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Status paper

Present Status and Revival of Millets Cultivation in Himachal Pradesh

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Millets are a highly varied group of small-seeded grasses, widely grown worldwide for grains and fodder. Millets are important crops in the semi-arid tropics of Asia, Africa and Europe, with 97% of millet production in developing countries. Globally, India is the largest grower of millets, with 26.6% of the world's and 83% of Asia's millet cropping area, followed by Sudan and Nigeria (Anonymous, 2023). This crop is favoured due to its productivity and short growing season under dry, high-temperature conditions. Owing to shorter growing periods, they fit well in a wide range of cropping systems under rainfed conditions and smartly adapt to climate change. Due to their climate change resilience, millets are sometimes referred to as famine crops because they can assure yield in famine situations and grain can be stored for years without any major storage pest attack.

According to an estimate, there has been a decline of 25.7% in the global area under millets cultivation, whereas a percent increase of 16.26 was noticed in terms of production from 1961 to 2018 (Table 1). Among the continents, the largest reduction in area (90.14%) and production (73.76%) was observed in Europe, followed by Asia (59.79%; 8.77%), whereas the tremendous increase in area and production of millets has been observed in Africa (74.90%; 102.49%).

A brief history in the Indian context

Millets were the first crop domesticated in Asia and Africa by the local populations, which later on spread across the globe. Proso millet is one of the oldest and is believed to be the first domesticated cereal grain, which was an early introduction to India for extensive cultivation. In Sanskrit, it was called *Cheenaka, Kakakangu, Kangu* and *Anu*. Similarly, foxtail millet has been referred to as *Bhavajja, Priya Gguka, Rajika* etc., confirming its ancient cultivation. Archaeological data of proso millet and other crops suggested a wider network of crop exchange in mountainous regions of South and Central Asia during the 3000-2000 BC period and in parts of the Indian valley of Kashmir.

The mention of foxtail millet as *Priyangava*, proso millet as *Aanava* and barnyard millet as *Shyaamaka* in Yajurveda indicate that their cultivation and consumption was very common, dating back to the Indian Bronze Age (1500 BC). In *Sushruta Samhita* (600-500 BC), *Sushruta* classified cereals into three types: *Dhanyavarga*, *Khudhanyavarga* and *Samidhanyavarga*. *Khudhanyavarga* includes millets with their names; kodo millet as *Kodrusaha*, barnyard millet as *syamaka* and coix as *gavedhuka*.

The mention of foxtail millet in "*Abhijnana Shakuntalam*" by Kalidasa (4-5th AD) and in the 10th-12th century AD "*Varaha Purana*" indicates the importance of millets in that era. Records of millets (sorghum, pearl millet, kodo millet, barnyard millet and finger millet) grown in *Kharif* in Malwa, Gujarat, Ajmer, Khandesh, Lahore, Agra, Allahabad, Awadh and Multan by *Abul Fazl* in "*Ain-i-Akbari*" highlight the importance of these crops in Indian context during Mughal period. Millets are grown on a 12.45 mha area,

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Table 1. Millets (excepts sorghum) production and top producing countries

	Area (tons/ ha)							Production (lakh/ tons)							Productivity (kg/ha)						
	1961-1963	1971-1973	1981-1983	1991-1993	2001-2003	2011-2013	2016-2018	1961-1963	1971-1973	1981-1983	1991-1993	2001-2003	2011-2013	2016-2018	1961-1963	1971-1973	1981-1983	1991-1993	2001-2003	2011-2013	2016-2018
Africa	118.39	133.23	108.75	168.99	197.69	191.28	207.07	69.42	74.51	77.62	109.66	142.48	113.39	140.57	586.00	559.00	714.00	649.00	720.00	597.00	677.00
America	2.66	2.53	2.46	2.26	2.15	1.67	1.68	3.26	2.98	3.07	3.36	2.89	2.45	3.63	1223.00	1176.00	1247.00	1486.00	1269.00	1361.00	2166.00
Asia	271.75	272.35	229.05	174.64	144.70	121.96	109.26	152.93	181.63	178.19	142.07	137.57	142.50	139.52	562.00	666.00	777.00	811.00	938.00	1171.00	1276.00
Europe	40.89	26.87	28.02	22.45	8.18	6.28	4.03	23.78	26.75	21.40	16.28	9.04	8.36	6.24	583.00	982.00	761.00	765.00	1079.00	1301.00	1517.00
Australia & New Zealand	0.29	0.33	0.33	0.30	0.36	0.35	0.35	0.32	0.36	0.32	0.26	0.29	0.36	0.36	1087.00	1067.00	975.00	855.00	814.00	1015.00	1022.00
World	433.98	435.31	368.61	368.65	353.10	321.54	322.38	249.70	286.24	280.59	271.63	292.27	267.0	290.31	557.00	686.00	761.00	736.00	823.00	832.00.	900.00

Source: FAO STAT 2018

(Each value represents average of 3 years)

yielding 15.53 mt at a rate of 1247 kg/ha. Sorghum is India's fourth most important food grain crop in terms of output (4.31 mt) and area (3.84 mha). More than 50% of the nation's land is planted with pearl millet (7.05 mha) which contributes roughly to an equal percentage in production. It's important to note that India produces the maximum amounts of barnyard millet (99.9%), finger millet (53.3%), kodo millet (100%), little millet (100%) and pearl millet (44.5%) in an area of 8.87 mha. Among all the millets, finger millet has shown the highest yields in recent years (Table 2).

About 21 states in India grow millets. They have been an integral part of tribal food in the states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka and Uttarakhand (Sood *et al*. 2019). However, in recent years, owing to their tremendous nutraceutical potential, they have also become popular in urban areas. Rajasthan (29.05%), Maharashtra (20.67%), Karnataka (13.46%), Uttar Pradesh (8.06%), Madhya Pradesh (6.11%), Gujarat (3.94%) and Tamil Nadu (3.74%) are the states with the high percent of the area under millets cultivation. The area under millet cultivation has been expanded recently in the states of Gujarat and Madhya Pradesh. Indian states like Andhra Pradesh (2626.58 kg/ha), Tamil Nadu (2153.22 kg/ha), Haryana (1906.78 kg/ha), Gujarat (1762.05 kg/ha) and Madhya Pradesh (1729.70 kg/ha) has achieved the maximum yields of millets. Compared to its predecessors, states like Gujarat and Andhra Pradesh have demonstrated high levels of productivity.

While examining the scenario of millets in India from 1950-51 to 2018-19 the millet area and production showed negative growth, *i.e.,* cultivation area and production is declining at the rate of 16.31 per cent and 13.58 per cent per year, respectively (Uma Gowri and Shivakumar 2020). Annual decline in productivity was observed till 2005, but after that it showed positive growth.

Table 2. The trend of area, production and yield for various millets in India

Crop		1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020	2021-2022
Finger Millet	**Area (m ha)**	2.33	2.49	2.51	2.43	1.85	1.48	1.17	1.01
	Production (Mt)	1.70	1.86	2.41	2.57	2.42	2.07	1.79	1.67
	Productivity (kg/ha)	725.40	746.80	956.30	1059.10	1319.50	1395.00	1591.38	1747.00
Sorghum	**Area (m ha)**	17.09	18.30	16.36	15.83	11.76	8.76	6.07	4.83
	Production (Mt)	7.65	9.29	9.75	11.09	9.80	7.27	5.07	4.31
	Productivity (kg/ha)	446.00	506.90	596.60	701.60	831.00	836.90	883.38	989.00
Pearl Millets	**Area (m ha)**	10.66	11.58	11.97	10.94	10.32	9.39	8.05	7.55
	Production (Mt)	3.21	4.00	5.35	5.08	7.33	7.87	9.02	9.22
	Productivity (kg/ha)	300.00	345.00	444.40	460.40	64.60	829.50	1130.10	1374.00
Total Millets	**Area (m ha)**	30.08	32.37	30.84	29.20	23.92	19.63	15.29	13.83
	Production (Mt)Productivity (kg/ha)	12.56 300.00	15.14 345.00	17.51 444.40	18.73 460.40	19.55 657.30	17.20 829.50	15.88 1130.10	15.53 1248.00

Source: INDIASTAT 2020; and Final Estimates-2021-22, DES, GoI
(Each value represents average of 10 years)

Scenario in Himachal Pradesh

In the Himalayan region, millets are an integral part of subsistence agriculture and are mostly used for food and beverages by small farmers. Finger millet is the major and versatile millet in these areas, followed by foxtail millet. In Himachal Pradesh, the physiography and agro-ecological situation across the foothills of Shivaliks to high hills of the great Himalayan range support cultivation of a wide variety of crops (cereals, vegetables, medicinal and aromatic plants, fruit crops etc.) depending on their adaptation. Traditional subsistence farming was based on cereals where millets and pseudocereals were important components. Millets such as pearl millet (*bajra*), sorghum (*jowar*), finger millet (*ragi*) and minor millets such as foxtail millet (*kangni*), proso millet (broomcorn millet/*chena*), barnyard millet (*Sanwa/ Samvat ke Chawal*), little millet (*Moraiyo/ Kutki/ Shavan/ Sama*) etc. are also cultivated (Table 3) in small pockets. Whole millets and millet flours are naturally gluten-free and significant alternatives to rice and wheat. With some variations, millets can easily replace wheat and rice in most recipes like flatbreads, pudding, pancakes, cookies, etc. Dual-purpose millets, *i.e.* yielding both grains and fodder are grown to ensure food and fodder security in rainfed/dry areas.

Foxtail millet cultivation in Karsog, Mandi

In Himalayan states, the pattern of millet consumption varies across states and has remained similar or reduced over time. According to the state's statistical reports (2019-20), in Himachal, the area under millets has decreased to 6000 hectares (approx. 6.71 thousand hectares) from almost 35000 hectares in the last four decades, having an annual production of 5.88 thousand tonnes.

Increased urbanization and shifting from traditional crops to high-value cash crops in Himachal Pradesh have played a great role in the disappearance of traditional food crops like millets. Keeping in view the present scenario of the world with respect to human health and particularly increasing incidences of diabetes

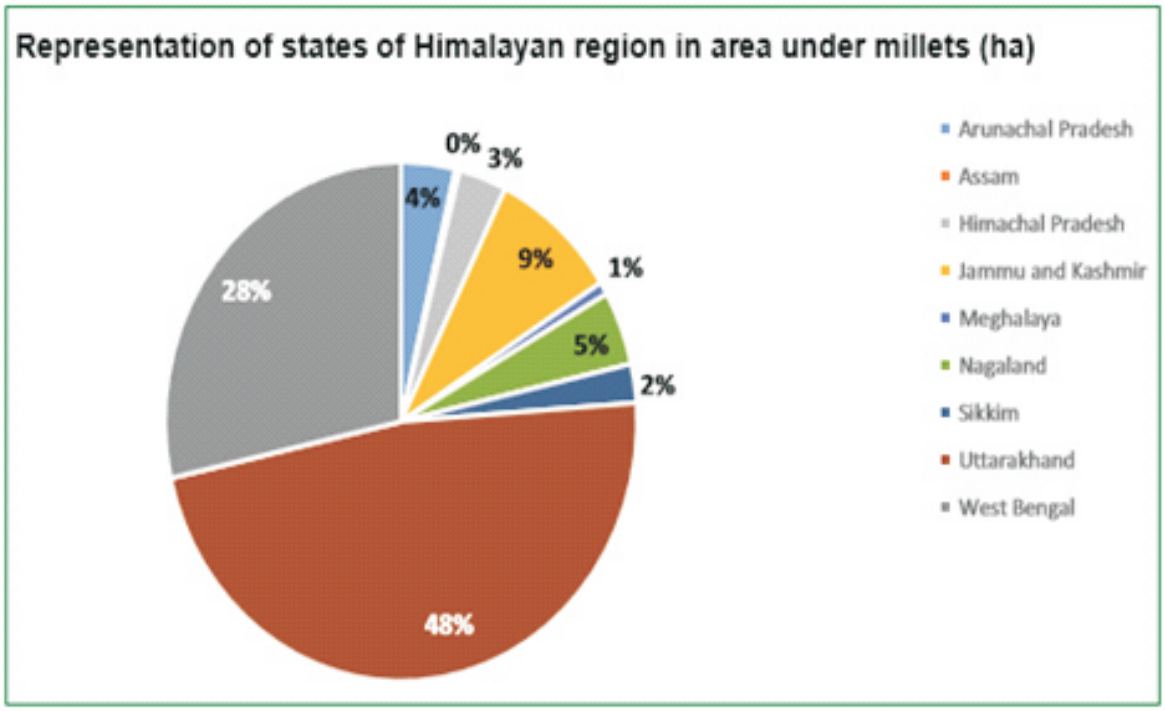


Table 3. Description of important millets prevalent in Himachal Pradesh

Name	Pearl millet	Great millet/ Indian millet	Finger millet	Foxtail millet	Proso millet	Indian Barnyard millet	Kodo Millet	Little millet
Scientific name	*Pennisetum glaucum* (L.) R. Br.	*Sorghum bicolor* L.	*Eleusine coracana* (L.) Gaertn.	*Setaria italica* (L.) P. Beauv.	*Panicum miliaceum* L.	*Echinochloa frumentacea*	*Paspalum scrobiculatum*	*Panicum sumatrense subsp. Sumatrense*
Common name	Bajra	Sorghum/ jowar/ chari/ broomcorn	*Ragi/mandal/ kodha*	*Kauni/kangni*	*Cheena/ chinee*	*Shownk, Sawa, Sawan/ Jhingora*	Kodo, Koda Millet	Kutki
Chromosome number	2n =2x= 14	2n = 2x = 20	2n=4x=36	2n = 2x = 18	2n=4x=36	2*n* = 6*x* = 54	2n=4x=40	2n=4x=36
Centre of Origin	West Africa	Tropical Africa	Highlands of Eastern Africa	China	China and Europe	India, Pakistan and Nepal	India	Southeast Asia
Pollination behaviour	Cross pollinated	Often cross pollinated (as natural cross pollination varies from 6-15%)	*Self-pollinated*	Self-pollinated	*Self-pollinated*	*Self-pollinated*	*Self-pollinated*	*Self-pollinated*
Cultivation in HP	For fodder purpose except Lahaul & Spiti and Kinnaur	For fodder purpose except Lahaul & Spiti and Kinnaur	Sirmaur, Shimla, Kullu, Mandi, Solan, Chamba, Kangra, Lahaul & Spiti and Kinnaur districts	Sirmaur, Bilaspur, Solan, Shimla, Mandi, Kangra, Hamirpur, Una, Kullu and Chamba districts	Temperate regions of Kinnaur, Shimla, Kangra, Sirmaur, Chamba, Mandi and Kullu districts	Sirmaur, Shimla and Kinnaur districts	Kullu, Mandi Kangra and Sirmour districts	Chamba and Shimla districts

in the Indian population, there is a dire need to ensure nutritional security in addition to food security and to bring the focus on potential crops like millets.

"There are some crops that give us money but fail to withstand the changing climate and then there are crops that survive extreme weather conditions but fail in the market", says Kishor Chand of Seraj valley of Himachal Pradesh, highlighting the dilemma that most farmers are facing in the age of climate change (Kumar 2021).

Foxtail millet cultivation in Karsog, Mandi

Boosting millet cultivation in fragile mountainous ecosystem will ensure sustainability and empower the average hill farmer and achieve the objectives of enhancing incomes, nutritional security and improving crop diversification. The hidden potential of rainfed areas to support food and nutritional security in a sustainable way for growing population has to be harnessed for which millets-the traditional crops of the area, suit the best. Recent trends of area and production in millets in HP is presented below (Table 4).

Detailed description of important millets

Pearl millet: ***Pennisetum glaucum*** also called bajra, cattail millet or bulrush is a type of millet grown on the Indian subcontinent and Africa since prehistoric times. It belongs to the genus *Pennisetum* and family Poaceae/Gramineae. The crop is cultivated for grain as well as for fodder. It is believed to be originated in India or Africa. It is grown all over India except Assam and part of northeast India.

Economic importance: It provides staple food for the poor in a short period in the relatively dry tracts of country. It is the most drought tolerant crop among cereals and millets. The pearl millet grains contain about 12.4% moisture, 11.6% protein, 5% fat, 67% carbohydrates and about 12.7% minerals which are eaten cooked like rice or chapattis are prepared out of flour like maize or sorghum flour. It is also used as feed for poultry and green fodder/ dry fodder for cattle.

Climate and soil: The crop has a wide adaptability and can grow under different day lengths, temperature and moisture stress. Most of the varieties developed in India are photosensitive, which helps grow the crop during monsoon, *Rabi* and arid season. It requires low annual rainfall ranging between 40-50 cm and dry weather. The crop may tolerate drought but cannot withstand high rainfall of 90 cm or above. Light soils of low inherent fertility and good drainage are best for this crop. The crop does not tolerate soil acidity.

Land preparation: The seeds are very small, so need very fine tilth. Two-three harrowing and ploughing are followed so that a fine tilth may be obtained to facilitate the sowing and proper placement of seed at appropriate depth.

Sowing: Most appropriate time of sowing is the middle or last week of July.

Seed rate: 4-5 kg/ha for the drilling method and 2.5-3 kg/ha for dibbling method

Spacing: 40-45 cm between rows and 10-15 cm apart plants within rows.

Manure and fertilizers: Generally, the crop requires a low quantity of nutrients. But experiments under All India Co-ordinated Millet Improvement Project have proved that new plant types of bajra, especially hybrids respond to very high doses of fertilizers like:

Table 4. Area, production and productivity of millets in Himachal Pradesh (Average of 2016-17 to 2020-21)

Crop	Area ('000 ha)	Production ('000 tonnes)	State productivity (kg/ha)	National productivity(kg/ha)
Bajra	0.30	0.18	583	1311
Ragi	1.62	1.68	1037	1588
Small millets	4.33	3.64	840	766

Source: Normal estimates of Area, Production and Yield of Selected Principal Crops April 2022; GOI Ministry of Agriculture & Farmers Welfare, Deptt. of Agri. & Farmers welfare, Directorate of Economics & Statistics, Agricultural Statistics Division, New Delhi

FYM: 15-20t/ha, 80-100 kgN/ha : 40-50 kgP_2O_5/ha : 40-50kgK_2O/ha.

The organic manures must be applied 20 days before the sowing for full decomposition. Fertilizers are applied in split doses, half of the nitrogen, full phosphorus and potash as basal, whereas one-fourth of nitrogen should be applied about 30 and 60 days after sowing.

Interculture: Thinning or gap-filling is followed during the first interculture. Hand weeding is followed to control the weeds.

Irrigation: The crop being drought resistant hardly needs any irrigation and is mostly grown under rainfed conditions. However, it is observed that the yield may be significantly increased by irrigating the crop at critical growth stages like maximum tillering, flowering and grain filling. Light irrigations and efficient drainage are very essential for bajra production.

Harvesting: The crop is harvested when grains become hard enough. Mostly two methods are adopted for harvesting the crop:

i) Cutting ear head from standing crop followed by cutting of remaining plants later
ii) Cutting of entire plants and stalking the plants for five days in sun for obtaining grains.

Grains are separated either by beating the earheads with sticks or by trampling the earheads under bullock feet.

Storage: The separated grains must be cleaned and dried in sun to bring about 12-14% moisture and then be bagged and stored in a moisture proof store.

Yield: Irrigated crop yields 30-35 q/ha, while rainfed crop yields 12-15 q/ha

Sorghum:*Sorghum bicolor*, also known as great millet, Indian millet, jowar, broomcorn, milo, durra is a cereal grain plant of the grass family Poaceae. Its edible starchy seeds are small, round, and usually, white or pale yellow (though some varieties are red, brown, black, or purple), which is used as food for humans, animal feed, and ethanol production. It originated in Africa and is now cultivated widely in tropical and subtropical regions round the globe. It is the world's fifth-most important cereal crop after rice, wheat, maize and barley. Sorghum grain cannot be consumed unless the indigestible husk is removed. During the early days the only way to remove the husk was by hand, with mortar and pestle. It is typically an annual, but some cultivars are perennial. It grows in clumps that may reach over 4 m high. The grain is small, ranging from 2 to 4 mm in diameter. Sweet sorghum cultivars are primarily grown for forage, syrup production and ethanol; they are taller than those grown for grain. Sorghum grows in a wide range of temperatures, altitudes and toxic soils, and can recover growth after some drought. The features like very large root-to-leaf surface area ratio, rolling its leaves to lessen water loss by transpiration in times of drought, going into dormancy rather than dying if drought continues, waxy cuticle protecting leaves and C_4 carbon fixation make it one of the most drought-resistant crop.

Economic importance: Sorghum grain is gluten-free, high in resistant starch, and more abundant and diverse phenolic compounds compared to other major cereal crops. In many parts of Asia and Africa, sorghum grain is used to make flat breads that form the staple food of many cultures. Popped grains are a popular snack in parts of Western India. An Indian bread called bhakri, jowar roti, or jolada rotti is prepared from this grain. It contains about 10-12% protein, 3% fat and 70% carbohydrates, therefore, it can satisfactorily replace other grains in the feeding programme for dairy cattle, poultry and swine.

Climate and soil: It is grown from sea level to as high as 1500 m amsl. Sorghum plants can tolerate high temperatures throughout their life cycle better than any other cereal crop, drought conditions very well as it remains dormant during moisture stress and resumes growth when favourable conditions prevail. It has low transpiration ratio. It does not tolerate frost. It can tolerate water logging conditions better than any other cereal crop; hence, it can be grown successfully in areas with an average annual rainfall of 60-100 cm. It is grown as *Kharif* crop in northern India, whereas, in the western and southern parts of the country; it is grown as *Rabi* crop also. The minimum temperature

for germination is 7-10°C and it needs about 26-30°C temperature for its optimum growth. The yields are adversely affected when mean temperatures exceed 26°C during the heading period. Sorghum is a short-day plant. It can grow on a wide range of soils; clay loam soils rich in humus having good water retention capacity are best suited for its cultivation. It does not thrive in sandy soils but does better in heavier soils. It does well in pH range of 6-8.5 as it tolerates salinity and alkalinity considerably.

Field preparation: Deep summer ploughing with moldboard plough followed by two ploughing with country plough, and harrowing and cross planking are required for getting a fine tilth.

Seed rate and spacing: There should be 1,50,000 plants/ha to attain maximum yield, for which a seed rate of 12-15 kg/ha is enough. The seed should be sown in rows 45 cm apart and plant to plant distance should be 12 cm. Seed should be shown at a depth of 3-4 cm.

Method of sowing: In northern India it is sown either by broadcasting or in rows behind the plough. Hybrids should be sown in lines for obtaining high yield.

Manures and fertilizers: Sorghum requires heavy doses of fertilizers because it removes nutrients in heavy amounts from the soil. In rainfed area application of farm yard manure @ 10-15 t/ha improves the water holding capacity and microbial activities. Apply 100-120 kg N, 50 kg P_2O_5 and 40 kg K_2O/ha for hybrids and improved varieties under irrigated conditions. Half dose of N and total amount of P_2O_5 and K_2O should be applied at the time of sowing. Fertilizer should be placed 3-5 cm to the side and 3-5 cm below the seed. The remaining half of the N should be top dressed after 30-35 days of sowing. In light soils top dressing should be done in two splits. Half of above dose should be applied in case of local varieties. In a rainfed crop, fertiliser quantity should be reduced to half of the irrigated and the entire quantity should be applied 10 cm deep in soil at sowing time.

Water management: Sorghum is a fairly drought-resistant crop that does very well in areas with 50 cm well-distributed rainfall. During the flowering and grain filling stages, the crop requires more water so it should be irrigated when there is less moisture in soil during these two critical stages. It should be sown on 5-7 cm high ridges in low-lying areas with proper drainage.

Harvesting and threshing: Most of the high-yielding sorghum hybrids and varieties take 100-120 days to mature. The crop should be harvested immediately after it is matured. The right stage for harvest is when grains have become hard having less than 25% moisture. Do not wait for stalks and leaves to dry because plants of hybrid sorghum appear green even after the crop is mature. Harvesting is done by cutting the entire plant, removing the ear heads first, and cutting down the plants later. Threshing is done with the help of threshers or by beating the ear heads with sticks or trampling bullocks. The threshed grain should be cleaned and dried in sun for about a week to reduce the moisture content to 13-15% for safe storage.

Yield: The grain yield of improved varieties under assured water supply ranges from 25-35 q/ha and that of hay between 150-170 q/ha. The green fodder from hybrid sorghum ranges between 500-600 q/ha while that of local varieties it ranges between 300-450 q/ha. With improved cultural practices, it is possible to harvest nearly 50 q/ha of grain and about 100-125 q/ha dry stover.

Important minor millets of the state

Finger millet: ***Eleusine coracana***, also known as Koda, Kodra, Ragi, Mandua, Mandal, is an annual herbaceous plant widely grown as a cereal crop in the State. It is a tetraploid and self-pollinating species that probably evolved from its wild relative *Eleusine africana*. Interesting crop characteristics of finger millet are the ability to withstand high drought and the long storage capability of the grains.

Origin: Finger millet is a domesticated cereal of African origin. Although the wild progenitor (*Eleusine africana*) is well established but location and African native range of this species where it was cultivated remains unclear. One limited genetic study suggested that the hills of western Tanzania might be the origin while many botanists have pointed to the Ethiopia highlands as a point of origin.

Economic importance: It is a staple food of many hill regions of the country. In northern hills, grains are used

in the form of chapattis. It can be ground into flour and cooked into cakes, roti and chilra, cooked like rice, puddings or porridge, fermented drink (or beer). Sprouted grains are recommended for children and elderly people. The straw from finger millet is used as animal fodder. The whole plant is used for making baskets, mats and thatching of the roof. Grain contains 12% moisture, 7.7% protein, and 1.5% fat. In a 100 g reference amount, finger millet supplies 336 calories, 22.6g dietary fiber and several dietary minerals. It is a good source of natural iron and helps in curing anaemia. It is rich in minerals, particularly calcium and potassium, which helps strengthen bones and teeth. It is good for growing children, lactating mothers, gluten-sensitive people and ageing people (Satyarthi *et al.* 2018).

Climatic requirement and soil: It can be grown from sea level to 2100 m amsl, on hill slopes and plains. Average rainfall of 50-100 cm is sufficient for its cultivation. It can grow on very poor to very fertile soils. Thrives best on well-drained loam or clay loam soil.

Seed rate and spacing: Spacing of 22-30 cm between lines and 8-10 cm within lines should be maintained. The seeds should be sown about 3 cm deep in the soil. The seed rate is 8-10 kg/ha.

Manures and fertilizers: Apply 8-10t/ha farm yard manure during field preparation. Use of chemical fertilizers @ 40:20:20 kg N, P_2O_5, K_2O per hectare is beneficial for good crop harvest.

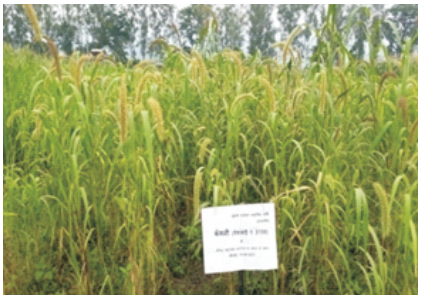
Water management: Tillering and flowering stages are critical for moisture stress. Water logging is harmful.

Weed control: Inter-cultivation and hand weeding with hoe should be done after 25 days of sowing. Two or three hoeings are sufficient to control weeds in problem areas.

Harvesting and threshing: Crop does not mature uniformly, so the harvest is to be taken up in two stages. When the earhead on the main shoot and 50% of the earheads of the crop turn brown, the crop is ready for the first harvest. At the first harvest, all earheads that have turned brown should be cut. After drying, thresh and clean the grains by winnowing. The second harvest is done around seven days after the first harvest. All earheads, including the green ones, should be cut. The grains should then be cured to obtain maturity by heaping the harvested earheads in the shade for one day without drying, so that the humidity and temperature increase and the grains get cured. After this dry, thresh and clean the grains as after the first harvesting.

Yield: Grain yields obtained are between 10-15q/ha from improved varieties like VL Mandua 204, VL Mandua 376, VL Mandua 378, VL Mandua 382 and VL mandua 352 recommended in Himachal Pradesh.

Foxtail millet: ***Setaria italica*** (synonym *Panicum italicum* L.), *Kangni, Kauni*, is an annual grass grown for human food. It is the second-most widely planted species of millet, and the most-grown millet species in Asia. The oldest evidence of foxtail millet cultivation was found along the ancient course of the Yellow River in Cishan, China, carbon dated to be from around 8,000 years before present. It has also been grown in India since antiquity. Foxtail millet is an annual grass with slim, vertical, leafy stems that can reach a 120–200 cm height. The seed head is a dense, hairy panicle 5–30 cm long. The small seeds, around 2 mm in diameter, are encased in a thin, papery hull which is easily removed in threshing. Seed colour varies greatly between varieties.



Economic importance: Grains can be cooked as rice and consumed particularly on religious occasions or fasts. It is used for curing fever, headache, chicken pox etc. Plant residue is used as fodder. It lowers triglycerides level, thus reduce the risk of heart attack. Linoleic acid and tocopherols present in foxtail millet enriches its antioxidant activities. It is an excellent source of fiber and protein rich in isoleucine, methionine, lysine, cystine, leucine and tryptophan.

Soil and climatic requirements: Thrives best on rich well drained loamy soils. It can be grown up to 2000 m amsl and receiving rainfall of 50-75 cm.

Seed rate and Spacing: It is a warm season crop, typically planted in late spring. Spacing of 20-25 cm between lines and 8-10 cm within lines should be maintained. Seed rate of 10-12 kg/ha is sufficient.

Manures and fertilisers: At the time of field preparation apply 8-10 t/ha farm yard manure. Use of chemical fertilizer at the rate of 40:20:20 kg N, P_2O_5, K_2O per hectare is beneficial for good crop harvest.

Water management: One or two irrigations are required.

Weed control: Two to three hand weedings are sufficient.

Harvesting: Harvest for hay or silage can be made in 65–70 days while for grain is in 75–90 days. Crop is harvested when ear heads are dry, either by cutting whole plant or ear heads separately. Threshing is done by stone roller or by trampling under the feet of bullocks.

Yield: A typical yield of 15–20 tons per hectare of green biomass or 3–4 tons per hectare of hay and a typical yield of 8–9 qt per hectare of grain can be achieved.

Proso millet: *Panicum miliaceum,* cheena, cheeni, broomcorn millet, common millet, hog millet, Kashif millet, red millet, and white millet was first domesticated about 10,000 BC in Northern China as archaeobotanical evidences suggest. The crop is extensively cultivated in China, India, Nepal, Russia, Ukraine, Belarus, the Middle East, Turkey, Romania, and the United States, where about half a million acres are grown each year.

This crop is notable both for its extremely short lifecycle, with some varieties producing grain only 60 days after planting, and its low water requirements, producing grain more efficiently per unit of moisture than any other grain species. Proso millet is a relatively low-demanding crop, consequently, it is often used in organic farming systems.

Economic importance: The grains are primarily used for human consumption. The whole grains are boiled like rice, roasted, cooked into porridge; ground and baked into flatbread or chapatti and cooked with milk to prepare *kheer*. Crop residue or grains are used as fodder and feed for animals. It contains higher protein than other millets and amino acids like lysine, methionine and tryptophan are two times higher than wheat and rice. Proso millet is rich source of B vitamins, especially vitamin B_6 and folic acid. It reduces the risk of heart diseases and also prevents breast cancer. Antioxidants present in proso millet play an important role in the body immune system.

Climate and soil requirements: It is sensitive to temperatures lower than 10 to 13°C. Proso millet is highly drought-resistant, making it interesting to regions with low water availability and longer dry spells. The soil should be light or medium-heavy. Due to its flat root systems, soil compaction must be avoided.

Seedbed and sowing: Seeding at 8-10 kg/ha is sufficient. A 16-25 cm distance between the rows and 8-10 cm plant to plant is recommended. The sowing depth should be 1.5 to 2 cm in optimal soil or 3 to 4 cm in dry soil.

Manures and fertilizers: During field preparation, apply 8-10 t/ha farm yard manure and 40:20:20 kg N, P_2O_5, K_2O per hectare is beneficial for good crop harvest.

Water management: At tillering if dry spell prevails for longer period, then irrigation must be given. Summer crop would require 2 irrigations; first at 25-30 days after sowing and second after 40-45 days of sowing.

Weed control: Keep weed free up to 35 days stage. Two weeding at an interval of 15-20 days would be useful.

Harvesting and postharvest treatments: Determining the best harvest date is not easy because all the grains do not ripen simultaneously. The grains on the top of the panicle ripen first, while the grains in the lower parts need more time, making compromise and harvest necessary to optimize yield. Harvesting can be done at the moisture content of the grains around 15-20%.

Yield: Average yields are between 5-6 q/ha for grains and 9-10 q/ha for dry fodder.

Barnyard millet: Among many cultivated and wild species of barnyard millet two most popular speciied are *Echinochloa frumentacea* (Indian barnyard millet) and *E. esculenta* (Japanese barnyard millet), also known as Shownk, Sawa, Sawan, Jhingora, Madira, is a very widespread genus of plants

in the grass family and tribe Paniceae. Some of the species are known by the common name cockspur grass. Some of the species within this genus are millets that are grown as cereal or fodder crops. The most notable of these are Japanese millet (*E. esculenta*) in East Asia and Indian barnyard millet (*E. frumentacea*) in South Asia.

Economic importance: Dehusked grains are cooked and consumed like rice. Popped grains are used for making *kheer* and *laddoos*. Grains are acceptable eatables during religious and ceremonial fasts. It is recommended for patients with cardiovascular diseases, diabetes, constipation etc. In terms of nutritive value, barnyard millet is superior to major and minor millets. Grains are a rich source of dietary fiber, iron, zinc, calcium, protein, magnesium, fat, vitamins and some essential amino acids.

Climate and soil: Barnyard millet is tolerant to a very wide temperature range and can be cultivated on soils having fragile ecology. It can grow in partially water-logged soils and thrives best on sandy loam to loam soil. Barnyard millet can be grown upto 2700m above mean sea level and 20-40 cm rainfall.

Seed rate and spacing: A seed rate of 4-5 kg/ha for nursery raising, 8-10kg/ha for direct sowing and 12-15kg/ha for broadcasting is enough. Row to row 20-25cm and plant to plant spacing 8-10cm spacing is recommended.

Manures and fertilizers: At the time of field preparation, apply 8-10 t/ha farm yard manure and 40:20:20 kg N, P_2O_5, K_2O per hectare is beneficial for good crop harvest. In irrigated half N can be top dressed after 25-30 days of sowing.

Water management: Barnyard millet does not require irrigation, however if dry spell prolongs, irrigation at panicle initiation stage should be given.

Weed control: Weed free up to 25-30 days after sowing. Two weeding are sufficient.

Harvesting: Cut from ground level, stack for a week and thresh using bullocks. Crop matures in 70-115 days.

Yield: 7-8 q/ha

Kodo millet (*Paspalum scrobiculatum*), also known as Kodo or creeping paspalum, is commonly grown in Central India and Southern India. It is an annual grass plant that produces seeds which are low in fat. It matures within 4 months and known as toughest grain to de-husk. It can also be used as good cover crop. It is rich in calcium, dietary fiber, phenols, protein, vitamins and minerals (Chandel *et al.* 2014). The grain is also rich in phytochemicals, which is believed to lower cholesterol, and phytate, which is associated with reduced cancer risk (Coulibaly *et al.* 2011). It is useful in curing asthma, migraine, blood pressure, heart attack and atherosclerosis, diabetic heart disease and for postmenopausal in women. Average yield: 4.5-6 q/ha.

Little millet (*Panicum sumatrense subsp. sumatrense)* also known as Kutki, Samai, Hog millet etc. The centre of origin of little millet is Southeast Asia as it was recovered at Indus Valley Civilization site of Harappa. It is an annual grass plant grown upto 2100m amsl. It is a short duration crop among all the millets and mature within 65-70 days after sowing. The seed of this millet can be cooked like rice. The seed contain complex carbohydrates, phenolic compounds and antioxidant content which helps to prevent metabolic disorders like diabetes, cancer, obesity etc. Average yield: 3-5 q/ha.

Reasons for negligence

There is a lot of scope to enhance productivity as there exist large yield gaps between research claims/FLDs and farmers' fields. These yield gaps need to be bridged by avoiding or/and working on the reasons for these yield gaps. Some of the reasons for yield gaps are:

1. During the colonial period, there was no emphasis on millets as the colonizers led the agricultural production to suit their needs of import which is evident from the fact that from 17th century to 20th century, the productivity of millets did not rise. These crops were further cornered when wheat and rice cultivation alongwith other fine grains was perfected during Green Revolution era. Both,

demand and supply side factors are responsible for reduction in area, production and consumption of millets in India in recent decades. On the demand side, negative perception of millets with the stigma "food for poor" and increased consumption of other fine cereals through PDS, the consumption of millets was reduced. On the supply side, limited production of these crops due to their neglect, particularly during "Green revolution" period during which technological interventions and other policy support from the government like improved package of practices, subsidies on inputs, better processing etc. favoured production of fine grains, further marginalized millets.

2. According to the Ministry of Agriculture & Farmers Welfare, in 2016 – 2017, the area under the cultivation of millet declined due to change in consumption pattern, conversion of irrigated area for wheat and rice cultivation, unavailability of millets seed, low yield, dietary habits and less demand. This resulted in fall in the level of nutrients like vitamin-A, protein, iron and iodine in women and children leading to malnutrition.
3. Many minor millets are not adapted to modern agro-ecosystems and mechanization because of some inherent problems like high seed shattering and unsynchronized maturity. Besides these basic traits, grain size is also an important yield component as the very small seeds of small millets are causing difficulties for mechanical planting and harvest and ultimately for their commercialization. Seeds of minor millets are subjected to dehulling before human consumption. The traditional methods of dehulling followed in developing countries are labor intensive and time-consuming (Sood *et al*. 2015).
4. Climatic factors such as rainfall pattern and distribution, edaphic factors such as soil type, soil fertility, agronomic management and moreover socioeconomic status of farming communities are equally important for better performance of millet production system (Sood *et al*. 2019). Incidence of diseases, insect-pests, parasitic nematodes, birds, parasitic plants and weeds are the most important biotic constraints associated with millets. Abiotic constraints of millet production are mainly associated with environmental and soil factors such as moisture stress, nutrient stress, salinity, alkalinity, acidity and heat stress.
5. Furthermore, the decline may be attributed to lack of concentrated crop improvement efforts, non-availability of improved seeds and large-scale cultivation of less productive and heterogeneous landraces or local cultivars, shift towards high-value cash crops, lack of government policies and low farm profitability have given them the status of minor or underutilized grains.

Knowledge gap in HP:

The agrarian livelihood of the state for the past four to five decades is significantly impacted by climate change as extreme weather events; precipitation and temperature are deviating from their long-term trends due to intensive mono-cropping agrarian system. This has drastically and negatively hit production and income from farms and affected the health of nature and humans. It is reflected in the form of drying water sources, reducing soil fertility, frail forests and increasing health concerns among people. Multiple factors have led to these trends, particularly the blind push for the Green Revolution-inspired approach in Himachal Pradesh. In the mono-cropping regime, this is accentuated by the lack of procurement support to millets and the insistence on the use of chemical fertilizers. Almost 90% of the households in the state have their food basket largely filled with rice and wheat imported from neighbouring states. This has made the state food-secure but taken away its food sovereignty. A combination of all these factors has erased millets from farms as well as plates of Himachalis.

Other possible reasons could be: 1) Cultivation in less endowed regions 2) less or imbalanced use of resources by the farmers 3) inability of farmers to adopt POP as recommended and also lack of location specific technologies 4) erratic weather conditions 5) lack of access to institutional credit 6) lack of required information, knowledge and market intelligence among farmers 7) non adoption of new hybrids / varieties by the states / farmers due to lack of knowledge on high yielding varieties, non-availability of quality seed (absence of seed chain), low seed replacement rate, poor socio economic conditions of farmers.

Change in focus for revival of millet cultivation

In today's context, again millets are gaining importance as climate change resilient crops owing to their agronomic advantages; highly suitable for low rainfall, ability to withstand fairly long dry spell and short duration. Being C_4 plants, they are more energy efficient, environment friendly with high water use efficiency and low input requirement, but respond positively to high input management. Earliness, low water requirement and high drought tolerance make the millets fit best in contingent crop planning. In India, out of the total net sown area of 136.8 million hectare, nearly 50 per cent is rainfed. According to report of the National Rainfed Area Authority, even after realizing the full irrigation potential, about half of the net sown area will continue to remain rainfed. Millet is one of the oldest cereals suitable for cultivation in rainfed areas under marginal conditions of soil fertility. Despite the importance of millet in India's food basket, over the years there has been a decline in the cultivated area under millet by as much as about 80 per cent for small millets, 46 per cent for finger millet, 59 per cent for sorghum and 23 per cent for pearl millet (Paul, 2022). Not just were traditions getting lost, also ignored due to looming climate change that poses a major threat for most modern crop varieties that cannot cope with the anthropocentric rise of temperature, sudden floods, erratic rainfall and such other phenomenon. Whereas, Indian millet grows over vast agro climatic regions and is quite resilient to global warming and climate change naturally.

In addition to these agronomic advantages, millets offer more comparative advantage compared to other food crops owing to their rich nutritional profiles and resilience to climate change. The protein content in millets like sorghum (10.4%), pearl millet (11.6%), prosomillet (12.5%), foxtail millet (12.3%) and barnyard millet (11.6%) is comparable with wheat (11.8) and much higher than rice (6.8). Though the finger millet contains lesser protein (7.3%), but is rich in mineral matter and calcium. Small millets, namely barnyard millet (14.7%), kodo millet (9.0%), little millet (8.6%) and foxtail millet (8.0%) are rich in fibre in comparison to wheat (1.2%) and rice (0.2%) (Table 5). More than 35 per cent of the population in rural India suffers from poverty and malnutrition while around 60 per cent of the Indian population lives in rural communities. According to UNDP, malnutrition and associated anaemia affect 79 per cent of children below the age of 3 years, 56 per cent women and 24 per cent men. The vast majority of India's population is so poor that they cannot afford even the least expensive balanced diets (Gulati, 2010).

The consumption of major cereals such as rice and wheat along with pulses, and decrease in addition of coarse cereals, food of animal origin, and fruits and

Table 5. Nutritional profile: Comparison of millets and cereals for quality parameters (per 100g of seed)

Grains	Energy (kcal)	Protein (g)	Carbohydrate (g)	Starch(g)	Fat(g)	Dietary Fiber (g)	Minerals (g)	Ca(mg)	P(mg)
Pearl millet	363	11.6	61.7	55	5	11.4	2.3	27	296
Sorghum	334	10.4	67.6	59	1.9	10.2	1.6	27	222
Finger millet	320	7.3	66.8	62	1.3	11.1	2.7	364	283
Foxtail millet	331	12.3	60.0	-	4.3	-	3.3	31	290
Proso millet	341	12.5	70.0	-	1.1	-	1.9	14	206
Barnyard millet	307	11.6	65.5	-	5.8	-	4.7	14	121
Kodo millet	353	8.3	66.1	64	1.4	6.3	2.6	15	188
Little millet	329	8.7	65.5	56	5.3	6.3	1.7	17	220
Maize	334	11.5	64.7	59	3.6	12.2	1.5	8.9	348
Wheat	321	11.8	64.7	56	1.5	11.2	1.5	39	306
Rice	353	6.8	74.8	71	0.5	4.4	0.6	10	160

Source: National Institute of Nutrition (NIN), Hyderabad

vegetables in the diet leads to deficiencies of micronutrients such as Fe, Zn, Ca, Vit A, folate and riboflavin among the population causing anaemia, keratomalacia, blindness and infertility in severe cases. According to Indian National Science Academy (INSA), malnutrition and deficiency of micronutrients in India, particularly among women, children, adolescents need immediate attention. Marginalized crops such as minor millets, can in fact contribute to nutrition security of rural and empowerment of women and other vulnerable groups. Nutrient to nutrient, every single millet is astonishingly superior to rice and wheat, therefore is the solution for malnutrition that affects a huge population of India (DHAN, 2012).

Overall, the basket of millets ensure greater biodiversity on-farm, reduces pests and climate risks. As one of the world's 17 mega-diverse countries, sustaining crop diversity is of critical importance in India for maintaining flora and fauna as for a country to be considered as "mega-diverse", it needs to have atleast 5000 species of endemic plants and marine border ecosystem. Regional crops fitting best in the cropping system of the area depending on water and soil types having nutritional security aspect will help to maintain this aspect.

Varieties and Accessions

To achieve genetic enhancement in any crop, a variety of crop improvement practices such as selection, hybridization, mutation and marker assisted selection can be employed (Singh *et al*. 2018). Though only a limited number of varieties of millets have been developed. These varieties have remarkably shown higher yield than the state average yield of the concerned crops achieved so far that could be exploited for making these nutritious crops more profitable. Twelve different varieties of pearl millet (eight), finger millet (three), and tiny millet (one) have been created as a result of concerted efforts in cooperation with other national and international initiatives (Yadava, 2020).

On the occasion of the 75th anniversary of the Food & Agriculture Organization (FAO) and the United Nations, the Prime Minister of India recently donated three bio-fortified varieties of two millet crops to the country. The small millet variation, CCLMV1, is rich in iron and zinc, while the finger types, CFMV 1 and 2, are rich in calcium, iron, and zinc. Different varieties and accessions maintained in NBPGR are mentioned in table 6 and 7.

Table 6. Indigenous collection of millets from the Indian Himalayan states in the ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi

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
HP	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**

Source: Bhat *et al.* (2019)

Table 7. Potential varieties of millets suitable for cultivation in the Indian Himalayan Regions

Millet Crop	Zone/Season	Recommended states	Suitable varieties
Sorghum	*Kharif*	J&K, Nagaland, Uttarakhand, Sikkim, Tripura	CSV 15, CSV 17, CSV 20, CSV 27, CSV 31, CSV 34; Hybrids-CSH 30, CSH 41
Pearl millet	*Kharif*	J&K, Nagaland, Uttarakhand, Sikkim	PC 383, ICMV221, Raj 171; Hybrids-MPMH17, MPMH 21, RHB-173
Finger millet	*Kharif*	Uttarakhand, HP, Arunachal Pradesh, Nagaland, West Bengal, J&K, Meghalaya	PRM-2, VL Mandua 347, VL Mandua 348, VL Mandua 352, VL Mandua 379, VL Mandua 376, VL Mandua 380, VL Mandua 382 (white grain)
Foxtail millet	*Kharif*	HP, Arunachal Pradesh, Sikkim, Nagaland, Meghalaya, Uttarakhand	SiA 3085, SiA 3156, Rajendra Kauni-1
Little millet	*Kharif*	HP, J&K, Nagaland, Sikkim	OLM 208, OLM 217, BL 6, DHLM 36-3, GNV-3
Kodo millet	*Kharif*	HP	JK 13, JK 65, JK 98, DPS 9-1, TNAU 86, RK 390-25
Barnyard millet	*Kharif*	Uttarakhand, HP, Nagaland, Meghalaya, J&K	VL Madira 172, VL Madira 181, VL Madira 207, DHBM 93-2, PRJ-1
Proso millet	*Kharif*	HP, J&K, Sikkim, Nagaland, Uttarakhand	PRC-1, CO(PV) 5, TNAU 151, TNAU 164, Pratap Cheena 1 (PR 18), TNAU 202
Forage jowar-single cut	*Kharif*	J&K, Arunachal Pradesh, Meghalaya	HC 171, HC 260, HC 308, CSV 30 F
Forage jowar Multi-cut	Summer	J&K, Arunachal Pradesh, Meghalaya	PC 106, SSG 59-3, HC 136, CSV 33 MF, Hybrid- CSH 24F

Source: Bhat *et al.* (2019)

Since the outbreak of the Novel Corona virus disease (COVID-19), 'immunity foods' have gained traction. In this context also, the micronutrient rich millets are suitable substitutes for reviving our traditional food systems and maintaining ecological harmony with nature. So, the current climate change reality and the increasing health consciousness are bringing back millets into focus of attention.

Millets can be used for development of various value-added products under different categories like:

Ready to use multigrain composite flour for making indigenous food products, bakery products, extruded products, flaked and popped products instant food mixes etc. These products can be developed by utilizing the whole millet flour or incorporating the wheat/ refined flour/ rice flour with millet flour in varying proportions. Composite flour refers to the mixture of flours of various cereals or legumes, millets to make use of local raw material to produce high quality products in an economical way. Generally, the composite flours are the mixture of starch rich tubers flour (e.g. cassava, yam and sweet potato), protein rich legumes flour (e.g. soya, peanut) and/or from cereals (e.g. maize, rice, millet, buckwheat) with or without wheat flour. Wheat flour with millet flour in varying proportions will be used for development of composite flour. The standardized composite flours shall be utilized for preparation of various traditional food products like *roti, chapatti, chilla and bhaturu.* Composite flour shall also be standardized for preparation of bakery products because people of all ages have a special liking for different bakery products, because of their taste, colour and easy to digest nature.

Extruded products: Extruded products such as breakfast cereals, pasta, noodles and third generation snack foods: Extrusion is a method, through which low cost nutritious food products can be produced. Extruders offer various advantages like lower operating costs, higher productivity along with presenting versatility and energy efficiency. Using extrusion, anti-nutritional factors of a raw material could also be minimized, thus increasing the consuming acceptability and leaving the product safe microbiologically. Millets with other flour such as wheat, rice and legume flour can be used for development of wide variety of products like breakfast cereals, pasta, noodles, baby foods and snack foods. Pasta meals like vermicelli, noodles, macaroni etc., are commonly liked by children of today's generation and by other age groups for their taste, inexpensive and easy method of preparation. Millet with refined wheat flour in varying proportion can be utilized for development of vermicelli, noodles macaroni etc. These Ready-To-Eat products are very popular, being crisp and friable in texture. By suitable processing it might be feasible to produce popped foods and flakes from millets. The relatively smaller size and quick hydration of millets make them most suitable for the production of flakes and popped products. Hence, attempts shall be made to produce millet based popped products and flakes for use as breakfast cereals.

Gluten free functional food products: Functional food products offer health benefits that extend beyond their nutritional value. Millets are gluten free so they can be a good substitute for wheat in celiac diseases. Also, they have low glycemic index, hence can be recommended for diabetic patients. They can help to combat cardiovascular diseases, anaemia, calcium and other micronutrient deficiencies. Attempts shall be done to prepare various functional foods like instant mixes.

Confectionery products- Indian sweets like *pinni, laddoo, burfi, panjeeri, kheer mix, halwa* mix shall be prepared using different millets.

Integrated agricultural strategies to boost millets production

The ultimate goal of breeding small millets is improvement of grain yield and maximization of biomass and harvest index.

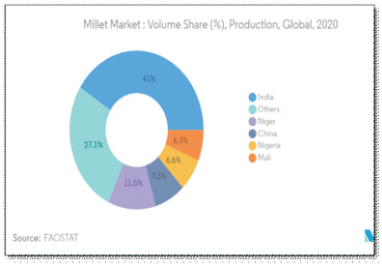
- Germplasm enrichment for various yield, biotic and abiotic as well as quality parameters
- Exploration, characterization, evaluation, documentation, purification and utilization of wild relatives and local germplasm of minor millets from the genetically diversified hotspots of HP
- Evaluation of core sets for biotic and abiotic stresses as well as quality traits
- Identification of trait specific germplasm for utilization in crop improvement
- DUS characterization of small millet varieties
- Identification of stable sources of resistance in different small millets
- Identification of elite germplasm and varieties with superior nutrition traits and bio- fortification of elite lines in different small millets
- Development of high yielding varieties with stable resistance suitable to different millet growing regions
- Breeder seed production be continued as per the requirement
- Protection of the potential landraces under PPV & FRA guidelines and registration with NBPGR
- Varieties suitable for mechanical harvesting in all millets adapted to different agro-climatic situations be identified
- Multiplication of identified material to further popularize and enhance farmers income of tribal regions.
- Testing and fine tuning of the available machinery to suit to different small millets
- Moisture, nutrient and crop management options available be fine-tuned for small millets-based cropping systems.
- Transfer of technology (production to consumption) through FLDs, training and print material.

Marketing status

India is the second-largest exporter of millets. The global millet market is projected to register a CAGR of 4.8% during the forecast period (2022-2027). By 2025, it is anticipated that the millet market would reach a value of over $12 billion from its current value of more than $9 billion. Millets are a growing industry in the Asia-Pacific region, with pearl millets ranking among the most sought-after products due to their

significant volume in international trade. The top 10 millet-importing nations- Japan, Indonesia, Germany, Belgium, the Netherlands, Italy, United Kingdom, Poland, China and the Republic of Korea—collectively import 64% of the world's millet. India is a major participant in terms of its capacity to meet global demand because it accounts for close to 20% of the value of millets exported globally. Eighty percent of India's exports go to its top ten destinations, which include Nepal, Saudi Arabia, Pakistan, the United Arab Emirates, Tunisia, Sri Lanka, Libya, Namibia and Morocco. India exported millets of USD 26.97 million in 2019-20 against USD 28.5 million, including the top three destination countries -Nepal (USD 6.09 million), UAE (USD 6.09 million), Saudi Arabia (USD 3.84 million). In addition to the fact that millet has been grown in China for many years, the country is currently displaying a modest growth in millet yields. The United Arab Emirates, Nepal, Saudi Arabia and Germany are the biggest export destinations. The amount of millets exported to Nepal and UAE has increased by more than 50%, indicating a growing demand for these grains. Kenya and Oman, two nations that get a smaller proportion of millets shipped from India, have experienced even greater increase in recent years.

With various creative chefs reimagining classic dishes to make millets the preferred grain for an urban population, Bengaluru, India is quickly becoming a centre for millets. Given the diversity of millets produced around the world, it is important to investigate such innovations using locally accessible grains that also help to reinforce the "farm-to-table" relationship for local farmers



Steps for revival: Initiatives undertaken

Now this is well established fact that increasingly erratic rainfall patterns and crop losses due to climate change factors have affected farms and there is lesser possibility of increasing the production of major staple cereals as already world is facing the challenges of increase in drylands and deepening of ground water level. Reviving millet based cropping systems, releasing new climate-resilient varieties and improving water use efficiency are among several measures being taken up by the government to accelerate the growth of rainfed areas.

- Through the efforts made by the Government, the production of millets has increased from 14.52 million tonnes in 2015-16 to 17.96 million tonnes in 2020-21. The production of bajra has also increased from 8.07 million tonnes to 10.86 million tonnes during the same period (Press release, Ministry of Agriculture & Farmers Welfare, Feb. 08, 2022). To encourage the farmers, government declares Minimum Support Price (MSP) of three major millets i.e. *jowar, bajra* and *ragi* before main season of *Kharif* every year.
- As part of the Rashtriya Krishi Vikas Yojana (RKVY), the Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) was established in 2012, with funding of Rs. 300 crores aiming to catalyze increased production of millets in the country for enhanced nutritional security mainly emphasizing millet harvesting machinery and technology and boosting the productivity of underproductive areas. The program's goal was to demonstrate more advanced production and post-harvest technology in a way that had a tangible effect on the country's millets production. Along with raising millet production, the scheme aimed to increase consumer demand for millet-based food products through processing and value addition strategies.
- With financial support from DST and RKVY-RAFTAAR, The Nutrihub-Technology Business Incubator (TBI) was founded in 2017 at ICAR-IIMR, Hyderabad to strengthen and support the millet-based startup ecosystem. It is currently assisting more than 200 millet-based startups with technology support, mentoring, capacity building, financial support, marketing facilitation and infrastructure support for manufacturing their value-added products through various processing lines.
- In view of the nutritional value, the government of India has notified millets as 'nutri-cereals' in April, 2018 and the 'National Year of Millets' was celebrated in 2018. Department of Agriculture & Farmers Welfare is implementing a Sub-mission on

Nutri-Cereals (millets) under National Food Security Mission (NFSM) since 2018-19 to increase area, production and productivity of millets in 212 districts of 14 states. The North Eastern states, Himachal Pradesh and UTs of Jammu & Kashmir and Ladakh have been given flexibility to include the districts under programme on nutri-cereals. To create domestic and global demand and to provide nutritional food to the people, Government of India proposed to United Nations for declaring 2023 as International Year of Millets, which was supported by 72 countries.

- The agriculture department of Tripura State has been popularizing cultivation of Sorghum every year since 2016.
- The Pungzm millet festival organized by the Wancho Cultural Society (WCS) of Arunachal Pradesh in February 2019 aimed at popularizing 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.
- The children's millet food company "Slurrp Farm" was a pioneer in 2021 in reintroducing millet to India and, more recently, the UAE. Slurrp Farm's parent firm, Wholesome Foods, recently completed a new round of fundraising that brought in USD 7 million. Slurrp Farm, a producer of millet-based children's food, may expand its global reach by stepping up product innovation and marketing efforts thanks to this money.
- The Indian Agriculture Ministry through its YouGov platform, has sponsored a number of projects, one of which is a competition to create a comic book with the title India's Wealth, Millets for Health. The competition, which is open to participants worldwide and closes on November 5th, 2022 aims to highlight India's millets, such as sorghum (jowar), pearl millet (bajra), finger millet (ragi/mandua), little millet (kutki), kodo millet, barnyard millet (sawa/jhangora), foxtail millet (kangni/kakun) and prosomillet (chena).
- The Millet Startup Innovation Challenge, which has a deadline of January 31, 2023 aims to identify technological and commercial solutions to the issues currently plaguing the millets ecosystem. Three innovative firms will be chosen, and each will receive a seed grant of Rs 1 crore to help them prepare their products for the market. The third-place cohort will receive Rs. 10 lakh each, while the remaining 15 hopefuls will receive Rs. 20 lakhs apiece.
- The Ministry announced that an audio song and documentary film contest on the value of millets will soon be started.
- Smt. Nirmala Sitharaman, India's Finance Minister, also disclosed a Rs 25 billion investment by the National Bank for University of Agricultural Sciences in Raichur for the Department of Agriculture and Rural Development (NABARD) establishing the Millet Value Chain Park, processing, value-adding and capacity-building incubator and millets' promotion (2022).
- 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 has organized promotional programmes in Meghalaya and Nagaland.
- The testimony to millets potential in Himachal Pradesh has been provided by farmers' collectives in recent years. One such initiative is *Parvatiya Tikau Kheti Abhiyan* (PTKA), a group of farmers in association with some NGOs who are working on the revival of millets in Karsog valley of Mandi district. Mr. Nekram, a progressive farmer and a key functionary of PTKA, says, "Initially, 7-8 years ago, we got going as a small group. We started with *kodra* (finger millet) and sowed it in intercropping with major crops. Over the years, the production even in an erratic precipitation year remained good and doctors started recommending its consumption for health reasons." This word-of-mouth publicity helped them expand to a group of 500 farmers in their region.
- In recent years, the Himachal Pradesh Government has initiated efforts in this direction. Under its *Prakritik Kheti Khushal Kisan Yojana* (PK3Y), the

agriculture department is promoting a non-chemical agricultural way. According to Ravindra, an agrarian system expert associated with the Revitalizing Rainfed Agriculture Network, "Millets disappeared because of an alternative agrarian system that arose post the 1960s and came with a package of input subsidies, research and extension institutions and assured market through procurement at the MSP. The revival of millets also needs a complete alternative system that can't be limited to input support, procurement or training/awareness but instead a mix of all these. We have to focus on production, productivity, processing and procurement simultaneously and rigorously if we want to bring back millets in a big way."

- Recently, Agricultural and Processed Food Products Export Development Authority (APEDA) launched a variety of "Millets in Minutes" product under category of Ready-to-Eat (RTE) such as Upma, Pangal, Khichadi, Noodles, Biryani, etc. All the millet products launched by APEDA are gluten free, 100 per cent natural and patented. The entire RTE products are vacuum processed without any additives, fillers and preservatives. Nutrition value is retained as original with a shelf life of 12 months in ambient temperature.

Promoting Organic millets

- Millet cultivation in rainfed areas generally relies more on natural resources for management of soil nutrients. With increasing health consciousness across the globe, the demand for organic produce is on the rise. The consumers would be very happy to purchase organically grown millets. Therefore, it would be a good venture to brand and market millets as organically grown as nutritionally rich super-foods to fetch premium price. Presently most of the organic producers and exporters in the country have millets in their portfolio (17 % organic export during 2015-16 comprised cereals and millets as per data from APEDA).
- Some non-pathogenic bacteria and fungi found in plant tissue commonly called as symbiotic endophytes responsible for nitrogen fixation and making it available to plants even at no nitrogen supplementation are also reported in finger millet (Goron *et al*., 2015)
- The first shipment of organic millets from the Himalayan area of India was sent to Denmark in 2021. Farmers provided their organic millets to the APEDA for processing and export in partnership with Uttarakhand Agricultural Produce Marketing and the Just Organik company.

Way forward

- A combination of climate resilience and value of millets is a potential answer for raising farm income and nutritional security in rainfed systems. Therefore, need of the hour is to adapt to the climate change by switching from water-intensive cereal/vegetable crops to drought-resistant millets in certain niches. Fibrous roots of these crops keep water runoff in check, aid in soil conservation, suit in sloppy lands and restore natural ecosystem. Of late, there is a visible growth in the demand for millets, which have been placed as gluten free nutri-cereal smart foods. This demand is being driven by the health and wellness industry and the food sector is growing fast.
- Therefore, boosting millet cultivation will empower the average hill farmer and help in achieving the objective of enhancing incomes, improving crop diversification and maintaining agro biodiversity.
- Green revolution style intensive mono-cropping of millets with high external input should not be promoted. The conserved traditional landraces of millets and pulses are endemic to the various agro-climatic zones and are embodiments of the generation old knowledge of our farming communities which needs to be respected. So, millets should not be seen in isolation; mixed farming system should receive attention in a holistic way and organic practices be promoted. Diversity of food fulfils nutritional needs and has an inbuilt characteristic of risk mitigation and ensures that even under adverse climatic conditions a few crops will survive.
- It is expected that awareness about nutria-cereals as health food will trigger higher demand leading for area expansion. Enhanced and consistent production will definitely enable stronger linkage of millet production systems with value-added activities and result in better price realization to farmers. Development of new high yielding

varieties, better scientific package of practices, processing and post-harvest technologies will further add to productivity increase. Therefore, to diversify food basket for sustaining food, nutritional and livelihood security of rural households, focused research for revitalizing millets keeping in view the present and future demand, sustainability of the system as a whole for improving productivity, improved agronomic practices, value addition, processing and marketing strategies is required.

- A key issue is whether we will be able to feed the projected global population of 9 billion by 2050 equitably, healthily and sustainably (Beddington, 2010). Even, if a person consumes enough calories, it is likely that he may have an inadequate consumption of vital micronutrients leading to micronutrient under nourishment (Hidden hunger). Thus, development of varieties with enhanced nutraceutical value and improved stress tolerance should be the priority area of research. Identifying and improving native crops that are highly adaptive to the local climate, have high nutritive value and can withstand biotic and /or abiotic stresses is one of the simplest solutions.

Even though millets themselves cannot stop the effects of climate change, they have the ability to make a difference. Himachal Pradesh should adopt a comprehensive approach for reviving millets in order to promote climate change resistance, boost the income of agricultural households and eventually attain food sovereignty.

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