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Review Paper

Problems and Prospects of Seed Production in Minor Millets and Other Potential Crops with Special Reference to Himalayan States of India

DEVENDER SHARMA AND LAKSHMI KANT*

ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan
Almora, Uttarakhand 263601, India
*lakshmi.kant@icar.gov.in

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ABSTRACT: Millets are known for ages for their high nutritional value and adaptability to harsh environments and serve as vital grain crops, particularly in small and marginal lands. There has been an increased awareness about millets in the recent times. India, as the largest producer and second-largest exporter of millets, is set to play a pivotal role globally. The increased awareness has, thus, created a huge demand for these crops. However, despite huge demand and their nutritional importance, millet farming faces multifaceted challenges. The review presents a comprehensive analysis of seed production in minor millets and potential crops in India, with special reference to the Himalayan states and underscores the pressing need for improved crop production practices and incentives to boost millet seed production. Special attention is paid toward the north-eastern region of India, where initiatives such as farmer-participatory seed production are fostering millet cultivation. Case studies from Arunachal Pradesh and Meghalaya exemplify successful endeavours to promote millet farming in these regions. The review advocates for measures to incentivize millet seed production, particularly in the Himalayan states and north-eastern region, to ensure sustained growth and fortify food security and nutrition in India.

Keywords: Millets, Minor Millets, Seed Production, Himalayan States, NE Himalaya, M.W. Himalaya

INTRODUCTION

Millets mean “slandered food” (poor man’s food)”. This group of crops, belonging to Poaceae family, are classified as small-seeded cereal crops and are predominantly grown for food and fodder in regions having low rainfall [1]. Thus, these are major food crops of dry, hilly and tribal areas, marginal land of temperate, subtropical and tropical regions and play an important role in food, nutrition, feed, fodder and fuel security of those regions. The government of India renamed 10 millet crops as “Nutri Cereals” *viz*; major [jowar, bajra, ragi], 5 minor millets [foxtail, proso, kodo, barnyard & little and 2 pseudo-cereals (amaranth and buckwheat) for production, consumption and trade point of view by F.No 4-4/2017-NFSM (E) dt 10.4.2018, the Gazette Notification was issued on 13-4-2018. Millets are broadly classified as ‘large/major’ (sorghum and pearl millet) and ‘small/ minor millets. The prominent minor millets include finger millet (*Eleusine coracana*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italica*), barnyard millet (*Echinochloa frumentacea*), proso millet (*Panicum miliaceum*) based on their seed size and extent of cultivation [2]. The group also includes fonio millet, teff, brown top millet, Job’s tears and guinea millet [3]. These have now brought under the category of ‘Shri Anna’ [4] .

Awareness as well as interest in millets as a highly nutritious food has increased tremendously with U.N. declaration of 2023 as the international year of millets. In addition to high calcium, iron, potassium, magnesium and zinc contents, it also has high vitamins, amino acids, and fatty acids [5, 6]. Millets possess specific morpho-physiological, molecular and biochemical characteristics leading to better tolerance to abiotic stresses than the major cereals [7, 8, 9]. Millets are recognized as low carbon- and water-footprint crops as they are C4 crops with greater potential to utilize atmospheric CO_2. In addition, millets are climate-smart and can be grown more successfully in drought-hit, arid regions than any other crop. A crop of millets requires about 80 per cent less water than crops like rice, wheat, or sugarcane and thus has a very low water footprint [10].

Millets are highly nutritious and contain high amounts of proteins, fibre, vitamins and minerals. Higher nutrition,

low glycemic index and high amylase inhibitory activity make them ideal food for managing and mitigating lifestyle diseases [11]. Millets are also a rich source of phytochemicals, which act as antioxidants and detoxifying agents [12]. In recent years, minor millets have gained immense significance worldwide for their potential to combat hunger and malnutrition and ensure food and nutritional security for the masses [13].

Millets are grown in 131 countries and comprise traditional food for 590 million people in Asia and Africa. The global production of millets is 89.17 MMT from an area of 74 Mha [1]. India is the World's largest millet producer, accounting for 80% of Asia's and 20% of global production. In India, millets are cultivated across 21 states, covering an area of 12.45 million hectares, producing 15.53 million metric tonnes with a yield of 1,247 kg/ha [14]. Kodo millet, little millet, and barnyard millet are exclusively grown in India, producing 1–3 million tonnes [15]. Like other crops, the productivity of millets has enhanced from 0.745 t/ha in 1961 to 1.29 t/ha in 2020, a 73% increase due to the adoption of new cultivars and package of practices [1]. However, during 1960–2020, the area under millets has reduced by 21% and the production increased by 34% on account of the increase in productivity.

In India, Rajasthan, Maharashtra and Karnataka are the topmost states in millet cultivation, with a share of 35%, 23% and 14% of total millet area, respectively. Maharashtra and Karnataka have the maximum area under sorghum, whereas Rajasthan, Gujarat, Uttar Pradesh and Maharashtra have more area under pearl millet. Finger millet has the largest area in Karnataka, Tamil Nadu and Uttarakhand. Karnataka is also the largest producer of minor millets (56% of total production) followed distantly by Tamil Nadu (14.0%) and Uttarakhand (9.3%). The rest of the states contribute about one-fifth of the total production [14].

MINOR MILLETS AND POTENTIAL CROPS IN HIMALAYAN STATES

Minor millets and potential crops are traditional crops of the Himalayan region and the hill states account for 10.18 and 10.89% of the total national area and production, respectively. The average productivity is 996 kg/ha compared to the national average of 1,176 kg/ha. Among the hill states, Uttarakhand, with an area of 130.8 thousand ha and production of 190 thousand tons, accounts for 65.1% and 75.2% of the total area and production, respectively, followed by Arunachal Pradesh, Jammu & Kashmir and Nagaland (Fig. 1).

The average productivity of minor millets in Uttarakhand is significantly higher (1,541 kg/ha) than the national average. In the last four years, the state has produced 13,658 q quality seed (Breeder Seed, Foundation Seed & Certified Seed) of minor millets and potential crops against a demand of 10,957 q, which has enhanced the state's seed replacement rate (SRR). The SRR of finger millet in the state is 45% [16].

MILLETS' TRADE AND GLOBAL SCENARIO

India produces nine commonly known millets and is the World's largest producer and second-largest exporter of millet. India is the topmost producer of Barnyard (99.9%), Finger (53.3%), Kodo (100%), Little millet (100%) and pearl millet (44.5%), producing about 12.46 million metric tonnes from an area of 8.87 million ha. Millets exports from India have continuously increased at 12% CAGR in the last three years [14]. The global millets market is valued at US$ 14.22 billion in 2023 and is projected to reach US$ 23.83 billion by 2033, with India playing a

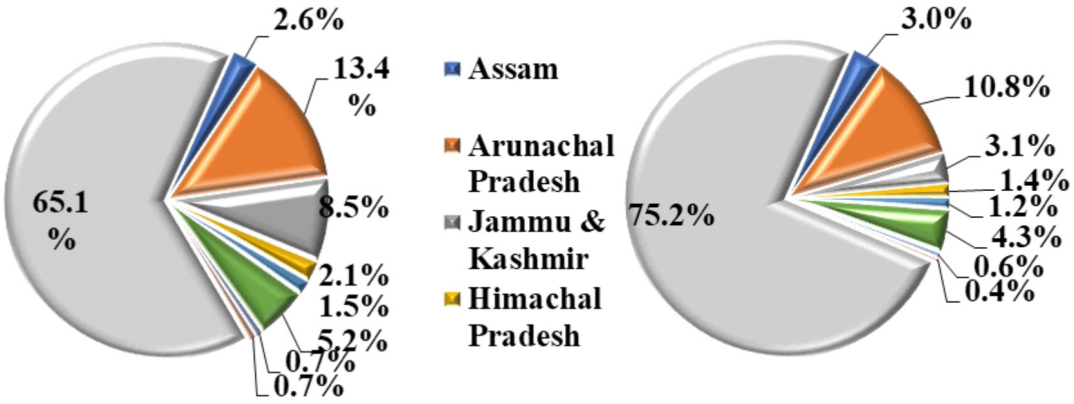


Figure 1. Share of small millet growing hill states to total area (left) and production (right) in the northern hill zone

pivotal role. The Indian millets market, valued at US$ 5.05 billion in 2022, reflects the country's dominance, producing over 40% of the World's millets. Recognizing the nutritional richness of millets, the United Nations declared 2023 the International Year of Millets. Worldwide, millet exports increased from $400 million in 2020 to $470 million in 2021. India exported millet worth around 64 million US$ during 2021-22, against 59.75 million US$ during 2020-21. The export share of millet from India is around 1% of total millet production [17]; however, India aims to tap into a US$ 2 billion export opportunity by promoting millet and millet-based products.

Despite the nutritional superiority and low C & water footprint of millet farming systems, the area under millet production has drastically decreased over the last six decades, especially since the Green Revolution [18]. However, there was a steady decline in the total millet cultivation during 1950-2020 and India witnessed a drastic change after the nineties, whereby production came down by 20% as the area declined by 54%, though the crop productivity exhibited a 73% increase during 2010-20 in comparison to 1980-90. Thus, a very high gain in productivity could not compensate for the reduced area and the overall production suffered a setback associated with a significant decrease in per capita availability [11].

The main reasons for the decline of millet crops in India are low remuneration compared to other competing crops, lack of input subsidies and price incentives, subsidized supply of fine cereals through PDS, and change in consumer preferences [19].

ENHANCING MILLETS PRODUCTIVITY

Availability of quality seeds of improved varieties is central to further enhancing minor millets productivity in the country to offset the diminishing area, fulfill the domestic demand and tap the export opportunities. Using quality seeds of appropriate varieties, yield levels can be enhanced by up to 40% [20]. Making available an adequate quantity of quality seeds of high-yielding cultivars, however, remains a major challenge as the minor millet seed system is mainly dominated by the informal sector (>90%) [21].

Seed production scenario of minor millets

Many high-yielding disease-resistant varieties have been developed and are available in finger millet and barnyard millet, which are suitable for cultivation in northern hills (Table 1).

During 2018-23, a total of 37.4 thousand quintals of minor millets and quality seeds of other potential crops was

Table 1. Details of prevalent notified popular varieties in North Hill Zone

Sl. No.	Varieties	Released by	Year of release	S.O. No.	Date of Notification	Recommended Area
Finger millet						
1	VL Mandua 352	CVRC	2014	S.O. 1919(E)	30.07.2014	All finger millet-growing states except T.N. and Maharashtra
2	VL Mandua 348	SVRC	2016	S.O. 3540 (E)	22.11.2016	Uttarakhand Hills (Organic Conditions)
3	VL Mandua 376	CVRC	2018	S.O. 399 (E)	24.01.2018	AP, Bihar, Gujarat, Jharkhand, Karnataka, MP, Odisha, Uttarakhand, Maharashtra and TN
4	VL Mandua 379	CVRC	2018	S.O. 1379 (E)	27.3.2018	Uttarakhand, Bihar, Jharkhand, NE States and MP
5	VL Mandua 380	SVRC	2019	S.O. 1498 (E)	01.4.2019	Uttarakhand Hills (Organic Conditions)
6	VL Mandua 378	SVRC	2020	S.O. 500 (E)	29.01.2021	Uttarakhand Hills (Organic Conditions)
7	VL Mandua 382	SVRC	2020	S.O. 500 (E)	29.01.2021	Uttarakhand hills (Organic Conditions)
8	VL Mandua 400	CVRC	2023	S.O. 1056(E)	06.03.2023	MP, Karnataka, Chhattisgarh, Bihar, Jharkhand, Gujarat and AP
10	PRM 1	SVRC	2009	S.O. 454(E)	11.02.2009	Uttarakhand hills
Barnyard Millet						
1	VL Madira 172	CVRC	2000	S.O.340 (E)	03.04.2000	UP, Gujrat and Karnataka
2	VL Madira 207	CVRC	2008	S.O.2458 (E)	16.10.2008	All barnyard millet-growing states except Gujrat and TN
3	PRJ1	SVRC	2009	S.O. 454(E)	11.02.2009	Uttarakhand hills
Buckwheat						
1	VL Ugal 7	SVRC	1992	S.O.814 (E)	04.11.1992	Hills of UP, especially mid hill region
Amaranth						
1	VL Chua 44	SVRC	2006	S.O. 599 (E)	25.04.2006	Mid and Higher Hill of Uttarakhand
2	VL Chua 110	SVRC	2020	S.O. 500 (E)	29.01.2021	Uttarakhand Hills (Organic Conditions)

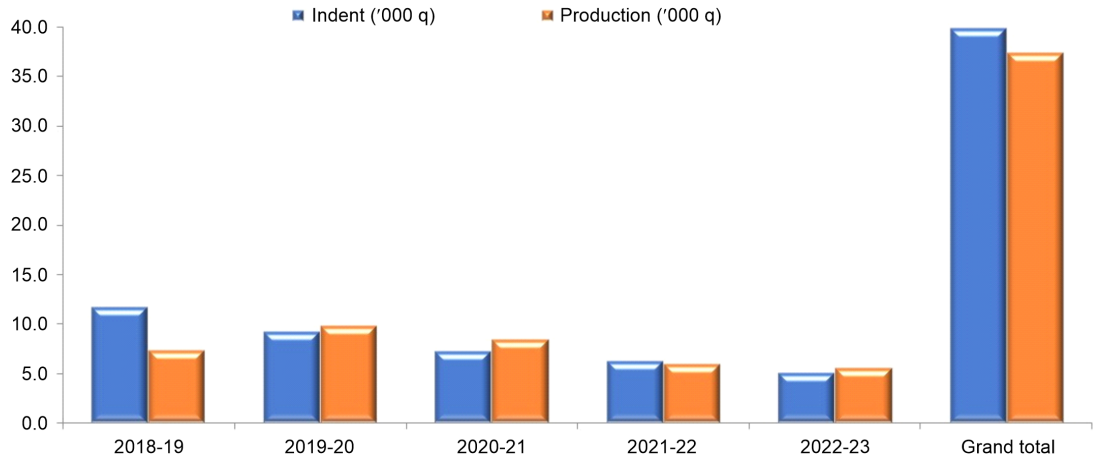


Figure 2. Indent and quality seed production (FS, CS and TL) of small millets during 2018-2023

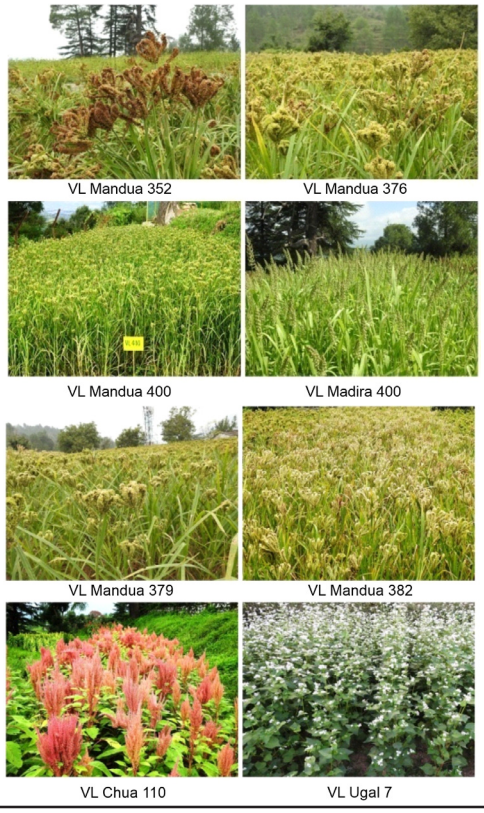
produced in the country against an indent of 39.9 thousand quintals (Fig. 2) [22, 23, 24, 25, 26, 27]

The details of indented varieties during 2018-2023 has been given in Table 2.

The quality seed includes breeder seed (B.S.), foundation seed (F.S.), certified seed (C.S.) and truthfully labeled (T.L.) seed. However, the actual quantity of seed produced and distributed/exchanged is estimated to be

Table 2. List of the Minor Millets and Potential Crop Varieties indented during 2018-2023

S.No.	Variety	Maturity(Days)	Yield(kg/ha)
Finger millet			
1.	VL Mandua 315	100-101	2,025
2.	VL Mandua 347	105-115	2,025
3.	VL Mandua 348	100-101	2,000
4.	VL Mandua 352	100	2,530
5.	VL Mandua 376	103-109	2,530
6.	VL Mandua 379	103-112	2,931
7.	VL Mandua 380	116-118	1,820
8.	VL Mandua 382	107-112	2,100
9.	VL Mandua 400	100-102	3,250
Barnyard millet			
1.	VL Madira 207	90-95	1,619
Amaranth			
1.	VL Chua 44	115-120	1,013
2.	VL Chua 110	112-115	1,350
Buckwheat			
1.	VL Ugal 7	60-70	810



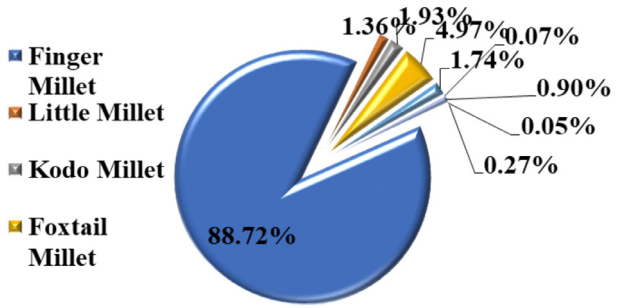


Figure 3. Share of different small millets in total small millets' quality seed production (FS, CS & TFL) during 2018-23

far higher as more than 90 per cent of the seeds of these crops are produced by the unorganized sector. The data reveals a progressive decline in the quantity of seed indented as well as seed produced during the last five years, with a reduction of 56.3 and 24.7 per cent in the indent and production, respectively, during 2023 compared to 2018. The overall shortfall in the production is 3.75 thousand quintals (9.58%) due to a production deficit of 4.23 thousand quintals (11.88 per cent) in finger millet, whereas production was surplus in other minor millets (12.34%) and potential crops (115.6%) [22, 23, 24, 25, 26, 27].

Finger millet had the highest share in the total seed produced (88.72%), whereas other minor millets accounted for 10.96% and the potential crops contributed 0.32% (Fig. 3) [22, 23, 24, 25, 26, 27].

The total breeder seed indent of minor millets and potential crops during 2018-23 was 751.85 q and the total production was 2,013.25 q. Though a definite trend was not observed for the seed indent, the breeder seed indents were lower in the subsequent years compared to the start year 2018 (Fig. 4.) [22, 23, 24, 25, 26, 27].

The average breeder seed production during 2020-21 to 2022-23 was about 20.41% lower than the average breeder seed production during 2018-19 and 2019-20. The reduction in breeder seed production in the later years may be attributed to efforts to rationalize the breeder seed production made by ICAR and DAC to harmonize the breeder seed indents with the actual quantity of targeted F.S. and C.S. Overall, the breeder seed produced during this period was 2.6-fold higher than the total breeder seed indented. The surplus in breeder seed production was 676.0 quintals (150.7%) in finger millet, 42.7q in other minor millets (12.3 %) and 1.96 q in other potential crops (94.2%) [22, 23, 24, 25, 26, 27].

In the total breeder seed produced, finger millet had the highest share (55.86%), followed by foxtail millet (18.84%), kodo millet (10.77%) and little millet (8.15%). The share of potential crops was 0.2% (Fig. 5) [22, 23, 24, 25, 26].

The total number of varieties in the seed chain showed a two-fold increase from 30 in 2018 to 63 in 2023(Fig. 6). The average number of varieties in the seed production chain during 2018-2023 was highest in finger millet (27), making up 50.9% of the total number of varieties. Little millet and kodo millet, with 6.8 and 6.4 varieties and 12.8% and 12.1% share, respectively, followed by finger millet in the second and third positions. Among potential crops, breeder seed of only amaranth was indented and the average number of varieties indented per year and their share in the total seed was 1.2 and 2.3%, respectively [22, 23, 24, 25, 26, 27].

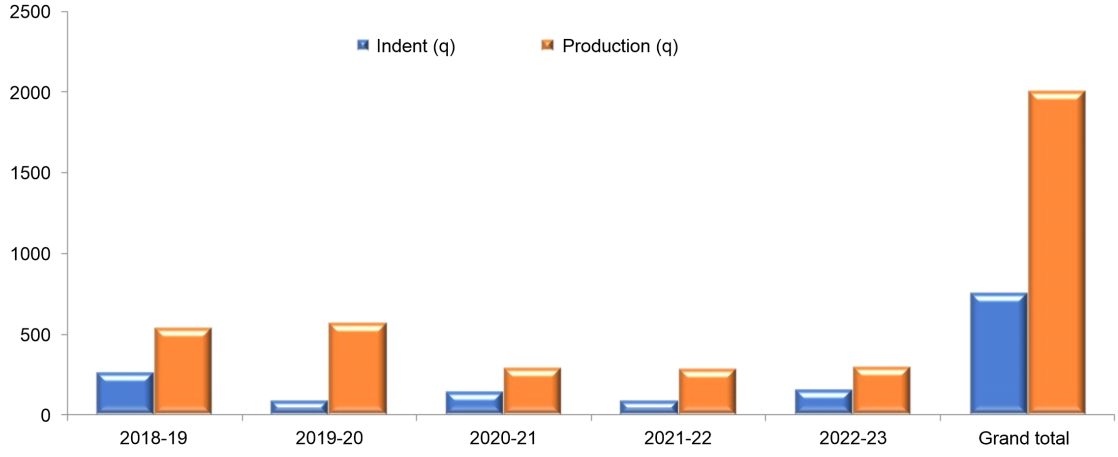


Figure 4. Breeder seed indent and production of small millets during 2018-2023

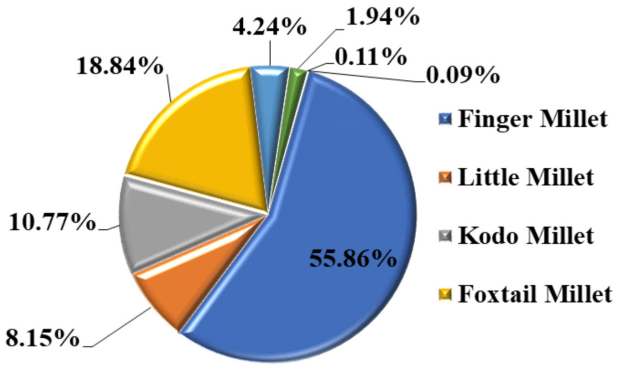


Figure 5. Share of different small millets in total small millets' breeder seed production during 2018-23

The average percentage of > 10-year-old varieties in the seed chain during 2018-23 was 35.6 and decreased from 46.7% in 2018 to 23.4 in 2023 (Fig. 7).

Among the crops, in finger millet, despite the availability of a good number of new high-yielding varieties, the average percentage of >10-year-old varieties was 42 (Fig. 8). The percentage in barnyard millet was 42.9. In amaranth, only variety VL *Chua* 44 was being indented until 2021; the percentage in its case, as a result of it, was 83.3. In proso millet, both the indented varieties are <10-yr old; the percentage, therefore, is 100 [22, 23, 24, 25, 26, 27].

During 2018-23, the average breeder seed production of minor millets was 187.4% in surplus of the breeder seed indented, whereas a deficit of 15.2% and 16.5%,

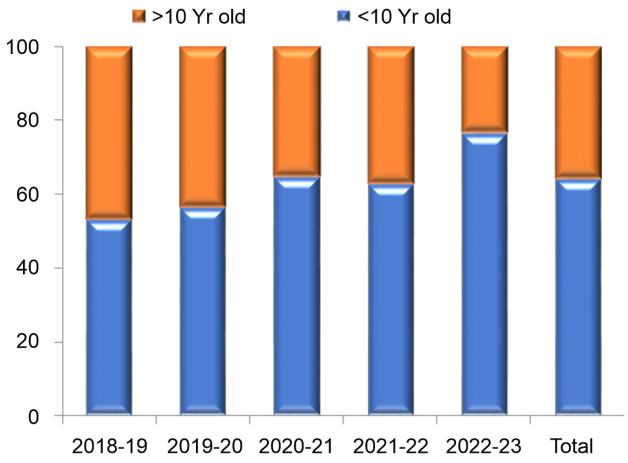


Figure 7. Percentage of >10 year old and <10 year old small millets' varieties in breeder seed chain during 2018-23

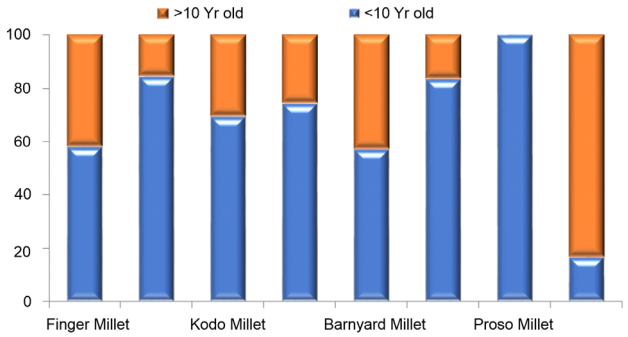


Figure 8. Percentage of >10 year old and <10 year old varieties of different small millets in breeder seed chain during 2018-23

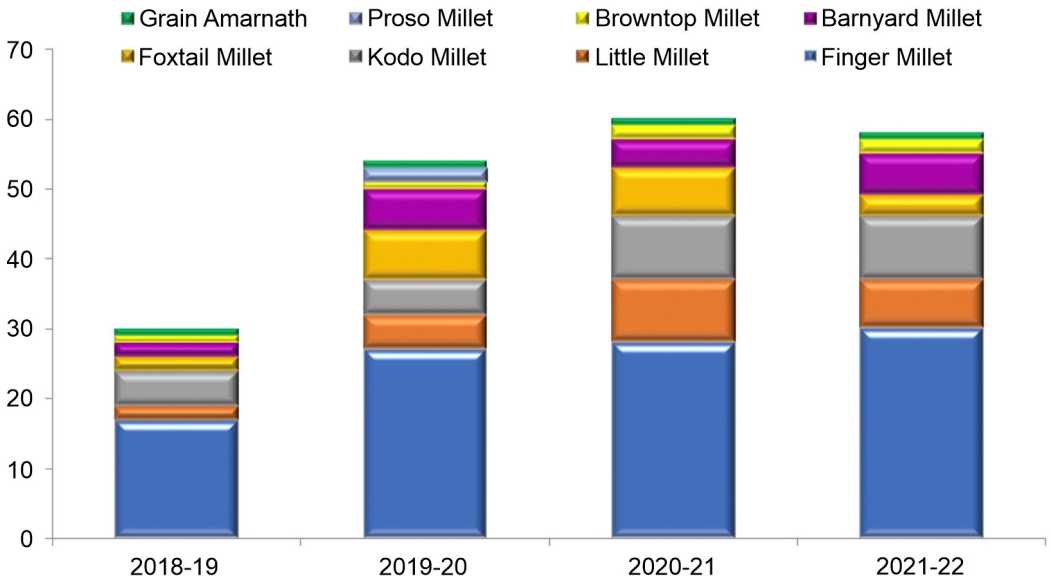


Figure 6. Small millets' varieties in breeder seed chain during 2018-23

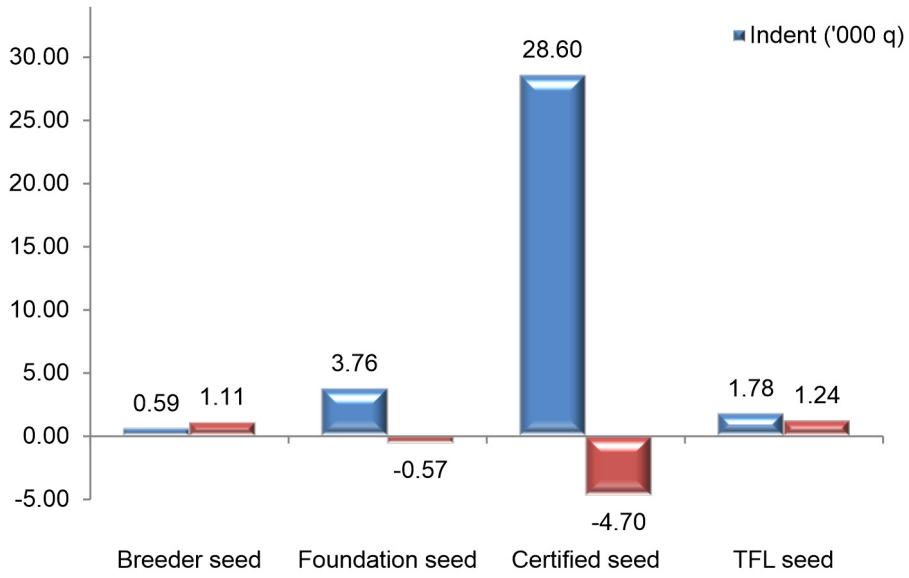


Figure 9. Indent and production surplus/deficit in BS, FS, CS & TFL seed of small millets during 2018-23

respectively, was observed for foundation and certified seed. The TFL seed was 70.0% in surplus of the indent (Fig. 9) [22, 23, 24, 25, 26, 27].

The varietal seed requirement (excluding the farmer-saved seed) of minor millets is almost fully catered by public sector varieties produced by ICAR institutes and SAUs. Many improved varieties are not in the seed chain as states have no significant demand for quality seeds. The increase in average yields of minor millets, therefore, has not been commensurate with the number of released new varieties [28].

Based on the cropped area during 2020-21, [29] worked out the certified seed required for 2026-27 for finger millet and little millet based on the standard seed multiplication ratio and seed replacement rate of 40%. It was found that more than the required breeder seed has been produced in these crops, which led them to suggest that realistic indents of appropriate varieties for breeder seed should be placed with the concerned organization and ensure its use in the production of foundation and certified seed.

Challenges in seed production of minor millets and potential crops

Seed production in minor millets and potential crops remains challenging for various reasons - some of these are of a general nature and some are specific to this group of crops.

Low yield levels: Minor millets are inherently low-yielding compared to the major cereals like wheat, rice and maize. The country's average yield gap for finger millets and minor millets over 2009-2014 was 183% and 156%, respectively [11]. As documented in the recent FLDs, grain yield gaps vary from 40% to 92% in various millets [28]. Low yields render seed production of minor millets less attractive. The availability of a cereal crop as a better alternative for seed production further draws the farmers away from minor millets seed production.

Prevalence of traditional cultivation practices: Traditional practices (seed broadcasting, manual weeding, intercultural operations with local devices, limited or no use of chemical fertilizers and other agricultural inputs) continue to prevail in the traditional minor millet growing areas, often due to lack of awareness or lack of access to resources or lack of mechanization. In hills and tribal areas especially, farmers prefer to cultivate millets under organic conditions, resulting in stagnant yields.

Lack of effective crop production packages: Unlike major cereals, effective crop production packages are not available for all minor millets.

- **Nutrient management:** Though generalized recommendations are available for minor millets, there is a lack of variety-specific packages which are essential for maximizing the yield potential of the new high-yielding varieties.

- **Limited weed management options:** This is one of the most limiting factors in increasing the millet area and production. Millets are poor weed competitors in the early stage of growth and the losses suffered may range from 55-61% in finger millet and up to 46% in Kodo millet if the weeds are not controlled timely [30]. By virtue of their grassy nature, minor millets are the target weeds of most herbicides used in major cereals. Manual weeding in minor millet is a very laborious and drudgery-prone practice as, besides the usual chore of removing unwanted vegetation, care must be taken to distinguish minor millet plants from other grasses of similar morphology during the early stages. The lack of effective weed control measures is the major hindrance in expanding minor millets cultivation and seed production in non-traditional areas, especially in fertile irrigated lands traditionally under rice-wheat system.

Lack of mechanization

- **Sowing and intercultural operations:** Owing to the predominance of manual operations, millet are labour-intensive crops. Migration of the young population to urban areas is a widely prevalent and perennial phenomenon across the states in India, with out-migration from hills and tribal areas being much higher compared to the plains [31]. The resultant reduction in the farming workforce and lack of suitable mechanization alternatives to compensate for the reduced workforce is another important reason for the decline in minor millets cultivation in the hill regions.
- **Harvesting and post-harvest operations:** Most minor millets produce tillers that are asynchronous in maturity with the main panicle, necessitating at least two rounds of manual harvesting. Manual threshing (beating harvested panicles with sticks to thresh out grains) is still the common practice of threshing in minor millets in most parts of the country. Additional post-harvest operations are required in some crops (such as pearling in finger millet). These operations, being labour-intensive and drudgery some, act as dissuasions to households that are small or comprise elderly members

Crop damage by wildlife

In the last decade, wildlife has emerged as a major cause of crop losses in minor millets, especially in the state of Uttarakhand, which ranks first and third, respectively, in barnyard millet and finger millet cultivation in the country. Over the last decade, the area under the two crops has declined by 31 and 34%, respectively, during 2012-13 to 2020-21 [32]. One of the reasons for the decline in the area is farmers' discontinuation of crop cultivation, including minor millets, due to increasing damage to the crop by wildlife like monkeys and wild boars

Lack of adequate remuneration and incentive: Minor millets are far from competing with the major cereals in seed production in terms of yield. The predominance of manual operations makes minor millets seed production more expensive. During 2018-19, the net return from finger millet cultivation in the three major finger millet growing states - Karnataka, Tamil Nadu and Uttarakhand - were Rs. -1,559, Rs. -4,571 and Rs. -10,731, respectively [33]. Without adequate intensification through premium pricing of procurements or subsidies, the seed produce risks being procured by local grain traders offering marginally higher prices.

PROSPECTS OF UPSCALING SEED PRODUCTION OF MINOR MILLETS AND OTHER POTENTIAL CROPS

The foremost pre-requisite for upscaling minor millets seed production is to bring it in parity with the seed production of major cereal crops like wheat, rice and maize in terms of economic gain, which can be achieved by increasing profits and would include the following interventions:

Cultivars with high yield potential and desired quality attributes

An appreciable number of high-yielding minor millet varieties have been developed in the country and introduced in the seed chain in the last few years. Higher yields translating into higher profitability are expected to attract farmers towards minor millets seed production. Developing high-yielding cultivars possessing regionally/ locally preferred quality attributes can facilitate weaning farmers away from local cultivars towards improved cultivars.

Further, the current breeding efforts are focussed mainly on enhancing yield levels of minor millets in their native ecologies. The need now, though, is to reorient focus on developing minor millet cultivars with semi-dwarf stature and fertilizer responsiveness and well adapted to different ecologies, similar to wheat and rice.

Improved packages for crop production

- **Promotion of transplanting method with direct-seeding method:** Compared to direct-seeding, the transplanting method in finger millet saves seed, allows pre- and post-transplanting application and facilitates inter-culture operations. Besides, the crop is uniform in stature and maturity and yields higher than the direct-seeded crop due to proper spacing and less competition for nutrients [34]. Promotion of transplanting methods in areas where broadcasting is traditionally prevalent can help farmers earn additional profit. There is a need to develop a suitable millet transplanter to reduce the drudgery and increase the efficiency.
- **Nutrient management:** Optimal variety-specific nutrient management packages for different millet crops/cultivars can help improve yields without adversely affecting other plant aspects.
- **Effective chemical weed management:** The lack of proper weedicide to control weeds is one of the major hindrances in the expansion of minor millet cultivation. Developing effective weed management packages will help minor millets-growing farmers save on cultivation costs and facilitate the adoption of minor millets in non-traditional areas also.

Mechanization of farm operations and post-harvest processing

- **Minor millet seeders, transplanters and harvesters:** The availability of millet-specific seeders and transplanters can enhance the efficiency of farm operations and reduce the dependence on a manual workforce for carrying out these operations.
- **Post-harvest machinery:** Millet threshers and other post-harvest machinery suitable for different farm sizes are now available. VL Millet Thresher-cum-Pearler, developed by ICAR-VPKAS, is very handy equipment for small farms. Enhancing farmers' accessibility to this farm machinery can reduce the cost of post-harvest operations, thereby saving time and increasing profitability.

Incentivizing minor millets seed production

Enhancing profitability from minor millets seed production through various policy interventions is important for attracting farmers to take up minor millets seed production. Some incentives that are already in place include Rs 3,578/ per quintal in Uttarakhand for grain and certified seed production of HYVs of nutri-cereals within 10-year-old varieties will provide 25% higher than the MSP (as per NSC formula) [35]. More such incentives need to be introduced to enhance the quality of seed production of minor millets.

Special focus on the North Eastern region

Minor millets are traditional crops in the North Eastern (N.E.) region and are cultivated on varying scales in different N.E. states. Finger millet is grown in a sizeable area in Arunachal Pradesh and intricately woven into tribal culture and food habits [36]. By virtue of the geographic location and favourable climatic conditions, NER offers vast scope for expansion of minor millets area in the country. Special schemes have been launched by GoI (NEH Component) and dedicated efforts are being made by ICAR to revive and upscale millet cultivation in the N.E. states [37].

PROMOTION OF MINOR MILLETS IN NER BY ICAR-VPKAS

Finger millet in Tawang (Arunachal Pradesh)

Initiated in 2018 in district Tawang (Arunachal Pradesh) under the NEH Programme with the evaluation of promising high-yielding VL millet varieties in collaboration with KVK Tawang, the cultivation of early high-yielding finger millet variety VL *Mandua* 376 has spread to over 50 hectares in district Tawang and the area is projected to double over the next 2-3 years through farmer participatory seed production and farmer-farmer seed exchange. The variety yielded 40-50% higher (14-16 q/ha) than the local cultivar (9-10 q/ha), besides maturing about three weeks earlier.

The introduction of VL Millet Thresher-cum-Pearler has further facilitated the variety adoption by saving time and labour and reducing drudgery in post-harvest operations.

Buckwheat in East Khasi Hills (Meghalaya)

It was initiated by the Meghalaya Farmers Empowerment Committee with the basic seed of buckwheat variety VL *Ugal* 7 provided by ICAR-VPKAS, buckwheat seed production in Meghalaya already scaled to over 100 acres in 2022 after a modest start in 2020 in 2.0 hectares. The state plans to expand its cultivation to 1,000 acres over the next few years.

Efforts are ongoing to replicate this initiative in other potential millet-growing districts in the NER.

FUTURE PROSPECTS AND OPPORTUNITIES

The prospects for seed production in minor millets and potential crops in India, particularly with regard to the Himalayan states, are promising and multifaceted. Efforts are underway to tackle existing challenges and capitalize on emerging opportunities in the agricultural landscape. One significant aspect of future prospects involves research and development endeavours to breed high-yielding cultivars adapted explicitly to local agro-climatic conditions. By leveraging advancements in agricultural science, breeders can tailor cultivars with enhanced yield potential, disease resistance and desirable quality attributes, thereby boosting productivity and farmer income. Moreover, promoting the adoption of improved crop management practices, including optimized nutrient management and effective weed control measures, can further enhance yields and ensure sustainable production systems.

Mechanization of farming operations is another critical area for future growth. Introducing millet-specific seeders, transplanters and harvesters can significantly reduce the manual workforce, mitigate the impact of rural out-migration and streamline production processes. Additionally, developing and disseminating post-harvest machinery, such as millet threshers and processing equipment, can improve efficiency, reduce post-harvest losses and enhance the quality of harvested grains.

Incentivizing millet seed production through policy interventions is vital for encouraging farmers to invest in these crops. Measures such as subsidies for quality seed production and premium pricing mechanisms can enhance the attractiveness of millet cultivation, particularly in comparison to other cash crops. Furthermore, initiatives aimed at strengthening the seed supply chain and improving market linkages can ensure timely access to quality seeds and facilitate market-driven approaches to production.

Special attention to the Northeast region presents unique opportunities for expansion and diversification of millet cultivation. By leveraging the region's favourable agro-climatic conditions and traditional farming practices, targeted interventions such as farmer-participatory seed production and the introduction of high-yielding varieties can catalyze growth in millet production. Moreover, initiatives to address specific challenges, such as crop damage by wildlife and lack of adequate remuneration, can further support the adoption of millets as a viable cropping option in the region.

On a broader scale, the growing global demand for millets and millet-based products offers significant export potential for India. By tapping in the international markets and showcasing the nutritional and environmental benefits of millets, India can position itself as a key player in the global millets market, thereby enhancing economic opportunities for farmers and contributing to food security and nutrition globally. Production of quality seeds (breeder, foundation and truthfully labelled seeds of all the millets are of prime importance in increasing the production and productivity of millets in India.

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REFERENCES

1. FAOSTAT (2023). FAOSTAT. https://www.fao.org/faostat/en/#data/ QCL/metadata
2. UPADHYAYA HD AND M VETRIVENTHAN (2018). Underutilized climate-smart nutrient rich minor millets for food and nutritional security. In: Tyagi et al. (Ed.) Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific – Thematic, Strategic Papers and Country Status Reports. Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand, November 13-15, 2017. P 109-120.
3. LYDIA PRAMITHA J, J GANESAN, N FRANCIS, R RAJASEKHARAN AND J THINAKARAN (2023). Revitalization of minor millets for nutritional and food security by advanced genetics and genomics approaches. *Frontier in Genetics.* **13**: 1007552. doi: 10.3389/fgene.2022.1007552
4. NAHATKAR S (2023). Promotional polices for millets in India: preliminary review and future challenges. In: Kumar et al. (Ed.) Souvenir: National conference on Production, Processing and Marketing of Millets: Issues & Solutions (1-2 March 2023, JNKVV, Jabalpur, India).P 145-54
5. DAYAKAR RAO B, BHASKARACHARY K, ARLENE CHRISTINA GD, SUDHA DEVI G AND TONAPI VA (2017). *Nutritional and health benefits of millets*. ICAR-Indian Institute of Millets Research.
6. NITHIYANANTHAM S, KALAISELVI P, MAHOMOODALLY MF, ZENGIN G, ABIRAMI A AND SRINIVASAN G (2019). Nutritional and functional roles of millets- A review. *Journal of Food Biochemistry* **43**: 1–10. https:// doi.org/10.1111/jfbc.12859
7. YADAV OP, RAI KN AND GUPTA SK (2012). Pearl millet: Genetic improvement for tolerance to abiotic stresses. In N. Tuteja, S. S. Gill, & R. Tuteja (Eds.), Improving crop resistance to abiotic stress (pp. 261–288). Wlley-VCH Verlag GmbH & Co. KGaA
8. GUPTA SM, S ARORA, N MIRZA, A PANDE, C LATA, S PURANIK, J KUMAR, AND A KUMAR (2017). Finger millet: A "certain" crop for an "uncertain" future and a solution to food insecurity and hidden hunger under stressful environments. *Frontiers in Plant Science*, **8**: 643. https://doi.org/10.3389/fpls.2017.00643

9. DE VRIES, F T, R I GRIFFITHS, C G KNIGHT, O NICOLITICH AND A WILLIAMS (2020). Harnessing rhizosphere microbiomes for drought-resilient crop production. *Science*, **368**: 270–274. https://doi.org/10.1126/science.aaz5192

10. SHARMA SK (2023). Conventional and natural farming approaches for millets. In: Kumar et al. (Ed.) Souvenir: National conference on Production, Processing and Marketing of Millets: Issues & Solutions (1-2 March 2023, JNKVV, Jabalpur, India).Pp. 154.

11. LAL SK, SK YADAV, RS RAMAKRISHNAN AND DK YADAVA. (2023). Prospects and problems of quality seed production of minor millets for sustainable livelihood. In: Kumar et al. (Ed.) Souvenir: National conference on Production, Processing and Marketing of Millets: Issues & Solutions (1-2 March 2023, JNKVV, Jabalpur, India). P 2-9.

12. DEVI PB, RAJENDRAN, VIJAYABHARATHI, SATHYASEELAN, SATHYABAMA, NAGAPPA, M GURUSIDDAPPA, VENKATESAN AND B PRIYADARISINI (2014). Health Benefits of Finger Millet (*Eleusine coracana* L.) Polyphenols and Dietary Fibre: A Review, *Journal of Food Science and Technology*, **51(6)**:1021–1040.

13. NAGARAJA TE, C NANDINI, S BHAT AND S G PARVEEN (2023). Artificial hybridization techniques in minor millets—A review. *Frontier in Plant Sciences* **14**: 1112117. doi: 10.3389/fpls.2023.1112117

14. ANONYMOUS (2022a). Knowledge paper on Millets the Future Super Food for India.https://www.assocham.org/uploads/files/Report_Millets%202022%20(Print%20Version)%20(1).pdf

15. NAAS (2022). Promoting Millet Production, Value Addition and Consumption.https://naas.org.in/Policy%20Papers/policy%20114.pdf

16. ANONYMOUS (2023a). https://agriculture.uk.gov.in., Department of Agriculture, Uttarakhand.

17. MOTWANI S (2023). Sustainable transformation of millets supply chain towards making India as global market leader. In: Kumar et al. (Ed.) Souvenir: National conference on Production, Processing and Marketing of Millets: Issues & Solutions (1-2 March 2023, JNKVV, Jabalpur, India).Pp. 154.

18. BHATT BV, K HARIPRASANNA, SOOGANNA AND CV RATNAVATHI (2023).Global and Indian scenario of millets. *Indian Farming*, **73**(1): 16–18.

19. NAAS (2013). Role of millets in nutritional security of India.https://www.millets.res.in/books/Policy66.pdf

20. CHAUHAN JS, SR PRASAD, S PAL, PR CHAUDHARY AND K UDAYABHASKAR (2016). Seed production of field crops in India: Quality assurance, status, impact and way forward. *Indian Journal of Agricultural Sciences,* **86**(5): 563–79.

21. SOOGANNA, R KULAKARNI, BV BHAT, N KANNABABU AND M KUMARA SWAMY (2023).Seed systems in millets. *Indian Farming,* **73**(1): 76-78.

22. ANONYMOUS (2018). Annual Report 2018. ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275103 (U.P.) India.

23. ANONYMOUS (2019a). Annual Report 2019. ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275103 (U.P.) India

24. ANONYMOUS (2020). Annual Report 2020. ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275103 (U.P.) India

25. ANONYMOUS (2021). Annual Report 2021. ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275103 (U.P.) India

26. ANONYMOUS (2022b). Annual Report 2022. ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275103 (U.P.) India

27. ANONYMOUS (2023c). Annual Report 2023. ICAR-Indian Institute of Seed Science, Kushmaur, Mau 275103 (U.P.) India

28. TONAPI V, VENKATESH BHAT, SANGAPPA AND D RAO (2023). Mainstreaming millets in food plates of all: issues and prospects affecting profitability, sustainable livelihoods, climate resilience and food &nutrition security. In: Kumar et al. (Ed.) Souvenir: National conference on Production, Processing and Marketing of Millets: Issues & Solutions (1-2 March 2023, JNKVV, Jabalpur, India).Pp. 154.

29. CHAUHAN JS, KH SINGH, PR CHAUDHARY, BB SINGH AND V KUMAR (2023).Breeding varieties and seed production chain of minor cereals in India: Status and strategies. *Indian Journal of Agricultural Sciences,* **93**(6): 583–590.https://doi.org/10.56093/ijas.v93i6.126191

30. DUBEY RP AND JS MISHRA (2023).Conventional and natural farming approaches for millets. In: Kumar et al. (Ed.) Souvenir: National conference on Production, Processing and Marketing of Millets: Issues & Solutions (1-2 March 2023, JNKVV, Jabalpur, India).Pp. 154.

31. ANONYMOUS (2019b). Human Development Report–Uttarakhand. Institute for Human Development, Delhi.https://www.ihdindia.org/pdf/UttarakhandHDR.pdf

32. ANONYMOUS (2023b). https://apeda.gov.in/milletportal/files/Statewise_Millet_Production.pdf

33. IIMR (2019). Cost of Cultivation Statistics of Millets | Millet Statistics by ICAR (Indian Council of Agricultural Research) & IIMR (Indian Institute of Millet Research). (milletstats.com)

34. NARAYAN H, B RAMACHANDRAPPA, MUDALAIRIYAPPA AND MN THIMMEGOWDA (2018).Yield and economics of finger millet with establishment methods under different planting geometry and nutrient source.*Indian Journal of Dryland Agricultural Research and Development*, **33**: 54. 10.5958/2231-6701.2018.00010.6.

35. ANONYMOUS (2022b). Millets BSP incentive 05Aug22.pdf

36. ANONYMOUS (2023d). APEDA. E-Catalogue For Export Of Millets And Value Added Products NORTH EAST ERN STAT ESNER_Millet_Value_Added_Products_Catalogue.pdf

37. BHAT BV, A ARUNACHALAM, D KUMAR, VA TONAPI AND T MOHAPATRA (2019). Millets in the Indian Himalaya, Indian Council of Agricultural Research, New Delhi.