Bioscene

Bioscene
Volume- 22 Number- 04
ISSN: 1539-2422 (P) 2055-1583 (O)
www.explorebioscene.com

Small Millets: The Neglected Crops with Potential to Combat Food Insecurity in Uttarakhand

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Abstract: Millets are generally small-seeded annual grasses mostly cultivated in rainfed areas all over the world andare regarded as famine crop for the rural poor. The statistical documentation for millets is generally poor as compared to other commercial crop like rice and wheat despite its high nutritional value. The results of the study shows that mainly four small millet species i.e., *Eleusine caracara* (finger millet), *Echinochloa frumentacea* (barnyard millet), *Panicummiliaceum* (proso millet) and *Setaria italic* (foxtail millet) were cultivated in the study area. Finger millet (Mandua) and Barnyard millet (Jhangora) are most popularly grown in the studied villages but the interviewees revealed that barnyard millet is mainly used as animal fodder. Proso millet (cheena) and foxtail millet (kauni) are another two crops cultivated in the area with a varied cultivation pattern across the villages. Millets are the one of the oldest foods and these are major food source of thousand peoples all around the world. The main purpose of the study is to collect the data on millet cultivation and its uses in Rudraprayag district of Uttarakhand as they are regarded as nutri-cereals. In the present investigation it has been shown that planting legumes and millet together as a crop boosted the output of legumes, which made the soil healthier and gave the farmer more food and nutrition security. Millets are a great food for boosting the nervous system because they are simple to digest. These initiatives would assist farmers in adopting new millets types in lieu of conventional, low-yielding varieties, while also increasing the crop's economic worth via value addition.

Keywords: Extension, Millets, Mixed cropping, Nutritional value,Small seeded, Healthier, Uttarakhand

Introduction

Uttarakhand is primarily an agricultural state because between 75 to 80 percent of its residents depend on farming for a living (Dewan and Bahadur 2005).However, its share of the nation's overall production and land area is incredibly small. In most of the districts of the state, the land holdings are

typically modest or less than one hectare (Negi, 2022). With 26.6% of the global millet area and 83% of the total millet cropping area in Asia, India is the world's largest millet producer (Muthamilarasan and Prasad 2021). Millets are a crucial component of tribal cuisine in the Indian states of Odisha, Jharkhand, Madhya Pradesh, Karnataka, Rajasthan, and Uttarakhand (Sood et al. 2019). However, due to their incredible nutraceutical potential, they have recently started to gain popularity in urban areas as well (Maitra and Shankar 2021). The area cultivated for millets worldwide has been decreased by an estimated 25.7% between 1961 and 2018. (FAOSTAT 2018). In Uttarakhand, Finger millet and Barnyard millet is grown mostly as compared to other millets (Uttarakhand Agriculture Department 2023). Millets are a very healthy crop since they are full of vitamins and minerals (Joshi et al., 2021).The total area, production and productivity of small millet in Uttarakhand is given in the list.

	Area (hac)	**Production (Thousand metric ton)**	**Productivity (kg/hac)**
2018-19	192.00	251.67	180.00
2019-20	182.00	265.77	270.32
2020-21	180.00	1460.00	1502.00

(Source: Uttarakhand Agriculture Department)

Farmers in the mountainous area devote a sizable portion of their land holdings to cultivating cereal/millet crops for their subsistence (Sati 2005). However, only about 22.41% of the state's GDP is contributed by the agriculture sector (Uttarakhand State Planning Commission 2007). Though the development of the agricultural sector continues to be the main focus of governmental policies, industrial development in this region is limited by a lack of better infrastructure facilities and the region's typical geographical conditions. This is because the development of mountainous regions is primarily linked to the advancement of agriculture and its related sectors (Rashika et al., 2024).

Antioxidant properties and a high nutritional value make millets ideal for a balanced diet (Misra et al., 2014). With 89 thousand tonnes produced, Uttarakhand has surpassed other states in the production of small millets (Indian Agriculture Statistical Report, 2011). Millets are a diverse group of small-seeded annual grasses that are grown as grain crops primarily in rainfed marginal lands (Negi et al., 2017). Compared to other irrigated crops like rice and sugarcane, which are currently promoted through government programmes and policies, these crops require a very small amount of water and either a very small amount of external input or none at all (Sati et al., 2025). Millets require around 25% less rainfall and also don't demand rich fertile soils for their survival and growth so regarded as famine crop for rural poor andalso a rich source of fodder for animals in Uttarakhand (Srivastava and Srivastava, 2022).The mainmillet species cultivated in the area are: *Pennisetumtyphoides*(pearl millet),

Panicummiliaceum(proso millet or common millet), *Setariaitalica*(foxtail millet); *Echinochloacrusgalli* var. *Frumentacea* or *E. colona*(Japanese barnyard millet orSawa), *Eleusinecoracona*(finger millet) and *Paspalumscorbiculatum*(kodo millet of India).

The majority of millet farmers use bio fertilizers made at home or in farmyards. As a result, the practise of using bio-fertilizers can greatly reduce the high cost of chemical fertilisers to farmers as well as government subsidies (Vetriventhan et al., 2020). Almost no pesticides are required for millet crops because the majority of them are not harmed by diseases or pests while they are being stored.In light of the changing climate, millet crops offer the agricultural sector great potential. Millets have excellent nutritional value because they are three to five times superior to other commercially supported crops like rice, wheat, and sugarcane (Negi, 2022).Despite having a high nutritional value, millet crops have statistical data that is much worse than that for rice and wheat. In 2009, the FAO reported that the production of millets worldwide increased to 26.7 million metric tonnes from 33.6 million hectares, up from 23.3 million metric tonnes in 2002 from 33.3 million hectares. Africa produced 20.6 million metric tonnes of millet in 2009, followed by Asia and India with 12.4 and 10.5 million metric tonnes, respectively (Obilana, 2002). India leads the world in millets production, accounting for 41.04% of the estimated 27.8 million tonnes produced worldwide (Global Millet market 2019-24). However, over the past two or three decades, millets have lost some of their significance as a staple food, particularly in India, as a result of poor government policies on millets, increasing urbanisation, rising levels of poverty among the population, and these factors combined (Vetriventhan et al., 2026). As a result, the current study was carried out to gather information on millet production and cultivation in the Rudraprayag district of Uttarakhand as well as to gather all available data on the nutritional makeup of various millets. This study also emphasises the requirement for distinct approaches to agricultural development in plain and hilly areas, as well as the expansion of suitable government policies for millet cultivation promotion.

Material and methods

During the year 2019–20, the present study was conducted in ten villages of the district Rudraprayag, Uttarakhand that were situated along various altitudinal gradients. To gather field data, ten villages were randomly selected from the district. For the household survey, a total of 92 households were chosen at random. The majority of the villages' residents rely on forestry and agricultural resources for their subsistence. Rice, wheat, barley, amaranth, barnyard millet, buckwheat, foxtail millet, finger millet, and proso millet are among the common traditional crops grown by villagers.

Table 1: List of studied villages with number of interviewees in district Rudraprayag

Village	Latitude	Longitude	Elevation (m)	No. of farmer interviewees
Kwiltha	30^{0}34'43 N	79^{0}04'77 E	1460	10
Kanthar	30^{0}21'76 N	78^{0}57'71 E	810	9
Patuli	30^{0}21'49 N	78^{0}57'58 E	818	7
Sayalsu	30^{0}21'24 N	78^{0}57'70 E	859	9
Khonu	30^{0}35'31 N	79^{0}04'61 E	1651	10
Chaumashi	30^{0}36'32 N	79^{0}04'43 E	1921	11
Butolgaon	30^{0}25'43 N	79^{0}04'10 E	873	10
Kansil	30^{0}25'87 N	79^{0}06'67 E	1244	7
Kyuja	30^{0}25'85 N	79^{0}06'44 E	1183	9
Raitoli	30^{0}16'14 N	78^{0}57'26 E	745	10

In the present study collection of primary data was carried out mainly through group discussion and interviews with the local people mostly aged people to document the traditional crops specially millets grown in the past and current status of these crops. The required information was mainly collected by personal visit to the household on the basis of their prior oral consent. The discussions with local elderly people and women were conducted mainly in Hindi and local dialect Garhwali.

Indicator for Millet Cultivation

An indicator list was prepared to collect the data on millet cultivation with changes in cultivation pattern over time. This was based on available literature and field data that is refined in consultation with local experts generally aged people (Table 2).

Table 2. Indicators used for assessing millet cultivation and their uses

Category	Indicators	Sub-indicators
Cultivation	Name of grown millet and varieties	-
	Area sown	-
	Purpose	-
	Agricultural methods	Local practices
		Availability of new technology
		Source of seeds
		Access to information related new variety and cultivation practices
	Changes in cultivation and	Millets cultivated in past and present

	Reasons for change	Perception changes
		High economic value of new crop
		Environmental changes
Storage	Type of storage	-
	Losses during storage	-
Consumption & uses	Local customs	-
	Local preferences	-
	Medicinal uses	-
	Other uses	-

Results and discussion

The results of the study shows that mainly four small millet species i.e., *Eleusine coracana*(finger millet), *Echinochloa frumentacea*(barnyard millet), *Panicummiliaceum*(proso millet) and *Setaria italic*(foxtail millet) were cultivated by the inhabitants (Table 3).

Table 3: Species of millets cultivated in the study area

Scientific Name	English name	Local name(s)	No. of cultivated villages
Eleusine coracana	Finger millet	Mandua/Koda/Madua/Ragi	10
Echinochloa frumentacea	Barnyard millet	Jhangora/Maadira/Sawa	10
Panicummiliaceum	Proso millet	Cheena	2
Setaria italic	Foxtail millet	Kauni	8

Local Agricultural Practices: Agriculture has traditionally been practised in this area under rainfed conditions. In accordance with the region's traditional cropping practices, multiple crops are grown in a single field during the kharif season in order to preserve crop biodiversity, replenish soil fertility, supply a variety of foods, and lessen pest and pathogen attack. In the hills of Uttarakhand, this system of regional practices or mixed cropping is referred to as the "Baranaja system."

Important mixed cropping systems identified in the region during study were:

- Paddy+ Foxtail millet + Barnyard millet + Sesame + Black Gram + Buckwheat
- Paddy + Sesame + Foxtail millet
- Paddy + Sesame + Foxtail millet + Corn +Proso millet

- Paddy + Soyabean + Black Gram + Foxtail millet + Buckwheat
- Finger millet+ Black Soyabean + Black Gram + Black-eyed peas + Amaranth
- Barnyard millet +Finger millet + Black Soyabean

The study's findings indicate that the majority of farmers engaged in agriculture for personal consumption. The amount of surplus produce depends largely on land ownership, climatic conditions, the type of produce, availability, and the accessibility of the intermediary. Surplus produce is typically sold in the nearby market or exchanged for other household useful consumable items. The majority of millet crops are grown in small, fragmented plots of land in combination with paddy (a variety that can grow in rainfed conditions) and other legume crops.Instead of growing traditional crops for family consumption, farmers in Butolgaon and Kansil have gradually shifted to growing cash crops. With the primary goal of selling them, farmers began to grow fruits and vegetables. However, this trend did not spread to other regions as well; only a small number of villages, mainly those closest to the road, have adopted it.

Crop rotation was a common practise among farmers in all the villages under study. Typically, this involved planting wheat, rice, and finger millet, followed by a period of fallow land. Since every village follows a similar pattern, no differences between the villages were reported.The practice of intercropping, or growing multiple crops simultaneously in the same field, appears to be more widespread throughout all 10 villages. More specifically, finger millet is frequently grown alongside black beans (black soyabean), black lentils (urad dal), amaranth, and barnyard millet in the villages of Raitoli, Patuli, Kanthar, and Kwiltha. Around the rice field, foxtail millet and proso millet are sometimes sown. People cultivate each crop separately in Butolgaon and Kansil, sometimes along the borders of the primary crop.

Nutritional Properties and Health Benefits of Identified Millet Crops: Compared to the most popular cereals, small millets are much more nutrient-rich (Bhat et al., 2018; Banerjee and Maitra 2020). Except for finger millet, which is a superior source of calcium ranging from 300-350 mg/100 g, the majority of millets are high-quality sources of iron and phosphorous (Roa et al., 2011; Layak et al., 2023). The small millets' protein content ranges from 7 to 12%, while their fat content is between 1 and 5%. (Table 4). According to Dida and Devos (2006), finger millet contains 16 times more calcium than maize and if it is substituted with rice, it has detrimental health effects that result in widespread anaemia. The millets also provide a wealth of essential amino acids, satisfying the protein needs of people who only consume plant-based foods (Chandel et al., 2014). The non-starchy polysaccharides and dietary fibre found in millets, which make up about 65% of its carbohydrate content, help to lower blood cholesterol, prevent constipation, and slow the release of glucose into the bloodstream during

digestion (Banerjee and Maitra 2020). Regular millet consumption also lowers the risk of developing duodenal ulcers, cardiovascular diseases, and diabetes.

Table 4. Nutritional composition of millets (per 100 g) compared to commercial crops

Food grain	Nutrient composition								
	Fat (g)	Protein (g)	Carbohydrates (g)	Crude fibre (g)	Mineral matter (g)	Energy (KCal)	P (mg)	Ca (mg)	Fe (mg)
Finger millet	1.3	7.3	72.0	3.6	2.7	328	283	344	3.9
Barnyard millet	2.2	6.2	65.5	9.8	4.4	307	280	20	5.0
Proso millet	1.1	12.5	70.4	2.2	1.9	341	206	14	0.8
Foxtail millet	4.3	12.3	60.9	8.0	3.3	331	290	31	2.8
Wheat (whole)	1.5	11.8	71.2	1.2	1.5	346	306	41	5.3
Rice	0.5	6.8	78.2	0.2	0.6	345	160	10	0.7

(Source: Nutritive value of Indian foods, NIN, 2007)

Millet Cultivation in Uttarakhand and Rudraprayag district: The area under agricultural cultivation in Rudraprayag district, indicate that amongst other cereal crops finger millet is one of the important crops in Uttarakhand (Figure 1).

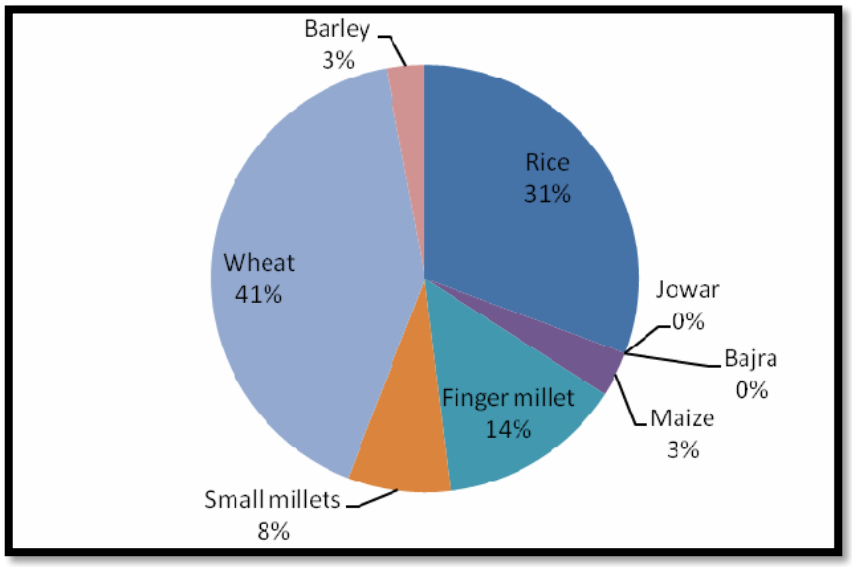

Figure 1: Cultivation of different millet crops by cultivated area (Source: Ministry of statistics and programme implementation (2012 b), India)

According to Uttarakhand agriculture statistics from 2009, the total area of finger millet cultivation is approximately 153000 ha, or 2.86% of the state's total area, while the corresponding figures for wheat, rice, and other millets are 398000 ha, 296000 ha, and 75000 ha. According to information from the ICAR's Agriculture Research Centre (Vivekan and Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, finger millet is cultivated on two times as much land as barnyard millet, and no information was available for other millets like foxtail and proso millet. A summary of the millets' production patterns in the Rudraprayag district is given in Table 5.

Table 5. Millet Production in the Rudraprayag district and Uttarakhand (Year 2007-2008)

State/district	Finger millet			Barnyard millet		
	Area (ha)	Production (t)	Productivity (q/ha)	Area (ha)	Production (t)	Productivity (q/ha)
Rudraprayag	6303	11017	17.48	3249	5550	17.08
Uttarakhand	128156	178733	13.95	67159	86783	12.92

Source: VPKAS, Almora, Uttarakhand/Year

In Uttarakhand, millets account for a sizable portion of agricultural production, but there are indications that millet cultivation is gradually declining in some Himalayan regions and is typically being replaced by cash crops. Farmers rely heavily on changes in society and the growth of market economies, but this trend is not yet widespread. For instance, cash crops are grown in small quantities in most of the studied villages, with the exception of Butolgaon, which does not help the locals' ability to provide for themselves. Farmers only began using modern agricultural methods once they had grown weary of using conventional farming methods.

Fertilizer Usage and Soil Quality: Across all studied villages, most people reported use of manure or cow dung as the main fertilizer for rainfed crops. It is observed that due to non availability of manure in sufficient quantity, use of urea and other fertilizers such as NPK used by some farmers, mostly on wheat and irrigated rice crops. The most interesting observation was that the necessity of artificially fertilize millets was not reported by any farmer.

Changes in Agricultural Practices: All ten of the villages residents engage in traditional agricultural methods and farmers claim to have passed on their knowledge to younger generations. People frequently cultivate traditional crops in the traditional way using their long-term stored seeds. They typically reserve a

certain amount of produce for sowing the following season. In general, there are no contacts with governmental agricultural centres in the study area, and any innovations that are used by the farmers are a result of ongoing NGO education and outreach efforts, such as vermicomposting and the use of organic pesticides. In the villages, some changes in the types of crops or the quantity grown are also acknowledged. These changes are related to migration, environmental conditions, and the high economic value of new crops.

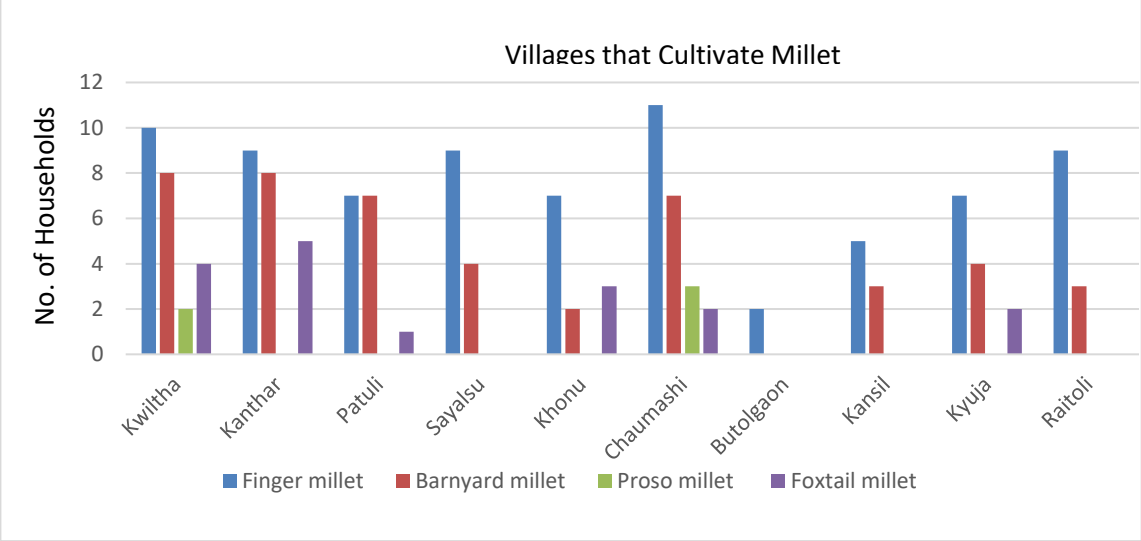

Table 6: Status of different millet cultivation in the villages

Village	Finger millet		Barnyard millet		Proso millet		Foxtail millet	
	Yes	No	Yes	No	Yes	No	Yes	No
Kwiltha	10	-	8	2	2	8	4	6
Kanthar	9	-	8	1	-	9	5	4
Patuli	7	-	7	-	-	7	1	6
Sayalsu	9	-	4	5	-	9	-	9
Khonu	7	3	2	8	-	10	3	7
Chaumashi	11	-	7	4	3	8	2	9
Butolgaon	2	8	-	10	-	10	-	10
Kansil	5	2	3	4	-	7	-	7
Kyuja	7	2	4	5	-	9	2	7
Raitoli	9	1	3	7	-	10	-	10

Table gives an overview of millets growers in each village of study area. The values 'yes' and 'no' indicate the number of interviewees who mentioned they grow or not the respective millet.

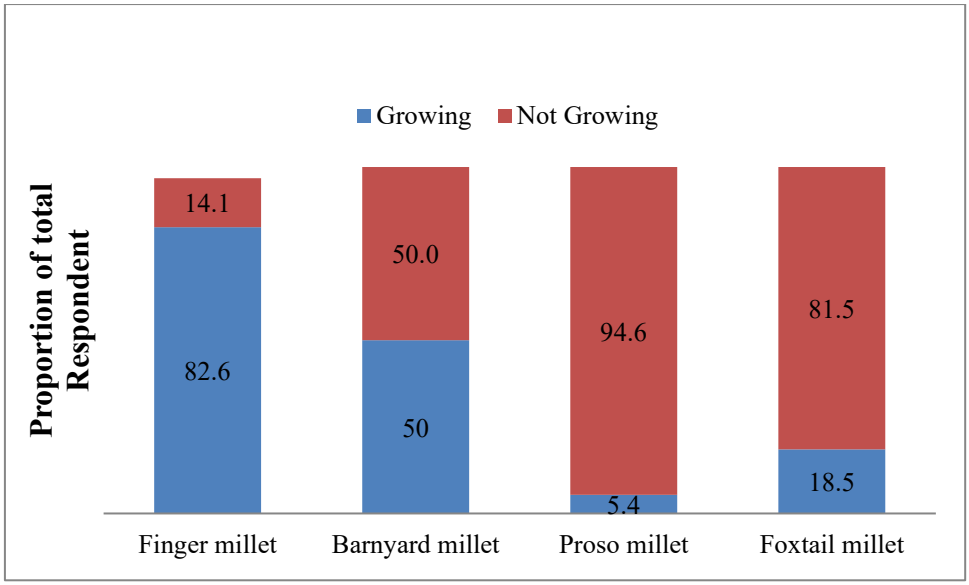

Figure 2: The respondents proportions who growing or not a certain millet

Positive responses (interviewees) about a particular crop were more prevalent than negative responses (interviewees), and these responses were seen as a sign of the millet's importance in the entire area. Figure 2 demonstrates that proso millet and foxtail millet are less commonly grown by farmers than the other two millets. The most common millet crop grown in the villages under study is finger millet. It is well-known throughout the area and is practically a household staple. The second-placed crop, barnyard millet, is mostly used as animal fodder (dry straw as fodder and cooked grains as a feed during and after pregnancy), according to the interviewees. Proso and foxtail millet follow these two crops, but their patterns of cultivation vary between the villages. Proso millet appears to be a crop that few farmers are familiar with.

Table 7. Millet Production and Consumption

Characteristics	Finger millet	Barnyard millet	Proso millet	Foxtail millet
Trends				
Recognize decline in production	3	3	4	4
New generation don't eat the grain	76	84	91	90
Growing				
Grown only for animals	0	8	2	1
Grown to sell	4	12	0	0
Self consumption	56	20	2	7
Eating				
It is healthy	60	73	3	3

Better than other crops	2	4	2	0
Good taste	8	7	1	1
Not Growing / Growing Less				
Never grow	0	0	10	15
Replaced - better crop for food	5	8	92	92
Replaced - better crop for money	5	8	56	51
Difficult to grow	0	0	0	0
Animal menace	0	0	0	0
Moved to city/Quit farming	5	5	5	5
No seed available	0	0	0	0
Insufficient land/resources (cow manure)	1	4	2	5
Insufficient water to grow it/irrigation facility not available	0	0	0	0
Not Eating				
Food for poor	2	5	6	4
Bad taste	0	0	3	2
Health benefits unrecognized	9	7	15	21
Difficult to digest	0	0	1	1
Difficult to dehusk	0	15	2	0

Finger millet /Mandua: Only 16 of the interviewees in the current study did not grow finger millet on their farms, including two farmers who had completely given up farming. Only for use by the family (who grind it into flour) or for local commerce is finger millet grown (Table 7). Farmers appear to be aware of the nutritional and health benefits of finger millet and barnyard millet, particularly in the Butolgaon, Kyuja, and Kansil villages. Farmers praised the grain for its deliciousness as well as the fact that it is a good source of calcium. However, some respondents from the villages of Khonu and Chaumashi described finger millet as tasteless, indicating a slight variation in these villages' preferences for finger millet. However, finger millet is a natural illustration of a nutritious food. No farmer was able to identify the variety grown among the cultivated varieties. They stated that these are conventional varieties, which mature six months after sowing and grow to a height of one metre.

Barnyard millet/Jhangora: In the past, barnyard millet was a significant component of many older people's diets, but today, almost no one is still interested in consuming it. In its place, livestock are fed on the crop straws. Barnyard millet is difficult to dehusk, according to locals, and as a result, people

are reluctant to include it in their diets. The majority of farmers agreed that it wasn't tasty and was difficult to digest. Some of the respondents claimed that the younger generation is not interested in eating these millet crops. The older generation is still aware of millets' nutritional value. In the past, barnyard millet was a significant component of many older people's diets, but today, almost no one is still interested in consuming it. In its place, livestock are fed on the crop straws. Barnyard millet is difficult to de husk, according to locals, and as a result, people are reluctant to include it in their diets. The majority of farmers agreed that it wasn't tasty and was difficult to digest. Some of the respondents claimed that the younger generation is not interested in eating these millet crops. The older generation is still aware of millets' nutritional value.

Foxtail millet/Kauni: The result of the study shows that the farmers cooked it as rice and still continues to eat the grain. They also perceived that the grain has medicinal properties and it is useful in curing chicken pox or stomach related problems. The people of the study area also reported that earlier they used to grow it, but not now. It indicates that cultivation of foxtail millet has abandoned by farmers quite recently. Many reasons are being invocated for this change, but no consistent pattern was found in the answers. In the Patuli and Syalsu village farmers remember this crop but all stated that seeds of the crop not available anymore.

Proso millet / Cheena: As pointed out earlier, this millet crop remains the mystery crop in the study area. People responded positively about the crop when we asked, they were growing this crop at past butadditional information could not be obtained.

Patterns of Change: It’s possible that finger millet will continue to be grown only for personal use. The grain's flavour and its well-known health advantages may be the real drivers of this crop's popularity. Some farmers reported that they are still eating these millet crops, but the majority of farmers acknowledged that the overall production of other millets is undoubtedly declining. Due to the laborious nature of small grain processing and a lack of sufficient land, millet cultivation can be abandoned in rural areas. Therefore, the public may favour work convenience over modest improvements in health.

Storage: In general, households don't create food reserves. The millets can be stored for at least a year. Farmers also stated that when storing grains for consumption, a small portion of the crop is saved as seed (depending on the amount of land available). In the majority of villages, people stored their grains in wooden boxes, but today some farmers have switched to tin containers, like drums, to better protect their crops from insects and mould. Nearly all farmers reported no significant losses during storage, and millet is primarily used for local consumption (Figure 3).

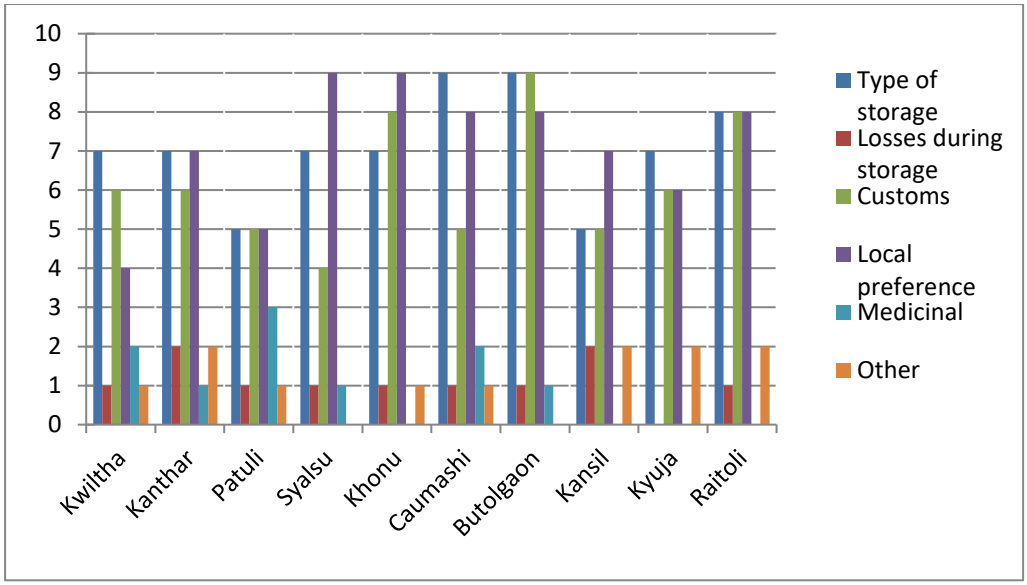

Figure 3: Shows type of storage, losses during storage and uses of the millet crops in studied villages

Factors responsible for Limiting Millet Productivity: In the study area, millets production is continuously declining and is subject to significant fluctuations. None of the other millet varieties, besides finger millet, has demonstrated any expansion in their cultivation area. The following are the primary reasons for limiting millet production:

(i) On marginal soils, millets are grown in rainfed conditions. The productivity of these crops is decreased by the soil's low capacity to retain moisture and climatic fluctuations.

(ii) These crops are frequently grown without fertiliser and manure. Low returns have been the result of poor variety adoption and inefficient agricultural practises like tillage, ploughing, sowing, weeding, and inter-culturing. The poor socio-economic status of the farmers is primarily to blame for the lack of adoption of improved crop management practises.

(iii) The mixed cropping system adopted by the farmers from years is in general suitable for sustaining agriculture.

(iv) Research on millet crop improvement and agro-techniques suitable for millet production are neglected till the date. There is also lack of organized programme for supply of improved variety seeds and market facilities for marketing of surplus produce at a lucrative price.

Additionally, there is a dearth of support for millet crop development and extension. Even though the State Agricultural Universities and the All-India Co-ordinate Research Project on Millet Improvement (AICMIP) have conducted numerous studies, millet crops still don't have enough development assistance. Therefore, there is a pressing need to expand these studies in order to increase the area and output of millet production.

Conclusion and Suggestions

Despite their low genetic potential, small millets are typically grown in dry lands due to the poor socio-economic conditions of the farmers. It has been found that intercropping legumes with millet as a component crop increased the yield of legumes, resulting in improved soil health and increased food/nutritional security for the farmer. Millets are a great food for boosting the nervous system because they are simple to digest. As a result, state-level training programmes on millet production and value addition are necessary to make developmental efforts. These programmes would help farmers adopt the new millets varieties in place of the traditional, low-yielding varieties while also raising the crop's economic value through value addition. Farmers must be made aware of new millet production techniques, and improved seed must be provided either for free or at heavily discounted prices by the government.

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