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Small Millets : Climate Resilient Crops for Food and Nutritional Security

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ABSTRACT

Small millets are considered as nutri cereals and are a source of food, feed and fodder. The crops are grown in a variety of agro-ecological situations like plains, coast and hills as well as in diverse soils and varying rainfall. They are known for resilience and drought enduring capacity and are relatively less prone to major pests and diseases. Crop improvement efforts focused to state / regional needs from the point of developing appropriate agro production technology for maximizing production / productivity. Package of practices such as time of sowing/ planting, choice of varieties, time and method of application of fertilizers have been developed for different regions of the countryfor cultivation various small millets. Plant protection measures to control economically important diseases and pests have been evolved. Rich diversity of small millets crops has made them well suited for contingency crop planning and also to address the issues of climate change. Small millets are superior in some or most of the nutritional components compared to most widely consumed rice and wheat. These millets contribute towards balanced diet, and can hence ensure nutritional security more easily through regular consumption along with keeping the environment safe as they are low input crops mostly adapted to marginal lands.Smallmillet crops are viewed as important for health and wellness of people and can help in preventing many kinds of diseases related to modern life style including obesity, diabetes. Of late, plenty of elite food chains have begun selling millets and millets based products on their shelves as health food. The importance of regular food use of nutrient dense millet for achieving a holistic food and nutritional security is widely recognized. This paper deals with all aspects of small millets with reference to varietal improvement, food and nutritional security.

SMALL millets are a group of six crops comprising of finger millet, kodo millet, little millet, foxtail millet, barnyard millet and proso millet. They are considered as nutri cereals and are a source of food, feed and fodder. They are grown from sea level to mid hills right from Tamil Nadu in the South to Uttarakhand in the North, and Gujarat in the West to Arunachal Pradesh in the Northeast. The crops are grown in a variety of agro-ecological situations v*iz*., plains, coast and hills as well as in diverse soils and varying rainfall. They are known for resilience and drought enduring capacity and are relatively less prone to major pests and diseases. These are indispensable in tribal and hill agriculture where crop substitution is difficult.

Small millets have always been of local and regional important and as a result have attracted little attention both at national and International level. Millets

Crop	Major Growing States
Finger millet	Karnataka, Maharashtra, Uttarakhand, Tamilnadu, Andhra Pradesh., Jharkhand, Orissa , Chattisgarh and Gujarat
Little millet	Karnataka, Maharashtra, Tamilnadu, Andhra Pradesh , Madhya Pradesh, Jharkhand, Orissa, Gujarat and Chattisgarh
Kodo millet	Madhya Pradesh, Chattisgarh, Maharashtra, Tamilnadu, Karnataka
Barnyard millet	Uttarakhand, Uttar Pradesh, Karnataka, Madhya Pradesh., North East and Tamilnadu
Foxtail millet	Telangana, Andhra Pradesh., Karnataka, Rajastan, Madhya Pradesh, Tamilnadu and Chattisgarh
Proso millet	Bihar, North East, Tamil Nadu, Karnataka and Maharashtra

Crop	Scientific Name	Chromosome No	Place of Domestication
Finger millet	*Eleusine coracana*	2n=36 (4x)	East Africa
Foxtail millet	*Setaria italica*	2n=18 (2x)	Central Asia-India
Proso millet	*Panicummliaceum*	2n=36 (4x)	Central Asia-India
Barnyard millet	*Echinochloa frumentacea*	2n=54 (6x)	India
Kodo millet	*Paspalumscrobiculatum*	2n=40 (4x)	India
Little millet	*Panicum sumatrance*	2n=36 (4x)	India

in general stated receiving with attention with launching of All India Coordinated Millets Improvement Project (AICSMIP) in 1969. In this project small millets also started receiving some attention at a selected few centres. Small millets improvement received the major boost during 1978-79 with the establishment of five crops specific lead research centres in the country under IDRC assistance. They were Almora in Uttarakhand (barnyard millet), Dholi in Bihar (proso millet), Dindori in Madhya Pradesh (kodo millet), Semiliguda in Odisha (little millet) and Nandyal in Andhra Pradesh (foxtail millet). The IDRC project continued till 1985 and the All India Coordinated Small millets Improvement Project (AICSMIP) was established in the year 1986 with head quarters at The University of Agricultural Sciences, GKVK, Bengaluru. With the inception of separate AICRP on Small Millets, research on small millets has been getting focused attention for developing varieties and other agro production and protection technologies suitable to different regions.

Area, production and productivity trends: The total area under these crops is around 1.92 m ha, of which finger millet alone occupies 1.19 m ha. Five-yearly analysis of data indicates a steady decline in the area from 7.56 m ha during 1951-55 to 1.92 m ha during 2011-15; with a drastic decline in the area of small millets other than finger millet from 5.29 to 0.73 m ha (Table I). The production of finger millet

TABLE I

Quinquennial area, production and productivity of small millets in India

Year	Finger millet			Small millet		
	Area ('000 ha)	Production ('000 t)	Productivity (kg ha^{-1})	Area ('000 ha)	Productivity (kg ha^{-1})	Production ('000 t)
1951-55	2274	1605	704	5290	2177	410
1956-60	2454	1873	764	5022	1955	389
1961-65	2555	1888	743	4677	1889	404
1966-70	2420	1887	779	4741	1784	376
1971-75	2442	2227	909	4489	1745	388
1976-80	2588	2650	1021	4326	1743	402
1981-85	2474	2612	1054	3459	1391	401
1986-90	2306	2510	1088	2754	1198	437
1991-95	1891	2511	1331	1950	851	439
1996-00	1718	2413	1402	1492	738	435
2001-05	1563	2088	1331	1173	510	435
2006-10	1350	1976	1471	970	467	480
2011-15	1190	1941	1631	731	467	639

TABLE II

Decade wise compound growth rates (CGR) for area, production and yield of finger millet and small millets during 1951 to 2010

Year	Compound growth rate (CGR)					
	Ragi			Small Millets		
	Area	Production	Yield	Area	Production	Yield
1951-1960	1.57	4.48	2.85	0.57	0.32	-0.12
1961-1970	-0.28	-1.00	-0.72	-0.32	-1.68	-1.35
1971-1980	1.25	4.28	2.99	-0.76	-0.51	0.25
1981-1990	-1.21	-0.10	1.13	-4.35	-3.26	1.36
1991-2000	-1.80	0.93	2.78	-5.36	-5.38	-0.09
2001-2010	-3.17	-1.73	1.70	-4.92	-2.93	2.08

TABLE III

Area, production and productivity in finger millets (Average of 2009-10 to 2013-14)

State	Area (lakhs ha)	Production (lakhs ha)	Productivity (kg / ha)
Karnataka	6.96	12.54	1801
Maharashtra	1.25	1.34	1070
Uttarakhand	1.22	1.68	1372
Tamil Nadu	0.87	2.24	2580
Other states	1.66	1.40	843
All India	11.96	19.2	1604

fluctuated between 1.61 m t in 1951-55 and 1.94 m t in 2011-15 with high of 2.65 m t during 1976-80 despite huge reduction in area. This was due to doubling of productivity of finger millet from 704 kg / ha to 1631 kg/ha and wide spread cultivation of high yielding blast tolerant varieties (Table I) (Anon., 2016).

Compound growth rates (CGR) for area, production and yield of finger millet and small millets : The area under finger millet showed a declining trend in all the decades' except during 70's. Similarly, production showed the positive growth rate only during the 70's and 90's. However, the productivity was positive during all the decades except in 60's. The other small millets had negative trend both in area and production. However, productivity trend was marginally positive, but was positive for yield during 70's, 80's and 2000's. (Table II).

Area, production and productivity in recent years Finger millet : The major finger millet growing states are Karnataka, Uttarakhand, Maharashtra, Tamil Nadu, Odisha, Andhra Pradesh and Gujarat. Of the total area under finger millet Karnataka alone occupies 60 per cent followed by Uttarakhand and Maharashtra with 10 per cent each (Table III).

Karnataka contributes nearly 70 per cent of finger millet production in the country followed by Uttarakhand and Maharashtra with about 9 per cent. Tamil Nadu has the highest productivity (2580 kg / ha), followed by Karnataka (1801 kg / ha) and Uttarakhand (1372 kg / ha).

Other Small Millets

In other small millets, the area declined is very drastic leading to lowering of production without any visible increase in productivity. This is largely attributable to confinement of these crops to marginal areas, non availability of quality seed of improved varieties and poor extension support.

Madhya Pradesh (32%) has the largest area under other small millets, followed by Chattisgarh (18%) and Uttarakhand (9%). Madhya Pradesh and Uttarakhand contribute 19 and 18 per cent of small millets production which is closely followed by Gujarat 15 per cent. Productivity of other small millets as a whole is high in Uttarakhand and Gujarat (Table IV).

In spite of the extraordinary nutritional qualities of millet grains and capacities of millet farming

TABLE IV

Area, production and productivity in small millets (other than finger millet) (Average of 2009-10 to 2013-14)

State	Area (lakhs ha)	Production (lakhs ha)	Productivity (kg / ha)
Madhya Pradesh	2.40	0.92	384
Chattisgarh	1.41	0.29	212
Uttarakhand	0.71	0.88	1226
Maharashtra	0.64	0.30	471
Gujarat	0.47	0.46	995
Other states	1.95	1.40	843
All India	7.58	4.39	580

systems, the area under millet production has been shrinking over the last five decades. The period between 1961 and 2009 saw a dramatic decrease in cultivated area under millets, more so in case of small millets (80 per cent for small millets other than finger millet, 46 per cent for finger millet). The area under all small millets other than finger millet has declined drastically in all states and the total production of small millets has declined by 76 per cent. The productivity has remained more or less stagnant in the last two decades. The area declined by 83 per cent from first five year plan to 12th plan, whereas, the production also fell by nearly 80 per cent. The productivity of small millets (other than finger millet) remained almost stagnant till 12th plan with a slight decline during 3rd and 4th plans.

Critical gaps in Small millets cultivation and utilization in India

The desired impact of the project, which has developed many high yielding cultivars, improved technology has not reached the end users in desired levels in all millets other than finger millet. There has been a decline in area and some of the major reasons for these appear to be ;

* Crops grown on diverse soil types and varying moisture regimes under rainfed conditions.
* Non adoption of improved varieties and crop management practices.
* Plateauing of yields due to genetic barriers and dependence of narrow genetic base
* Non availability of sustainable and profitable cropping systems for maximizing returns to farmers
* Instability in production and productivity on account of vulnerability to biotic and biotic stresses.
* No organized programme for production and supply of seeds of improved varieties.
· Under exploitation of potential of value chain for diversified uses.

Research achievements

Crop improvement: Research on crop improvement focused to state/regional needs from the point of developing appropriate agro production technology for maximizing production/ productivity. The work is multi-disciplinary and applied in nature. Crop improvement led to development of high yielding varieties with resistance to blast disease, quality fodder, early and medium maturity and white seed in finger millet, resistance to head smut in kodo millet and resistance to shoot fly in both proso and little millets. So far, a total of 256 varieties in 6 small millets have been released in the country (Table V).

Out of 86 varieties were released before 1986 (pre coordinated era and 170 during 1986-2016 (post coordinated project era). The break up for various

TABLE V

Varieties released in small millet crops

Crop	No. of Varieties released		
	Before 1986	After 1986	Total
Finger millet (1918-2016)	45	78	123
Foxtail millet (1942-2016)	12	22	34
Little millet (1954-2016)	6	17	23
Proso millet (1954-2016)	8	16	24
Barnyard millet (1949-2016)	4	17	21
Kodo millet (1942-2016)	11	20	31
Total	86	170	256

small millets is 123 in finger millet, 34 in foxtail millet, 23 in little millet, 31 in kodo millet, and 21 in barnyard millet. Pure line selection has been the approach so far in little and kodo millet and as a result the genetic gain made has been very limited and the varieties are less diverse too. On the country recombination breeding has been the approach especially in finger millet resulting in creation highly diverse and productive varieties (Table VI).

TABLE VI

State wise important / popular varieties in small millets

State	Varietites
	Finger Millet
Karnataka	GPU 28, GPU-45, GPU-48, PR 202, MR 1, MR 6, Indaf 7, ML-365, GPU 67, GPU 66, KMR 204, KMR 301, KMR 340
Tamil Nadu	GPU 28, CO 13, TNAU 946 (CO 14), CO 9, CO 12, CO 15
Andhrapradesh	VR 847, PR 202, VR 708, VR 762, VR 900, VR 936
Jharkhand	A 404, BM 2
Orissa	OEB 10, OUAT 2, BM 9-1, OEB 526, OEB-532
Uttarakhand	PRM-2, VL 315, VL 324, VL-352, VL 149, VL 146, VL-348, VL-376, PES 400
Chattisgarh	Chhattisgarh-2, BR-7, GPU 28, PR 202, VR 708 and VL 149, VL 315, VL 324, VL 352, VL 376
Maharashtra	Dapoli 1, PhuleNachani, KOPN 235, KoPLM 83
Gujarat	GN 4, GN 5, GNN 6
Bihar	RAU 8
	Kodo Millet
Madhya Pradesh	RK-65-18,JK 439, RBK 155, JK 13, JK 65 and JK 48, JK 137, RK 390-25, JK 106, GPUK 3
Tamil Nadu	KMV 20 (Bamban), CO 3, TNAU 86, GPUK 3
Gujarat	GK 1 and GK 2, GPUK 3
Chattisgarh	RBK 155 and JK 439, Indira Kodo-1, Indira Kodo- 48, GPUK 3
Karnataka	GPUK 3, RBK 155
	Foxtail Millet
Andhrapradesh	SiA 3088, SiA 3156, SiA 3085, Lepakshi, SiA 326
Karnataka	SiA 326, HMT 100-1 and PS 4,Sreelaxmi, KO 12,Narasimharaya, SiA 3088, SiA 3156
Tamil Nadu	TNAU 196 and TNAU 43, CO (Ten) 7,TNAU 186, CO 1, CO 2, CO 4, CO 5, K2, K3
Rajasthan	Prathap Kangani (SR 1) and SR 51, SR 11, Sreelaxmi, SR 16, SiA 3085
Uttar Pradesh	PRK 1 and PS 4, SiA 3088, 3085, Sreelaxmi, Narasimharaya, S-114, SiA 326
Uttarakhand	PS 4 and PRK 1, Sreelaxmi, SiA 326
	Little Millet
Orissa	OLM 203, OLM 208, OLM-217
Madhya Pradesh	JK-4, JK 8 and JK 36
Andhra Pradesh	OLM 203, JK 8
Tamil Nadu	Paiyur 2, TNAU 63 and CO 3,C0-4,K1, OLM 203, OLM 20
Chattisgarh	JK 8, BL 6, BL-4, JK 36
Karnataka	OLM 203, JK 8
Gujarat	GV 2, GV 1, OLM 203, JK 8
Maharashtra	PhuleEkadashi, JK 8, OLM 203
Tamil Nadu	Co-5, TNAU 151, TNAU 164, TNAU 145, TNAU 202, CO 4, K2, CO 3,CO 2, GPUP 21, GPUP 8
	Proso Millet
Uttarakhand	PRC 1, TNAU 145, 164, 151, CO 4
Karnataka	GPUP 8 and GPUP 21, TNAU 145, 164
Bihar	BR-7, TNAU 164, 145, PR 18
Andhra Pradesh	Sagar, Nagarjuna, CO 4, CO 3
	Barnyard Millet
Uttarakhand	VL 172, VL 207, PRJ 1 and VL 29, PRS 1
Uttar Pradesh	VL 172 and VL 207, Anurag, VL 29
Tamil Nadu	CO 1 and CO 2, VL 181, VL 29
Karnataka	VL 172, RAU 11, VL 181
Gujarat	Gujarat Banti- 1

Germplasm conservation, evaluation and utilization: Recognizing the importance and conservation and easy access to germplasm, AICSMIP established a separate germplasm unit at Bengaluru in 1979. This unit since then has been making efforts to collect as well as pool the available germplasm from various sources and make it available to breeders in the country. Project coordinating unit is also recognized as National Active Germplasm Site (NAGS) by ICAR / NBPGR and has the mandate to assist in collection, conservation, evaluation and documentation of small millets germplasm in the country. Presently the unit at Bengaluru is maintaining one of the largest collections of more than 10,000 accessions of 6 small millets.

In order to improve the efficiency for utilization of germplasm, core subsets have been formed and made available to breeders working at different centres. Selected germplasm have also been evaluated in the all India testing network and a number of superior accessions were identified and a couple of them have been released for general cultivation in different parts of the country. (Ravikumar *et.al.*, 1990, Byregowda *et.al.,* 1999, 2000, Gowda *et.al.,* 1990)

Majority of the accessions have been screened for agronomic, physiological, pathological and even important grain quality parameters. There is good data base available for most accessions and germplasm catalogues have been brought out (Seetharam *et al*., 2006). In order to improve the efficiency for utilization of germplasm, core subsets have been formed and made available to breeders working at different centres. The exotic collections especially from Africa in finger millet have been largely used in recombination breeding resulting in release of many superior high yielding varieties in many states. The African germplasm have thick stem, dark leaves, robust growth, large ears, and high grain density and source of resistance to blast disease (Naik *et al*., 1993). Hybridization between African and Indian elite varieties has been highly rewarding and has resulted in the release of many high yielding varieties in the country (Seetharam, 1998; Paroda *et.al.,*1989; Seetharam *et.al.,* 1993; Seetharam, 2006).

Seed production: Large, scale seed production and distribution which is the key to success in spread of HYV's is very weak in many states especially in crops other than finger millet in the entire country. This has led to opportunity deprivation of benefits of improved varieties to farmers in most parts of the country. The harnessing of yield advantages from these improved varieties is the need of the hour in order to make small millets cultivation competitive and economically viable. The success of GPU-28 variety of ragi in Karnataka is a best example in harnessing the benefits of a good seed production and distribution program involving line departments like Karnataka State Seed Corporation Limited and Karnataka State Department of Agriculture

Crop production and protection technologies: Package of practices such as time of sowing/ planting, choice of varieties, time and method of application of fertilizers have been developed for different regions of the countryfor cultivation various small millets. Management practices for aberrant weather conditions for mitigating early, mid and late season drought have been worked out. Remunerative cropping systems involving different pulse crops in millet for different regions have been evolved (Krishne Gowda *et.al.,* 2004). Technology transfer attempted through frontline demonstrations on the farmer's field and on large scale station demonstrations have helped in narrowing down the yield gap that existed between farmers field, demonstration plot and research station trials. (Seetharam and Krishne Gowda, 2008; Anon., 2011; Seetahram, 2015a, b).

Plant protection measures to control economically important diseases and pests have been evolved (Seetahram 2015a, b). Several blast resistant lines were identified from the germplasm available at NAGS and crop protection for management of blast diseases has been recommended. Two sprays of *P. fluorescens* (0.2%) or *P. fluorescens+T. harzianum* (0.2%) were comparable to edifenphos (0.1%) for controlling *ragi* blast especially under organic production situations. Three new diseases *viz.,* Banded sheath blight of *ragi*, Head smut of barnyard millet and Udbatta of kodo millet were recorded and reported. New donors resistant to banded sheath blight and smut have been identified. An IPM package involving clean cultivation,

early sowing with higher seed rate (one and a half times) followed by trapping the adult flies with fish meal traps was found effective in mitigating the menace of shootfly in little, barnyard, kodo and proso millet.

Small millets for nutritional security

Physical properties and nutritional profile: The small millets are small seeded grains and resemble paddy or rough rice in the morphological features of kernel. The kernel consists of distinct husk, bran and endosperm tissues. Normally, husk accounts to 15 to 20 per cent of the kernel where as the bran amount to about 5 per cent and the endosperm to about 75 per cent of the kernel, respectively. The seed coat and husk of foxtail, little and proso millet are generally of single entity with glossy appearance, whereas, kodo and barnyard millet contain multiple layered seed coat. Normally the seed coat of kodo millet is of brown colour, foxtail millet is yellowish where as the other millets are grayish coloured. The husk is non-edible and unusually hard to digest similar to the husk in paddy, where as the bran is edible. To prepare edible items out of millets, the husk is separated by milling and along with that generally, the bran is also separated similar to milled rice (Malleshi, 2015).

Small millets are more nutritious compared to fine cereals. Finger millet is the richest source of calcium (300-350 mg/100 g) and other small millets are good source of phosphorous and iron. The protein content ranges from 7 to 12 per cent and fat content from 1 to 5.0 per cent. The millet protein has well balanced amino acid profile and good source of methionine, cystine and lycine. These essential amino acids are of special benefit to those who depend on plant food for their protein nourishment. The millet grain contains about 65% carbohydrate, a high proportion of which is in the form of non starchy polysaccharides and dietary fibre which help in prevention of constipation, lowering of blood cholesterol and slow release of glucose to the blood stream during digestion. Lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycemia (diabetes) are reported among regular millet consumers. Millet grains are also rich in important vitamins *viz*., Thiamine, riboflavin, folin and niacin. Millets are comparable to rice and wheat or rich in some of the minerals. (Tables IX to XII).

From the data presented here it is evident that small millets are superior in some or most of the nutritional components compared to most widely

TABLE IX

Nutrient composition of millets compared to fine cereals (per 100 g)

Food gain	Carbohydrates (g)	Protein (g)	Fat (g)	Energy (k Cal)	Crude fibre (g)	Mineral water (g)	Ca (mg)	P (mg)	Fe (mg)
Finger millet	72.0	7.3	1.3	328	3.6	2.7	344	283	3.9
Kodo millet	65.9	8.3	1.4	309	9.0	2.6	27	188	0.5
Proso millet	70.4	12.5	1.1	341	2.2	1.9	14	206	0.8
Foxtail millet	60.9	12.3	4.3	331	8.0	3.3	31	290	2.8
Little millet	67.0	7.7	4.7	341	7.6	1.5	17	220	9.3
Barnyard millet	65.5	6.2	2.2	307	9.8	4.4	20	280	5.0
Sorghum	72.6	10.4	1.9	349	1.6	1.6	25	222	4.1
Bajra	67.5	11.6	5.0	361	1.2	2.3	42	296	8.0
Wheat (whole)	71.2	11.8	1.5	346	1.2	1.5	41	306	5.3
Rice (raw, milled)	78.2	6.8	0.5	345	0.2	0.6	10	160	0.7

(Source: Nutritive value of Indian foods, NIN, 2007; *MILLET in your Meals*, http://www.sahajasamrudha.org/)

TABLE X

Essential amino acid profile of millets (mg / g of N)

Millet	Arginine	Histidine	Lysine	Tryptophan	Pheny I Alanine	Tyrosine	Methionine	Cystine	Threonine	Leucine	Isoleucine	Valine
Foxtail	220	130	140	60	420	-	180	100	190	1040	480	430
Proso	290	110	190	50	310	-	160	-	150	760	410	410
Finger	300	130	220	100	310	220	210	140	240	690	400	480
Little	250	120	110	60	330	-	180	90	190	760	370	350
Barnyard	270	120	150	50	430	-	180	110	200	650	360	410
Sorghum	240	160	150	70	300	180	100	90	210	880	270	340
Bajra	300	140	190	110	290	200	150	110	140	750	260	330
Rice	480	130	230	80	280	290	150	90	230	500	300	380
Wheat	290	130	170	70	280	180	90	140	180	410	220	280

(Source: Nutritive value of Indian foods, NIN, 2007; *MILLET in your Meals*, http://www.sahajasamrudha.org/)

TABLE XI

Vitamin profile of millets

Millet	Thiamin (mg)	Niacin (mg)	Riboflavin	Vit. A (carotene) (mg / 100g)	Vit. B6 (mg / 100g)	Folic Acid (mg / 100g)	Vit. B5 (mg / 100g)	Vit. E (mg / 100g)
Foxtail	0.59	3.2	0.11	32	-	15.0	0.82	31.0
Proso	0.41	4.5	0.28	0	-	-	1.2	-
Finger	0.42	1.1	0.19	42	-	18.3	-	22.0
Little	0.3	3.2	0.09	0	-	9.0	-	-
Barnyard	0.33	4.2	0.1	0	-	-	-	-
Kodo	0.15	2.0	0.09	0	-	23.1	-	-
Sorghum	0.38	4.3	0.15	47	0.21	20.0	1.25	12.0
Bajra	0.38	2.8	0.21	132	-	45.5	1.09	19.0
Rice	0.41	4.3	0.04	0	-	8.0	-	-
Wheat	0.41	5.1	0.1	64	0.57	36.6	-	-

(Source: Nutritive value of Indian foods, NIN, 2007; *MILLET in your Meals*, http://www.sahajasamrudha.org/)

TABLE XII

Micronutrient profile of millets (mg / 100g)

Millets	Mg	Na	K	Cu	Mn	Mb	Zn	Cr	Su	C l
Foxtail	81	4.6	250	1.40	0.60	0.070	2.4	0.030	171	37
Proso	153	8.2	113	1.60	0.60	-	1.4	0.020	157	19
Finger	137	11.0	408	0.47	5.49	0.102	2.3	0.028	160	44
Little	133	8.1	129	1.00	0.68	0.016	3.7	0.180	149	13
Barnyard	82	-	-	0.60	0.96	-	3	0.090	-	-
Kodo	147	4.6	144	1.60	1.10	-	0.7	0.020	136	11
Sorghum	171	7.3	131	0.46	0.78	0.039	1.6	0.008	54	44
Bajra	137	10.9	307	1.06	1.15	0.069	3.1	0.023	147	39
Rice	90	-	-	0.14	0.59	0.058	1.4	0.004	-	-
Wheat	138	17.1	284	0.68	2.29	0.051	2.7	0.012	128	47

(Source: Nutritive value of Indian foods, NIN, 2007; *MILLET in your Meals*, http://www.sahajasamrudha.org/)

consumed rice and wheat. These millets contribute towards balanced diet, and can hence ensure nutritional security more easily through regular consumption along with keeping the environment safe as they are low input crops mostly adapted to marginal lands. Declining small millets cultivation has resulted in reduced availability of these nutritious grains to needy population and also the traditional consumers have gradually switched over to more easily available fine cereals due to Government policies. This is a disturbing trend and needs urgent focus by the agricultural experts and policy makers. Immediate policy and market support, value addition and promotional activity are necessary for arresting the further decline not only in cultivation but also consumption. Improving productivity and enhancing demand should be the twin approaches. Development of health foods and their commercialization should receive focused attention to promote the millets among the urban elite, which would lead to reduction in life-style related disorders (Malleshi, 2015).

Future research priorities

* Utilization of trait specific germplasm for crop improvement activities
* Basic and strategic research for Improvement for :
  i. Resistance to biotic (blast in finger millet, shoot fly in little, proso and foxtail millets) and abiotic stresses (drought, temperature, salinity).
  ii. Development of parental lines and hybrid technology in finger millet using GMS.
  iii. Gene discovery and allele mining from small millet genetic resources (water and nutrient use efficiency and nutritional quality).
  iv. Basic research on host plant resistance to major diseases and understanding of causal organisms.
  v. Taxonomy and biology of major insect pests (stem borer, shoot flies etc) on specific host plants.
  vi. Value addition.
* Varietal diversification in all small millets
* Emphasis on developing innovative water moisture conservation practices, better crop establishment, crop geometry, efficient nutrient management/soil health and precision farming.

* IPM technology for mitigating menace of shoot flies in little, barnyard, kodo and proso millets and studies on taxonomy and biology of major insect pests of (stem borer, shoot flies etc) on specific host plants.

* Selective mechanization of key operations such as ploughing, inter cultivation and harvesting.

· Research on value addition to increase the utility of small millets in food, feed and other allied industries and development of suitable versatile milling machinery for small millets.

* Small millets are a rich source of nutra-ceuticals and other health beneficial components. Validation of these properties by generating relevant data in order to enhance their value as food and health promoting grains.

Future prospects

After years of neglect, small millets, which can suitably designated as climatic resilient crops or climate smart crops or nutri-cereals are now receiving more attention in agricultural Research and Development agenda in the country. Rich diversity of small millets crops has made them well suited for contingency crop planning and also to address the issues of climate change. The plasticity exhibited has made them flexible for apparent early as well as delayed planting, very low and high rainfall areas, various elevations and different soil regimes. These positive features have not been duly recognized and exploited in the country.The versatile small millets like foxtail millet, barnyard millet, proso millet and little millet would fit in any situations of climatic change and would save the farmers from a total crop failure. The farmers who had shifted from millets to other crops are keen to go back to millets in view of the stable harvests ensured, easy crop production, drought resistance, and ecofriendly production.

Small millet crops are viewed as important for health and wellness of people and can help in preventing many kinds of diseases related to modern life style including obesity, diabetes. Of late, plenty of elite food chains have begun selling millets and millets based products on their shelves as health food. Small millets can be further processed towards various foods such as flakes, quick food cereals, ready to eat snacks, supplementary foods, extrusion cooking, malt based products, weaning foods and more importantly health foods. The importance of regular food use of nutrient dense millet for achieving a holistic food and nutritional security is widely recognized.

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