Indian Institute of Millets Research entitled “Millets for Climate Resilience in the Himalayan Region in India” is a synthesis of information on Importance of millets in Himalayan agriculture, Profile of Millets status, issues, and strategies for Millet Development in individual Himalayan states. It is hoped that this publication will be a valuable source of information on millets for all the researchers, policy makers and the industry.

Dated the 14th May, 2019
New Delhi

(T. MOHAPATRA)

PREFACE

The Himalayan region represents a unique agricultural ecosystem which is ancient and less disturbed by rapid changes in cultivation systems and culture as compared to plains. The sub-mountainous and mountainous regions are unique civilization streams where food culture and agriculture systems are shaped as per the climatic variations and crop adaptations. Millets are relatively easily adaptable food grains across tropical and sub-tropical agriculture in warm season. As the cropping pattern and utilization of millets in these regions is different, mainstreaming of millets production and consumption in these areas needs a different approach compared to the arid and semi-arid plains of the country. In this background, ICAR-Indian Institute of Millets Research is putting together this publication summarizing all aspects of millets production and consumption in the Himalayan region on state-wise basis. In this region, each state further gets further culturally divided into different distinct tribes each with their own food habits and millets funds place in these traditions in various ways. From shifting cultivation or jhum system to mixed cropping and use of hybrids – all cultivation practices are found in this region. Similarly uses of millets as staple food and fermented food and beverages are in vogue in varying degrees and dimensions as practiced by different communities across the Himalayan region. Millets are also grown in the Himalayan region of Nepal as well, which are not covered in this book.

Finger millet is the predominant millet crop in the eastern Himalayan region. Foxtail millet and proso millet are also found in most states. Pearl millet and sorghum are grown in Western Himalayan zones. Nagaland is one state where most of the millet crops are cultivated. It is also documented that cultivation of millets have disappeared from some districts where mono-cropping has replaced traditional cultivation methods. This compilation is an attempt to reflect upon the current status of cultivation and utilization of millets in the Himalayan region and also to assist in deciding upon research area and priorities for millets to be relevant for this unique region. Further, it helps in visualizing the status of millets as food crops in setting up policy interventions in the North-Eastern region. As these regions have no access to improved seeds and production technologies, interventions by state governments to provide these inputs for sustainable and economic production of millets become important. Appropriate processing and value addition technologies need to be made available to make it convenient and profitable to utilize millets in these hilly regions. There is also a dire need to collect land races of different millets from all states to ensure preservation of genetic diversity.

The authors appreciate the contribution of Dr. V Ravikumar in preparing state-wise maps. The assistance of Dr. KV Raghavendra Rao in coordinating with the press, composing and corrections is acknowledged. The photographs contributed by Mr. HS Gawali and Mr. G Krishna Prasad need a special mention. We also thank M/s Balajiscan Private Limited, Hyderabad for excellent composing and printing of the book.

- Authors

Table of Contents

1

About millets

Millets are a groups of cereal food grain crops which are profusely seeding, adapted to cultivation over a range of tropical and subtropical climates and can be grown with very low inputs. These crops are climate resilient, hardy and dryland crops also termed as Nutricereals which contribute substantially for food and nutritional security. Generally, these are rain fed crops grown in areas with low rainfall and thus resume greater importance for sustainable agriculture and food security. Major millet crops include sorghum (jowar), pearl millet (bajra), finger millet (ragi/*mandua*), foxtail millet (*kangni*/Italian millet), or little millet (*kutki*), kodo millet, barnyard millet (*sawan/jhangora*), proso millet (*cheena*/common millet), and brown top millet (*korale*). In certain countries of Africa, other millets such as fonio and teff are grown. Millets were the first crops to be domesticated by the mankind in Asia and Africa which later on spread across the globe as critical food sources to the evolving civilizations. All these millets are nutritionally rich, complete their life cycle in 2 to 4 months, adapting to the shorter cropping windows that facilitated wider adaption, shifting cultivation and withstanding nature's unforeseen vagaries. All millets are essentially *kharif* season crops that complete their life cycle in the monsoon period. However, most of them give satisfactory to excellent yields in other warmer seasons as well. Millets are especially drought tolerant and can perform well in areas receiving rainfall of 450 mm or more.

Millets had been the lifeline of dry regions of Asia and Africa for food and fodder. All the millets are invariably used as staple foods in certain regions of the world. However, they are also used for fodder, feed, bird seed, for brewing, as industrial material, etc. in many countries. Despite the fact that they are staple in the diets of millions of people residing in the semi-arid and arid regions of the world, millets are sometimes referred to as famine crops since they are the only crops that assure yields in famine situations. They are also called as orphan crops since they are the last option for cultivation as they have less demand in the market and profits earned are also lower than other crops. However, these neglected crops are important by virtue of their contribution to the means of livelihood, food and nutritional security of the poor in various parts of the world and they diversify our food basket (Table 1).

Sorghum (*Sorghum bicolor*), or great millet is the world's fifth major cereal in terms of production and acreage. Sorghum is among the most efficient crops of the world in use of solar energy and water to produce food and biomass, is a drought tolerant crop that is environmentally friendly. In the semi-arid regions sorghum is a dual-purpose crop, as both grain and stover are highly valued for human and animal consumption, respectively. It is grown extensively in north-western, western and central India and southern peninsula, with maximum acreage in Maharashtra and Karnataka.

Pearl millet (*Pennisetum typhoides*) is has the greatest potential of all millets. It is probably the most drought and heat tolerant of all cereals being associated with cultivation in high temperatures, light soils and semi-arid growing conditions. Nevertheless, it responds spectacularly to good management with exceptional potential for grain as well as fodder production. It is extensively grown in Rajasthan, Gujarat and Haryana because it can adapt well to nutrient-poor, sandy soils in low rainfall areas.

Major millet crops cultivated in India and their regional names

Sorghum (*Sorghum bicolor*)

Bengali	:	Jowar
Gujarati	:	Jowari, Juar
Hindi	:	Jowari, Juar
Kannada	:	Jola
Marathi	:	Jowari, Jondhala
Oriya	:	Juara
Punjabi	:	Jowar
Tamil	:	Cholam
Telugu	:	Jonna

Pearl Millet (*Pennisetum typhoides*)

Bengali	:	Bajra
Gujarati	:	Bajri
Hindi	:	Bajra
Kannada	:	Sajje
Marathi	:	Bajri
Oriya	:	Bajra
Punjabi	:	Bajra
Tamil	:	Kambu
Telugu	:	Sajja

Finger Millet (*Eleusine coracana*)

Bengali	:	Marwa
Gujarati	:	Nagli, Bavto
Hindi	:	Ragi, Mandika, Marwah
Kannada	:	Ragi
Marathi	:	Nagli, Nachni
Oriya	:	Mandia
Punjabi	:	Mandhuka, Mandhal
Tamil	:	Keppai, Ragi, Kelvaragu
Telugu	:	Ragi Chodi

Foxtail Millet (*Setaria italica*)

Assamese	:	Konidhan
Bengali	:	Kaon
Gujarati	:	Kang
Hindi	:	Kakum
Kannada	:	Navane
Marathi	:	Kang, Rala
Oriya	:	Kanghu, Kangam, Kora
Punjabi	:	Kangni
Tamil	:	Tenai
Telugu	:	Korra

Little Millet (*Panicum miliare*)

Bengali	:	Sama
Gujarati	:	Gajro; Kuri
Hindi	:	Kutki, Shavan
Kannada	:	Same, Saave
Marathi	:	Sava, Halvi, vari
Oriya	:	Suan
Punjabi	:	Swank
Tamil	:	Samai
Telugu	:	Samalu

Kodo Millet (*Paspalum scobiculatum*)

Bengali	:	Kodo
Gujarati	:	Kodra
Hindi	:	Kodon
Kannada	:	Harka
Marathi	:	Kodra
Oriya	:	Kodua
Punjabi	:	Kodra
Tamil	:	Varagu
Telugu	:	Arikelu, Arika

Proso Millet (*Panicum miliaceum*)

Bengali : Cheena
Gujarati : Cheno
Hindi : Chena; Barri
Kannada : Baragu
Marathi : Vari
Oriya : China Bachari bagmu
Punjabi : Cheena
Tamil : Pani varagu
Telugu : Variga

Barnyard Millet (*Echinochloa frumentacea*)

Bengali : Shyama
Gujarati : Banti
Hindi : Sanwa
Kannada : Oodalu
Oriya : Khira
Punjabi : Swank
Tamil : Kuthiraivolly
Telugu : Udalu, Kodisama

Brown top Millet (*Brachiaria ramosa*)

Kannada : Korle
Telugu : Andu korra

Table 1: Area harvested, production and yield of millets in the world (2016)

S No.	Millet crop	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent contribution to total millets production	No. of major production countries
1	Barnyard millet	146.3	151.2	1034	0.16	2
2	Finger millet	2106.3	3417.7	1623	3.62	9
3	Foxtail millet	1057	2290	2166	2.42	3
4	Kodo millet	200	84.2	419	0.09	1
5	Little millet	255.5	119.9	469	0.13	1
6	Pearl millet	27161	23092	850	24.43	40
7	Proso millet	944.1	1449.5	1535	1.53	36
8	Sorghum	44771	63931	1428	67.63	91
	Total millets	**76185.7**	**94331.4**	**1238**	**100**	**131**

Source: IIMR Estimates Based on FAO Data

Finger millet (*Eleusine coracana*) is an important crop under cultivation serving as the primary food for rural populations of Southern India and East and Central Africa. Finger millet or ragi has a relatively wide range of adaptation within moderate temperatures and moisture ranges. It is most widely cultivated on hills and plains, lateritic soils in the 50-100 cm rainfall belt of the tropics and sub-tropical regions. It has high-yielding potental producing highest mean yield among the millets in India, and is frequently grown both dry and irrigated

on lands where moisture is insufficient for rice. More than 60% of finger millet is produced by the state of Karnataka in India, which is about 34% of global production. Finger millet is highly adaptable to higher elevations and is grown in the Himalayas up to an altitude of 2300 m.

Foxtail millet (*Setaria italica*), grown in semi-arid regions, has a low water requirement and successful almost entirely to its short growing season. It matures in 65-70 days. Foxtail millet can be planted when it is too late to plant most other crops. It is drought - resistant, grows at higher elevations (up to 600 feet) and is frequently sown as an alternate crop with sorghum on black cotton soils when rainfall is deficient. It also grows well on loamy or alluvial and clayey soils. Foxtail millet: In Himalayan region it is known as kauni, while in China it is known as 'Xiao Mi' which means 'Little Rice'.

Proso millet or common millet (*Panicum miliaceum*), is a relatively short-duration emergency or quick-season irrigated crop with low moisture requirements. Proso millet is well suited for many soil types and climate conditions. Compared to all millets proso is a short season crop, reaching maturity 60 to 75 days after planting. It is most frequently grown as a late seeded summer crop. This millet was grown in Russia, China, the Balkan countries and Northern India in historical times, being later replaced in most areas by rice and other cereals.

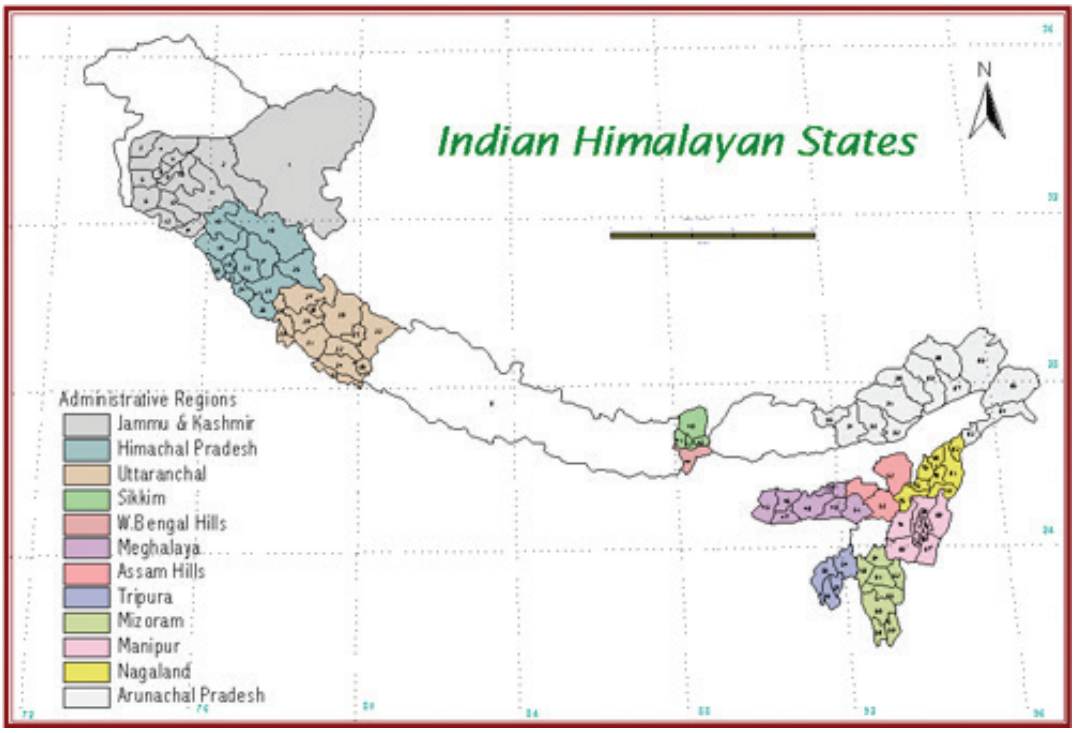
Kodo millet (*Paspalum scrobiculatum*) is extensively grown on the poorest of soils and reputed to be extremely hardy, drought resistant and grows on stony or gravelly soils which would not support other crops. It is relatively long in duration requiring five or six months to mature compared with two to four months for the other millets. Little millet (*Panicum miliare*) is similar to proso millet, and is grown on a limited scale with minimum care on poor lands. Little millet matures quickly and withstands both drought and water logging. Both kodo and little millet are grown in parts of Madhya Pradesh, Chhattisgarh and Tamil Nadu. Little millet is also grown in many other states, but on a limited scale. . In many tribal areas, little millet is considered as a cash crop as it fetches much higher prices than rice.

Barnyard millet (*Echinochloa frumentacea*) is predominantly cultivated in India, China, Japan, and Korea for food as well as fodder. Japanese and Indian species of this millet are vigorous and have a wide adaptation in terms of soil and moisture requirements. Brown top millet (*Brachiaria ramosa*), a native of India, has relatively limited cultivation to the parts of Karnataka and Andhra Pradesh. It is primarily used as a food crop in India. It can be grown even in less fertile sandy loam soils and matures in 60-80 days and is the most inexpensive crop to grow and does not need weeding and has no serious pests and diseases.

2

Millets in Himalaya

The Indian Himalayan Region (IHR) which spreads across ten states is endowed with abundance of natural resources in the forms of water, forest, fertile soil, pleasant climatic conditions and panoramic landscapes. The Himalayas is known for its rich bio-diversity of plants, animals, and microorganisms due to their various ecological niche and altitudinal variations. Evidently, the Himalayan highlands are important centres of crop plant diversity due to high ecological heterogeneity and high local socio-cultural integrations. The agro-climatic zones of the Himalayas vary from hot sub-humid tropical to temperate, alpine and glacial. Development concerns in the Himalaya also revolve around how resources of the region could be managed for conserving/improving the environmental values of the region together with socio-economic development of the people. About 85% of the Himalayan populace is directly or indirectly dependent on traditionally practiced integrated hill agriculture, animal husbandry, agro-forestry and forestry for livelihood.



Source: ENVIS Centre on Himalayan Ecology (2014), MoEF & CC, GoI.

Land resources use pattern

Total geographical area and per cent share of the Himalayan region depicts that the undivided Jammu and Kashmir State has the highest area and it shares 6.8 per cent of India's geographical area. Arunachal Pradesh seconded it (2.5 per cent). Himachal Pradesh stands third with 1.7 per cent. The lowest area is occupied by Sikkim (0.2 per cent). The other states are Tripura (0.3), Nagaland (0.5), Mizoram (0.6), Manipur and Meghalaya (0.7 each) and Uttarakhand (1.6 per cent). Mountain geography and inaccessibility due to difficult terrains and lack of infrastructure have compelled the people to adopt the agro-biodiversity system. In the western, central and eastern Himalaya, agriculture is practiced as terraced cultivation while, in the eastern extension of Himalaya, shifting cultivation is the main form of farming system (Sati, 2015).

Farming is a major source of livelihood

Agriculture is the major source of livelihood and the food basket is characterized by traditionally grown cereal crops. Rearing livestock goes parallel and it supports agricultural practices. Similarly, forest contributes to agriculture and livestock activities and thus, agriculture, livestock and forests form an integral part in economic development. Economy of the region is highly dependent on the limited arable land and about 59 per cent workforce is involved in agricultural practices (Nandy and Samal, 2005). The Himalayas have rich bio-resources consisting of many indigenous varieties of cereals such as rice, maize, finger millet, wheat, buckwheat, barley, sorghum, pearl millet.

There are broadly five agro-climatic zones in the IHR. Each zone has its own characteristics and subsequently, the farming system varies. The first zones comprise of the high altitude temperate climate (humid to arid), where annual rainfall is <1200 mm. Jammu and Kashmir including Leh Ladak falls under this zone, is very famous for the cultivation of temperate fruits. The second zone characterizes hill temperate to cold and frigid climate (humid to sub-humid), varies according to altitudes. Annual rainfall is 1200 to 1800 mm. Himachal Pradesh and Uttarakhand states are located in this zone. The economy is largely dependent on subsistence terraced cereal farming including millets and cultivation of developed temperate fruits.

Sub-tropical to temperate climate, humid during about eight months of summer and semi-humid, during the four months of winter, characterizes zone third. Annual rainfall varies from 1800 to 2200 mm. The four states of Nagaland, Mizoram, Manipur and Tripura lie in this zone, is influenced by the subsistence based shifting cultivation.

Sub-Himalayan West Bengal, Sikkim, Assam hills and Meghalaya states fall under zone four, obtains 2200-2800 mm annual rainfall with developed tea and subsistence shifting cultivation. The climatic conditions vary from sub-tropical to temperate (cold and frigid in Sikkim), humid during about eight months of summer and semi- humid during the four months of winter.

Zone fifth consists of temperate to cold and frigid climate, humid to semi-humid, obtains >2800 mm annual rainfall. Arunachal Pradesh lies in this zone where farming system is characterized by the cultivation of temperate fruits (moderate) and subsistence crops including millets (terraced).

Agro-climatic zones in Himalayan region and their characteristics

Agro-climatic zone	Climate	Rainfall (in mm)	State/regions	Major farming systems
Zone I	High altitude temperate (humid to cold arid)	<1200	Jammu, Kashmir & Ladakh	Developed temperate fruits cultivation
Zone II	Hill temperate to cold and frigid (humid to sub- humid)	1200-1800	Himachal Pradesh and Uttarakhand	Developed temperate fruit cultivation and subsistence terraced cereal farming
Zone III	Sub-tropical to temperate climate humid during about eight months of the summer and semi humid during the four months of winter	1800-2200	Nagaland, Mizoram, Manipur and Tripura	Subsistence shifting cultivation
Zone IV	Sub-tropical to temperate climate (Cold and frigid in Sikkim) humid during eight months of summer and semi humid during the four months of winter	2200-2800	Sub Himalayan West Bengal, Sikkim, Assam and Meghalaya	Developed tea cultivation and subsistence shifting cultivation
Zone V	Temperate to cold and frigid climate humid to semi humid	>2800	Arunachal Pradesh	Moderate temperate fruit cultivation and subsistence terraced cultivation

(Source: Modified from Agro-Climatic Regional Planning, Planning Commission, 1989)

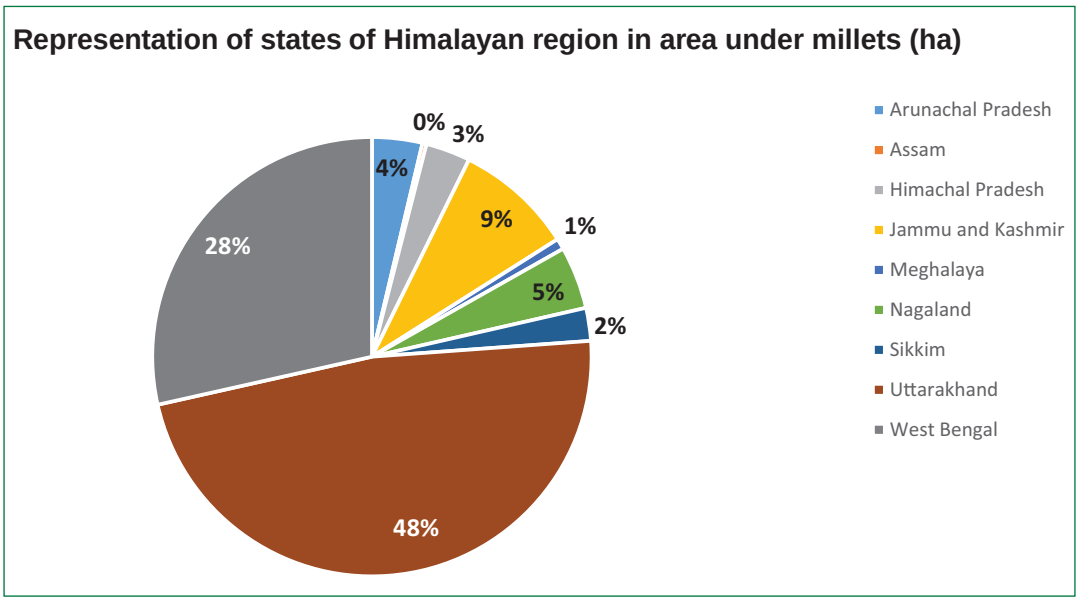
Despite moderate to high rainfall, moisture availability for crops is limited due to high runoff. Food crops comprising of cereals and millets are grown during *kharif* season under terraced or shifting cultivation.

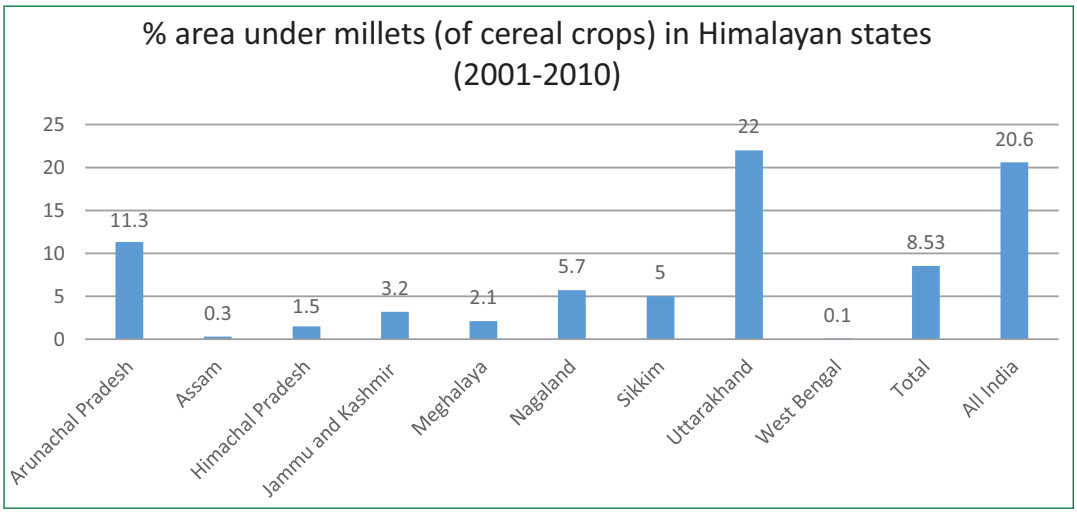
Importance of millets in the Himalayan agriculture

Millets form an integral part of subsistence agriculture in the Himalayan region predominated by small farmers. Millets are used for food and beverages though their use for fodder and bird feed are insignificant. Finger millet is the major and versatile millet in these areas followed by foxtail millet. Barnyard millet is confined mostly to Uttarakhand while bajra and jowar are cultivated in few districts of Jammu & Kashmir and Himachal Pradesh. Proso millet is grown in few packets in some states. The pattern of millet consumption varies across states and has remained similar or reduced over time. In Arunachal Pradesh for instance, the cultural utility of millets is high, whereas communities in Assam and Tripura don't include millets.

Area, production and yield of millets in Himalayan region (Mean of 20 years - 1997-2016)

Millet Crop	Parameter	Arunachal Pradesh	Assam	Himachal Pradesh	Jammu and Kashmir	Meghalaya	Nagaland	Sikkim	Uttara-khand	West Bengal	Total
Jowar	Area (ha)			96	757		160		4		1017
	Production (q)			30	378		213		3		623
	Yield (kg/ha)			311	499		1329		686		613
Bajra	Area (ha)			109	1954		160		12		2235
	Production (q)			56	1130		190		12		1388
	Yield (kg/ha)			511	579		1185		1016		621
Ragi	Area (ha)			258			55		10092	10751	21157
	Production (q)			270			50		13402	12536	26259
	Yield (kg/ha)			1046			911		1328	1166	1241
Small millets	Area (ha)	1458	118	833	729	316	1442	954	8670	486	15005
	Production (q)	1372	47	560	355	277	1423	981	10747	694	16456
	Yield (kg/ha)	941	399	672	487	874	987	1029	1240	1429	1097





** Total across regions (8.53%) excludes Jammu & Kashmir and West Bengal where most districts do not grow millets*

Total millets	**Area (ha)**	1458	118	1296	3440	316	1817	954	18778	11237	39414
	Production (q)	1372	47	916	1864	277	1875	981	24164	13230	44726
	Yield (kg/ha)	941	399	707	542	874	1032	1029	1287	1177	1135

Similar to rest of India, the official statistics about cultivation of each of the small millet crops are not available for the Himalayan states. Cultivation of millets in North-East region, similar to other tribal regions of the country, are known for growing small millets in shifting cultivation (locally know as 'Jhum'), in conjunction with rice. Now it is confined to Hilly areas of Assam, mainly North Cachar hills, and Nagaland, hilly pockets like West Garo hills of Meghalaya.

Credit: Sahaja Samrudha

3

Millets are a part of food basket in India

Since centuries, the millets have provided food and nutritional security to the populations in the disadvantaged geographical regions. Agronomic advantages e.g. highly adapted to low rainfall conditions, able to withstand fairly long dry spells, recover fast after delayed rain, make them good contingent crops. Millets are highly resilient in adapting to different ecological conditions; ideal crops for climate change and contingency plantings. Being C4 plants these are more environment friendly with high water use efficiency and low input requirement, but equally responsive to high input management. In addition to these agronomic advantages, millets can offer other benefits in ecological, nutritional, and socioeconomic areas. Besides being farmer-friendly, the unique nutritional properties of millets, i.e., high fiber, quality protein & mineral composition, being called as “nutricereals”.

In India, millets are traditionally consumed as staple foods in the Indian diet. Some typical dishes of millets in India are Jowar (sorghum) *roti* or *bhakri* in Maharashtra, parts of Karnataka, Madhya Pradesh, Uttar Pradesh and Rajasthan; bajra (pearl millet) *roti* in Punjab, Haryana, parts of Uttar Pradesh, Rajasthan and Tamil Nadu, and ragi (finger millet) *mudde* in Karnataka, parts of Tamil Nadu and Andhra Pradesh. Pearl millet is boiled to make an Indian porridge called *Kambam Choru* in Tamil Nadu. In Uttarakhand, finger millet is eaten as *roti*, barnyard millet as *paleu* or *chencha*, a savoury porridge cooked in buttermilk. *Zan* is the most popular porridge recipe of Monpa tribes of Arunachal Pradesh made from finger millet and vegetables.

The dehusked grain of small millets is cooked like rice and eaten or made into porridge. In parts of South India, the grain is processed very similar to the parboiling of rice. It can also made into flour, used for making puddings or cakes. Another method is to cook cracked grains with vegetables and spices to prepare a food similar to curried rice. Barnyard and little millet found place for niche use, as a *bhagaar* food, consumed during fasting. Kodo millet and little millet in Madhya Pradesh and Chhattisgarh, finger millet in Orissa, Andhra Pradesh and Uttarakhand, barnyard millet in Uttarakhand and Tamil Nadu, etc. are continuing to be under cultivation and consumption in the tribal areas. Foxtail millet grain is usually cooked whole like rice (millet rice) or made into meal. It is also consumed as stiff porridge called *sargati*, or as leavened bread known as *roti*, after the de-hulled grain has been milled into flour. More data on levels of consumption, commerce, etc. are not available and mostly it is

localized in the production belts as well as in some niche market areas in the growing states. Sprouted grains are also eaten as vegetable in some regions.

Many other traditional foods from millets are made from popped flour mixed with sugar / jaggery / ghee / milk / butter milk and salt. In several rural households a vast variety of traditional snacks are made from finger millet and other millets. Milled millet can be further processed towards various food uses such as flakes, quick food cereals, ready to eat snacks, supplementary foods, extrusion cooking, malt based products, weaning foods, and more importantly health foods.

Malting of finger millet for food uses is in practice from time immemorial in several parts of India. It has superior malting properties and the malt has acceptable taste, very good aroma and shelf life. Traditional foods prepared from barnyard and other millets such as *idli*, *dosa* and muruku are very popular in southern India. Sorghum and millets are used for developing various value added products like biscuits, sweets, vermicelli, ready mixes and multi-grain *atta*. In some regions minor millets remain cultivated only on a small scale but are culturally important for particular foods stuffs, such as ritual breads made from brown top millet in restricted districts of South India.

4

Millets for nutritional security

Nutritional insecurity is a major threat to the world's population that is highly dependent on cereals-based diet, deficient in micronutrients. Millets are nutritionally superior as their grains contain high amount of proteins, essential amino acids, minerals, and vitamins. Almost all the miDllets are used for human consumption in most of the developing countries, but their use has been primarily restricted to animal feed in developed countries. Millets are nutritionally comparable to major cereals for carbohydrates/ energy, and serve as good source of protein, micronutrients and phytochemicals. The millets contain 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fibre.

Millets possess unique nutritional characteristics specifically have complex carbohydrates, rich in dietary fibre as well as unique in phenolic compounds and phytochemicals having medicinal properties. Millets are natural source of iron, zinc, calcium and other nutrients that are essential for curbing the problem of malnutrition in India. They have higher content of niacin, B6 and folic acid, and calcium, iron, potassium, magnesium and zinc. Finger millet is the richest source of calcium (300-350 mg/100 g) and other small millets are good source of phosphorous and iron. Millets are easy to digest, contain a high amount of lecithin and are excellent for strengthening the nervous system. The below table summarizes the nutritional comparison of millets with two of the world's most important staple foods, rice and wheat.

Studies have shown that diets rich in whole grains such as millets are protective against the non-communicable diseases like diabetes, cancer and cardiovascular diseases, due to protective effects of health promoting phytonutrients. It is well recognized that, the incidence of diabetes mellitus and gastro-intestinal tract related disorders are minimal among the population using these grains as staple food. Millets contain slow releasing glucose, i.e., low in glycemic index. This is very much important in fighting the global problem of diabetes.

Millets are good for people who are gluten-intolerant. Its fibre content also helps to prevent constipation and may reduce the risk of developing bowel disorders including bowel, colon.

Being staple foods, millets can beneficially replace at least one to two portions of cereal intake of an average adult. Various traditional and modern dishes can be made out of millets. Food market especially in urban areas is selling several modern day foods, ready to cook and ready to eat items, making available an array of options for consumers to embrace

Nutritional comparison of millets with rice and wheat

(in 100g dry weight of edible grain)

Grain (Millet /Cereal)	Carbo-hydrates (g)	Protein (g)	Fat (g)	Energy (Kcal)	Dietary fibre (g)	Ca (mg)	P (mg)	Mg (mg)	Zn (mg)	Fe (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Folic acid (µg)
Sorghum	67.7	09.9	1.73	334	10.2	27.6	274	133	1.9	3.9	0.35	0.14	2.1	39.4
Pearl Millet	61.8	10.9	5.43	347	11.5	27.4	289	124	2.7	6.4	0.25	0.20	0.9	36.1
Finger millet	66.8	07.2	1.92	320	11.2	364.0	210	146	2.5	4.6	0.37	0.17	1.3	34.7
Kodo millet	66.2	08.9	2.55	331	06.4	15.3	101	122	1.6	2.3	0.29	0.20	1.5	39.5
Proso millet	70.4	12.5	1.10	341	-	14.0	206	153	1.4	0.8	0.41	0.28	4.5	-
Foxtail millet	60.1	12.3	4.30	331	-	31.0	188	81	2.4	2.8	0.59	0.11	3.2	15.0
Little millet	65.5	10.1	3.89	346	7.7	16.1	130	91	1.8	1.2	0.26	0.05	1.3	36.2
Barnyard millet	65.5	06.2	2.20	307	-	20.0	280	82	3.0	5.0	0.33	0.10	4.2	-
Wheat	64.7	10.6	1.47	321	11.2	39.4	315	125	2.8	3.9	0.46	0.15	2.7	30.1
Rice	78.2	07.9	0.52	356	02.8	07.5	96	19	1.2	0.6	0.05	0.05	1.7	9.32

Source: *Indian Food Composition Tables 2017; Nutritive value of Indian Foods 2007*

millets. Higher protein content of millets provides bulk of the daily recommended dose when consumed as staple food. Higher quantity of minerals in millets is helpful for body building and maintenance functions. Fibre-rich diet ensures easy and normal bowel movement. Comparable (to other cereals) portion of carbohydrates and their slower release ensures good control of blood sugar levels and facilitates delaying the next meal.

Epidemiological studies have revealed that populations with millets-based diets recorded lesser incidence of esophageal cancer. The millets are rich in anti-oxidants and thus support in managing stresses better and are good for our immunity system. Above all, millet-based diet, characterized by lower glycemic index, is excellent for preventing the incidence of life-style diseases, managing diabetes and reducing obesity.

5

Health benefits of millets

Data on scientific evidences for nutritional and health benefit of millets are now available even as consumers are actually finding that millets are superior nutritious cereals beneficial for human health. Millets are recommended for well-being of infants, lactating mothers, elderly, and convalescents as suitable.

Investigations have shown that diets rich in millets, including whole grains are potentially protective against the non-communicable diseases like diabetes, cancer and cardiovascular diseases, due to protective effects of health promoting phytonutrients. Millets grains, being free of gluten proteins, are good staple food for people who are gluten-intolerant.

Millets were indeed one of the oldest foods known to humans but they were discarded in favor of wheat and rice with urbanization and industrialization. With diabetes, hypertension and cardiovascular diseases becoming more prevalent in recent times, millets have returned as a viable option to live healthy life without consuming loads of anti-diabetic and anti-hypertension medicines that are not only very expensive but also have several side effects.

Millets contain more dietary fibre and higher amalyse inhibitory activity and thus millets-based foods are low in glycemic index. This is very much important in delaying and management of diabetes (hyperglacemia). It is well recognized that, the incidence of diabetes mellitus and gastro-intestinal tract related disorders are minimal among the population using these grains as staple food. All millets have proven to possess excellent anti-hyperglycemic activity. Research findings pointed that millets show anti-diabetic properties which is due to the presence of slow digestible starch (SDS) in good amounts, prolongs digestion and absorption of carbohydrates in intestine. Sorghum based foods have low glycemic index and reduces the postprandial blood glucose level and glycosilated hemoglobin. Another study also points to the fact that blood glucose level showed considerable reduction of non-obese patients with non-insulin-dependent diabetes mellitus (NIDDM), who consumed sorghum bran papadi. Finger millet based diets have shown lower glycemic response due to high fiber content and also alpha amylase inhibition properties which are known to reduce starch digestibility and absorption.

Millets are more nutritious compared to fine cereals. They contain higher protein, fat and fibre content. The dietary fibre, due to higher viscosity and water holding capacity, plays a

key role in reduction of blood glucose level as well as insulin response. It also lowers the level of cholesterol and decreases the risk of bowel disorders. Dietary fibre components exert their beneficial effects mostly by way of their swelling properties, and by increasing transit time in the small intestine. The fibre content also helps to prevent constipation and may reduce the risk of developing bowel disorders including bowel, colon.

Millets contribute to antioxidant activity with phytates, polyphenols, tannins, anthocyanins, phytosterols and pinacosanols present in it having important role in aging and metabolic diseases. All millet grain and especially sorghum fractions possess high antioxidant activity *in vitro* relative to other cereals and fruits. Finger millet tops in antioxidant activity among common Indian foods.

The high levels of tryptophan in millets produce serotonin, which is calming to our moods. Niacin in millet can help lower cholesterol. Millet consumption decreases triglycerides and C-reactive protein, thereby preventing cardiovascular disease. Pearl millet has a free lipids content range of 5.6-7.1% and bound lipids range of 0.57-0.90%. The presence of good amounts of phospholipids consisting both lecithins and cephalins, also offer many health advantages. These compounds are having great role in general metabolism, being concentrated in brain are useful in brain function, behavioral disorders and stress. They help in regeneration of membranes and protect liver, lungs, kidneys, and gastrointestinal tract. These compounds are known to enhance the bioavailability of other nutrients and medicines.

The niacin content in pearl millet is higher than all other cereals whereas, finger millet proteins are unique because of the sulphur rich amino acid contents. Kodo millet is rich in B vitamins especially niacin, pyridoxine and folic acid as well as the minerals such as calcium, iron, potassium, magnesium and zinc. It is also rich in fiber and low in fat content. It contains a high amount of lecithin and is an excellent for strengthening the nervous system. Barnyard millet is the richest source of crude fiber and iron. Barnyard millet grains possess other functional constituents' viz. γ-amino butyric acid (GABA) and β-glucan, used as antioxidants and in reducing blood lipid levels.

6

Present status of millets cultivation and consumption in India

India is the leading producer and consumer of millet crops and their products. The people in arid and semi-arid regions of the country grow and consume millets as staple food. Grain and fodder yielding 'dual purpose' millets are grown basically to ensure food and fodder security in the rainfed agriculture.

Contribution of India to Global Millets Production during 2016

Crop	Area (000 ha)	Production (000 tons)	Yield (kg/ha)	Per cent of world production	World Production rank
Barnyard millet	146.0	151.0	1034	99.9	1
Finger millet	1138.3	1822.0	1601	53.3	1
Foxtail millet	72.6	50.2	691	2.2	3
Kodo millet	200	84.2	419	100	1
Little millet	255.5	119.9	469	100	1
Pearl millet	7129	10280	1442	44.5	1
Proso millet	31	20.0	645	1.4	9
Sorghum	5650	4410	781	6.9	6
Total millets	**14622.4**	**12531.7**	**857**		

Source: IIMR estimates1 based on FAO/DES-GOI data

Though millets are one of the earliest grains that are being cultivated and consumed by the people, in the last few decades India and the world have witnessed significant decrease in the area under the millets crops. However, the productivity of these crops has gradually gone up due to adoption of high yielding varieties and improved production technologies.

Area (million ha), production (million ton) and productivity (kg/ha) of millets in India

Crop / Year	Category	1955-56	1965-66	1975-76	1985-86	1995-96	2005-06	2015-16
Sorghum	Area	17.36	17.68	16.09	16.10	11.33	8.68	6.08
	Production	6.73	7.58	9.50	10.20	9.33	7.63	4.24
	Productivity	387	429	591	633	823	880	697
Pearl Millet	Area	11.34	11.97	11.57	10.65	9.32	9.58	7.13
	Production	3.43	3.75	5.74	3.66	5.38	7.68	8.07
	Productivity	302	314	496	344	577	802	1132
Finger Millet	Area	2.30	2.70	2.63	2.41	1.77	1.53	1.14
	Production	1.85	1.33	2.80	2.52	2.50	2.35	1.82
	Productivity	800	492	1064	1049	1410	1534	1601
Small Millets	Area	5.34	4.56	4.67	3.16	1.66	1.06	0.65
	Production	2.07	1.56	1.92	1.22	0.78	0.47	0.39
	Productivity	388	341	412	386	469	443	602

Source: *Directorate of Economics and Statistics, Department of Agriculture & Cooperation, Government of India.*

The area, production and consumption of millets in India have come down in the recent decades both due to demand side and supply side factors. There lies significant gap in both the demand and the supply side. On the demand side, the consumption of millets have come down due to increased consumption of other fine cereals, negative perceptions of millets as a food for the poor and policy neglect when compared to other crops. On the supply side, limited productivity of crops and their growing situations and lack of their processing centres in the vicinity which prevents the farmers from realizing additional yield benefits from the improved package of practices and additional income generation. The main reasons for declining the millets crops in India were found to be low remunerative as compared to other competing crops, lack of input subsidies and price incentives, subsidized supply of fine cereals through PDS, and change in the consumer preferences. These have led to shift from production of millets to other competing crops such as soybean, maize, cotton, sugarcane and sunflower in the country as a whole[1].

Consumption pattern

In the last two to three decades sorghum grain, especially sourced from *kharif* season are diverted to industrial uses such as livestock and poultry feed, starch, potable alcohol and ethanol production due to poor quality and mould affected grains. The declining trend in sorghum consumption and other nutritious cereals in general is attributed to the shift in dietary patterns of consumption towards a diet that includes more of livestock products, fruits and vegetables[26] which is mainly driven by an increase in income and urbanization wherein people are too busy to spend much time in preparation of their daily diet. Secondly, the shift is

due to the consumption of fine cereals which are supplied through PDS at subsidized prices. The annual per capita consumption of sorghum has declined by 75% in urban areas, and 87% in rural areas during 1972-73 to 2011-12.

Though millets are one of the earliest grains that are being cultivated and consumed by the people, in the last few decades India and the world have witnessed significant decrease in the area under the millets crops. The main reasons for decline of the millets crops in India are low remuneration as compared to other competing crops, lack of input subsidies and price incentives, subsidized supply of fine cereals through PDS, and change in the consumer preferences (NAAS, 2013). These factors had led to shift from production of millets (jowar in particular) to other competing crops such as soybean, maize, cotton, sugarcane and sunflower in the country as a whole.

Trends in Direct Consumption of Sorghum *vs* major Cereals in India

(*Kg/person/year*)

Commodity	1973-74	1983 -84	1993-94	2004-05	2011-12
Rural					
Rice	84.0	80.7	85.4	78	71.7
Wheat	42.8	54.3	53.5	51	51.5
Sorghum	**19.0**	**12.5**	**9.7**	**5.16**	**2.4**
Urban					
Rice	65.5	64.7	64.2	57	53.8
Wheat	52.6	58.6	57.4	53	48.1
Sorghum	**11.0**	**6.0**	**4.9**	**2.7**	**1.56**

Source: Compilation of Rao et al. (2018), Nutricereals for Nutritional Security, IIMR, Hyderabad.

Reasons for decline in millets area and consumption in India

Demand side factors	Supply side factors
1. Rapid urbanization	1. Increasing marginalized cultivation
2. Changing consumer tastes and preferences due to rising per capita incomes	2. Low profitability-low remuneration for millets vis-à-vis competing crops
3. Government policies favoring other crops such as output price incentives and input subsidies	3. More remunerative crop alternatives in *kharif* competing with millets in question
4. Supply of PDS rice and wheat at cheaper price introduced in non-traditional areas of fine cereals.	4. Decline in production and quality (as in *kharif* sorghum because of poor quality of grains due to blackening of grains, fetching low price to the farmers)
5. Poor social status and inconvenience in their preparation (especially sorghum) and	5. Lack of incentives for millet production and
6. Low shelf-life of grain and flour.	6. Development of better irrigation infrastructure / options as in small millets.

(Source: DMD, 2014; NAAS, 2013)

Biology, agricultural importance including climate resilience, world, India and Himalayan situations

Crop name	Climate adaptation	Crop duration (days)	Av.yield (kg/ha)	Adaptation for impacts of climate change
Finger millet	Wide adaptation up to 2300 m	90-130	1226	Moderately resistant to heat, drought and humidity, adapted to wide altitude range
Foxtail millet	Wide adaptation up to 2000m	70-120	565	Adapted to low rainfall, high altitude
Kodo millet	Tropic/ Sub-tropic up to 1800m	120-180	312	Long duration, but very hardy, needs little rainfall, comes up in very poor soils, good response to improved management
Barnyard millet	Wide adaptation up to 2000m	45-60	857	Very short duration, not limited by moisture, high altitude adapted
Little millet	Tropic/ Sub-tropic up to 2100m	70-110	349	Adapted to low rainfall and poor soils; used as famine food; can withstand water logging to some extent
Proso millet	Wide adaptation up to 3500m	60-90	323	Short duration, low rainfall, high altitude adapted

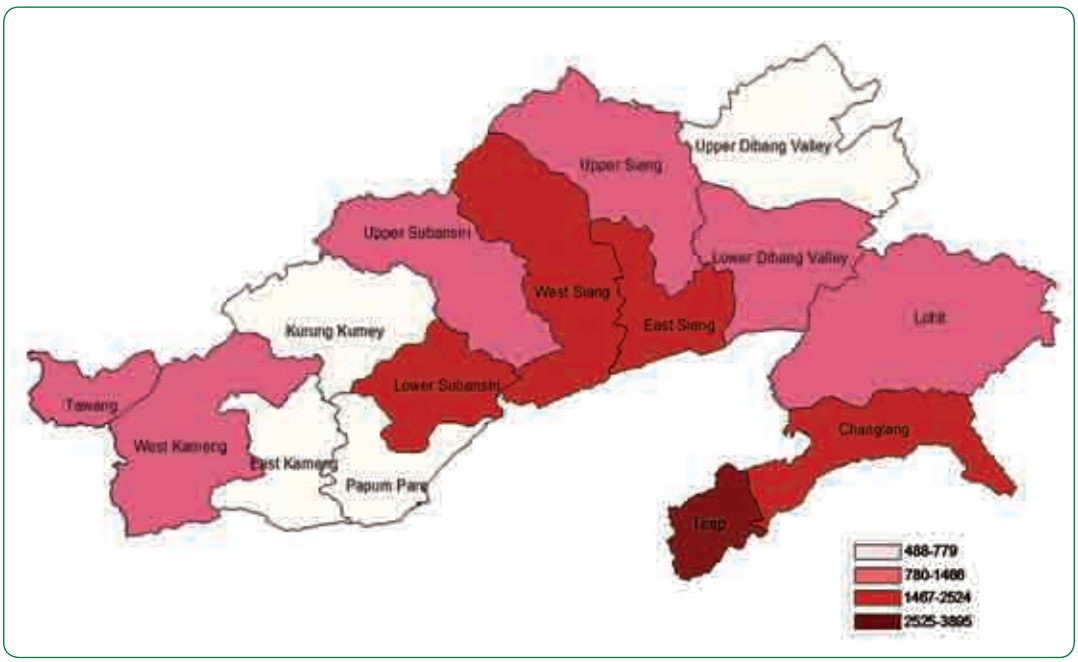
7

State-wise Millet Profiles in the Indian Himalayas

The area under millet crops and their production during the past 20 years have been profiled to understand the scope and future of cultivation of millets in these regions (see chapter 2 for crop-wise and state-wise statistics). The state-wise information have been summarized below.

Arunachal Pradesh

Small millets such as finger millet and foxtail millet are under cultivation in limited area in Arunachal Pradesh. Recently, KVK, Lohit, has introduced forage jowar in the area to overcome the fodder crisis in summer season and the results have been encouraging, enabling enhanced fodder availability.



Cultivated area under millets (ha) in Arunachal Pradesh

This ancient and traditional Jhum agriculture system is the backbone of food supply in the state. Even when there was no supply of food grains and vegetables from other sources, this traditional agriculture practices helped them to fight during the lean season. Besides rice, millets like foxtail millet, proso millet, finger millet and pearl millet and a wide array of other edible plants, under jhum cultivation, provide varieties of indigenous food items throughout the year for traditional used such as ceremonies, occasions and celebrations. Moreover, due to the undulating hilly terrain, high rainfall, poor irrigation facilities and unavailability of plain land, the permanent type of settled agriculture or terrace cultivation was not much successful in this area. Hence, jhum cultivation became the only feasible means for sustenance.

Productivity of Millets (kg/ha) - Arunachal Pradesh

Interventions: Under NFSM, distribution of quality seeds of jowar, bajra, finger millet and foxtail millet and to farmers in suitable areas are planned by the central and state governments.

Future action plan: Provision of seeds of improved cultivars of small millets such as finger millet and foxtail millet which are being cultivated under local varieties and development and dissemination of improved package of practices for the state for these millet crops is a priority.

Assam

Jowar and bajra are not generally grown in the state and small millets are cultivated in hilly regions, sometimes as a part of jhum cultivation (e.g., in Karbi Anglong district) where productivity would be naturally lower. Foxtail millet and barnyard millet are in cultivation in the state.

Cultivated area under millets (ha) - Assam

Productivity of Millets (kg/ha) - Assam

Future action plan: Adoption of improved cultivars of foxtail millet and barnyard millet which are already under cultivation using local varieties and development and dissemination of improved package of practices for the state for these millet crops is a priority. Finger millet, another nutritious millet can be popularized in the state for its nutritional merits. Forage sorghum and forage pearl millet can cater to fodder needs of the cattle.

Jammu and Kashmir

Bajra is the major millet crop presently grown in the state and the productivity levels are very low, highlighting the need to adopt suitable package of practices including improved cultivars to sustain bajra cultivation in the state**.** Bajra has a special importance in unirrigated plain area of Jammu and Kathua districts. The yield of the crop is low because of local seed and local cultivation practices.

Jowar is suited the suitable crop for the Kandi belts of Jammu division. Some area under jowar was also reported in some districts such as Kishtwar, in earlier years, which has now been evidently diverted for other beneficial crops.

Foxtail millet (local ‘‘Shol’’ or ‘‘Kangni’’) and Proso millet (local ‘‘Ping’’ or ‘‘China’’) were cultivated throughout Kashmir till several decades ago and are presently grown in negligible areas. Foxtail millet was more common and was sown as substitute for paddy, when it was apparent from snowless mountain peaks that water availability will not be adequate for cultivation of latter. Proso millet was sown in rainfed drylands. Husked grains of these crops were hard to cook and were eaten as porridge. In some places both these millets are grown in mixed cropping for fodder.

The Doda and Kishtwar districts have a wide range of local high value crop cultivars among which prominent are saffron of Kishtwar, drought tolerant millets like foxtail millet (locally known as shol) and proso millet (local name is ping) grown in low rainfall areas, in the month of May. Good yields are realized using local varieties in Paddar area of Doda.

Historical perspective

Palaeobotanical studies at Qasim Bagh, a site of the Northern Neolithic culture in the Kashmir Valley, India, have produced important new data on the spread of agriculture across Inner Asia, and on the cross-transmission of Chinese and West Asian cultivars. Directly dated proso millet and compact wheat, and a series of charcoal dates suggest that the Valley of Kashmir was integrated into a wider network of crop exchange in the mountainous regions of South and Central Asia from at least the 5th/4th millennium BP transition (Spate et al., 2017). The evidence of Qasim Bagh supplements recent data from other Central Asian sites which suggest that exchange of East and West Asian cultivars took place earlier than previously believed. Valley of Kashmir was integrated into a wider network of crop exchange in the mountainous regions of South and Central Asia during the 3000-2000 BC period.

Lawrence ER (1895), in the book “Valley of Kashmir” (Published by Henry Frowde, Oxford University Press Warehouse, Amen Corner, E.G. London) wrote that in the Kashmir valley, rice grows in the delta and uppoer areas, but at a height of 7000 feet of the Kashmir valley

the rice is replaced by the millets. He described that “among millets, shol (foxtail millet) and ping (proso millet) are the important autumn (kharif)crops. In the traditional method of apiculture, in a bad year vegetable marrow and kangni, a millet, are given to the bees. Kangni or Shol (foxtail millet) is an extremely useful plant, it is apparent from the look of the mountains that snow water will be scarce a large area of rice land is at once sown in kangni. The land, if a good crop is hoped for, must be carefully ploughed about four times, and the seed is sown in April and May about the same time as rice. Some weeding is done, but as a rule the hardy kangni is left to look after itself until it ripens in September. The grain, which is husked like rice, is not esteemed by the Kashmiris as a food, as it is considered to have heating properties. There are two varieties of kangni, the smaller and the greater, and the former is preferred as a food. The former is a red grain and the latter white. An average crop gives about three maunds (approx. 1.2 quintal) per acre.”

“China or Ping (proso millet) is very like rice in appearance, but is grown in dry land. The field is ploughed three times, and after sowing cattle are turned on to the land and tread the soil down. The seed is sown in June and the crop is harvested in September. It is occasionally weeded, but like the katigiii, with which it is always associated under the official name ‘ cheap food stuff,’ the china does not receive much attention. As a food it is not considered either pleasant or nourishing, and whereas the kangni is abused for being hot, the China is denounced as being cold. It is a troublesome grain, as it is very hard and takes a very long time to cook. It is red or white in colour and is husked like rice in a mortar. An average crop would be about four maunds (approx. 1.6 quintal) per acre”.

Future action plan: Interventions by state and extension agencies for matching the bajra production efficiency of the state with that of national levels is the immediate requirement to arrest the dwindling cultivation of this crop in the state. Exposure of the interested farmers to other millets may initiate cultivation of those nutricereals in the state benefitting the resource poor farmers and nutritional security of the consumers.

Himachal Pradesh

Small millets were extensively grown in the state by different tribal populations and the extent has gradually come down with some of them disappearing from some districts. Finger millet, proso millet, foxtail millet and kodo millet were historically known to be grown in the state.

Area under small millets in erstwhile Punjab Province in 1940s

(includes Himachal Pradesh region of Shimla, Kangra, etc., among others)

Millet Crop	Punjab/ Himachali name	Average area for the quinquinneal year ending 1940-41 (acres)	Remarks
Finger millet	Ragi/ Mandal	21,000	White grain preferred for human consumption over brown; Grain yield-4-5 q /acre; Fodder yield: 11q/acre; Green fodder crop (3 cuts) yield: 56q/acre
Foxtail millet	Kangni	9,500	Mostly used as feed for birds and famine food; Grain yield-2.5q/acre; known for medicinal properties
Proso millet	Cheena or Charai	30,000	Mostly for green fodder for cattle and horses; Grain yield-1.5-2q/acre; known as nutritious crop
Little millet	Swank	26,000	Consumed by poor people and Hindus during fasting and Lohri festival; Grain yield-1.5-2.5q /acre; Green fodder crop (3 cuts) yield: 37-56q/acre
Kodo millet	Kodra or Katai	800	A minor crop of the province

Source: Roberts and Singh (1947)

These millets are mainly grown on poor soils. A major portion of the area under these millets is fed to livestock as green fodder. Though used as food by certain number of people of the hilly districts and also by some in the plains, the grains of inferior millets are not considered as wholesome article of diet, though Even in nutritive ratio these millets compare favourably with maize, wheat and barley.

Cultivated area under millets (ha) - Himachal Pradesh

Productivity of Millets (kg/ha) - Himachal Pradesh

Finger millet (Ragi/Mandal)

This is principally grown in the hills and some of the sub-montaneous districts. Ragi is mainly grown in Kullu, Mandi, Kangra and Sirmour districts of Himachal Pradesh (Kumar, 2013). The grain is eaten by poor classes as a staple food in the hills. It has excellent storing properties being free from insect attacks and not liable to become mouldy. For this reason it has been used for storage against scarcity and famine. There are two types generally grown- black grained and white grained. White grained type is preferred to the other when grain is to be utilized for human consumption but for obtaining fodder both are equally good.

One of the indigenous fermented alcoholic beverage widely consumed in Himachal Pradesh is sur. Sur is a ragi based fermented beverage mostly prepared in the Lag valley of Kullu district, Chhota Bhangal area of Kangra District and Mandi (Joshi et al, 2012).

Foxtail millet (Kangni)

It is largely grown in Kangra and has a wider range as regards season than other millets and is often grown after famines when quick return is required. The crop is often sown on manured lands near the villages in hill valleys in May-June. Unlike other small millets, its

grain is very little used as human food. The grain is generally fed to poultry and cage birds. Whenever taken as human food it is boiled like rice. When boiled with milk it forms a light and pleasant meal for invalids. Medicinally it is said to act as diuretic and astringent and is sometimes used externally in the case of rheumatism.

Proso millet (Cheena)

This is of little economic importance except as an early fodder or grain crop. For this purpose it is sown in March and is ready for green fodder in the month of April. The fodder is relished by cattle and horses. For grain, the crop is harvested in May and June. It is considered to be nutritious and in many places it is eaten after cooking like rice or taken with lassi, the preparation being called Mat. Cheena is integral to the traditional food and food habits in the Gaddi shepherd family of Chamba.

Little millet (Swank)

This is the quickest growing plant of all the millets and is supposed to ripen within six weeks to two months after sowing. It is usually sown broadcast and is often grown for green fodder, or cheap grain in August and September before bajra is ready. The grain is chiefly consumed by poorer classes of people. Hindus consider it to be a very sacred grain and it is preferred by them for religious offerings. On Ekadashi festival it is taken by them in different ways and forms. At Lohri festival also, they start and break the fast with this sacred food.

Kodo millet (Kodra)

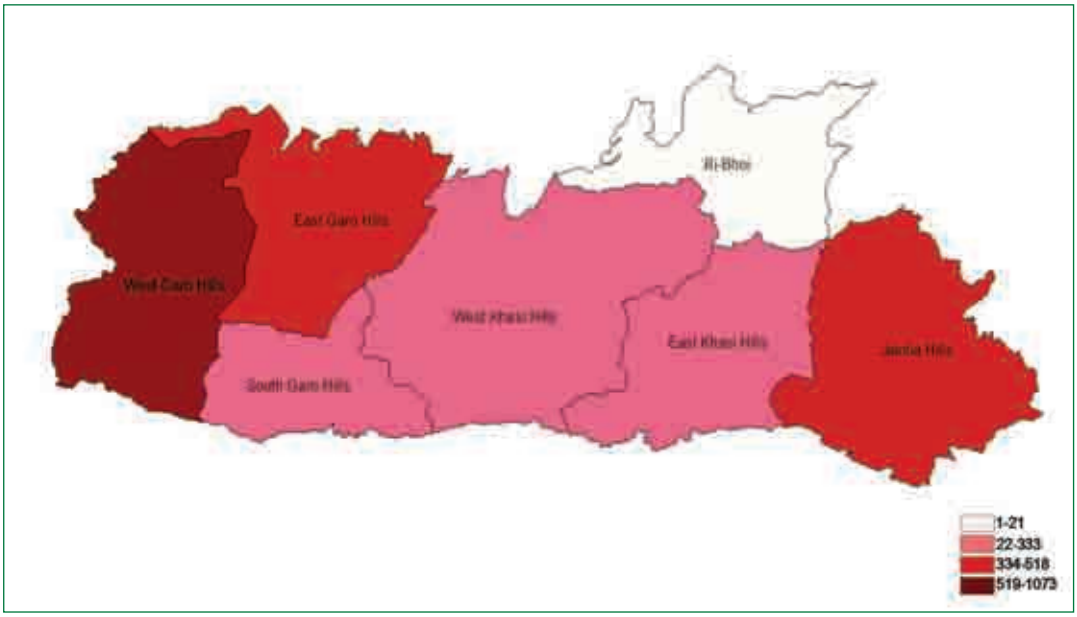
It is only grown in Simla district and that too, to a small extent.

Manipur

Very little documented area and production of millets is available for this state. Millets are a part of jhum cultivation. Paite tribals and Thadou-Kuki ethnic group cultivate millets through Jhum. On the Mim Kut (first harvest festival; mim= job's tears), day, every family offers the first fruits of their Jhum fields to the spirits of their family members who had expired. These include fruits, maize, millets or Job's tear. The millets are made as cake and offered on this occasion.

Meghalaya

Ragi and foxtail millet are grown in nearly one thousand ha each in the state. The productivity levels of the millets are very low compared to national average. Krai-truh is the common name of finger millet in Khasi Hills of Meghalaya. Jowar is not generally grown in the state whereas some limited cultivation of bajra is recorded. Small millets are cultivated in hilly regions, including jhum cultivation systems.



Cultivated area under Millets (ha) - Meghalaya

Productivity of Millets (ha) - Meghalaya

Raishan (*Digitaria cruciata* var. *esculenta* Bor) is a millet crop endemic to the Khasi hills of Meghalaya. It is a minor cereal cultivated in the Khasi hills (Singh and Arora, 1972). It has longer racemes than the wild form, and a turgid, persistent grain. Raishan was domesticated in the late nineteenth century by Khasi natives in Meghalaya and is cultivated only in the Khasi Hills. It is a cold tolerant grass used for food and fodder. During the Khasi lunar month of U Nai wieng (November), the farmers harvest the paddy, they cook raishan and rice cakes in wieng or big earthen pots to feed the people or helpers in their field. The people of clan (Kur) of Rynjah do not eat the grains of (k)raishan, which indirectly helps in conservation of the plant. Singh and Arora (1972) reported that raishan yields up to 800 kg/ha.

Future action plan: Adoption of improved cultivars of small millets which are already under cultivation using local varieties and development and dissemination of improved package of practices for the state for these millet crops is a priority.

Mizoram

Sato or millet is a part of the staple food of the Mara tribe of Mizoram, who practice shifting cultivation – juhm. Millets such as sorghum (faisa), pearl millet (bhutun) and small millets are part of their jhum cultivation. No details and statistics of cultivation of millets in the state are available. Some of the extension agencies are trying to popularize suitable millets in the state.

Nagaland

This is a state where all millets- Bajra, jowar, ragi and small millets are cultivated though in very small acreages. The productivity levels are generally lower than national average, especially in finger millet.

Cultivated area under millets (ha) - Nagaland

Productivity of Millets (ha) - Nagaland

Millets form important survival foods during natural calamities in Nagaland. Millet based food crop farming has helped the survival needs of the subsistence farmers. Millets are mainly grown in the districts of Phek, Tuensang, Kiphire and some areas of Kohima. Traditionally millets were commonly known for making brew and formed an integral part of community diet. But in recent times, value of millets has increased to a large extent. Millet cluster of crops are also the survival crops when water is limited and people are solely dependent on erratic rains. Millets are not grown as a monocrop in settled farms but they are mostly combined with tubers, vegetables and oilseeds as a cluster crop in forest farms and jhum fields. Millets have a resilient capacity to withstand droughts, soil infertility and pest attacks which sustains the livelihoods of millions of food crop farmers whose lives and livelihoods are blended into the natural spaces. Millets connect generations with its climate resistant capacity and nutritional strength which is higher than other staple diets like rice and corn.

As an agrarian society, the Angami Naga tribe celebrates “Tsiinyi” or millet festival, in the month of August, to mark the completion of millet harvest. (source: Zetsuvi, S Ketholesie., Traditional culture of the Angami Nagas, HPH books, Dimapur, 2014, First Edition). Millet kichdi and millet apang are common dishes and millet consuming tribes in Nagaland.

Credit: North East Network

North East Network-Nagaland, a women's rights organisation, millets have been revived in Chizami village of Phek district of Nagaland

Future action plan: State government may emphasize on improving sustainability and efficiency of small millets cultivation. Improved varieties, and efficient and sustainable cultivation practices of all millets need to percolate to farm level to promote millet cultivation in the state

Sikkim

This is an organic agriculture certified state and millets form an ideal crop to adopt in the state profile with no synthetic inputs and provide superior nutrition. With only small millets (mainly finger millet) being grown in the state, there is a scope to increase area under organic agriculture as millets offer a means to make farming more beneficial with minimum inputs for cultivation.

Finger Millet cultivation in South Sikkim-Lingmoo area

Cultivated area under millets (ha) - Sikkim

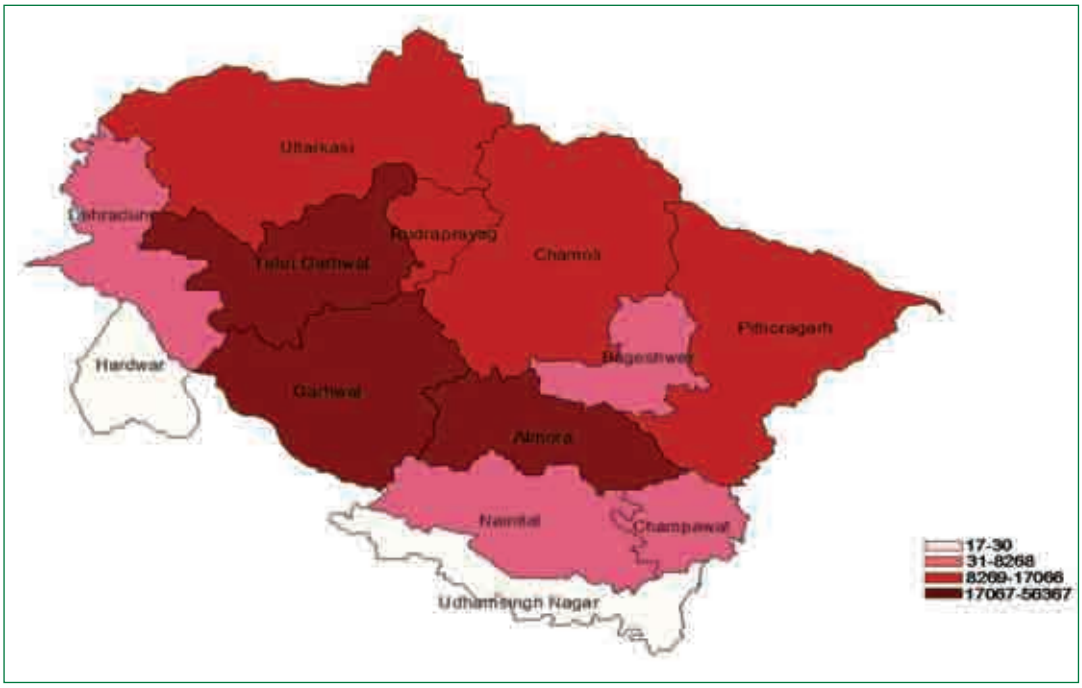
Productivity of Millets (kg/ha) - Sikkim

Future action plan: Introduction of improved cultivars of millets with efficient organic farming techniques can augur well for the state agriculture. The nutritional benefits along with organic label can enable fetching premier value in the market.

Uttarakhand

Uttarakhand state has more area under finger millet (1.08 lakh ha) and small millets (0.6 lakh ha) with yield levels per unit area surpassing the national average in both cases. Moderate climate with relatively more fertile soils with protective moisture provisions account for the higher productivity in the state. Most of the produce in consumed in the households themselves, leaving less marketable surplus.

The major crops of *kharif* season, among others, include barnyard millet, finger millet, foxtail millet, among others. During *kharif* season mixed cropping (baranaja), as complete mixtures, of millets, legumes, amaranths, buckwheat, sesame, etc. is a common practice in some areas. Lack of formal seed exchange system of traditional landraces is one important limiting factor to continued survival of these landraces especially those grown by marginal farmers.



Cultivated area under millets (ha) in Uttarakhand

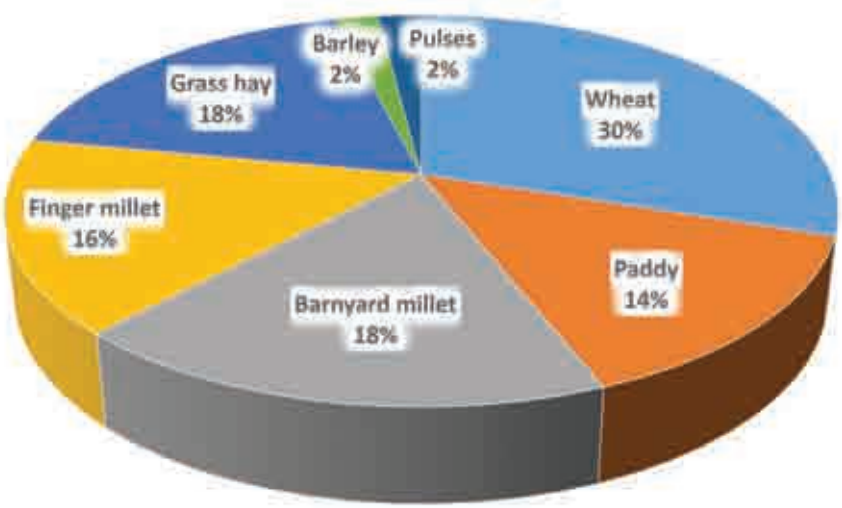
Productivity of Millets (kg/ha) - Uttarakhand

Within the past less than a decade, some of the crops cultivated previously have become locally extinct from many villages. Foxtail millet has almost become extinct from the state which was widely cultivated about 20 years ago. As it was matured 15–20 days before barnyard millet, it was one of the important crops of the Baranaja system. The dishes prepared from foxtail millet had a high nutritive value. Besides, Sorghum was also cultivated by the villagers in the past about 3 decades ago, but now its cultivation was also stopped. (Kala, 2010).

Production of finger millet and barnyard millet doubled compared to three years ago. To further increase this, the Department of Agriculture has kept the new target. In this way, in the coming years, the production of remaining millet crops, might also increase. Statistics show that in Uttarakhand, traditional crops like finger millet and barnyard millet are getting good market. Finger millet grain yield was 6 to 7 quintals per hectare in the year 2014-15 whereas in 2017-18, it reached 12 quintals per hectare. Now the market is getting a decent price for these crops (Rajyasameeksha, 2018). Barnyard porridge is a famous dish in Uttarakhand (locally called as madira ki kheer).

Millets in Uttarakhand

Millet Crop	Local name	Local varieties
Finger millet	Ragi/ Mandal	Nangchuniya, Tokaria, Putkya, Garhwalo, Jhankaria, Bhuwakhetia (round head inflorescence variety), Lumariyaw, Dhuniyaw, Lal madu (red grains), Safed Madu (whitish grain), Garau, Putki, Dwit, Ganoli, Gol Madu (fingers closed), Timasi (matured in three months), Chhaimari (matured in six months), Chaumasi (fingers smaller as matured during rainy season), Chhitalu (fingers open and drooping), Nangchuni (The ears can be removed with the help of nail after maturation), Katuriya Mandua (big or long fingers and closed).
Barnyard millet	Madira, Jhangora, Sanwa	Thul Madira (The ears long, thick and red), Nan Madira (The ears small, ash coloured, and taste), Jharu Madira (Wild relatives of Madira), Bhatkkahnti Madira (Grains easily removed from the ears after maturation)



Proportion of different sources of dry fodder contributing to livestock feeding in Uttarakhand

(Singh and Gaur, 2008)

Millet-based highly diverse cropping systems

Finger millet: The grain is mainly consumed in the form of porridge and bread, but a major part of the produce is utilized for preparing the beverages. Little and proso millets are generally grown as a rainfed crop, sown to coincide with the onset of the southwest monsoon. In the Himalayan foothills of Uttar Pradesh and Himachal Pradesh it may be grown either as an early- or late-summer crop. [Kimata, M., S. G. Mantur, et al. 1997. "Cultivation and utilization of small millets in hill regions, Uttar Pradesh and Himachal Pradesh, India', Environmental Education Studies, Tokyo Gakugei University 7: 33-43.]

Barnyard millet: The release of variety PRJ 1, which was a direct selection from ICRISAT germplasm, in 2003 for Uttarakhand state is among few notable examples of effective utilization of barnyard millet germplasm. The variety yielded 45.4% higher than the check variety VL 29 (Upadhyaya et al., 2008). PRJ 1 belongs to *Echinchloa esculenta*, whereas all the existing adapted material in Uttarakhand hills was of species *E. frumentacea*. Much, therefore, needs to be carried out to enhance utilization of barnyard millet germplasm for genetic improvement of the crop.

Postharvest Processing: To support barnyard millet growing farmers, Singh et al. (2003) at VPKAS, Almora, developed Vivek Millet Thresher 1, which can thresh 40–60 kg barnyard millet grains per hour. This machine is suitable for marginal farmers in hilly and tribal areas due to its low cost, small size, light weight and ability to do both threshing and dehusking. The machine can dehusk 5– 6 kg grains per hour by changing the sieves but require 3–4 passes.

Future action plan: As the state has lost substantial area of millet cultivation, bringing it back can be achieved by offering good market for the produce. Besides, the efforts of NGOs, self-help groups, FPOs can revive the millet cultivation with complementary policy support. Inclusion of millets in PDS and MDM coupled with procurement would be rewarding to the state millet farmers.

Vivek Thresher-cum-Pearler for Finger millet and Barnyard millet was developed by Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR), Almora (Uttarakhand).

West Bengal

The state of West Bengal has very less area under millets except for the Darjeeling district that has nearly 0.1 lakh ha under ragi with yield levels matching the national average. Small millets such as foxtail millet are also grown in limited areas in Coochbehar and Darjeeling districts. Tongba, a local brew like a beer which is prepared from millets by fermenting with yeast is popular.

Future action plan: The state may promote cultivation of millets in suitable hilly regions and can realize yield levels of other hilly states such as Uttarakhand. Millets such as bajra and jowar may be popularized in dry and rainfed regions.

8

Millet-based foods in the Indian Himalayan Region

The Himalayan people have developed the ethnic foods to adapt to the harsh conditions and environment. The intake of such foods has been in the systems for centuries and people have adapted such foods to protect and sustain them. People living in high altitude (>2500) are adapted to cereals and food grains grown in dry and cold climates, with less vegetables and more meat products. More diversity of food items ranging from rice, maize to vegetable, milk to meat is prevalent in the elevation less than 2500 to 1000 m. Ethnic foods possess protective properties, antioxidant, antimicrobial, probiotics, bio-nutrients, and some important health-benefits compounds. Due to rapid urbanisation and development, introduction of commercial ready-to-eat foods had adverse effects on production and consequently consumption of such age-old cultural ethnic foods is declining. The people should be ascertained about the worth indigenous knowledge they possess, and biological significance of their foods. Detailed health status in terms of consumption of both fermented and non-fermented foods and their cultural adaption need to be carried out urgently (Tamang et al. 2010).

Food Culture

There are two categories of ethnic foods-fermented foods and non-fermented foods. More than 150 varieties of ethnic fermented food and alcoholic beverages and drinks, more than 300 types of non-fermented ethnic foods, and about 350 wild edible plants are consumed in the Himalayas as staple, snacks, side dish, curry, soup, confectionery, condiments, refreshing, disserts, pickles, alcoholic drink, savoury, masticator and stew. Each food prepared by different ethnic communities in the Himalayas is unique and unparallel, due to wide geographical location, food preference, climatic conditions, and availability of plant or animal sources. The Himalayan culture is wedged between the Buddhist-Mongolian culture in the north and Hindu-Aryan culture in the south, hence, the Himalayan food culture is a fusion of the Hindu and the Buddhist cuisines with modifications based on ethnical preference and social ethos over a period of time. Rice or maize is a staple food in Sikkim and Arunachal Pradesh, whereas barley or millet is a staple cereal in Ladakh. Bhat-dal-sabji-tarkari-dahi/mohiachar combination, which is corresponding to steamed rice-legume soup-vegetable-curry-curd/butter milk pickle, is a typical recipe of every meal in the Eastern Himalayas.

Ladakhi, Tibetan, Bhutia, Mongpa, Drukpa and Lepcha usually eat tukpa (noodles in soup), skiu or momo (small dumpling of wheat flour with meats), baked potato, tsampa (ground roasted barley grains), chhurpi (cottage cheese), kargyong and gyuma (sausages), butter tea and chyang (alcoholic beverage).

Drinking of locally fermented beverages and distilled alcoholic drinks is the social provision among many ethnic Himalayan people. Alcoholic beverages locally called kodo ko jaanr or chang made from fermented finger millets or barley are common in Sikkim, northern part of Arunachal Pradesh and Ladakh. In high mountains (>2500 m), yak milk and its products are popular food items. The Himalayan food is less spicy and prepared in butter made from cow milk or yak milk, but now commercial edible oil is also used. Majority of the Himalayan ethnic people are non-vegetarians except the Brahmin communities belonging to Hindu, who are strict vegetarians. Non-vegetarians eat chicken, mutton, lamb, chevon, pork, beef, buffalo, yak, fish, etc. Beef and yak is taboo to a majority of the Hindu communities.

In Uttarakhand, finger millet is eaten as roti, barnyard millet as paleu or chencha, a savoury porridge cooked in buttermilk. Zan is the most popular porridge recipe of Monpa tribes of Arunachal Pradesh made from finger millet and vegetables.

Millet based foods

A. Cooked Food

Zan

Zan is the most popular porridge recipe of monpa tribes of Arunachal Pradesh.It is prepared using millet flour. They have this as breakfast before going to work. It is nutritious and keeps one full. They usually add salt and consume it or with some meat, fermented soya beans, veggies and fermented cheese.

Zan, the popular finger millet porridge recipe of Monpa tribes of Arunachal Pradesh

Panchkuti Khichdi

Himachal Style Panchkuti Khichdi recipe is a pearl millet preparation with five different kinds of dal cooked in one pot. The Panchkuti has a goodness of all the dals that will benefit you in one dish. The whole spices are tempered with ghee and then poured over the khichdi which gives a distinct aroma and helps to lift up the flavor of the dish.

Himachal Style Pearl millet Panchkuti Khichdi

Source: Archana's kitchen

Finger millet/Kodra/Mandua ki roti

Some 25-years ago there was a limited variety of foods in Kullu Valley. Paddy and maize were the main crops in mountains as climate was favorable for growing these crops. Kodra (cereal) and Salyara formed the daily meals of people. Kodra was considered to be an energetic food as it contained iron. Kodra roti (Finger Millet bread) were cooked in every house. Presently it is occasionally prepared by the people of Kullu Valley.

Mandua Ki Roti (Chapatis) in Uttarakand are gluten free and extremely easy to digest, it is rich in protein and calcium. With ample fibers it is good food for diabetes. Mandua in other places are known Ragi or Finger Millets. In the hills of India they are part of regular diet regime due to which perhaps people living in these hills are so fit and rarely fall ill.

Kodo ko roti – Sikkim

Photo credit: Krish Dulal - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=62493221

This is also known as Kodo ko roti in sikkim and Temae Tan in Manipur. Generally served with tomato achar, Kodo ko Roti is made from finger millet. Although it looks like a pancake, it has a subtle sweet taste as well.

Traditional millet based foods of Himachal Pradesh

Product	Raw material	Method	Area
Tchhoso roti	*Kodra* flour, fats	Thick *roties*, occasional food.	Lahaul Spiti

Source: Savitri and Bhalla, 2007

Baadi

Baadi is a dish of Uttarakhand, made out of finger millet flour. Baadi is best eaten with Gahat ki dal or Phaanu. This dish is tasty as well as health to eat. Baadi has high nutritional value, and is a ready to cook dish. You need to boil water, add mandua in it and let it cook for few minutes. For more taste add ghee in it.

Baadi from Uttarkhand

Traditional millets staple foods of Uttarakhand

Local food name	major ingredients
Madua/Jhangora ka bhat	Barnyard millet
Madira/Jhangora ki roti	Barnyard millet flour
Madua ki roti	Finger millet flour
Lesuwa roti	Finger millet and wheat flour
Kauni ka bhat	Dehusked Foxtail millet
Kauni ki roti	Dehusked Foxtail millet
Ginjada (Madira)	Dehusked Barnyard millet and black soybean (bhat)
Ginjada (Kauni)	Dehusked Foxtail millet and black soybean (bhat)

Source: Mehta et al. (2010)

Traditional millets sweet dishes of Uttarakhand

Local sweet dish name	major ingredients
Madira/ Jhangora ki kheer	Barnyard millet (dehusked seeds), milk
Kauni ki kheer	Foxtail millet (dehusked seed), milk
Madua ki badi	Finger millet flour, jaggery
Madira/Jhangora ka halwa	Barnyard millet (dehusked seed)

Source: Mehta et al. (2010)

Jhangore ki Kheer

It is a delicious Pahari dessert made using jhangora (barnyard millet), milk, sugar and deliciously garnished with kewra essence, almonds and raisins. This scrumptious dessert is prepared on festivals and special occasions like Diwali, Holi, Birthday, etc.

Jhangora ki kheer

Palau

Palau is a mixture prepared with the help of boiled Jhangora and Mattha (butter milk) in Uttarakhand. Jhangora and Mattha are its main ingredient which are beneficial to our body in many ways. Like other dishes this dish do not require many ingredients and thus its simple to prepare.

Juma

Juma is a favorite dish of Lahaul Spiti prepared in winters. Wheat flour/millet flour is mixed with spices and this paste is stuffed in sheep intestines. This is then steam cooked and eaten hot with chutney or tchati (mutton soup).

Other traditional foods of Himachal Pradesh

Product	Raw material	Form	Area
Juma	Sheep intestines	Wheat/millet flour dough stuffed in sheep intestines.	Lahaul Spiti

Source: Savitri and Bhalla, 2007

B. Fermented food

Traditional fermented foods and beverages occupy special place in North-Eastern states of India due to their nutritive value, taste, health aspects, social, ritual and cultural importance. Fermentation is one of the oldest and relatively low energy yielding process and an easily manageable preservation technique which increases the shelf life of food products. It improves the nutritional quality of food by developing suitable physiochemical characteristics and gives tastes, flavor and texture to the food. Alcoholic beverages are one of the important fermented products prepared and consumed by indigenous tribes of India since the time immemorial. In the North Eastern region of India, most of the fermented beverages are pro-

duced manually and locally using traditional practices. Beverages are the drinks which have stimulating and refreshing qualities and occupy an important position among various tribes of Himalayan States due to their festive, cultural, ethnic and nutritive values.

Sura

In some tribal areas of India including Himachal Pradesh, the preparation of customary alcoholic beverages and the consumption are permitted at home scale**.** There are a number of popular cereals and fruit based fermented alcoholic beverages prepared and consumed traditionally in rural areas of Himachal.

Sura is a finger millet based brown-coloured fermented beverage mostly prepared in *Lug* valley of Kullu district, Chhota Bhangal area of Kangra, and Mandi of Himachal Pradesh (Savitri and Bhalla, 2007). It is prepared by natural fermentation of finger millet flour. Flour is knead in the form of dough and is kept for 10 days in a container. After 10 days half-baked *roties* are made, put in to container and water is added. After two days, *dhehli* made from traditional herbs is added and it is kept for 8-10 days for fermentation. *Sura* is consumed during local festivals like *shoeri saja* and marriages in rural area in Kullu especially lug valley.

Madua Apong

Apong and Madua Apong are the two commonly used beverages of Arunachal Pradesh produced traditionally from rice and millet respectively under uncontrolled fermentation. Madua Apong is a dark red colored organic wine made up of Temm [Millet] among the tribes. These are commonly brewed by the Nyishi Tribe (Srivatsava et al. 2012). It is more than a brewed wine for Nyishi tribe, for them, it is a part of their identity and religion. It plays a key role in the traditional Nyishi tribal community as it is related to shamanic observance, ritualistic values, and folk tales. The Nyishi tribe celebrates Nyokum Yullo Festival annually in the month of February and during the Festival, Apong is served as a staple, given to everyone, yet it is not a social drinking session and it is a holy event to invoke the blessing of Nyokum goddess.

How is Apong made: After harvesting of millet from the fields, it is sun-dried or in some cases above the traditional fireplace inside the kitchen. It is then dry roasted till it gets a blackish color in a large wok stirring continuously to avoid burning. Spread the roasted millet on the ground on a bamboo mat to cool down. After the millets have cooled down it is mixed with crumbled cakes of *Ipoh* (local yeast made by grinding rice) and its transferred to an airtight container for the fermentation process to begin. It takes a month or so for the fermented stock to start emitting a strong smell to show it is ready. During this time, the container is stored in a cool dry place. Subsequently, the mixture is distilled to collect Apong.

The starter culture for alcoholic beverage preparations is done in differently by different tribes of Arunachal Pradesh (Srivatsava et al. 2012). A millet-based starter culture is practiced by the people of *Khowa* tribe, who use a small quantity of millet also along with rice (for 1 kg of rice, about 300 g of millet is used).

Apong served by Nyishi tribe women

Chang/ Kodo ko jaanr

The most popular fermented finger millets-based mild alcoholic beverage with sweet-sour and acidic taste is kodo ko jaanr or chyang or chee prepared and consumed by the Gorkha, the Bhutia, the Lepcha, the Monpa and many ethnic groups of Himalayan region (Rai et al., 2012). Traditionally, it is made from fermented finger millet and served on a bamboo container which is traditionally called the 'Tongba' and is sipped using a bamboo pipe/straw. The millet filled Tongba is usually topped up with warm water and allowed to settle for 5 min after which a blunt bamboo pipe/straw with perforated sides is inserted to drink it. The blunt end blocks the millet while the perforation acts as a filter to the water and alcohol pass through. Every now and then as the Tongba becomes dry, warm water is poured into it until the millet loses its flavor.

The local Lepcha community of Sikkim calls the drink *Chi* and offers it to their deities during most of their religious ceremonies. Besides Sikkim, and other NE states, it is prepared in Darjeeling as well.

Source: Tamang, Jyoti Prakash; Okumiya, Kiyohito; Kosaka, Yasuyuki (2010) Cultural Adaptation of the Himalayan Ethnic Foods with Special Reference to Sikkim, Arunachal Pradesh and Ladakh. Himalayan Study Monographs 11: 177-185

Chang, though is a mild-alcoholic, sweet-flavored beverage, as it has high calories, vitamin content, beneficial lactic acid bacteria, and yeast, is considered more as food than an alcoholic beverage. combination of finger millet and sorghum to be the best substrate in terms of total quality and overall acceptability (Ray et al., 2016).

Synonym of Chang(Chaang/Chyang) are-Mandokpenaa thee (called by Limbu community), Sampicha ummaak (rai), Naarr paa (Gurung) Saangla chi (Tamang), Chirs Shyaabu (Sunwar), Paadaare haan (magar), Gyaar chyyaang (Sherpa), Minchaa chhyaang (bhutia), and Mong Chee (Lepcha).

Some of the indigenous local varieties of finger millet of these regions are ‘mudke’, ‘nangrey’, ‘fyakre’, ‘nangkatwa’, etc. Improved varieties have also been introduced in these regions.

Chang is the welcome drink in areas where it is prepared/Wikipedia Commons

Vitamin cynocobalamin, which is not present in finger millet, is synthesized by the fermenting microorganisms. The essential amino acids like valine, threonine, leucine and isoleucine are in higher concentration in chang. Because of high calorie, ailing persons and post-natal women consume the extract of Chang to regain the strength.

Tongba Chowk in Nepal, featurea a huge Tongba vessel, the container used to drink chang

9

Seed systems in the Indian Himalaya for Millet Crops

Millets have been integral to the traditional seed systems in the Himalayan states of India. In the subsistence farming practiced in these regions, household seed saving and seed exchange have been the major culture with little scope for seed marketing. Seed production and storage have unique ways of doing them in different cultures and regions, depending on the crops. These had been the result of biocultural innovations developed by communities in response to climatic and socioeconomic dynamics.

Millet seed storage vessel in Uttarakhand/Photo Credit: Vijay Jardhari

Storage of seeds in cylindrical pits, baked clay pots, earthen granaries, containers made of ropes plastered with mud, are the common seed storage structures while hanging the seed-bearing earheads is seen in some places. Many farmers use local herbs and plants as pesticides to save them from insect pests.

One well documented method of crop diversification that is integral to traditional seed sustenance systems is the baranaja (12 grains) mixed cropping system in Uttarakhand. This included several millets besides pulses and oil seeds. The system also augurs well for seed conservation, besides biodiversity, nutritional security and sustainability.

Storage of cereals is an important traditional measure, especially in hilly areas, to mitigate the impact of unusual climatic conditions. In Uttarakashi, Garhwal and Uttarakhand, grain stores are wooden structures looking similar to small temples called “kothar.” It was shared by members of local community, in many places, that reason behind keeping the kothar outside the house was to protect the damages of grain from possible risk of fire, as most of the houses were made of wood in past.

Kothar, storage structure for millets and other cereal crops in Garwal

Seed exchange was also known to occur in the jhum cultivation within and between communities. For realizing higher yield potentials, inadequate supply and poor public distribution of quality planting material and seeds of crop varieties is a major challenge in the Himalayan region, as even state governments are not able to even arrange for minikits and input supplies due to logistic limitations.

(Photo Credit: Piran Elavia)

Nagaland Chakhesang farmers dry foxtail millet (top right) to collect the seeds for future planting

(Photo Credit: NESFAS-2015)

Seed Biodiversity in seed exchange festival in Chizami, Nagaland with millets being a component

10

Revival of millets in the Himalayan Region

Millets are the climate resilient crops and can adapt to wide ranges of climatic conditions. They can be grown in marginal soil conditions as a rainfed crop. For over a decade, various civil society groups have been attempting to revive and mainstream millets in the Himalayan region, as these were the traditional crops suited for the region and part of culture. Eventually, the nutrition-rich low-input demanding millet crops can easily be brought back to cultivation and consumption through favourable policy and technological interventions.

Several NGOs and local bodies such as NESFAS (North East Slow Food and Agrobiodiversity Society), North East Council (NEC) of Government of India, etc. have initiated consistent efforts to enhance awareness about millets and their foods among the communities. NESFAS have organized promotional programmes in Meghalaya and Nagaland. Woncho Cultural Socieity (WCS) of Arunachal Pradesh who regard millet as close to their culture, had organized millet festival in a big way during February 2019 at Longding. The agriculture department of Tripura State has been popularizing cultivation of Sorghum every year since 2016.

Generation of higher demand for the dryland crops like millets will significantly increase the farmers' income. Creation of demand for millets will help the farmers in getting better price and market for their produce. Proper value addition measures can be taken up at farm level to overcome these problems which will boost the millets cultivation nationwide and therefore will positively impact the farmers' income.

The Pungzm millet festival organized by the Wancho Cultural Society (WCS) in February 2019 aimed at popularising the importance of millets and millets based food products. WCS maintains that millet has been the staple cereal of the Wancho tribe since ages but due to lack of knowledge about the price and nutritional values many farmers are abandoning its production. During the festival, stalls of local cuisines of variety of millets were installed, wherein taste workshops on millet products, and seminars were conducted.

SSC Shillong & NESFAS workshop on cooking millets in Meghalaya

Pungzm" Millet Festival 2019 organized by Wancho Cultural Society (WCS) at Longding, Arunachal Pradesh.

Artists performing threshing dance during Pungzm (Millet festival) in Arunachal Pradesh

Farmers exhibition in Nagaland showcasing traditional varieties of millets

11

Future outlook

The Indian Himalayan region had been a major niche region for millet crops as a component of the ethnic culture and livelihood, as reflected by the various food use and fermented beverages preparations that were in vogue till rice became available in plenty. The farmers easily abandoned growing millet due to their ignorance of nutritional benefits and sustainable nature of the crops. However, of late, revival of local culture and efforts of civil society groups and local bodies to bring back millets cultivation and make millet-based products available for consumption has begun in a small but consistent manner.

At this stage the need of the region is availability of beneficial agroproduction technology, access to machinery for processing of millets and creating awareness about health and nutritional benefits of millets and how they were interwoven in the forgotten cultural traditions. Embracing the forgotten millets can be a sustainable solution to several ills of the region- malnutrition, access to food, efficient crops that suit low input agriculture, etc. Millet-based fermented beverages are nutritionally superior and are readily acceptable as their own cultural identity. The combined efforts of state and civil society groups should join hands towards this cause, with the Indian government should extending the benefits of National Food Security Sub Mission on Nutricereals to the Indian Himalayan states.

12

References

Dikshit KR, Dikshit JK (2013) North-East India: Land, People and Economy Advances in Asian-human Environmental Research. Springer Science & Business Media, 800 pages. Pp 617.

DMD (2014) Status Paper on coarse Cereals. Directorate for Millets Development. Department of Agriculture and cooperation. Ministry of Agriculture, Government of India, Jaipur.http://www.nfsm.gov.in/Publicity/2014-15/Books/Status%20Book.pdf

Joshi VK, Garg V, Abrol GS (2012) Indigenous fermented foods. In: (Joshi VK and Singh RS eds.) Food Biotechnology: Principles and Practices. IK Publishing House, New Delhi pp 337-374

Kala, CP (2010) Status of an indigenous agro-forestry system in changing climate: A case study of the middle Himalayan region of Tehri Garhwal. India Journal of Forest Science. 56(8): 373–380

Kumar A (2013) Refinement of the technology of the traditional sur production in Himachal Pradesh. M.Sc Thesis, Department of Food Science and Technology, UHF, Solan. 2013; 98.

Lawrence ER (1895) Valley of Kashmir. Henry Frowde, Oxford University Press Warehouse, Amen Corner, E.G. London

Mehta PS, Negi KS, Ojha SN (2010) Native plant genetic resources and traditional foods of Uttarakhand Himalaya for sustainable food security and livelihood. Indian Journal of Natural Products and Resources. 1(1): 89-96

NAAS (2013) Role of Millets In Nutritional Security Of India. Policy Paper No. 66. National Academy of Agricultural Sciences (NAAS), New Delhi

Nandy SN, Samal PK (2005) An outlook of agricultural dependency in the IHR. ENVIS Newsletter: Himalayan Ecology 2: 4-5.

Rajyasameeksha (2018) https://rajyasameeksha.com/news/3872-Koda-jhangora-demand-increasing-in-uttarakhand-

Ray S, Bagyaraj DJ, Thilagar G, Tamang JP (2016) Preparation of Chyang, an ethnic fermented beverage of the Himalayas, using different raw cereals. Journal of Ethnic

Foods, Volume 3, Issue 4, Pages 297-299, ISSN 2352-6181. https://doi.org/10.1016/j.jef.2016.11.008

Roberts W, Singh K (1947) A Text Book of Punjab Agriculture. Lahore Civil and Military Gazzette Ltd. Lahore pp 280-284.

Saklani A (1987) The History of a Himalayan Princely State Change, Conflicts and Awakening (An Interpretative History of Princely State of Tehri Garhwal, U.P.) (A. D. 1815 to 1949 A.D.) Durga Publications, Delhi

Sati VP (2015) Natural Resources Potentials and Socio-Economic Status in the Indian Himalayan Region. Nature & Environment 20 (2): 48-58.

Savitri, Bhalla TC (2007) Traditional foods and beverages of Himachal Pradesh. Indian Journal of Traditional Knowledge. 6(1): 17-24.

Shrivastava et al. (2012) Biotechnology in Tradition-Methods of starter preparation for alcoholic beverages employed by different tribal communities of Arunachal Pradesh. Indian Journal of Traditional Knowledge 11(1): 194-201.

Singh HB and Arora RK (1972) Raishan (*Digitari*a sp.)—a minor millet of the Khasi Hills, India. Economic Botany. 26 (4): 376–380.

Singh KP, Kundu S, Gupta HS (2003) Development of higher capacity thresher for ragi/kodo. In: Recent Trend in Millet Processing and Utilization, 109—116. CCSHAU, Hisar, India.

Singh V, Gaur RD (2008) Rangeland Ecosystems in the Himalayan Mountains. Daya Books, Delhi pp 146.

Spate M, Zhang G, Yatoo M, Betts A, (2017) New evidence for early 4th millennium BP agriculture in the Western Himalayas: Qasim Bagh, Kashmir, Journal of Archaeological Science: Reports 11:568-577, ISSN 2352-409X, https://doi.org/10.1016/j.jasrep.2016.12.038.

Tamang JP, Namrata Tamang, Thapa S, Dewan S, Tamang B, Yonzan HH, Rai AK, Chettri R, Chakrabarty J, Khare N (2012) Microorganisms and Nutritional value of Ethnic fermented foods and alcoholic beverages of North East India. Indian Journal of Traditional Knowledge.11(1): 7-25.

Tamang JP, Okumiya K, Kosaka, Y (2010) Cultural Adaptation of the Himalayan Ethnic Foods with Special Reference to Sikkim, Arunachal Pradesh and Ladakh. Himalayan Study Monographs 11: 177-185.

Thapa S, Tamang JP (2004) Product characterization of *kodo ko jaanr*: fermented finger millet beverage of the Himalayas. Food Microbiology 21: 617–622.

Upadhyaya HD, Gowda CLL, Sastry DVSSR (2008) Plant genetic resources management: collection, characterization, conservation and utilization. J. SAT Agric. Res. 6: 1-15.

Annexure –I Mean Area, Production and Yield of Millets in Millet-growing Districts of Indian Himalayan Region during past 20 years (1997-2016)

State	District	Bajra			Jowar			Ragi			Small millets			Total millets		
		Area (ha)	produc-tion (ton)	Yield (kg/ ha)	Area (ha)	produc-tion (ton)	Yield (kg/ha)	Area (ha)	produc-tion (ton)	Yield (kg/ ha)	Area (ha)	produc-tion (ton)	Yield (kg/ ha)	Area (ha)	produc-tion (ton)	Yield (kg/ ha)
Arunachal Pradesh	Anjaw	-	-	-	-	-	-	-	-	-	1106	1046	945	1106	1046	945
	Changlang	-	-	-	-	-	-	-	-	-	1830	1446	790	1830	1446	790
	Dibang Valley	-	-	-	-	-	-	-	-	-	779	695	892	779	695	892
	East Kameng	-	-	-	-	-	-	-	-	-	624	638	1022	624	638	1022
	East Siang	-	-	-	-	-	-	-	-	-	2214	2645	1195	2214	2645	1195
	Kurung Kumey	-	-	-	-	-	-	-	-	-	488	471	965	488	471	965
	Lower Dibang Valley	-	-	-	-	-	-	-	-	-	1466	1130	771	1466	1130	771
	Lower Subansiri	-	-	-	-	-	-	-	-	-	1710	1826	1068	1710	1826	1068
	Papum Pare	-	-	-	-	-	-	-	-	-	651	809	1243	651	809	1243
	Tawang	-	-	-	-	-	-	-	-	-	948	1082	1142	948	1082	1142
	Tirap	-	-	-	-	-	-	-	-	-	3895	2985	766	3895	2985	766
	Upper Siang	-	-	-	-	-	-	-	-	-	1170	980	838	1170	980	838
	Upper Subansiri	-	-	-	-	-	-	-	-	-	1319	1549	1174	1319	1549	1174
	West Kameng	-	-	-	-	-	-	-	-	-	1148	1113	970	1148	1113	970
	West Siang	-	-	-	-	-	-	-	-	-	2524	2161	856	2524	2161	856
Assam	Cachar	-	-	-	-	-	-	-	-	-	25	12	472	25	12	472
	Karbi Anglong	-	-	-	-	-	-	-	-	-	212	83	390	212	83	390

State	District	Bajra			Jowar			Ragi			Small millets			Total millets		
		Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)
Himachal Pradesh	Bilaspur	63	33	524	4	0	25	17	21	1235	1	-	-	85	54	637
	Chamba	38	18	474	1	0	100	8	4	538	1298	342	264	1345	364	271
	Hamirpur	38	22	571	-	-	-	6	5	909	6	2	318	49	28	581
	Kangra	197	104	525	282	89	316	7	5	768	181	77	426	667	275	412
	Kinnaur	-	-	-	-	-	-	32	30	948	1618	707	437	1650	737	447
	Kullu	-	-	-	-	-	-	263	199	758	476	106	224	739	306	414
	Lahul And Spiti	-	-	-	-	-	-	-	-	-	122	50	409	122	50	409
	Mandi	65	33	507	-	-	-	897	834	930	647	241	372	1610	1108	688
	Shimla	32	16	503	-	-	-	811	1150	1417	3730	3306	886	4573	4471	978
	Sirmaur	38	19	502	-	-	-	286	185	646	249	208	837	573	412	719
	Solan	19	12	613	-	-	-	-	-	-	-	-	-	19	12	613
	Una	490	245	500	-	-	-	-	-	-	-	-	-	490	245	500
Jammu and Kashmir	Baramulla	-	-	-	-	-	-	-	-	-	344	113	328	344	113	328
	Doda	67	34	515	-	-	-	-	-	-	1732	519	299	1799	553	307
	Jammu	9153	5313	580	1497	898	600	-	-	-	-	-	-	10651	6211	583
	Kargil	-	-	-	-	-	-	-	-	-	516	287	556	516	287	556
	Kathua	1390	752	541	652	163	249	-	-	-	26	130	5000	2068	1045	505
	Kupwara	45	27	600	-	-	-	-	-	-	87	52	598	132	79	598
	Leh Ladakh	-	-	-	-	-	-	-	-	-	2362	1350	572	2362	1350	572
	Rajauri	315	212	672	123	73	599	-	-	-	-	-	-	437	285	652
	Srinagar	-	-	-	-	-	-	-	-	-	36	36	1000	36	36	1000
	Udhampur	754	445	589	-	-	-	-	-	-	-	-	-	754	445	589

State	District	Bajra			Jowar			Ragi			Small millets			Total millets		
		Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)
Meghalaya	East Garo Hills	-	-	-	-	-	-	-	-	-	448	398	889	448	398	889
	East Jaintia Hills	-	-	-	-	-	-	-	-	-	312	377	1208	312	377	1208
	East Khasi Hills	-	-	-	-	-	-	-	-	-	333	370	1109	333	370	1109
	North Garo Hills	-	-	-	-	-	-	-	-	-	103	108	1056	103	108	1056
	Ri Bhoi	-	-	-	-	-	-	-	-	-	21	19	939	21	19	939
	South Garo Hills	-	-	-	-	-	-	-	-	-	211	206	977	211	206	977
	South West Garo Hills	-	-	-	-	-	-	-	-	-	234	160	684	234	160	684
	West Garo Hills	-	-	-	-	-	-	-	-	-	1073	599	558	1073	599	558
	West Jaintia Hills	-	-	-	-	-	-	-	-	-	206	280	1358	206	280	1358
	West Khasi Hills	-	-	-	-	-	-	-	-	-	222	248	1119	222	248	1119
Nagaland	Dimapur	205	308	1505	321	554	1724	36	37	1031	1721	1929	1120	2283	2828	1238
	Kohima	163	177	1087	93	99	1068				1737	1676	965	1992	1952	980
	Mokokchung	149	172	1150	169	217	1284	74	64	866	935	863	923	1328	1316	991
	Mon	161	181	1120	130	149	1142	43	41	949	1236	1249	1011	1570	1619	1031
	Phek	136	146	1078	109	127	1166				1972	1895	961	2216	2168	978
	Tuensang	159	169	1067	232	294	1267	79	68	859	1237	1192	964	1706	1723	1010
	Wokha	164	199	1211	118	141	1200	41	39	946	1590	1515	953	1913	1894	990

State	District	Bajra			Jowar			Ragi			Small millets			Total millets		
		Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)	Area (ha)	production (ton)	Yield (kg/ha)
Sikkim	East District	146	169	1157	108	120	1111	-	-	-	1105	1063	961	1360	1352	994
	North District	-	-	-	-	-	-	-	-	-	1126	1409	1251	1126	1409	1251
	South District	-	-	-	-	-	-	-	-	-	653	575	880	653	575	880
	West District	-	-	-	-	-	-	-	-	-	897	854	953	897	854	953
Uttarakhand	Almora	-	-	-	-	-	-	-	-	-	1139	1087	954	1139	1087	954
	Bageshwar	-	-	-	-	-	-	34079	39197	1150	22289	25754	1155	56367	64951	1152
	Chamoli	2	2	1000	-	-	-	6134	8495	1385	2132	2721	1276	8268	11217	1357
	Champawat	-	-	-	-	-	-	9824	14524	1478	7242	8876	1226	17066	23400	1371
	Dehradun	2	2	1000	-	-	-	5920	8555	1445	2002	2999	1498	7924	11556	1458
	Haridwar	20	19	950	3	2	667	2120	3193	1506	2011	2167	1078	4154	5381	1295
	Nainital	11	14	1303	6	4	696	-	-	-	-	-	-	17	18	1093
	Pauri Garhwal	1	1	1000	-	-	-	3265	4683	1434	1094	1493	1365	4360	6177	1417
	Pithoragarh	42	40	952	-	-	-	25371	31712	1250	23819	28752	1207	49232	60504	1229
	Rudra Prayag	-	-	-	-	-	-	8332	12175	1461	4382	6561	1497	12714	18736	1474
	Tehri Garhwal	-	-	-	-	-	-	6463	9482	1467	3701	5014	1355	10164	14496	1426
	Udam Singh Nagar	-	-	-	-	-	-	13839	19461	1406	21463	27818	1296	35303	47280	1339
	Uttar Kashi	4	5	1227	-	-	-	26	38	1442	-	-	-	30	43	1411
West Bengal	Darjeeling	-	-	-	-	-	-	5734	9312	1624	5230	6065	1160	10965	15377	1402

Annexure II- Potential varieties of millets suitable for cultivation in the Indian Himalayan Regions

Millet crop	Zone/ season	States with major/potential area	Recommended Variety
Sorghum	kharif	Jammu & Kashmir, Nagaland, Uttarakhand, Sikkim, Tripura	CSV 15, CSV 17, CSV 20, CSV 27, CSV 31, CSV 34; Hybrids- CSH 30, CSH 41
Pearl millet	Kharif	Jammu & Kashmir, Nagaland, Uttarakhand, Sikkim	PC 383, ICMV221, Raj 171; Hybrids- MPMH17, MPMH 21, RHB-173
Finger millet	Kharif	Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Nagaland, West Bengal, Jammu & Kashmir, Meghalaya	PRM-2, VL Mandua 347, VL Mandua 348, VL Mandua 352, VL Mandua 379
Foxtail millet	Kharif	Arunachal Pradesh, Himachal Pradesh, Sikkim, Nagaland, Meghalaya, Uttarakhand	SiA 3085, SiA 3156, Rajendra Kauni-1
Little millet	Kharif	Himachal Pradesh, Jammu & Kashmir, Nagaland, Sikkim	OLM 208, OLM 217, BL 6, DHLM 36-3, GNV-3
Kodo millet	Kharif	Himachal Pradesh	JK 13, JK 65, JK 98, DPS 9-1, TNAU 86, RK 390-25
Barnyard millet	Kharif	Uttarakhand, Himachal Pradesh, Nagaland, Meghalaya, Jammu & Kashmir	VL Madira 207, DHBM 93-2, PRJ-1
Proso millet	Kharif	Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttarakhand, Nagaland	PRC-1, CO(PV) 5, TNAU 151, TNAU 164, Pratap Cheena 1 (PR 18), TNAU 202
Forage jowar-single cut	Kharif	Jammu & Kashmir, Arunachal Pradesh, Meghalaya	HC 171, HC 260, HC 308, CSV 30 F
Forage jowar-Multi-cut	Summer	Jammu & Kashmir, Arunachal Pradesh, Meghalaya	PC 106, SSG 59-3, HC 136, CSV 33 MF, Hybrid- CSH 24F

Annexure- III Area, production and yield of millet crops in millets growing districts of Indian Himalayan Region

[Mean of 20 years - 1996 to 2017]

Pearl millet growing districts in the Indian Himalayan Region

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Jammu and Kashmir	Kupwara	9153	5313	580
Himachal Pradesh	Lahul and Spiti	1390	752	541
Nagaland	Mokokchung	754	445	589
Himachal Pradesh	Kinnaur	490	245	500
Uttarakhand	Rudra Prayag	205	308	1505
Meghalaya	South West Garo Hills	164	199	1211
Himachal Pradesh	Shimla	163	177	1087
Himachal Pradesh	Solan	161	181	1120
Meghalaya	South Garo Hills	159	169	1067
Himachal Pradesh	Sirmaur	149	172	1150
Jammu and Kashmir	Srinagar	146	169	1157
Sikkim	South District	136	146	1078
Himachal Pradesh	Kullu	67	34	515
Himachal Pradesh	Kangra	65	33	507
Meghalaya	East Jaintia Hills	63	33	524
Jammu and Kashmir	Leh Ladakh	45	27	600
Meghalaya	West Garo Hills	42	40	952
Jammu and Kashmir	Kargil	38	19	502
Meghalaya	East Khasi Hills	38	22	571
Assam	Karbi Anglong	32	16	503
Jammu and Kashmir	Kathua	19	12	613
Uttarakhand	Uttar Kashi	11	14	1303
Jammu and Kashmir	Udhampur	2	2	1000
Sikkim	West District	1	1	1000

Sorghum growing districts in the Indian Himalayan Region

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Jammu and Kashmir	Kupwara	1497	898	600
Himachal Pradesh	Lahul And Spiti	652	163	249
Uttarakhand	Rudra Prayag	321	554	1724
Meghalaya	South Garo Hills	232	294	1267
Himachal Pradesh	Sirmaur	169	217	1284
Himachal Pradesh	Solan	130	149	1142
Meghalaya	South West Garo Hills	118	141	1200
Sikkim	South District	109	127	1166
Jammu and Kashmir	Srinagar	108	120	1111
Himachal Pradesh	Shimla	93	99	1068
Uttarakhand	Uttar Kashi	6	4	696
Meghalaya	East Jaintia Hills	4	0	25

Finger millet growing districts in the Indian Himalayan Region

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Uttarakhand	Udam Singh Nagar	34079	39197	1150
Meghalaya	West Garo Hills	25371	31712	1250
Meghalaya	West Khasi Hills	13839	19461	1406
Nagaland	Zunheboto	10751	12536	1166
Himachal Pradesh	Una	9824	14524	1478
Meghalaya	West Jaintia Hills	8332	12175	1461
Jammu and Kashmir	Udhampur	6134	8495	1385
Nagaland	Wokha	5734	9312	1624
Sikkim	West District	3265	4683	1434
Himachal Pradesh	Kangra	897	834	930
Assam	Karbi Anglong	811	1150	1417
Jammu and Kashmir	Kargil	286	185	646
Uttarakhand	Haridwar	263	199	758
Meghalaya	South Garo Hills	79	68	859
Himachal Pradesh	Sirmaur	74	64	866
Himachal Pradesh	Solan	43	41	949
Meghalaya	South West Garo Hills	41	39	946
Uttarakhand	Rudra Prayag	36	37	1031
Himachal Pradesh	Hamirpur	32	30	948
Meghalaya	East Jaintia Hills	17	21	1235
Meghalaya	East Khasi Hills	6	5	909

Small millets growing districts in the Indian Himalayan Region

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Meghalaya	West Garo Hills	23819	28752	1207
Uttarakhand	Udam Singh Nagar	22289	25754	1155
Meghalaya	West Khasi Hills	21463	27818	1296
Himachal Pradesh	Una	7242	8876	1226
Nagaland	Wokha	5230	6065	1160
Meghalaya	West Jaintia Hills	4382	6561	1497
West Bengal	Darjeeling	3895	2985	766
Assam	Karbi Anglong	3730	3306	886
Jammu and Kashmir	Doda	2524	2161	856
Himachal Pradesh	Bilaspur	2214	2645	1195
Jammu and Kashmir	Udhampur	2132	2721	1276
Sikkim	South District	1972	1895	961
Himachal Pradesh	Shimla	1737	1676	965
Himachal Pradesh	Kullu	1732	519	299
Uttarakhand	Rudra Prayag	1721	1929	1120
Uttarakhand	Chamoli	1710	1826	1068
Himachal Pradesh	Hamirpur	1618	707	437
Meghalaya	South West Garo Hills	1590	1515	953
Himachal Pradesh	Chamba	1466	1130	771
Meghalaya	South Garo Hills	1237	1192	964
Himachal Pradesh	Solan	1236	1249	1011
Uttarakhand	Dehradun	1170	980	838
Nagaland	Dimapur	1148	1113	970
Nagaland	Tuensang	1139	1087	954
Uttarakhand	Almora	1106	1046	945
Jammu and Kashmir	Srinagar	1105	1063	961
Sikkim	West District	1094	1493	1365
Uttarakhand	Pithoragarh	1073	599	558
Himachal Pradesh	Sirmaur	935	863	923
Uttarakhand	Bageshwar	779	695	892
Uttarakhand	Tehri Garhwal	653	575	880
Uttarakhand	Champawat	651	809	1243
Himachal Pradesh	Kangra	647	241	372
Jammu and Kashmir	Baramulla	624	638	1022
Assam	Cachar	488	471	965
Nagaland	Zunheboto	486	694	1429
Uttarakhand	Haridwar	476	106	224
Nagaland	Mon	448	398	889

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Nagaland	Kohima	344	113	328
Sikkim	North District	333	370	1109
Uttarakhand	Nainital	312	377	1208
Jammu and Kashmir	Kargil	249	208	837
Nagaland	Phek	234	160	684
Meghalaya	Ri Bhoi	222	248	1119
Meghalaya	East Garo Hills	212	83	390
Uttarakhand	Pauri Garhwal	211	206	977
Jammu and Kashmir	Rajauri	206	280	1358
Jammu and Kashmir	Jammu	122	50	409
Meghalaya	North Garo Hills	103	108	1056
Jammu and Kashmir	Leh Ladakh	87	52	598
Himachal Pradesh	Mandi	36	36	1000
Himachal Pradesh	Lahul and Spiti	26	130	5000
Sikkim	East District	25	12	472
Meghalaya	East Khasi Hills	6	2	318
Meghalaya	East Jaintia Hills	1	0	0

Millets (all crops) growing districts in the Indian Himalayan Region

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Uttarakhand	Udam Singh Nagar	56367	64951	1152
Meghalaya	West Garo Hills	49232	60504	1229
Meghalaya	West Khasi Hills	35303	47280	1339
Himachal Pradesh	Una	17066	23400	1371
Meghalaya	West Jaintia Hills	12714	18736	1474
Nagaland	Zunheboto	11237	13230	1177
Nagaland	Wokha	10965	15377	1402
Jammu and Kashmir	Kupwara	10651	6211	583
Jammu and Kashmir	Udhampur	8268	11217	1357
Assam	Karbi Anglong	4573	4471	978
Sikkim	West District	4360	6177	1417
West Bengal	Darjeeling	3895	2985	766
Jammu and Kashmir	Doda	2524	2161	856
Uttarakhand	Rudra Prayag	2283	2828	1238
Sikkim	South District	2216	2168	978
Himachal Pradesh	Bilaspur	2214	2645	1195
Himachal Pradesh	Lahul and Spiti	2068	1045	505
Himachal Pradesh	Shimla	1992	1952	980
Meghalaya	South West Garo Hills	1913	1894	990
Himachal Pradesh	Kullu	1799	553	307

State	District	Area (ha)	Production (ton)	Yield (kg/ha)
Uttarakhand	Chamoli	1710	1826	1068
Meghalaya	South Garo Hills	1706	1723	1010
Himachal Pradesh	Hamirpur	1650	737	447
Himachal Pradesh	Kangra	1610	1108	688
Himachal Pradesh	Solan	1570	1619	1031
Himachal Pradesh	Chamba	1466	1130	771
Jammu and Kashmir	Srinagar	1360	1352	994
Himachal Pradesh	Sirmaur	1328	1316	991
Uttarakhand	Dehradun	1170	980	838
Nagaland	Dimapur	1148	1113	970
Nagaland	Tuensang	1139	1087	954
Uttarakhand	Almora	1106	1046	945
Uttarakhand	Pithoragarh	1073	599	558
Uttarakhand	Bageshwar	779	695	892
Nagaland	Mokokchung	754	445	589
Uttarakhand	Haridwar	739	306	414
Uttarakhand	Tehri Garhwal	653	575	880
Uttarakhand	Champawat	651	809	1243
Jammu and Kashmir	Baramulla	624	638	1022
Jammu and Kashmir	Kargil	573	412	719
Himachal Pradesh	Kinnaur	490	245	500
Assam	Cachar	488	471	965
Nagaland	Mon	448	398	889
Nagaland	Kohima	344	113	328
Sikkim	North District	333	370	1109
Uttarakhand	Nainital	312	377	1208
Nagaland	Phek	234	160	684
Meghalaya	Ri Bhoi	222	248	1119
Meghalaya	East Garo Hills	212	83	390
Uttarakhand	Pauri Garhwal	211	206	977
Jammu and Kashmir	Rajauri	206	280	1358
Jammu and Kashmir	Leh Ladakh	132	79	598
Jammu and Kashmir	Jammu	122	50	409
Meghalaya	North Garo Hills	103	108	1056
Meghalaya	East Jaintia Hills	85	54	637
Meghalaya	East Khasi Hills	49	28	581
Himachal Pradesh	Mandi	36	36	1000
Sikkim	East District	25	12	472
Jammu and Kashmir	Kathua	19	12	613
Uttarakhand	Uttar Kashi	17	18	1093

Annexure IV: Recommended package of practices for the cultivation of millets

1. Sorghum

Sorghum sowing time suitable for Indian Himalaya region is – in kharif - with the onset of rains till to July; in Summer - January to February

The first ploughing should be done with soil turning plough so that 20-25 cm deep soil may become loose. It should be followed by two to three harrowing or three to four inter-crossing ploughings with country plough. The field should be manured with 10 to 15 tonnes FYM. Application of 100-120 kg nitrogen, 50 kg P_2O_5 and 40 kg K_2O per hectare are recommended for hybrid and improved varieties of sorghum under irrigation condition. In case of rainfed crop, quantity of fertilizer should be reduced to half of the irrigated condition. Half dose of nitrogen and total amount of phosphorus and potash should be applied at the time of sowing. The remaining half quantity of nitrogen should be top dressed after 30-35 days after sowing.

Line sowing (Row to row 45 cm, plant to plant 10-12 cm and depth 3-4 cm) is preferred though broadcasting is also followed. A seed rate of 8-10 kg/ha is recommended. For seed treatment, Thiram or Agrosan should be used @ 3 g/kg of seed to control seed borne diseases. Pre-emergence application of atrazine at the rate of 0.5- 1.0 kg active ingredient per hectare has been found highly selective for sorghum.

Usually, sorghum is grown as a rainfed crop. Three essential irrigations at vegetative stage, flowering stage and grain filling stage require more water. Cultural methods such as planting time, planting geometry, inter-cropping, crop rotation, inter-cultivation etc. are traditional and very useful in managing the weeds.

Shoot fly and stem borer are the major insect pests of Sorghum. Deep ploughing one month before planting exposes immature stages of insects. Adopt synchronous and timely/early sowings of cultivars with similar maturity to reduce the damage by shoot fly, midge, and head bugs and rotate crop with non-host crops.

Shoot fly: Planting with the onset of monsoon in Kharif and between September last week to first week of October in Rabi is ideal to escape from shoot fly. Another important practice is to increase seed rate by 1.5 times ie @10-12 kg/ha and remove the dead hearts at the time of thinning. Seed treatment with Thiamethoxam (cruiser) 70 WS @ 3 g /1 kg is recommended. When the shoot fly damage reaches 5 to 10% DH spray with Cypermethrin 10 EC (750 ml/ha) or quinalphos 25 EC (400 g a.i./ha).

Stem Borer: Destroy the stubbles, panicles to prevent carryover of the pest before the onset of monsoon. Carbofuran 3G granules may be applied in the whorls @ 8 – 12 kg/ha at 20 DAE or the entire field can be sprayed with Metasystox 25 EC @ 2 ml / liter.

Midge: Spray at 50% anthesis (1 midge/panicle) and grain filling stage with Cypermethrin 25 EC @ 1.0 ml/liter or Carbaryl 10% dust @20 – 25 kg/ha.

Earhead bugs and head caterpillars: The crop may be sprayed at the completion of flowering and at the milk stage with cypermethrin 25 EC @ 1.0 ml/liter.

Grain mold: Molds occurs when flowering coincides with rainfall. The grains turn black, white or pink in color. To control grain mold, spray ear-heads with Aurefungin (200 PPM) + Captan (0.2%) three times from flowering at 10 days interval or Dithane M-45 (0.2%) + Bavistin (0.2%) twice at 10 days interval after commencement of flowering.

Downy mildew: On the young leaves downy whitish growth, mostly on the lower surface with yellowing on the corresponding upper surface is seen. For control, spraying with Metalaxyl (Radomil) 0.1% solution may be adopted.

Most of the high yielding sorghum hybrids and varieties take about 100-115 days to mature. With improved cultural practices it is possible to harvest under irrigated condition, grain 50 qtl/ha and fodder-100-125 qtl/ha. Grain yield of 25-30 qtl/ha and fodder yield of 80-100 qtl/ha are realized under rainfed condition.

2. Pearl millet

Pearl millet can be grown in different soils. It does not grow well in soils prone to waterlogged conditions. Sowing Time for Indian Himalaya: Kharif - with the onset of rains till to July; Summer - January to February. The field should be ploughed once or twice followed by harrowing to create fine tilth. Manure and fertilizer requirements include 8-10 tons of farmyard manure or compost, 100 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare. Fertilizer doses may split into two; a basal dose of 40 kg N and all P_2O_5 and K_2O at the time of planting and topdressing of nitrogen in two equal splits at tillering and panicle emergence may be practiced.

Three systems of pearl millet sowing are followed: (1) on a flat surface, or (2) using ridge and furrow system, or (3) on a broad-bed and furrow system. The seed should be sown at 2.5 cm – 3 cm depth Gap filling should be done by transplanting seedlings after 2-3 weeks of sowing if scanty population exists. The required seed rate for pearl millet is 1.5-2 kg/acre.Seed treatment with biopesticides (*Trichoderma harzianum* @ 4g kg-1) or thiram 75% dust @ 3 g kg-1 seed will help against soilborne diseases. Seed treatment with 300-mesh sulfur powder @ 4 g kg-1 seeds controls the smut disease. For removing ergot affected seeds, they are soaked in 10% salt solution. Seed treatment with metalaxyl (Apron 35 SD) @ 6 g kg-1 seed controls downy mildew. Seeds are treated with *Azospirillum* (600 g) and *Phosphobacterium* to enhance the availability of nitrogen and phosphorus.

The field should be irrigated soon after sowing and life irrigation is done on the third day of sowing. In the absence of rains, irrigation should be done during tillering, milky stage and maturation stages which are the critical stages. The first weeding should be done at 30 – 35 days after sowing and repeatedly subsequently if required.

Grains attain physiological maturation 30 – 35 days after 50% flowering. The physiological maturation can be identified by change in the colour of the seeds from green to straw yellow. Pearl millet should be harvested as early as possible to minimize losses due to birds and

bad weather. Harvesting is done in two pickings since, the maturation of the earheads are not uniform because of the tillering habit of the crop.

Pearl millet is affected by pests like shoot fly, root grub and diseases like downy mildew and ergot at different growth stages. Cultural control methods like clean cultivation, planting date adjustment, and uprooting of disease affected plants can substantially reduce the damage and minimize yield losses. Sometimes, diseases and pests attack may be controlled through chemicals.

IPM Module for managing pest complex: Seed treatment with Imidacloprid 70 WS @ 3 g/kg seed + 5 % neem oil spray at 30 DAG + endosulfan 4 % / endosulfan 0.07 % spray at 50 % flowering Follow 2:1 pearl millet + red gram/horse gram inter-cropping system.

Downy mildew control: Use Ridomil 25 WP (1000 ppm) 20 DAS; Use more than one hybrid/ improved variety in the same year or rotate hybrids/improved varieties in alternate years to check the spread of downy mildew.

Shoot fly: Early planting with the onset of monsoon has effectively controlled shoot fly incidence and two dusting of malathion 5% dust @ 25 kg/ha at 10 and 20 DAG or two sprays of neem oil (with 4 gm soap/lit of water) 0.05 % or two sprayings of endosulfan 0.07 % at 10 and 20 DAG.

3. Finger millet

Finger millet can be grown in poor to fertile soil. The crop can tolerate salinity better than any other crops. Land should be ploughed 2 - 3 times to get fine tilth and levelled.

2 to 3 kg seed required for sowing an acre. Poor germination, often, is the result of inadequate moisture after sowing in low rainfall areas. Under these conditions, the adoption of a simple technique like seed hardening will not only improve germination and subsequent plant stand but also impart early seedling vigour and tolerance to drought. For seed hardening, soak seeds in water for 6 hours. Drain the water and keep the seeds in wet cloth bag tightly tied for two days. At this stage, the seeds will show initial signs of germination. Remove seeds from the wet cloth bag and dry them in shade on a dry cloth for 2 days. Use the above hardened seeds for sowing.

Line sowing is ideal and seed drills giving spacing of 22.5 – 30 cm between rows should be used, leaving a spacing of 7.5 – 10 cm between plants. Sowing by seed-cum-fertilizer drill is advantageous for line sowing besides efficient utilization of applied nutrients.

Finger millet responds well to fertilizer application especially to N and P. Recommended dose of 40:20:20 kg/ha N:P:K may be applied. With judicious application of farmyard manure inorganic fertilizer efficiency is enhanced. Entire P_2O_5 and K_2O are to be applied at sowing, whereas nitrogen is to be applied in two or three split doses depending upon moisture availability. In areas of good rainfall and moisture availability, 50% of recommended nitrogen is to be applied at sowing and the remaining 50% in two equal splits at 25-30 and 40-45 days after sowing. In areas of uncertain rainfall, 50% at sowing and the remaining 50% around 35 days after sowing is recommended.

Weed control: In line sown crop 2-3 inter-cultivations are necessary. In assured rainfall and irrigated areas spraying 2, 4-D sodium salt @ 0.75 kg.a.i./ha as post-emergent spray around 20-25 days after sowing effectively controls weeds. Isoproturon @ 0.5 a.i/ha as pre-emergence spray is also effective in control of weeds. In broadcast crop two effective hand weedings will minimize weeds as inter cultivations is not possible.

Harvest is done once the ear heads are physiologically mature, as they turn from green to brown colour. Harvesting is done in two pickings since, the maturation of the ear heads is not uniform because of the tillering habit of the crop. Second harvesting should be done seven days after the first one. Harvested mature ear heads are threshed with bamboo sticks. Threshed grains are further cleaned by winnowing.

Finger millet is affected by pests and diseases like pink stem borer, aphids, root aphids, ear head caterpillars, blast, brown spot, mottle streak virus etc., at different growth stages.

To control root aphids, mix Dimethoate 3 ml in one litre of water and drench the rhizosphere of the infested and surrounding plants with the insecticidal solution. For the control of blast disease, choosing resistant variety and treating seeds with carbendazim @ 2 g/kg seed effectively controlled the blast incidence and resulted in higher yield. Spraying of SAAF @ 0.2 % at 50% flowering and one more need based spray after 10 days is also effective in controlling neck and finger blast. Mancozeb @2.5g/l water or Tricyclazole@0.6g/l of water are also useful.

Smut: Since the disease is mainly seed-borne, it can be controlled by treating the seed with organo-mercurials or steeping the seed for 10 to 30 minutes in 2 per cent copper sulphate solution or 0.5 per cent formalin for about 30 minutes.

4. Foxtail millet

Early sowing in the monsoon always produces higher yields than later sowings. The longer duration varieties gave higher fodder yield when sown early. Foxtail millet needs moderately fertile soil for good yield. Land should be ploughed 2 - 3 times to get a fine tilth and levelled.

Sowing: Recommended seed rate is 2 kg/acre (5 kg/ha). Selected seeds should be treated with *Azospirillum* @ 125 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm at a depth of 3 – 4 cm. Seed treatment with Carbendazim @ 2 g/ kg seed prevents head smut diseases. Seed treatment with Ridomil MZ @ 2 g/litre takes care of downy mildew

Nutrient management: During final plough apply compost or farmyard manure @ 5 tonnes/ acre (12.5 tonnes/ ha) and incorporate into the soil. Instead of this cattle penning can also be practiced. Recommended dose of 40:20:20 kg/ha N:P:K may be applied. For organic production, 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure.

Weeding can be done with a tyne harrow or by hand when the crop is 30 days old. Allow the weeds to dry for 2 - 3 days after hand weeding.

Kharif season crop does not require any irrigation. However, if the dry spell prevails for longer period, then 1-2 irrigations should be given to boost the yield. Summer crop requires 2 - 5 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

Harvest is done once the earheads are physiologically mature. Normally crop is ready for harvest in 80 - 100 days after sowing. Physiologically mature earheads will start to dry. Plants are either harvested intact with earheads or earheads alone. The earheads are dried before threshing. The earheads are threshed by stone roller or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

Foxtail millet is affected by pests like army worm, cut worm, leaf scrapping beetle and shoot fly and diseases like blast and rust at different growth stages. Sowing early in July minimized the incidence of blast and rust. Some of the chemical control measures include Mancozeb (0. 2%), for blast, brown spot and rust, If these diseases appear at the early stages of the crop.

5. Kodo millet

Kodo millet is generally grown in kharif season with protective irrigation. Land should be fertile with good drainage facility. During final ploughing apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. NPK application of 20:20:20 kg/ha is recommended. Otherwise, 50 kg neem cake and 500 kg vermicompost per acre (125 kg neem cake and 1250 kg vermicompost per hectare) should be applied as basal manure. Seeds can be sown in the ridges with a spacing of 30 × 10 cm. Recommended seed rate is 2-3 kg/acre. Selected seeds should be treated with *Azospirillum* @ 60 g/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds should be sown at the depth of 3 – 4 cm.

The field should be maintained weed free from the initial stage. It is essential to control the weeds in the initial stages of plant growth especially upto 35 – 40 days after sowing. Generally, two weedings at an interval of 15 days are sufficient. Weeding can be done with hand hoe or wheel hoe in line sown crop.

Kharif season crop does not require any irrigation, it is mostly grown as a rainfed crop. In the absence of rains one or two irrigation can be done. During heavy rains the excess water from the field should be drained out.

Head smut disease is known to be prevalent during some years which is seed borne. Steeping the seeds in 1.5 per cent copper sulphate or dusting with copper carbonate at 6 g/kg of seed are equally effective. Organo-mercurial dusts for seed treatment also control the disease. Bavistin 25 SD [carbendazim], Dithane M45 [mancozeb] and Parasan [phenylmercury acetate] at 2 g/kg seed also give best disease control.

Normally crop is ready for harvest in 100 days. Physiologically mature ear heads will turn from green to brown colour. Plants are cut close to the ground level, bundled and stacked for a week before threshing. The ear heads are threshed by trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

6. Little millet

Little millet can be cultivated in both rich and poor soils. Well drained loam or sandy loam soils rich in organic matter are ideal for cultivation. The field should be harrowed for 2 – 3 times to make it a fine tilth and levelled. Seeds should be sown in June – July at the onset of monsoon rains. Summer crop should be sown in the month of February – March. Before final ploughing compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) should be applied and ploughed into the soil. NPK application of 20:20:20 kg/ha is recommended. Recommended seed rate is 2-3 kg/acre. Selected seeds should be treated with *Azospirillum* @ 60 g/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds are broadcast manually or by seed driller in furrows at a depth of 3 – 4 cm.

The field should be maintained weed free at least upto 35 days after sowing for retaining the soil moisture and nutrients. Subsequent weeding should be done at an interval of 15 – 20 days. Weeding can be done with hand hoe or wheel hoe. *Kharif* season crop does not require any irrigation. However, if the dry spell prevails for longer period at least one irrigation should be given at the tillering stage to boost the yield. First irrigation should be given 25 - 30 days after sowing followed by the second one at 40 – 45 days after sowing. Summer crop requires 2 - 4 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

There are no major problems of disease and pest incidence in little millet. However, the shootfly incidence is severe in some years which could be controlled by applying carbafuron, preferably along with azotobacter bio-fertilizer.

Normally crop is ready for harvest in 80 - 85 days after sowing. The crop should be harvested when two thirds of the grains are ripe. The harvested earheads are threshed by hand or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

7. Proso millet

Best season for seed production is June - July and February – March. Proso millet can be cultivated in both rich and poor soils. Well drained loam or sandy loam soils rich in organic matter are ideal for cultivation. The field should be harrowed for 2 – 3 times to make it a fine tilth and levelled. During final plough apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil. NPK application of 40:20:20 kg/ha is recommended.

Recommended seed rate is 2-3 kg/acre. Selected seeds should be treated with *Azospirillum* @ 60 g/kg of seeds. Seeds can be sown in the ridges at a depth 3 - 4 cm with a spacing of 30× 10 cm or are broadcast manually. The field should be maintained weed free at least upto 35 days after sowing for retaining the soil moisture and nutrients. Subsequent weeding should be done at an interval of 15 – 20 days. Weeding can be done with a hand hoe or wheel hoe.

Kharif season crop does not require any irrigation. However, if the dry spell prevails for longer period 1 - 2 irrigations should be given at the tillering stage to boost the yield. First

irrigation should be given 25 - 30 days after sowing followed by the second one at 40 – 45 days after sowing. Summer crop requires 2 - 4 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

Shootfly is a major pest on the crop. Varietal differences exist for shootfly damage and hairy varieties are less susceptible to shootfly than the glabrous varieties. Carbofuran 3G @ 1.5 kg a.i./ha as soil application is effective in reducing shootfly incidence in proso millet.

Normally crop is ready for harvest in 65-75 days after sowing. The crop should be harvested when two thirds of the seeds are ripe. The harvested ear heads are threshed by trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

8. Barnyard millet

Barnyard millet can be cultivated in both rich and poor soils with variable texture. Well drained loam or sandy loam soils rich in organic matter are ideal for cultivation. Mainly a kharif crop, can be grown in summer with irrigation. Apply compost or farmyard manure @ 5 tonnes/acre (12.5 tonnes/ha) and incorporate into the soil, followed by NPK application of 20:20:0 kg/ha. For organic production, 50 kg neem cake and 500 kg vermicompost per acre should be applied as basal manure.

Recommended seed rate is 2-3 kg/acre. Selected seeds should be treated with *Azospirillum* @ 60 gms/kg of seeds. Treated seeds should be sown with a spacing of 30 x 10 cm. Seeds are broadcast manually or by seed driller in furrows at a depth of 3 – 4 cm.

The field should be maintained weed free at least upto 35 days after sowing for retaining the soil moisture and to get high yields. Subsequent weeding should be done at an interval of 15 – 20 days. Weeding can be done with a hand hoe or wheel hoe.

Kharif season crop does not require any irrigation. However, if the dry spell prevails for longer period at least one irrigation should be given at the tillering stage to boost the yield. First irrigation should be given 25 - 30 days after sowing followed by the second one at 40 – 45 days after sowing. Summer crop requires 2 – 4 irrigations depending upon soil type and climatic conditions. During heavy rains the excess water from the field should be drained out.

Barnyard millet is commonly affected by shoot fly and three types of smut diseases at different growth stages. The crop is affected by head smut, grain smut and kernel smut. Seed treatment with carbendazim 2 g/kg seed reduces the risk for infestation. For controlling *Helminthosporium* leaf spot, Mancozeb@2.5g/l of water is recommended.

Normally crop is ready for harvest in 75 - 90 days after sowing. The crop should be harvested when two thirds of the seeds are ripe. The harvested ear heads are threshed by hand or trampling under the feet of bullocks. The threshed grains are further cleaned by winnowing.

Annexure V: Indigenous collection of millets from the Indian Himalayan states in ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi

(as accessed from NBPGR dashboard on 2 May, 2019)

State/UT	Finger millet	Foxtail millet	Little millet	Kodo millet	Proso millet	Sorghum	Barnyard millet	Pearl millet	Total
Arunachal Pradesh	323	60	1		2	6			392
Assam	22	26			3	5			56
Himachal Pradesh	201	85	26		53	6	2	2	375
Jammu, Kashmir and Ladakh	11	41			4	12	4	11	83
Manipur	16					3			19
Mizoram						2			2
Nagaland	1	53			6	5			65
Tripura		16				15			31
Uttarakhand	889	71	14		19	73	187	20	1273
West Bengal	48	53	19	8		36			164
Total	**1511**	**405**	**60**	**8**	**87**	**163**	**193**	**33**	**2460**

ISBN : 81-89335-89-8

Indian Council of Agricultural Research
Ministry of Agriculture & Farmers' Welfare, Government of India
Krishi Bhawan, New Delhi