SPECIAL ISSUE ON MILLETS

INTERNATIONAL YEAR OF MILLETS 2023

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INTENSIVE AGRICULTURE

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EDITORIAL

On the initiatives of Government of India, the United Nations General Assembly unanimously adopted the resolution and declared year 2023 as the 'International Year of Millets' (IYM). The International Year of Millets aims to raise awareness of the importance of millets as a sustainable and resilient crop for food security and nutrition.IYM provides an opportunity for governments, organizations, and individuals to come together and support the promotion and cultivation of millets. This includes research and development to improve millet varieties and production techniques, as well as education and awareness campaigns to highlight the nutritional and environmental benefits of millets.

Millets are group of small-seeded grasses, highly adaptable to various climates and can grow in dry and marginal lands. They have served as a traditional staple for hundreds of millions of people in Sub-Saharan Africa and Asia for thousands of years and are now cultivated across the world. Despite their importance, millets have often been overlooked in favor of other crops such as wheat and rice. However, as the global population continues to grow and the effects of climate change become more pronounced, it is increasingly important to promote and support crops that are resilient and can provide food security in the face of changing conditions.

In India, more than 170 lakh tones of millets are produced with an average yield of 1239 kg/ha. The productivity of millets has increased by adoption of High Yielding Varieties/ Hybrids by farmers. They are mainly cultivated in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Odisha, Madhya Pradesh, Rajasthan and Uttarakhand states.

In India, National Year of Millets was celebrated in 2018. The initiative of Government of India to promote millet cultivation through revamped National Food Security Mission Operational Guidelines (NFSM) has focused on 212 millet districts in 14 states to provide incentives to farmers for quality seed production/distribution, field-level demonstrations, trainings, primary processing clusters and research support. Further, the 'One District One Product' initiative, which identifies agro-climatically suited crops with niche demand, has identified 27 districts as focused millet districts.

The International Year of Millets is of paramount importance in recognizing the vital role that millets play in food security and sustainable agriculture. It could be an opportunity to promote millets as a healthy food option and addressing the problem of hidden hunger caused by micronutrient deficiencies. It is important to create a supportive ecosystem for farmers by providing them necessary resources and knowledge to grow millets and also to educate consumers about the nutritional benefits of millets. It is also important to support the livelihood of smallholder farmers and communities who rely on millets as a staple food crop. This support may include providing access to improved millet varieties, cultivation practices, markets and other resources that can help them to increase their yields as well as income.Overall, the International Year of Millets is a positive step towards promoting sustainable and nutritious food systems in India, and can have a long-term impact on the country's food and nutritional security as well as farmers' livelihoods.

Dr. Sanjay Kumar Joshi

Grain Amaranth: Nutrient Enriched Grain of Future

H.L. Raiger, D. Mishra, N.K. Jajoria, Parvati Deewan and Y.S. Dhaliwal

Grain amaranth, an edible pseudocereal is now a crop of interest because of its higher quality protein and micronutrient content. Grain amaranth possess C_4 pathway, which confers physiological advantage of high rate of photosynthesis. This crop can be grown even in challenging climatic conditions. Three major species which are considered for grain production include: *Amaranthus hypochondriacus, A. cruentus* and *A. caudatus.* In some of the Indian languages, it is known as *rajgira* (king of seeds) in Gujarati, *ramdana* (seed sent by god) in Bihar, Odisha and Uttar Pradesh, *Chuka* in Bengal, *Kalaghesa, chumera* and *ganhar* in central India and *Bathu* in Himachal Pradesh.

Grain Amaranth has exceptionally high nutritive values with high content of protein, lipids and minerals as well as balance composition of essential amino acids. The tiny seeds of grain amaranth can be well compared with maize and other true cereals in nutritional values and yield. It is an excellent source of iron and B-carotene thus, can help in circumventing iron and vitamin 'A' deficiency in human beings. Presence of higher amount of folic acid also helps in increasing the blood haemoglobin level.

In India, grain amaranth is primarily cultivated in hilly regions but in late 1990s, its cultivation gained momentum in Central and Western Plateau regions of India. It is estimated that the crop is grown in about 40-50 thousand hectares in India.

Grain amaranth was one of the major crops of All India Coordinated Project on under-utilized crops and now it is major crop in AICRN on Potential Crops since its initiation. More than 1000 germplasm accessions have been evaluated under multilocation testing i.e. nursery screening program of the project. Out of these accessions, 22 varieties have been developed and released so far for both hill and plain regions but all the varieties are through selections. Besides, research for standardizing agro-technologies for better agronomy and seed production, quality evaluation, products development has been carried out. As a result of adoption of high yielding varieties, seed production, improved techniques for agro-production, extension activities, seed distribution to the farmers and marketing linkages, the area and production of grain amaranth has significantly increased across the country in general and Gujarat in particular.

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Grain amaranth cultivation in Gujarat has gained momentum as compared to other parts of the country. In Gujarat, there has been remarkable increase in the area, production and productivity of Rajgira during last 10 years. The area under this crop is increasing, particularly in Banaskantha and Kheda districts where this crop replaces wheat and potato because of water scarcity. The cultivation area under this crop in Gujarat is about 12,000 hectare. It is either grown as a sole crop or taken as a border crop in the fields of Lucerne or cumin or taken as a mixed crop with mustard and vegetables in Banaskantha, Mehsana, Gandhinagar, Sabarkantha and Patan districts of North Gujarat and Kheda and Anand district of Middle Gujarat during *Rabi* Season.

Both local and export markets are flooded with exotic crops, making it difficult for introduction of indigenous crops. As a result, indigenous crops such as amaranth remains largely a crop of small producers and consumed largely in areas where these are produced. In Gujarat, Palanpur APMC market of Banaskantha district is one of the biggest markets for amaranths grain selling /purchasing, from where the grain is exported to other parts of the country. Most of the farmers sell their produce in the APMC markets, Palanpur. There are also a few middlemen who buy grains from the farmers and market it to the food companies outside the state.

It is unlikely that the area under grain amaranth would increase significantly owing to its limited use as a food crop. There is a potential price risk if this crop is put to larger area. Nevertheless, there are new avenues in the domestic consumption through Government Policy intervention in social schemes like ICDS, mid-day meal, Antyodaya programme, sale of amaranth fortified wheat floor at subsidized rates to BPL families, promotion of products through local agriculture and religious/tourism places etc. There is need to focus on improvement and promotion of grain amaranth using modern breeding and bio-technological tools and by using IT based tools for its products, their value chain at all levels such as producers, consumers and policy makers.

Distribution and Adaptation

Amaranths are widely distributed throughout the Old and New World. Sixty species of the genus *Amaranthus* are reported native to the New World and about 15 to the Old World and Australia. In Asia-Pacific region covering India, China, Manchuria, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand and Israel, these are cultivated as minor crops and sporadic in nature. In India, these are cultivated both in hills as well as plains covering states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Tripura, Jharkhand, Chhattisgarh, Maharashtra, Gujarat, Odisha, Karnataka, Kerala and Tamil Nadu.

The crop is mainly cultivated in mid and high hills of the Himalayan region as a pure as well as mixed crop. The crop is sporadically grown in other parts of the country including North Eastern region.

Nutritional Value

This crop has an exceptionally high nutritive value with high content of protein, lipids and minerals as well as balance composition of essential amino acids. The tiny seeds of grain amaranth can be compared favorably with maize and other true cereals for its nutritional values and yield. The grains are gluten free and act as a good food supplement among the patients suffering from celiac disease. Amaranth is thus an ideal crop

having better nutritional properties and endowed with C_4 metabolism suited to survive and thrive in an environment affected by climate change. The protein in amaranth seeds being of high quality, the responsible 'AMA-1' gene has been isolated from this crop and is being introduced in to other important food crops like rice and potato. In potato, the product with higher yield and protein content has been found to be safe. The product has cleared tests related to toxicity and other side effects. The leaves are also rich in protein and are extremely useful from human nutrition viewpoint.

Comparative food value of grain amaranth with other cereals

Crop	Protein (%)	Carbohydrates (%)	Lipids (%)	Minerals (%)
Amaranth	16.0	62.0	8.0	3.0
Wheat	12.0	69.0	1.7	2.7
Rice	6.7	78.0	0.3	0.3
Maize	11.0	66.0	3.5	1.1
Barley	11.0	69.0	1.3	1.9

Uses

- Amaranth has multiple uses. Its tender leaves are used as vegetable.
- The grains are used in various culinary preparations. Popped grains are used in the form of puddings or mixed with sugar syrup to make sweet balls (*laddoo*), with honey to make flat round breading and with milk and sugar to make porridge. The grains are also used for making candy. The grains can be used in the preparation of breads, biscuits, flakes, cake, pastry, crackers, ice-cream, and lysine rich baby foods. Its flour can be used for making

Amino acid composition of grain amaranth with other cereals (g/100 g protein)

Amino acids	Amaranth	Wheat	Rice	Maize	Barley
Lysine	5.0	2.8	3.8	2.9	3.0
Methionine	4.0	1.5	2.3	3.4	3.2
Cystein	4.0	2.2	1.4	3.4	3.7
Isoleucine	3.0	3.3	3.8	4.1	4.0
Leucine	4.7	6.7	3.2	13.0	7.5

Quality parameters (%) of released varieties of grain amaranth

S.No	Variety	Protein (%)	Oil (%)	Ca (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)	Cu (mg/100 g)	Mn (mg/100g)	K (mg/100g)	Lysine (g/100g Protein)	Starch (%)
1	Annapurna	12.20	7.53	279.29	6.90	4.36	-		568.00	5.40	62.10
2	GA-1	13.23	8.20	236.75	5.74	2.70	-	-	418.00	4.83	-
3	GA-2	13.70	7.31	299.74	11.07	12.14	0.25	1.13	428.00	4.50	62.40
4	Suvarna	12.57	7.61	302.84	13.05	4.25	0.23	1.05	412.00	5.23	58.90
5	PRA-1	13.10								4.80	-
6	PRA-2	15.00	6.94	278.26	6.16	4.00	-	-	574.00	4.90	60.20
7	PRA-3	13.60	6.36	287.02	6.79	4.61	-	-	643.00	5.60	60.20
8	Durga	14.10	7.38	305.50	8.04	4.65	-	-	566.00	4.80	55.80
9	BGA-2	13.57	7.54	300.98	12.23	4.08	0.28	1.08		4.87	-
10	GA-3	12.43									
11	VL Chua-44	11.80	6.30	308.00	10.40	5.20	-	-	-	-	-
12	RMA-4	12.38									
13	RMA-7	12.34	7.24	300.50	14.36	3.87	0.24	1.04	454.00	-	-
14	KBGA-1	12.10	7.20	322.00	10.60	4.80	-	-	-	-	-
15	KBGA-4	12.30	6.80	-	13.10	2.50	0.18	0.80	-	-	-
16	Chhattisgarh Rajgira-1	11.70	6.50		13.80	1.90	.25	.90			
17	Suvadra	11.40	7.10	-	14.60	2.40	0.12	1.10	-	-	-
18	GA-4	12.4	7.2	298	9.7	4.8	-	-	-	-	-
19	GA-5	11.85	7.71	-	14.40	1.80	0.22	1.10	-	-	-
20	GA-6	11.52	7.80	-	16.45	2.90	0.21	1.20	-	8.58	-
21	KBGA-15	12.30	8.71								
22	Phule kartiki	13.8			25.30					5.20	

Source: Annual Report 1984-2021, AICRN on Potential Crops

chappatis when mixed with maize and finger millet flour. Grains can also be fermented for making beer.

- Amaranth is reported to have several other agro-industrial uses as well. It has great potential for application in high quality plastics, cosmetics, pharmaceuticals and natural dyes. The grains are also used in preserving meat and apple fruits. Amaranth oil, containing 'squalene' a cosmetic ingredient and skin penetrate, is also used as a lubricant for computer discs.
- Black seeded cultivars are used as cattle feed. Plant

parts are also used as pig feed. High forage yields, high protein and low levels of oxalates and nitrates in amaranth offer a good scope for its utilization as a promising forage crop.

- The tribal people use its grains for the treatment of measles and snakebites as well as for foot and mouth diseases of animals. The stem and leaf extracts are used in the treatment of kidney stones. The topopherol fraction of amaranth oil contains important cholesterol lowering agents, some of which could be useful in treating cardiovascular diseases. The plant is also used in piles to purify blood. The leaves are used to relieve chest congestion.

Morphological Characteristics

Vegetative growth: *Amaranthus*, collectively known as amaranth or pigweed, is a cosmopolitan genus of herbs. Amaranths are fast growing, cereal like (pseudo-cereal) plants that produce high protein minerals and other beneficial amino acids. Amaranths belong to the family Amaranthaceae and are referred as pseudo-cereal to distinguish them from true cereals which belong to family Gramineae / Poaceae. Amaranth plants are annual, erect, fast growing semi-hard plants with broad leaves and have creamy, pinkish or reddish inflorescence that produce very small round seeds of varying colours and luster and are rich in proteins and minerals. The plants vary from branched to unbranched types. The plant height varies form 0.3 m to 4 m, depending on the species, growth habitat and environment. According to the utilization of cultivated amaranths for human consumption, species can be divided into grain and vegetable amaranth. There are about 75 species in genus '*Amaranthus'*. Two sections are recognized in this genus*:* Amaranthotypus Dumort (Out crossing species) and Blitopsis Dumort (Species with large extent of self –pollination). The grain species belong to section Amaranthotypus. Some of the species in this group are dioecious, but most of the species are monoecious having compound inflorescence. Most of the species have 2n = 32 or 34 except polyploid species *Amaranthus dubius* which has 2n = 64. About 20 species are found as wild or/ the useful species of grain amaranth.

Reproductive growth: Amaranth is predominantly an autogamous plant, but outcrossing rate varies 5-39 per cent which is sufficient to facilitate gene flow among populations. Amaranthus is monoecious crop i.e. in the same inflorescence tens of thousands of intricate flowers (> 1 mm diameter) with male and female flowers are present, where several female flowers are arranged circularly around a male flower. This complex floral morphology becomes a barrier for hand emasculation and artificial hybridization. Amaranths have various combination of anatomical characteristics such as C4 metabolism, well developed root system, stomatal conductance, and maintenance of leaf area resulting in increased efficiency of using CO_2 under a wide range of temperatures (from 25°C to 40°C),

Useful species of grain amaranth

S. No.	Type	Species
1.	Grain type	*Amaranthus hypochondriacus* (L.), *A. cruentus*, *A. caudantus*, *A. edulis*,
2.	Vegetable type	*A. dubius*, *A. bolitum*, *A. viridis*, *A. tricolor*
3.	Vegetable and fodder type (Dual purpose)	*A. hybridus*
4.	Wild type	*A. spinosus*

with higher light intensity and moisture stress environments which makes this plant adaptable under diverse geographic and environmental conditions. Using C4 carbon fixation pathway, plants tend to require less water than the C3 carbon-fixation pathway enabling the *Amaranthus* to sustain adaption or grow in rainfed areas. Uttarakhand is the state of India, where most of the crop cultivation depends on rain water. Therefore, grain amaranth has been referred as a crop of diverse agro-climatic conditions.

Varietal Development

About 20 species are found as wild and/or cultivated throughout India. A total of 5734 germplasm accessions of Amaranth are present in National Gene Bank (NGB) for long-term conservation. In addition, 57 accessions are cryopreserved at Tissue Culture and Cryopreservation Unit (TCCU), New Delhi. Among them, 40 different species are *Amaranthus acutilobus* (3), *A albus* (4), *A amora* (6), *A australis* (2), *A blitoides* (2), *A blitum* (29), *A cannabinus* (5), *A caudatum* (10), *A caudatus* (207), *A caudatus var. albiflorus* (1), *A caudatus var. atropurpurea* (1), *A cordatus* (3), *A crispus* (1), *A cruentus* (157), *A deflexus* (2), *A dubius* (66), *A edulis* (1), *A. fimbriatus* (2), *A. flavus* (1), *A. floridanus* (2), A. gangeticus (Vegetable type) (26), *A. graecizans* (30), *A. hybridus* (86), *A. hypocondriacus* (3141), *A. leucocorpus* (2), *A. lividus* (2), *A. mangostanus* (7), *A. oleraceus* (23), *A. palmeri* (3), *A. paniculatus* (17), *A. polygonoides* (4), *A. powellii* (3), *A. pumilus* (5), *A. retroflexus* (9), *A. rudis* (1), *Amaranthus. sp. (1351). A. spinosus* (34), *A. tricolor* (Vegetable type) (422), *A. tristis* (7), *A. viridis* (Vegetable type) (56). Among them, 504 accessions are vegetable type amaranths. These genetic materials are available to amaranth breeders for utilization in their breeding programs.

Cultivation Practices

Selection of site: Well drained soils with near neutral pH (6.00-8.00) are best suited for cultivation of grain amaranth. Amaranth being susceptible to acidic

S. No.	Varieties	Year	Av. yield (q/ha)	Characteristics	Recommended areas	Developed by
1	Annapurna	1984	22.50	High yield potential, high protein (15%) drought tolerant and wider adaptability	Mid and high Himalayan region of India	ICAR-NBPGR RS Shimla
2	GA-1	1991	19.50	High seed yield and drought resistant	Gujarat, Maharashtra	SDAU, S.K. Nagar
3	Suvarna	1992	16.00	Drought tolerant, high yield	Peninsular region (Karnataka, Orissa) Gujarat	UAS, Bangalore
4	PRA-1	1997	14.50	High grain yield	Uttarakhand hills	UUHF, Ranichauri
5	PRA-2	2001	14.50	High grain yield	North- West Himalayan region except J&K	UUHF, Ranichauri
6	GA-2	2002	15.50	High grain yield	Gujarat state	SDAU, S.K. Nagar
7	PRA-3	2003	16.50	High grain yield	North- West Himalayan region except J&K	UUHF, Ranichauri
8	BGA-2	2006	13.26	High grain yield and Early maturing	Karnataka, Orissa and Tamil Nadu	OUAT, Bhubaneswar
9	Durga	2006	21.00	High grain yield and Early maturing	North west hill zone comprising states of Himachal Pradesh Uttarakhand and J &K	ICAR-NBPGR RS Shimla
10	VL Chua 44	2006	13.20	Early maturing and has non spiny bract for easy threshability	Mid and higher hills of Uttarakhand	VPKAS, Almora
11	GA-3	2008	12.58	High grain yield	States of Gujarat and Jharkhand	SDAU, S.K. Nagar
12	RMA- 4	2008	13.90	High grain yield	States of Rajasthan, Jharkhand and Orissa	AU, Mandor
13	RMA-7	2010	14.66	High grain yield	Rajasthan, Gujarat, Orissa, Maharashtra, Haryana, Delhi states	AU, Mandor
14	KBGA-1	2012	15.00	Early maturity	Karnataka	UAS, Bangaluru
15	Phule kartiki	2012	15.00	Medium maturity, high grain yield	Maharashtra	MPKV, Rahuri
16	Prachi	2015	11.60	High yielding medium maturity	Odisha state	OUAT, Bhubaneswar
17	Ruchi	2015	11.90	High yielding medium maturity	Odisha state	OUAT, Bhubaneswar
18	Chhattisgarh Rajgira-1	2017	14.00	Medium maturity, high grain yield	Chhattisgarh	IGKV, Ambikapur
19	KBGA-4	2017	21.00	Medium maturity, high grain yield	Karnataka	UAS, Bangaluru
20	Suvadra	2018	17.50	Medium maturity, high grain yield	Odisha, Chhattisgarh, Jharkhand, Maharashtra and Gujarat	NDAUT, Bhubaneswar
21	GA-4	2020	16.45	High yielding	Karnataka State	SDAU, S.K. Nagar
22	GA-5	2020	19.02	High yielding	Gujarat, Rajasthan, Maharashtra and Jharkhand State	SDAU, S.K. Nagar
23	GA-6	2020	18.50	High yielding medium maturity	Gujarat State	SDAU, S.K. Nagar
24	VL Chua-110	2020	13.00	High yielding medium maturity	Uttarakhand Hills	VPKAS, Almora
25	KBAG-15	2021	2.00	High yielding medium maturity	Karnataka	UAS, Bangaluru

and alkaline conditions, the soils and waters affected by salts should not be used for its cultivation.

Field preparation: Grain amaranth being a small seeded crop requires a fine seed bed for proper seed-soil contact and good germination. For this purpose, soil is turned with a mould board plough prior to onset of rains. This is followed by two to three ploughings and plankings on receipt of soaking rains. At the time of sowing, the field must have fine grain structure, adequate moisture and should be free from weeds.

Sowing time: In hills, the crop is generally sown in the months of May-June soon after onset of monsoon. However, in plains it can be sown either in Rabi or Kharif season. But, generally it is cultivated in Rabi season and is sown in months of October – November.

Crop spacing: Sowing the seeds 2 cm deep in rows with spacing of 45 cm and 10-15 cm distance between plants have been observed to give good yields. Thinning / gap filling should be done after two weeks of germination to maintain proper plant to plant distance.

Seed rate: A seed rate of 1.5 kg/ha is enough for obtaining desired plant stand. If the rains are delayed in Kharif and irrigation is not available in time during Rabi season, dry sowing can also be done. The seeds will germinate after downpour or as and when irrigation is given.

Fertilizer requirement: The crop gives a good response to fertilizer application of 60:40:20 kg N:P:K /ha. Half of N with full dose of P and K should be given as basal application. Remaining half dose of N can be given after 30 days of sowing. In light soils of Gujarat, additional application of FYM @ 5 tons / ha is recommended. In boron deficient soils of Odisha, soil application of boron @ 1 kg/ha or foliar spray of 0.33% boron increases grain yield by 8-10 %. Substitution of 25 % N by FYM or Neem Cake results in higher grain yield as compared to application of chemical fertilizer alone.

Weed Control: Weeds compete with the crop for space, light, nutrients and moisture and can cause considerable loss if not controlled in time. The period between 20 to 50 days after sowing (DAS) has been observed to be critical for crop-weed competition in grain amaranth. Therefore, two hand weedings at 25 and 40 DAS or pre-emergent application of Oxyflurofen @ 50 g/ha with one hand weeding at five weeks after sowing are recommended for effective weed control.

Irrigation: Grain amaranth is mostly grown as rainfed crop in the hills during Kharif season. However, in plains, when grown during rabi season, it has been found to respond favourably to application of irrigations. Optimal irrigation schedule for grain amaranth has been worked out to be 0.6 Irrigation Water (IW)/ Cumulative Pan Evaporation (CPE) in northern plains and 0.8 IW/CPE in Gujarat. Depending upon these conditions about 3-4 irrigations are sufficient for getting good yield in amaranth.

Suitable intercrop systems: Amaranth is usually grown in crop mixtures. Intercropping amaranth with French bean, rice bean, ragi, groundnut and pigeonpea have been found profitable. Simply mixing seeds of different crops and broadcasting may not give desired results. However, to obtain maximum advantage from the mixed crop and to facilitate separate harvesting of component crops, the crops should be sown in different lines and in appropriate row ratios. In hills, intercropping French bean and amaranth in 2:1 ratio and applying fertilizer doze recommended for French bean only (N:P:K @ 20 : 40:20 kg/ha) resulted in highest B:C ratio (2.57).

Plant protection: There is no report of serious problem for pests and diseases in this crop. However, leaf head blight, white rust, damping off, mycoplasma and viral diseases may affect this crop. Among insect pests, leaf webber, caterpillars, aphids, blister beetle, flea beetle, bugs, stem weevil and stem borer have been reported to affect this crop. Use of certified seeds, disease resistant varieties and, spraying of insecticides and fungicides are recommended for management of insect pests and diseases.

Diseases of Amaranth:

Damping-off: *Pythium ophanidermatum, Rhizoctonia solani* and *Aphanomyces* sp: Seeds may rot in soil before emergence or stem canker in seedling/root necrosis results in wilting. Deep seeding/too

Prominent intercropping system in Gujarat (Grain amaranth+ gram 1:1)

thick planting/over-watering of the plants should be avoided.

Wet Rot/blight: *Choanephora cucurbitarium:* Fungus has hairy appearance (Silk-like threads) consisting fungal spores on plants with mechanical or insect damage. It is spread by air and infects seeds especially in warm and moist conditions. Spraying of copper based fungicides is useful for controlling the disease.

Anthracnose: *Colletotrichum gloeosporioides*: Symptoms are necrotic leaf lesions resulting in dieback of leaves and branches. Avoid damage to plant parts creating wounds for pathogen to enter.

Leaf spot *(Alternaria* sp.*)* and **leaf rust** *(Albugo sp.)*: Small concentric rings on lower shaded leaves which are small, round, yellow, brown or black which become larger up to 3" diameter. Infected leaf may die and the whole plant may be defoliated. Flowers drop off and cankers appear on older stems. In severe infection use *Trichoderma viride* 1% WP @ 2.5 kg/ha for soil as well as foliar treatment. Spray of Propiconazole 25% EC @ 125 g a.i./ha is effective and economical in leaf spot and leaf rust.

Suitable Intercrop Systems and Appropriate Row Ratios for Mixed Cropping of Grain Amaranth

S. No.	Intercrop system	Appropriate row ratio	Region for which recommended
1.	French bean + amaranth	2:1	Hill regions
2.	Rice bean + amaranth	2:1	Hill regions
3.	Ragi + amaranth	6:2	Karnataka
4.	Groundnut + amaranth	6:1	Karnataka
5.	Pigeonpea (90 cm row to row distance) + amaranth	1:2	Karnataka, Odisha
6.	Pigeonpea (75 cm row to row distance) + amaranth	1:1	Odisha
7.	Grain amaranth + Gram	1:1	Gujarat

Insect Pests of Amaranth:

Amaranth stem weevils: *Hypolixus truncatulus, H. nubilosus* (Curculionidae: Coleoptera): The larvae tunnel the stems and adult feeds on tender leaves. Plants wither and lodge due to hollowing of stem. Extensive tissue coloration, decay and cankers in branches, stem and root collars is observed. Percentage infestation varies from 35% to 81% in different regions in India. Uproot and destroy damaged plants to reduce number of weevils. Spray azadirachtin 0.03% (300 ppm) @ 1000-2000 ml in 200-400 litre of water/acre. Azadirachtin 5% W/W neem extract concentrate @ 80 ml in 160 litre of water/acre.

Plant Bugs: *Cletus* sp. (Coreidae: Hemiptera): Damage to flowering head and seeds at seed fill stage. It causes seed discolouration, shriveling and pre-mature dying of seeds. Use of insecticide *i.e. imidacloprid* 17.8% SL @ 20g a.i./ha. Neem seed kernel extract (NSKE) 5% @ 5ml/litre of water was found effective and economical.

Defoliator insect-pests: *Spodoptera litura* and *Hymenia recurvalis, Psara basalis, Atractomorpha crenulata, Pyrgomorpha conica* (Pyrgomorphidae: Orthoptera): The larvae of these defoliator insect pests, leaf eating caterpillar, leaf webber feed gregariously on the leaves while in case of grasshoppers the nymph and adult both defoliate the plants. Follow clean cultivation and destroy the grassy weeds and affected plant parts. Spray insecticides *i.e.* Spinosad 45% SC @ 75 g a.i./ha. Profenophos 50% EC @ 750 g a.i./ha. Emamectin benzoate 5% SG @ 11g a.i./ha.

Aphids: *Myzus persicae* and others (Aphididae: Hemiptera): The insects suck the plant sap and heavily infested plants have wrinkled leaves, stunted growth and deformed seeds. Young plants may dry out and die while older plants cause crop loss and reduce seed viability.

Conserve natural enemies for natural control of aphids. Use of insecticides i.e. imidacloprid 17.8% SL 20g a.i/ha and neem seed kernel extract (NSKE) 5% @ 5 ml/litre of water is effective and economical.

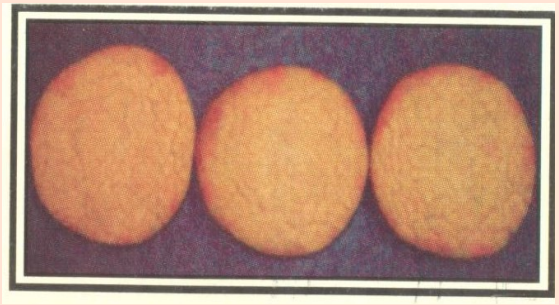
Cutworms: *Agrotis* sp. (Noctuidae: Lepidoptera): At night, cutworm caterpillar emerges from the soil and cut through the stem of young plants just above ground levels as well as underground. Plants wilt and die. Remove weeds 10-14 days ahead of planting the crop. Spraying of Spinosad 45% SC @ 75 g a.i./ha, Profenophos 50% EC @ 750 g a.i./ha, Emamectin benzoate 5% SG @ 11 g a.i./ha is effective and economical.

Yield: The average productivity of grain amaranth is estimated around 16 q/ha. The grain amaranth yield upto 40 q/ha have been obtained in hill regions and 25 q/ha in plain regions. There is an ample scope for increasing the yield of grain amaranth in India through efficient agronomic management of the crop.

Amaranth Based Value Added Products

1. Biscuits

Ingredients: Refined wheat flour: 720 g; Amaranth flour: 180 g; Sugar :520 g; Shortening: 256 g; Sodium bicarbonate : 10 g; Salt : 8.4 g. ; Glucose solution (8.9 g of glucose dissolved in 150 ml water: 132.0 ml



Method of preparation: Sieve the composite flour, baking powder, salt and ground sugar. Cream the shortening and mix the above ingredients in it. Add glucose solution and make pliable dough with water. Roll the dough to ¼ inch thickness. Cut into desired shape and place the biscuit 2.5 cm apart on a non-greased tray. Bake in a preheated oven at 200^{0}C for 15 to 20 minutes.

2. Salty Bites

Ingredients: Refined wheat flour : 650 g; Amaranth flour : 350 g; Sugar : 500 g; Shortening : 550 g; Baking powder : 3 g; Salt : 4 g

Method of preparation: Pop amaranth grains seeds in cauldron at a temperature of 210^{0}C. Upon cooling, grind the popped seeds to power. Sieve the refined wheat flour, popped amaranth flour and baking powder. Cream the fat and mix the above ingredients in it. Dissolve sugar and salt in water, add to the mixture and knead to pliable dough. Roll the dough to ¼ inch thickness. Cut into desired shape and place the biscuit 2.5 cm apart on a non-greased tray. Bake in a preheated oven at 200^{0}C for 15 to 20 minutes.

3. Amaranth Coconut Ladoos

Ingredients: Amaranth powder : 1000 g; Sugar : 1750 g; Desi ghee : 250 g; Coconut powder : 750 g

Method of preparation: For preparation of amaranth flour, pop the amaranth seeds in cauldron at a temperature of 210^{0}C. Grind the popped seeds upon

cooling. Heat clarified butter in a cauldron and add amaranth powder and coconut powder in it. Stir for half minute on low heat and keep it aside. Prepare syrup of one thread consistency by dissolving sugar in equal amounts of water. Add the mixture of amaranth powder, coconut powder and ghee in it and mix thoroughly. Shape in to round balls with hand using water if necessary. Store in air tight containers on cooling.

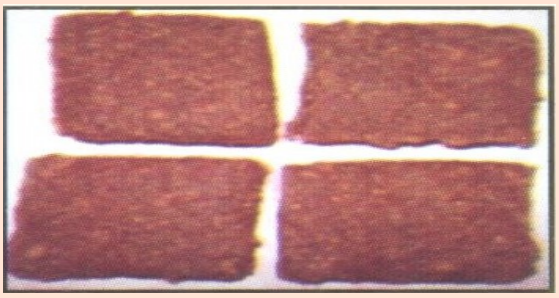
4. Ladoos

Ingredients: Popped amaranth: 1000 g; Jaggery: 1000 g; Water: 600 ml

Method of preparation: Dissolve jaggery in hot water to prepare syrup of two thread consistency. Mix popped amaranth seeds thoroughly with jaggery syrup. Prepare small (10 g) sweet balls of this mixture when hot. Shape the balls into round by hand and store in air tight containers.

5. Amaranth Burfi

Ingredients: Amaranth powder : 1000 g; Sugar : 500 g; Ghee : 150 g; Glucose solution : 100 ml.



Method of preparation: Cook sugar and water together till the syrup reaches 118^{0}C temperature and a syrup of multi string consistency is achieved. Add liquid glucose and ghee and stir well. Remove from heat and add amaranth powder stirring continuously. If necessary add one table spoon of water and keep stirring till the temperature comes down to 65^{0}C. Knead lightly to make soft dough. Roll out on a flat greased surface to one centimeter thickness. Rub a butter paper over the surface to smoothen it evenly. Cut in square shape.

6. Rewari

Ingredients: Popped amaranth : 400 g; Jaggery : 1600 g; Water : 400 ml

Method of preparation: Prepare syrup by dissolving jaggery in a cauldron by dissolving water in it. Boil the syrup till it reaches hard ball stage. Drop the resultant mixture over popped amaranth with the help of a spoon. For each rewari one teaspoon of syrup is required. The popped amaranth seeds stick with the syrup and result in round shaped rewari. Spread the rewaries over a clean tray, cool and store in air tight container.

7. Gajak

Ingredients: Popped amaranth : 800 g; Jaggery

: 1200 g; Water : 400 ml

Method of preparation: Prepare thick syrup by dissolving jaggery in hot water. Add popped amaranth seeds to this syrup and mix thoroughly. Pour the mixture on to a greased tray. Spread the mixture evenly by rolling pin to obtain a gajak of uniform thickness.

8. Panjeeri

Ingredients: Amaranth flour : 800 g; Jaggery power : 600 g; Popped lotus seeds : 200 g; Coconut (grated): 250 g; Almonds (crushed): 250 g; Raisins (cut): 200 g; Cashew nut (crushed): 200 g; Edible gum: 25 g; Desi ghee: 850 g.

Method of preparation: Pop amaranth seeds and grind in mixer grinder to make flour of it. Heat small amount of ghee in a cauldron and fry popped lotus seeds and edible gum in it. Crush fried popped lotus seeds and edible gum and keep aside. Add crushed/cut/grated dry fruits and crushed popped lotus seeds and edible gum in amaranths flour. Add jaggery power and mix thoroughly. Put rest of ghee in this mixture and mix well. Store in air tight container.

9. Instant Energy Mix

Ingredients: Amaranth flour : 500 g; Almond powder : 500 g; Desi ghee: 1000 g; Mishri powder : 1750 g

Method of preparation: Pop amaranth grains and grind in mixer grinder to flour. Grind almonds and mishri to form powder. Mix amaranth flour, almond powder, mishri powder and ghee thoroughly. Keep in air tight container. Mix two to three tea spoons of the mixture in hot milk before serving.

Amaranth is considered as a staple Indian diet and is described as a "superfood" because of its high protein content and well-balanced amino acid profile. In terms of nutrient content, amaranth surpasses many staple crops (cereals) such as rice, corn, and wheat. Additionally, lysine content is twice as much than in rice and thrice as much than in corn. Along with desirable agronomic traits, this crop has been largely applauded for its gluten-free nature. Not only it benefits the vegan and gluten allergy human beings, but it also has the potential to supply high-quality proteins and at the same time provides antimicrobial activities in the packaged food items. Despite all these properties, this crop is still not in the mainstream cultivation practices in India and the world. As the planet is expecting massive increase in human population and global climate change, we firmly believe that this widely distributed, ancient, protein-rich pseudo-cereal has a potential to augment our food system and demand in future. By adopting improved varieties and agro-techniques as described above, the yield of grain amaranth in both hills and plains can be substantially increased. It will not only ameliorate economic condition of the farmers dwelling in the hills and plains, but will also enhance the availability of nutritious food to check malnutrition in human beings.

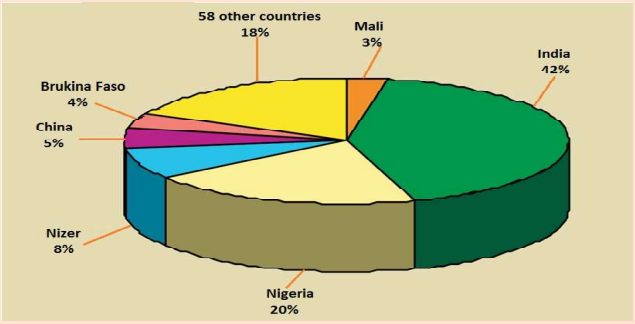
Quality Seed Production in Pearl Millet Hybrids

Dr. K. K. Dhedhi, Dr. M. M. Talpada and Dr. K. D. Mungra

Year 2023 is being celebrated as International Year of Millets and National Agricultural Research System under the aegis of Indian Council of Agricultural Research has been entrusted with the theme of Enhancing Production and Productivity of millets which include varietal development, quality seed production, seed availability, area expansion, creating awareness and development of value chain for creating demand of millets.

The Food and Agriculture Organization (FAO) of the United Nations organized an opening ceremony for the International Year of Millets – 2023 (IYM-2023) in Rome, Italy. Millets are good for the consumer, cultivator and climate. Millets are nutritious and can be cultivated in semi-arid zones besides consuming less water for irrigation. There is need for diversity on our land and our dining tables. Raising awareness to create 'Millet Mindfulness' is an important part of this movement. There is an opportunity to contribute IYM2023 celebrations worldwide and organize campaigns to promote the cultivation and consumption of Millets, both in India and abroad during the year, 2023. Millets are considered 'Smart Food' as they are easy to cultivate, mostly organic and contain high nutritional value. Millets are basically Asian crops, climate resilient, lead to sustainable development and help ensure Food Security & Nutrition for all.

Millets are one of the oldest foods which thrive well in dry zones or rain-fed areas and can be nurtured in low-fertile land and mountainous regions. The easy storage of millets under normal conditions has given them the status of Famine Reserves. Millet has gained popularity in the West because it's gluten-free, high in protein, fiber, and antioxidant contents. Millet is a cereal grain that belongs to the Poaceae family and is widely consumed in developing countries like Africa and Asia. India is the largest producer of different varieties of millets. Important millets cultivated in



Global Pattern of pearl millet Consumption

Nutritional Constituents in pearl millet grains

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India are; Bajra (pearl millet), Jowar (sorghum) & ragi (finger millet). Other varieties include, Jhangora (barnyard millet), Barri (proso or common millet), Kangni (foxtail millet), Kodra (kodo millet) etc.

India is the largest pearl millet growing country contributing 42 per cent of production in the world. The chief pearl millet growing States are Rajasthan, Maharashtra, Gujarat, U.P. and Haryana, which account nearly 90 per cent of total of around 10 million hectare cultivable pearl millet area in India. Gujarat State is well ahead in seed production and a leading hybrid pearl millet seed production State. It is not only providing seed requirement of its own, but supplying hybrid pearl millet certified seed to other States also. The Gujarat State Seed Corporation, private organizations, GULCOMASOL and National Seed Corporation are mainly involved in pearl millet hybrid seed production.

Pearl millet hybrid seed is produced to exploit potentiality of hybrid vigour and is developed by using cytoplasmic genetic male sterility. Cytoplasmic genetic male sterility (CMS) was first reported by Menon (1957) in Balley district of Mysore. Burtan (1958) led to the development of hybrids in this crop. Tift 23A

Sr. No	Hybrid	Pedigree	Year of release	Recommended Season	Recommended area for sowing	Maturity duration and salient features
1	GHB 732	ICMA 96222 X J-2340	2007	*Kharif*	Gujarat, Rajasthan, Haryana, Punjab, M. P., U. P. & New Delhi	80-85 days, medium tall, good tillering, medium broad leaves, medium long thick compact ear heads, globular grains with attractive color.
			2011	Summer in Gujarat		
2	GHB 905	ICMA 04999 X J-2454	2012	*Kharif*	For Zone 'A' of the country	70-75 days, medium tall, good tillering, medium broad leaves, medium long, medium thick semi-compact, cylindrical ear heads, globular grains with attractive color.
3	GHB 1129 (Jam Shakti) Biofortified Medium type	ICMA 99222 x J-2565	2019	both for *Kharif* and Summer	Gujarat	Medium maturing, medium size, globular, grey brown coloured grain, Compact cylindrical head resistant to downy mildew and blast diseases. Fe >70 ppm and Zn> 40 ppm
4	GHB 1225 (Moti Shakti) Biofortified Medium type	ICMA 98222 x J-2591	2019	*Kharif*	Gujarat	Late maturing, compact thick panicle, deep gray hexagonal shaped medium grain and resistant to downy mildew and blast diseases. Fe >70 ppm and Zn> 40 ppm
5	GHB 1231 (Sawaj Shakti) Biofortified Medium type	ICMA 11222 x J-2597	2020	*Kharif*	Gujarat	Late maturing, conical shape thick panicle, yellow coloured globular shaped medium grain and resistant to downy mildew and blast diseases. Fe >70 ppm and Zn> 40 ppm
			2021	Summer and semi rabi	Gujarat	
6	GHB 538 (EDV-DM) (Maru sona) Early type	ICMA 95444 × J-2340 Improved	2021	*Kharif*	Gujarat	Early maturing, high level of resistant to downy mildew, cylindrical, medium thick and compact earhead, light brown anther colour, moderately resistant against shoot fly and stem borer

supplied by Dr. Burtan in 1961 resulted in development of pearl millet hybrid in India.

In Gujarat, the following pearl millet hybrids are recommended for general cultivation that have been recently released at Gujarat State as well as National level by Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat).

The certified seed is produced under the guidance of State seed certification agency. Pearl millet hybrid seed production is taken up according to the prescribed standards of production and processing in terms of isolation distance, genetic purity and seed quality. Seed certification and seed law enforcement agencies have an important role to play in certified hybrid seed production and distribution, because the crop performance is dependent on the quality of the certified seed used.

In hybrid seed production, the first stage *i. e.,* production and maintenance of parental lines are referred to as foundation seed production and the production of hybrid seed is referred to as certified seed production. The various steps involved in hybrid seed production are discussed below:

Maintainer Line (B-line): Line B is male fertile but non-fertility restoring. Genetic purity of B-line is very important in order to maintain male sterility and to produce high quality CMS line. Production of B line should be taken up separately in isolation of more than 1000 meter.

Cytoplasmic male sterile (CMS) line (A-line): The male sterile line (A-line) carries male sterility due to cytoplasmic genetic factors. It is maintained by crossing with male fertile, non-pollen restoring strain (B line), which is a sister strain of line A in an isolation of 1000 meter. Line B is essentially similar to line A in all respects, except that line B is pollen fertile, where line A is pollen sterile.

Restorer Line (R-line) : The restorer line is male fertile which has fertility restorer R, dominant gene. This gene restores male fertility in the male sterile line, hence it is known as restorer gene. The seed of restorer line (R-line) is produced in an isolation field, just like open pollinated varieties, keeping minimum isolation distance of 1000 meter.

Crop Management and Cultural Practices:

1. **Land Requirement and its Preparation:** Pearl millet crop requires light and medium black, sandy or sandy loam soil for cultivation. The seeds of pearl millet are being smaller in size; require fine seed bed preparation for good germination. For this purpose, one to two deep ploughing and two to three harrowing is sufficient to prepare the field to the desired tilth. Land to be used for seed production should be free of volunteer plants. Well drained, uniformly leveled field is the best in which pearl millet crop was not grown in the previous season.
2. **Climatic Requirement:** Pearl millet is a short day C_4 plant. It is well adapted to a wide range of Agro-climatic Zones and a temperature range of 20-30 °C is optimum.
3. **Registration**: The registration of pearl millet hybrid seed production plot should be done for *kharif* season up to 15th July and for summer season up to 15th February at office of the State Seed Certification Agency.
4. **Source of Seed:** Breeder/foundation seed of approved variety is necessary for raising a seed crop. The seed should be of known purity, appropriate class and be obtained from the sources approved by authorized official agency. The breeder seed should be obtained from authorized institute or agency. Whereas, the foundation seed should be obtained either from State Seed Corporation, State Universities, National Seed Corporation, GUJCOMASOL or other registered private company.
5. **Isolation Distance**: Pearl millet is a cross pollinated crop due to protogynous nature. Hence, maintenance of proper isolation distance is one of the important basic requirements for hybrid seed production. Seed field should be isolated from the contaminants at distance of 1000 m and 200 m for foundation and certified seed plot, respectively.
6. **Sowing Time:** Pearl millet hybrid seed production programme is taken in all three season *viz*., *kharif*, semi-rabi and summer. The season wise proper time of sowing is as under:

Kharif : 15th June to 15th July (on the onset of monsoon)
Semi-Rabi : 15th September to 15th October
Summer : February to 15th March (Immediate after reduction in cold temperature)

Summer is the best season for obtaining good quality of hybrid seeds as the problem of insect/pests and diseases is minimum during summer season. The best time of sowing is first fortnight of February in summer season when temperature is not too low. Hybrid seed production in monsoon is not advisable because there are chances for occurrence of diseases which affect the quality of seeds.

7. **Seed Rate:** Female (Male sterile line) : 3 kg/ha
   Male (Restorer line) : 1 kg/ha
8. **Planting Distance**: Planting should be done by providing wider distance of 60 cm between two

Pearl Millet Hybrid Seed Production Plot

rows and 10 to 15 cm between two plants within rows. Distance within row should be maintained by thinning at 15 to 20 days after sowing.

9. **Method of Sowing**: Pearl millet, being a cross-fertilized crop, produces hybrid seed by crossing male sterile line (Line-A) with a specific restorer line (Line-R) in an isolated plot. The hybrid seed is produced by growing six rows of male sterile line (Line-A) alternated by two rows of restorer line (Line-R) *i. e.* 6 : 2 (female : male) ratio. For providing the abundant pollen to the border lines of female, 2 to 3 restorer lines should be sown surrounding the seed plot. The sowing of seeds should be done either by hand sowing (dibbling) or drilling and care should be taken that seed should not be sown more than 5 cm deep in furrow for better germination. Seeds of parent mixed with similar pearl millet grain size of sand at equal rate of seed at the time of sowing are advisable in order to get better distribution of seed.
10. **Synchronization of Flowering:** It is a very important to get synchronization of flowering of parental lines in order to obtain satisfactory and higher hybrid seed yield. Therefore, prior knowledge on flowering patterns of both the parents in hybrid seed production is necessary. The parental lines of some recommended pearl millet hybrids are not synchronized in flowering and flowering behavior of parental lines also vary from region to region, season to season and mainly based on temperature and day length. Several methods are employed to ensure synchrony. The commonly followed technique is staggered sowing *i. e.*, adjusting the planting dates of the parents so that they flower simultaneously. If the difference in flowering between the two parents is only 2-3 days, it is possible to manipulate it through, foliar spray of Urea (2 %) or DAP (2 %) to the late parent at boot stage of crop, and is repeated 2-3 times at 4-5 days interval. If parents differ in their days to 50 % flowering by more than 3 days, staggered sowing is recommended.

    It is recommended that the male parent (J-2340) should be sown 5 to 6 days earlier than female parent (ICMA-95444) in the seed production plot of GHB-538. The male and female parents of GHB-732, GHB-905, GHB-1129, GHB-1225 and GHB-1231 should be sown simultaneously, in the seed plot.
10. **Manure & Fertilizers**: In pearl millet seed production plot, farm yard or compost manure @25-30 carts/ha should be given in order to improve soil structure and crop productivity. The recommended dose of fertilizer for Gujarat State is 120 kg Nitrogen and 60 kg Phosphorus per hectare. Half dose of Nitrogen and full dose of Phosphorus (300 kg Narmdaphos or 130 kg DAP & 80 kg Urea) is to be applied in furrow before sowing as basal dose and the remaining dose *i.e.*, 40 kg Nitrogen (87 kg Urea or 160 kg Narmdacane) should be applied after three weeks of sowing and 20 kg Nitrogen (43 kg Urea or 80 kg Narmdacane) at boot stage

of the crop. Top dressing fertilizer should be given when sufficient moisture is available in the soil.

11. Irrigation: Pearl millet hybrid seed production programme should be taken under assured source of irrigation during summer season. Tillering, flowering, grain filling and grain development are the most critical stages of pearl millet crop. Moisture stress at any of these stages will result in significant reduction in seed size, yield and quality. So the crop should be irrigated as and when needed. Generally, summer pearl millet crop requires 8 to 10 irrigations at the interval of 8 to 10 days. The actual interval and frequency of irrigation would depend upon variety, soil type, seasonal conditions and rainfall.

12. Weeding & Intercultural Operations: The seed production plots should be kept free from weeds during the first 40-50 days of crop growth. For this, one to two hands weeding and two to three interculturing should be done with blade harrow from 10 days of crop to dough stage for improving physical condition of soil as well as control of weeds in seed production plot. In situation of labour shortage, chemical weed control through pre emergence Atrazine application @ 0.5 kg a.i./ha is recommended.

13. Roguing: The timely rouging is very important to obtain 100 per cent hybrid seed of the required quality and purity. It is essential to know the diagnostic characters of the different male and female parents to make accurate roguing. The following types of plants may be removed from seed production plot before flowering.

a) Volunteer plants with the seed plot in the production plot.
b) Off types from seed parent and male rows.
c) Greater in height and highly vigour than normal plants.
d) Female plants from male rows and male plants from female rows.
e) Pollen shedder plants from seed parent rows.
f) Volunteer pearl millet plant in the field falling within the isolation distance.
g) Downy mildew (DM), Ergot and grain smut disease affected plants.

14. Field Inspection: The State Seed Certification Agency (SSCA) is responsible for the seed certification in each State. The field meant for seed production is inspected by the staffs of SSCA. Minimum of four inspections should be done in pearl millet seed production plot at different crop growth stages as follows:

The first inspection should be done before flowering preferably with in 30 days after sowing in order to check isolation distance, volunteer plants, planting ratio, errors in planting, incidence of downey

Minimum field standards laid down for certification

S.N.	Factors	Foundation	Certified
(A)	**Field Standards**		
1	Isolation (minimum) in meter	1000	200
2 (a)	Off type (earheads) in seed parent (Max.) (At any one inspection at and after flowering)	0.05 %	0.10 %
2(b)	Off type (earheads) in pollinator (Max.) (At any one inspection at and after flowering)	0.05 %	0.10 %
3	Pollen shedder heads in seed parent (Max.) (At any one inspection at and after flowering)	0.05 %	0.10 %
4 (a)	* Plants infected by Downey Mildew (*Sclerospora graminicola* (Sacc.) in seed parent (Max.) at any one inspection.	0.05 %	0.10 %
4(b)	@Plants infected by Downey Mildew (*Sclerospora graminicola* (Sacc.) Schroet) in pollinator (Max.) at any one inspection.	0.05 %	0.10 %
5	**Ergoted earheads (*Claviceps microcephala* (Fr.) Tul) in seed parent (Max.) at final inspection.	0.02 %	0.04 %
6	@@Earheads infected by grain smut in seed parent (Max.) at final inspection	0.05 %	0.10 %

**, @ Complete stool should be considered as one infected unit.*
*** Seed from such fields that have been reported to have the ergot infection even within the prescribed limits at field stage shall be subjected to floatation treatment with brine to become eligible for certification.*
@@ Seed fields with incidence of grain smut more than the maximum permissible limit can, however, be certified if such seed is treated with an approved organo-mercurial fungicides not earlier than a month prior to its sowing.

mildew and other relevant factors. The second and third inspection should be made during flowering in order to verify isolation, off-type plants, pollen shedder, incidence of downey mildew and other relevant factors. The fourth inspection should be made at maturity and prior to harvesting, in order to determine the incidence of downy mildew, ergot, grain smut and to verify the true nature of plants and other relevant factors.

15. Harvesting and Threshing: The crop is ready for harvesting when the grains show blackening of the hilar region which is morphological criterion of physiological maturity. This physiological maturity is attained after 24 days of full stigmatic stage and plant show light yellowish colour. At this stage, the seeds are physiologically mature having highest seed quality. First harvest the male rows and keep their earheads separately to avoid mechanical admixture. The field should be checked thoroughly to see that no male earheads are left in the seed plots. After completely removing the male heads from field plot, female rows should be harvested, cut the fully matured earheads of female rows and allow for drying in sun light on threshing floor. The seed harvested from the female rows is the hybrid seed. When the earheads are dry, the threshing is done with help of thresher or by beating earheads on Pacca floor without any injury to seeds. Proper care must be taken to avoid mechanical damage and admixture during harvesting and threshing. For this, the threshing floor and thresher should be cleaned before use. Threshed seeds should be dried in sun light to bring down the moisture content to around 10-11 % for safe storage.

16. Seed Processing: The seed processing is done for separating the undesirable material such as inert matter, weed seeds, other crop seeds, damaged and deteriorated seeds. Hence, seed should be cleaned, dried, graded and treated with proper fun-

Table 1: Minimum seed certification standards for pearl millet

Sr. No.	Factors	Foundation	Certified
1	Pure seeds (Minimum)	98.0 %	98.0 %
2	Inert matter (Maximum)	2.0 %	2.0 %
3	Other crop seeds (Maximum)	10/kg	20/kg
4	Weed seeds (Maximum)	10/kg	20/kg
5	Ergot sclerotia, seed entirely or partially modified as sclerotia, broken sclerotia, or ergoted seeds (Maximum) (By number)	0.02 %	0.04 %
6	Germination (Minimum)	75.0 %	75.0 %
7	Moisture (Maximum) (a) for general container	12.0 %	12.0 %
	(b) for vapor-proof container	8.0 %	8.0 %

Photograph of different pearl millet hybrids

GHB-732

GHB-905

GHB-1129 (Jam shakti)

GHB-1225 (Moti shakti)

GHB-1231 (Savaj shakti)

GHB-538 (EDV-DM) (Maru sona)

gicides as per regulations of the Seed Certification Agency. The cleaned and graded seed should be properly packed in standard packing, labeled and sealed by seed certification agency. Packed seed should be stored in a dry, insect free and rat proof godown preferably in a cold storage to maintain its germination during storage period.

17. Seed Testing: Once the seed is cleaned and graded, it should be tested in Seed Testing Laboratory. For this purpose, seed samples are drawn randomly from the processed seed lot and are analyzed in notified seed testing laboratory for confirming to the minimum seed standards laid down in certification.

Kodo Millet of Sikkim: A Future Prospect

Abujam Anuradha Devi[1], Ph. Baleshwor Sharma[2], P.P. Dabral[3], Ram Singh[4] and M. Victoria Devi[5]

Millets are dual-purpose crops grown for food as well as fodder. Many studies have proved that millets have significant contribution in climate change mitigation as well as in reducing carbon pressure. Millets are C4 plants which absorb more carbon dioxidefrom the atmosphere and convert it to oxygen. They have high efficiency of water use, require low input and hence are more environment friendly. Millets can be considered as miracle cereal for poor because of their dual purpose thereby providing food or livelihood security to millions of rural households and contributing to the economic efficiency of farming.

Millets are one of the oldest cereal crops cultivated since time immemorial. Millets were among the major staple crops before the green revolution however, post-green revolution; millets have been given less attention due to the introduction of fine cereal crops. The concept that millets are staple food of the poor and vulnerable populations is also one reason for their low consumption and utilization. Consequently, the cultivation of millets slowly declined and many of them are on the verge of genetic erosion. Millets are known for their good adaptation to various types of ecosystems due to high resilience and stress tolerance characteristics besides their high nutrition value. The importance and prospects of millets are now only realized as brought by drastic climatic change, global warming, and of course as the food for future.

Amongst millets, finger millet (*Eleusine coracana*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*), proso millet/ white millet (*Panicum miliaceum*), barnyard millet (*Echinochloa frumentacea*) and browntop millet (*Brachiaria ramose*) are grown wild or cultivated in India. The finger millet, *Eleusine coracana*, is known as *ragi* in India and *Kodo* in Nepal and hence there is some overlap of its common name in the Indo-Nepal bordering regions especially the Sikkim state of India. In Sikkim, among other minor millets, the finger millet, *Eleusine coracana* is well adapted and cultivated for various food products like chapati, bread, baked products, and more popularly for the production of alcoholic beverages. *Kodo ko jaanr* is a popular mild alcoholic beverage prepared from finger millet in the Eastern trans-Himalayan regions like Darjeeling and Sikkim in India, Nepal, and Bhutan.

In Sikkim, Finger millet has occupied a very important place among the cereal crops of the state. Finger millet in Sikkim is popularly known as "Kodo". It is a kharif crop and is cultivated throughout the state irrespective of elevation in an area of 5000 ha, producing about 4713 tonnes of grain. The crop occupies about 4.11% of the gross cultivated area. Finger millet has record for maximum area (0.754 thousand hectare) and highest production (0.804 thousand tonnes) in East Sikkim district and highest productivity (1070.48 Kg/hectare) in West Sikkim.Each part of the millet crop has been economi-

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Area, Production and Productivity of Finger millet in Sikkim

Year	Area(000'hectares)	Production(000'tones)	Productivity(kg/ha)
2003-2004	4.15	3.57	860.24
2004-2005	4.15	3.60	867.00
2005-2006	4.15	3.78	910.84
2006-2007	4.14	3.90	942.03
2007-2008	3.76	3.53	938.83
2008-2009	3.76	3.53	940.00
2009-2010	4.25	4.18	983.53
2010-2011	3.00	2.89	964.33
2011-2012	3.50	3.45	985.71
2012-2013	2.98	2.96	993.29
2013-2014	2.96	2.97	1002.03
2014-2015	3.07	3.09	1005.20
2015-2016	2.85	2.91	1020.33
2016-2017	2.61	2.69	1031.46
2017-2018	2.47	2.55	1031.65
2018-2019	2.11	2.18	1031.66
2019-2020	2.28	2.37	1036.89
2020-2021	2.05	2.13	1037.98

Source: ENVIS Hub-On Status of Environment, Forest and Environment Department, Government of Sikkim

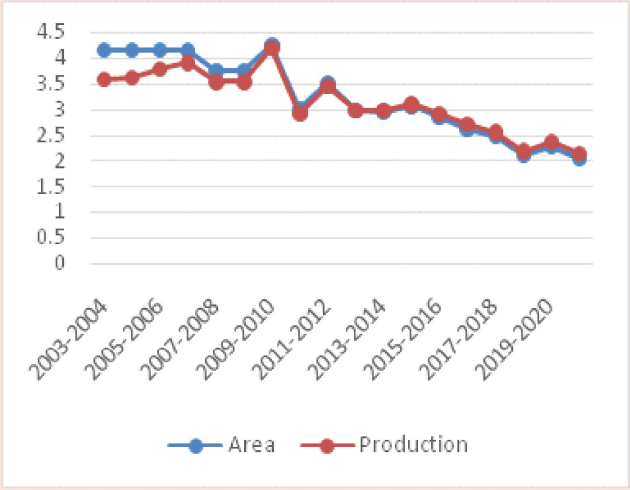

Figure1: Trend of area and production of Finger millet

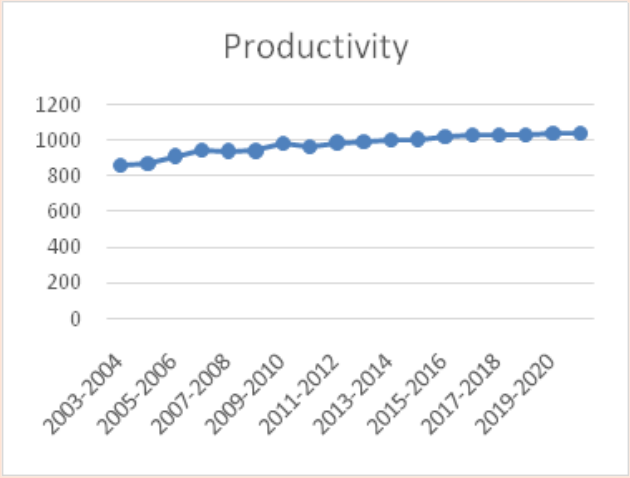

Figure 2: Trend of productivity of Finger millet

Parameter	Finger Millet	Kodo millet	Rice	Wheat
Proximate composition (per 100g)				
Moisture (g)	13.1	12.8	13.7	12.8
Protein (g)	7.3	8.3	6.8	11.8
Fat (g))	1.3	1.4	0.5	1.5
Carbohydrate (g)	72.0	65.9	78.2	71.2
Dietary Fibre(g)	11.5	2.47	4.1	12.5
Total Ash (g)	2.7	2.6	0.6	1.5
Energy kcal	328	309	345	346
Vitamins (per 100g)				
Carotene (µg)	42	0	0	64
Thiamine (B1) (mg)	0.42	0.33	0.06	0.45
Riboflavin (B2) (mg)	0.19	0.09	0.06	0.17
Niacin (B3) (mg)	1.1	2.0	1.9	5.5
Folic acid (B9) (µg)	18.3	23.1	8.0	36.6
Ascorbic acid (mg)	0	0	0	0
Minerals (per 100g)				
Calcium (mg)	344.0	27.0	10.0	41.0
Phosphorous (mg)	283.0	188.0	160.0	306.0
Iron (mg)	3.9	0.5	0.7	5.3
Magnesium (mg)	137.0	147.0	64.0	138.0
Sodium (mg)	11.0	4.6	-	17.1
Potassium (mg)	408.0	144.0	-	284.0
Copper (mg)	0.47	1.60	0.07	0.68
Manganese (mg)	5.49	1.1	0.51	2.29
Molybdenum (mg)	0.102	-	0.045	0.051
Zinc (mg)	2.3	0.7	1.3	2.7
Chromiun(mg)	0.028	0.02	0.003	0.012
Sulfur (mg)	160.0	136.0	-	128.0
Chlorine (mg)	44.0	11.0	-	47.0
Essential Amino acid (mg/g N)				
Arginine	300.0	270.0	480.0	290.0
Histidine	130.0	120.0	130.0	130.0
Lysine	220.0	150.0	230.0	170.0
Tryptophan	100.0	50.0	80.0	70.0
Phenylalanine	310.0	430.0	280.0	280.0
Tyrosine	220.0	-	290.0	180.0
Methionine	210.0	180.0	150.0	90.0
Cysteine	140.0	110.0	90.0	140.0
Threonne	240.0	200.0	230.0	180.0
Leucine	690.0	650.0	500.0	410.0
Isoleucine	400.0	360.0	300.0	220.0
Valine	480.0	410.0	380.0	280.0

cally utilized into different form. The grain is mainly used for malting and preparation of alcoholic beverage which is locally called as "Tongba" or "Jansu" or "Chang". The millet powder is also used for making bread locally called as "Dhainro" and stalk of the millet is used as fodder specially during winter season. The finger millet is considered ethnically important in the society, as it is used as offering in form of beverages to God during *Losar* celebration of Bhutia community as well as during marriage ceremony.

Present status of finger millet in Sikkim

Millet is highly resilient and hardy crop to climate change. The crop is grown all throughout the four seasons in the state during Bhaduary, Mangsirey, Pangdur and Kartikey. Over the year from 2003-04 to 2020-21, there is decline in area and production by almost 50 percent. However, marginal increase in productivity of millet has been observed over the years. Increase in productivity of millet depends on availability of sufficient amount of water/rain. In Sikkim, finger millet grows during kharif season when sufficient water is available for cultivation.

Nutritional Value of Finger Millet

Millets are excellent sources of carbohydrates, proteins, fats, minerals, vitamins, essential amino acids and dietary fibers. Finger millet is a rich source of carbohydrates and comprises free sugars (1.04 %), starch (65.5 %), and non-starchy polysaccharides. The dietary fiber content of finger millet (11.5 %) is much higher than the fiber content of rice, kodo millet, however, is comparable to that of wheat. The carbohydrate content of finger millet is comparable to that of wheat but lower than that of polished rice.Finger millet contains higher levels of sulfur-containing amino acids, namely, methionine and cysteine, compared to rice. Finger millet lipids consist of 70–72 % neutral lipids mainly triglycerides and traces of sterols, 10–12 % of glycolipids, and 5–6 % of phospholipids. As a whole, lipids contain 46–62 % oleic acid, 8–27 % linoleic acid, 20–35 % palmitic acid, and traces of linolenic acid. Finger millet is exceptionally rich in calcium (344 mg) compared to all other cereals and millets and contains 283 mg phosphorus, 3.9 mg iron per 100gm, and many other trace elements and vitamins. The potassium content of finger millet is also high (408 mg) compared to other cereals and millets.

Finger millet contains high antioxidant properties due to various health-promoting polyphenolic compounds and is a good cereal crop for addressing diabetes. Several studies have reported the antidiabetic properties of finger millet. The beneficial aspects of finger millet in terms of health such as glucose lowering, cholesterol-lowering, anti-ulcerative potential, nephroprotective properties, antioxidant properties, wound healing properties, and anti-cataractogenesis properties of finger millet were reported by several authors. Fermented finger millet drink is also used as a natural probiotic treatment for diarrhea.Finger millets are also gluten-free and hence market demand for it is now increasing due to frequent incidences of celiac disease and increasing awareness of the consumption of gluten-free foods.

Conclusion

Millet is a resilient crop which is adaptable to any climatic condition and considered as farmers friendly economic food. Among the millets in Sikkim, finger millet is significant socio-economic-nutritional secured food, as every part of the crop has been efficiently utilized. Area and production have been declining over the years but due to sufficient availability of water in Sikkim, productivity is marginally increased. Advantages of conducive climate could pave a way ahead to increase area under the finger millet in the state. Finger millets are also gluten-free with high antioxidant properties due to various health-promoting polyphenolic compounds and are good cereal crop for addressing diabetes. These extraordinary traits of the crop proved it as nutritional, healthy and economically secured crop.The use of finger milletas commercial food will help and encourage small and marginal farmers to grow finger millets for new opportunities.

Millets: Key to Tackle Unsustainable Agriculture System

R. S. Sohu, Ruchika Bhardwaj, Savita Sharma and Devinder Pal Singh*

Agriculture system in Punjab, post green revolution has led to monotonous rice-wheat system of cultivation. Punjab's agriculture, is now considered as the most dreadful example of unsustainable agriculture worldwide, although the green revolution has brought to the special tag for Punjab as 'food bowl state' of India. But post green revolution scenario has led Punjab to face heavy price for ensuring food security of the country. More importantly the loss of crop biodiversity especially the traditional crops where oilseeds, millets, maize and pulses were also grown along with wheat. Actually the 'miracle' seed of semidwarf varieties of wheat and rice were high yielding only under intensive inputs such as fertilizers and irrigation water and in the absence of intensive inputs theses varieties were poor performers than indigenous varieties. Furthermore, the Government policies kept on promoting wheat rice monoculture. Not only the country attained self-sufficiency in grain production for indigenous human consumption but also is the major exporter of these staples. Therefore, less people are affected by hunger and die from starvation but are suffering from hidden hunger due to micro nutrient deficiency which leads to high rate of annual deaths of children under the age of five and also their retarded growth.

The Punjab state was selected by Indian Government to be the first site for ushering in green revolution due to its reliable water resources which were considered as the great source of crop insurance in severe drought condition. Today, depletion of water table is the major problem which Punjab is facing. Along with water crises the depleted soil organic matter is making Punjab's soil unproductive leading to more use of inorganic fertilizers to get good yields. Increased use of chemical fertilizers led to drastic reduction of plant resistance to pests which further led to the massive use of chemical pesticides.

Now, when the shift from monoculture is the need of hour for Punjab to sustain agriculture, its biodiversity and ecology should be kept in mind before helping farmers to wean off rice wheat cropping system. The cultivation of millets is ages old practice and farmers of Punjab are well versed with the package of practices of indigenous millet crops particularly bajra (pearl millet) and jowar (sorghum), but traditionally grown and produced millet crops were eventually lost due to unavailability of high yielding seeds of millets and hence farmers moved to rice and wheat cropping system.

The scientists at Punjab Agricultural University, Ludhiana are consistently putting efforts to keep millets in the stream and good number of varieties have been developed for major millets (bajra and sorghum). Two recently developed varieties of bajra and sorghum viz., PCB 165 (2020) and SL 45 (2022), respectively are very good millet varieties as along with the food security, due to high yield potential both these varieties are very good source of nutritional security as well. Major and minor millets are treasure trove of minerals, very high in dietary fiber, low in glycemic index and rich in micro nutrients. Besides, cultivation of millets is a source of economic as well as ecological

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security as they are short duration crops (90-100 days) and require very less inputs for their growth. Even some genotypes can survive under severe drought conditions. Due to their ability to withstand harsh weather conditions, millets are called climate smart/climate resilient crops and are needed to bring back into cultivation in the global warming scenario.

Millets are multifaceted crops which provide multiple securities. Salient features of millet crops are as under:

- Ancient food grains and are first plants domesticated for food.
- **Nutritional security:** Provides nutritional diversity and source of nutrition for people with special food needs especially for diabetic and people with gluten allergies. Highly enriched with minerals, dietary fibre and micronutrients especially Fe and Zn and thus, can control malnutrition.
- **Climate resilience:** Next generation climate resilient crops due to low water requirement and high temperature tolerance and are very well suited to dry land agriculture. As they can withstand **higher temperatures**, thus, they are perfect choice as **'climate-smart cereals'.**
- **Water security**: As per the current situation of agriculture system especially in Punjab, which is facing major problem of depleting underground water resources, millets are an option, as they **use almost 30 per cent less irrigation water** in comparison to paddy cultivation.
- **Environmental and Ecological security**: Rewarding yield, with minimum chemical fertilizers and pesticides use. So, it is also not adding the adverse effect of chemicals on natural resources as well as human health, rather millets have certain health benefits for human.

Characteristic features of PAU developed millet varieties

The PCB 165 (dual purpose variety) of bajra and SL 45of sorghum are good options for cultivation in the *kharif* season. Furthermore, the produce of PCB 165 and SL 45 has very good potential to be utilized for development of valuable crops. The use of produce in the value addition chain is an important source of remuneration for the farmers growing PCB 165 and SL 45. Furthermore, different products developed from these varieties are very good source of nutrition to the people consuming it as PCB 165 is rich source of iron and zinc and is a good source to tackle anemia in the anemic children. PCB 165 is a dual purpose variety i.e. it can be grown for fodder as well as grain whereas SL 45 variety of sorghum is a fodder variety but its grain can be used for value addition also.

Detailed characteristic features of PCB 165 and SL 45:

	Characters	Sorghum variety SL 45	Bajra variety PCB 165
Fodder yield and quality traits	Green Fodder Yield (q/ha)	677.5	647.5
	Dry Matter Yield (q/ha)	167.5	112.5
	Plant height (cm)	297	251
	Days to 50% flowering	99	72
	Crude Protein (%)	8.7	7.6
	In *vitro* DMD (%)	46.9	45.6
Grain yield and quality traits	Grain yield (q/ha)	21.4	35.7
	Crude protein (%)	12.1	12.1
	Fat (%)	3.5	4.5
	Total minerals (%)	2.8	3.7
	Crude fibre (%)	3.5	4.2
	Iron (Fe) content (µg/g)	23.1	55.1
	Zinc (Zn) content (µg/g)	21.6	36.5

Health benefits of millets

- Millets can help in tackling health challenges
- Obesity- High in Dietary fibre and antioxidants.
- Prevent type 2 diabetes: Low Glycemic index (GI) of millet based product
- Reducing blood pressure
- Reduces risk of gastrointestinal conditions like gastric ulcers or colon cancer
- Eliminate problems like constipation, excess gas, bloat-

Different products developed from the grains of sorghum and bajra varieties

Overall acceptability of value added products developed from millets

Products	Overall acceptability*	
	Pearl millet (PCB 165)	Sorghum
Pinni	9.0	9.0
Chapatti	8.0	8.0
Nutritional bar (Multigrain)	9.0	9.0
Gachak (100% popped grains)	9.0	9.0
Chilla	9.0	9.0
Popped grains	9.0	9.0
Jaggery Balls	8.0	-
Flour	9.0	9.0

* (The results of OA are average of 15 semi trained panelists rounded off to nearest whole number. Sensory evaluation of the products was done on 9-point hedonic scale).

ing and cramping

- Probiotic feeding micro flora in our inner eco-system
- Cure the lifestyle problems as they are gluten-free, have a low glycemic index (good source of nutrition for diabetic people) and are high in dietary fibre
- Nutritional security: Millets are Nutri-cereals that are highly nutritious and known to have high nutrient content which includes proteins, essential fatty acids, dietary fibre, B-Vitamins and minerals such as calcium, iron, zinc, potassium and magnesium.
- Combat Malnutrition and Hidden hunger: nutritional deficiency, especially among children and women.
- Tackle Anemia: Increasing anaemia in women and children due to iron deficiency can be controlled as bioavailability of iron and zinc from millets is better as compared to other cereals.

Insect Pests of Millets and their Management

G. M. Parmar, R. P. Juneja, K. D. Mungra and R. J. Chaudhari

Millets are a group of highly variable small-seeded grasses widely grown as cereal crops or grains for both human food and fodder. Major millets, such as pearl millet, sorghum, finger millets (ragi), proso millet and foxtail mlllet are the most widely grown millets in India. Minor millets such as Indian barnyard millet, little millet and kodo millet are grown in the pockets on marginal lands. Pearl millet is one of the most extensively cultivated cereals in the world, after rice, wheat, and maize, and particularly in arid to semi-arid regions. More than 100 insect-pests have been reported to be associated with pearl millet based cropping system, but only few of them are potential pests of significant economic importance. The insect-pests *viz.*, shoot fly, stem borer, white grubs, ear head worms and grey weevil are the key pests of millets in India and need proper control measures. The description of major and minor insect-pests along with their scientific name, importance, status, nature of damage and their control measures are as under:

Shoot fly, *Atherigona approximate* (Malloch):

Host plants: Pearl millet, sorghum, maize, wheat, minor millets and fodder crops.

Nature of damage: The fly has assumed the status of a serious pest in a number of states, especially in Gujarat, Tamil Nadu and Rajasthan. The maggots feed on the seedlings and produce dead heart. Sometimes, the shoot is not killed due to quick plant growth. The fly also causes damage to ear heads in later stages of the crop and the ear head appears like cat's tail. It is reported that about 23.3 to 36.5 per cent grain losses are caused by shoot fly. The population fluctuation of shoot fly was studied at Jamnagar and revealed that the incidence ranged from 6.4-13.2 per cent during 15 to 50 days after germination of the crop.

Stem borer, *Chilo partellus* (Swinhoe):

Host plants: Pearl millet, sorghum, maize, sudan grass, baru and other grasses.

Nature of damage: This is a major pest and most destructive and cosmopolitan species. At seedling stage, borer larvae feed in plant whorls and thus parallel shot hole appears in the opening leaves followed by dead hearts at later stage. Whereas, at ear head stage the silver ear head/ empty ear head appears and losses up to 20-60 % have been reported. The study carried out for 10 years on population fluctuations of pearl millet stem borer revealed that its incidence is noticed 15 days after germination of the crop (4.4%) and gradually increased to its peak (15.1%) at 77 days after germination of the crop.

Ragi stem borer (*Sesamia inferens*):

Noctuidae: Lepidoptera

The pink larva bores into the stem and damages the central shoot resulting in dead heart. Borer holes are visible on the stem near the nodes. The larvae cause

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dead hearts and stem tunnels. The female lays about 150 creamy white and hemispherical eggs that are arranged in two or three rows between the leaf-sheath and the stem of the host plant. Egg period remains till seven days. The fully grown larvae measures about 25 mm and is pale yellow with a purple pink tinge and a reddish-brown head. The larval period is 25 days but in cold months it may be extended to 75 days. Pupation occurs in the larval tunnel in the stem and the adult emerges in 12 days. One generation may take 6- 7 weeks. The life cycle is completed in 45-75 days. There are 4-6 generations per year.

White grub

Holotrichia consanguinea Blanchard, *Holotrichia longipennis* and *Holotrichia serrata L.:*

This is a serious pest of ground nut, sorghum and pearl millet in Gujarat. The pest is prevalent in its larval stage in the fields from March to October. The grubs feed on roots in the soil. The problem is more serious in lighter soils. The grub rapidly moves from one plant to another under the soil. The damaged plant starts drying up and ultimately dies. The seedlings are attacked by this pest. Larvae cause major devastation resulting in the failure of the crop.

Ear head worms:

(a) *Helicoverpa armigera* Hubner:

Host plants: Pearl millet, sorghum, maize, wheat, minor millets

Nature of damage: The losses up to 10-15% has been reported at Jamnagar and it is observed that egg laying by female moth is specifically done on the bajra ear heads at ear head emergence stage and freshly hatched larvae feed on stigma which ultimately leads to poor grain setting and it is sometimes misguided with sterility. Most of the larvae are dark greenish brown, but they can also be pink, cream or almost black. They do not hide in the soil during the day and are therefore, easier to find in the ear head. Pupation takes place in the soil.

(b) Hairy caterpillar, *Amsacta spp, Estigmene lactinea* (Black) and *Amsacta moorei* Butl.

These caterpillars have been reported as sporadic pests in semi-arid areas of the country. These caterpillars are difficult to kill when in advance stage, however, advantage can be taken of their habit of pupating gregariously in the soil of infested fields.

(c) *Eublemma silicula* (Swinh.)

Nature of damage: The caterpillars are observed feeding on the maturing grains, hidden under small dome-shaped or elongated structures formed from the dry anthers. The caterpillars feed mostly on the upper part of maturing grains. The excreta of insect leads to fungal attack thus quality of grain are deteriorated. The infestation by this pest is varied in different varieties and hybrids. The pest remains active from late August to early September. The attack is visible immediately with the commencement of grain formation.

Sorghum midge (*Contarinia sorghicola):*

(Cecidomyidae: Diptera):

The maggot feeds on the developing grains and pupates there. White pupal cases protruding out from the grains and chaffy grains with holes are the damaging symptoms. Pupal cases can be seen attached to the glumes of damaged spikelet. The completion of one generation in a fortnight helps the pest to complete four to five generations in a season with overlapping generations especially when flowers are available. Some larvae pass the dry season by entering diapauses which may last 8-9 months and is terminated by warm and humid conditions in August/September. The adult fly is small, fragile with a bright orange abdomen and a pair of transparent wings. It lays eggs singly in developing florets resulting in pollen shedding. A female lays, about 30-35 eggs at the rate of 6-10 in each floret. The incubation period is 3-4 days, the maggot has four instars with duration of 8-I0 days and total larval period is 9 - ll days.

Leaf roller/binder (*Marasmia trapezalis*):

Host plants: Pearl millet, maize and sorghum

Nature of damage: Larvae feed on the tips of leaves causing leaf rolling. Larvae also feed by scrapping the green tissues inside leaf folds. Sometimes heavy attack is found. This is an occasional pest. Inci-

dence of leaf roller is found moderate to low in bajra growing areas. Special control measures are seldom necessary.

Blister beetles: *Mylabris pustulata* Thunb., *Cylindrothorax tenucollis*

Host plants: Pearl millet, sorghum, maize

Nature of damage: Since the pest feeds on the flower petals and the pollen grain, seed setting in the pearl millet spike is affected. Different species of the beetles are present in nature. The beetle secrets an acidic substance, which on coming in contact with the human body, causes a "Blister" and hence the name is "Blister beetle".

Cotton grey weevil (*Myllocerus subfasciatus*) (Guerin: Meneville):

Host plants: Pearl millet, cotton, maize, sugarcane, ragi, lady's finger.

Nature of damage: This is an occasional serious pest of bajra. Adult causes severe damage to leaves leaving only the midribs. Beetle grubs feed on the roots. In some cases grub damage in seedling stage becomes very serious.

Ear head beetle/Blossom beetles (Chaffer beetle):

Anatona stillata Newman, *Oxycetonia versiclor* Fab., *Chiloloba acuta* weed have been found on bajra crop. These insects are principally pollen feeders. These are seen on bajra ear heads. The larvae develop in organic matter in soil and few infest roots of plant also. These are medium sized to large beetles and are brilliantly coloured and dorsally flattened with a large scutellum.

Management

As an immediate remedy, chemicals have been used extensively, mainly on high yielding varieties and hybrids. It is emphasized that studies should be intensified on varietal resistance, mass rearing techniques, predators and parasites and manipulation of population by cultural practices leading to the possibility of using all available methods on an integrated basis for future pest management programmes in sorghum and millets. The various management measures are as follows:

Cultural methods

1. Collect and burn stubbles and chafii ear heads and feed the stalks to cattle before the onset of monsoon rains. This will reduce the carryover of stem borers and midge.
2. Deep plough one month before sowing will expose immature stages of insects and serve as a food for predators.
3. Adopt synchronous and timely/early sowings of cultivars with similar maturity over large areas to reduce the damage by shoot-fly, midge, and head bugs.
4. Rotate millets with cotton, groundnut, or sunflower, to reduce the damage by shoot fly, midge, and head bugs.
5. Intercropping sorghum with pigeon pea, cowpea, or lablab also reduces the damage by stem borers.
6. Treat seeds with thiamethoxam 35 FS @ 9.0 ml/kg or imidacloprid 600 FS @ 8.75 ml/kg to improve plant stand, seedling vigour, and reduce the damage by shoot fly and stem borer and sucking pest.
7. Use higher seed rate of pearl millet at the time of sowing @ 5 kg/ha and delay thinning (to maintain optimum plant stand) to minimize shoot-fly damage.
8. Initiate plant protection measures at 8 % and 5 % Economic Threshold Level (ETL) against shoot fly and stem borer, respectively in pearl millet crop.

Mechanical methods

1. Set up light traps till midnight to monitor, attract and kill adults of stem borer, grain midge and ear head caterpillars.
2. Set up sex pheromone traps for monitoring of adult male moths of *Helicoverpa sp.* @ 5 traps/ha at 1 ft height above ear head formation from flowering to grain hardening.
3. Set up the fishmeal traps @ l2/ha till the crop is 30 days old to reduce shoot fly damage.

Biological methods

1. Two foliar spray of *Beauveria bassiana* 1.15 WP (2×10^6 cfu/g) 5 g/l at 30 and 60 days after germination for management of shoot fly and stem borer in pearl millet.
2. In case of small and marginal farmers who cannot

afford the chemical pesticides can apply any one of the botanical materials available to them either neem seed kernel suspension or neem leaves suspension or mint leaves suspension @ 5% spray.

3. Apply one spray of HNPV 250 LE/ha at anthesis stage of pearl millet crop for effective and economical management of ear head worm *Helicoverpa* sp.

Chemical methods

1. When the shoot fly damage reaches 8% damage, the crop may be sprayed with quinalphos 25 EC 0.05%
2. Granular formulation of insecticides may be applied as basal application for control of pearl millet shoot fly.
3. Two sprays of profenophos 50 EC @ 0.05% or fenobucarb 50 EC @ 0.1% at 20 and 40 days after germination was found effective from the study at Jamnagar for the control of shoot fly.
4. For stem borers, dust or granules can be applied in the whorl leaves of damaged plants or the entire field can be sprayed with fenvalerat at 0.01%.
5. Whorl application of insecticides is also suggested for control of sorghum stem borer.
6. For sorghum midge, the crop may be sprayed at 50 % flowering stage.
7. For ear head bugs and head caterpillars, the crop may be sprayed at the completion of flowering and at the milk stage.

Looking to the status of the pests in changing climate, an integrated approach for management of these pests is need of the hour. A farmer friendly IPM package for the control and management of economically important insect pests, focused on pearl millet and finger millet is priority. Major pests in millets are shoot fly, stem-borer, white grubs while in finger millet, major pest is pink borer. The available evidence suggests that pearl millet and finger millet are relatively less subjected to many pests compared with other graminaceous crops such as sorghum. There is need to generate data on yield loss due to key pests of millet crops and effectiveness of natural enemies and their use in existing ecosystems. The traits responsible for resistance must be incorporated into agronomically suitable cultivars.

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Millets: Eco-Friendly Powerhouse of Nutrition

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One of the earliest foods consumed by humans is millets, which may have been the first cereal grain to be farmed for household use. In India, remnants of millets have been discovered in the Harappa and Mohenjo-Daro archaeological sites, and millets are mentioned in a number of ancient Indian texts. The Ministry of Agriculture and Farmers Welfare has acknowledged the value of millets and designated them as "Nutri-Cereals" for production, consumption and trade point of view.

Millets are grown on 12.45 million hectares in India, yielding 15.53 million tonnes at a productivity of 1247 kg/ha. The fact that India produces the highest amounts of Barnyard (99.9%), Finger (53.3%), Kodo (100%), Little millet (100%) and Pearl millet (44.5%) from an area of 8.87 million hectares is note-

Major millets

Sorghum (Jowar)

Pearl millet (Bajra)

Finger millet (Ragi)

Minor millets

Foxtail millet (Kakum)

Kodo millets (Kodon)

Barnyard millet (Sanwa)

Little millet (Kutki/Shavan)

Proso millet (Chenna/Barri)

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worthy. 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 highest percentage of land cultivated with millets.

Millets are an important staple cereal crop for millions of smallholder dryland farmers across Asia and sub-Saharan Africa and also called dryland cereals because they require less water and agricultural inputs than other similar staples. Millets are mostly grown in low fertile land, mountainous, tribal, and rainfed regions of India, such as Rajasthan, Andhra Pradesh, Chhattisgarh, Gujarat, Haryana, Odisha, Karnataka, and Tamil Nadu as they are tolerant to drought, high temperatures, and other climatic uncertainties.

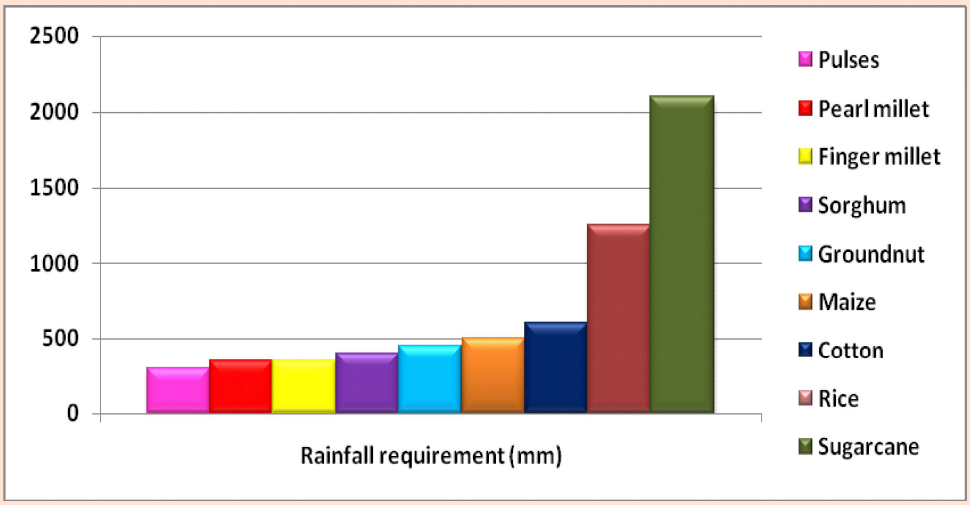
Nutrition composition and health benefits:

Millets are good source of energy, protein, vitamins, and minerals, including trace elements, according to their nutritional makeup. A substantial percentage of the millet grain's 65% carbohydrate content comes in the form of non-starchy polysaccharides and dietary fibre, which lower blood cholesterol, prevent constipation, and block the release of glucose into the bloodstream after digestion. Millet grains are also rich in important vitamins viz., Thiamine, riboflavin, folic acid and niacin. The millet kernel, which can be consumed, is a plentiful source of phytochemicals, including dietary fibre and polyphenols (0.2–0.3%). Millets' phytates, polyphenols, and tannins play a significant role in ageing and metabolic illnesses and contribute to antioxidant activity. Bran of the millets is rich source of dietary fiber, termed as complex unavailable polysaccharides. Due to higher viscosity, glycemic index and water holding capacity, dietary fibres play a key role in reduction of blood glucose level as well as insulin response.

Millets have potential health benefits, and studies have shown that consuming millets lowers the risk of heart disease, helps in curing diabetes, improves digestion, lowers the risk of cancer, detoxifies the body, increases immunity in respiratory health etc. due to presence of nutrients such as resistant starch, oligosaccharides, lipids, antioxidants such as phenolic acids, avenanthramides, flavonoids, lignans and phytosterols etc. Fiber content in millets helps in eliminating disorders like constipation, excess gas, bloating and cramping. Some of the health benefits of millets are as under:

Sorghum:

- Sorghum contains magnesium, vitamin E, phenolic compounds, tannins, and other nutrients that minimise the risk of developing diabetes by delaying the upsurge in blood sugar and insulin levels.
- Sorghum also contains a healthy amount of dietary fibre, ranging from 9.7 to 14.3 grams, which acts as a bulking agent, a cholesterol-binding agent, an increase in transit time, and a delaying agent for the absorption of carbohydrates. These properties have a significant positive impact on the prevention and management of diseases like constipation, irritable bowel syndrome, and obesity.



Water requirement of different crops (Source: Millet Network of India - Deccan Development Society - FIAN, India)

Pearl millet:

- Pearl millet's lignin and phytonutrients function as potent antioxidants, reducing heart-related disorders. Because of this, pearl millet is regarded as

Table 1: Proximate Composition, Dietary Fibre (per 100 g) and vitamins profile of millets.

Millets	Moisture (g)	Protein (g)	Ash (g)	Total Fat (g)	Dietary Fibre (g)	Carbo hydrates (g)	Energy (KJ)	Thiamine – B1 (mg)	Riboflavin – B2 (mg)	Niacin-B3 (mg)	Biotin -B7 (µg)
Bajra	08.97 ± 0.60	10.96 ± 0.26	1.37 ± 0.17	5.43 ± 0.64	11.49 ± 0.62	61.78 ± 0.85	1456 ± 18	0.25 ± 0.044	0.20 ± 0.038	0.86 ± 0.10	0.64 ± 0.05
Sorghum	09.01 ± 0.77	09.97 ± 0.43	1.39 ± 0.34	1.73±0.31	10.22± 0.49	67.68 ± 1.03	1398 ± 13	0.35 ± 0.039	0.14 ± 0.014	2.10 ± 0.09	0.70 ± 0.06
Ragi	10.89 ± 0.61	07.16 ± 0.63	2.04 ± 0.34	1.92 ± 0.14	11.18 ± 1.14	66.82 ± 0.73	1342 ± 10	0.37 ± 00.041	0.17 ± 0.008	1.34 ± 002	0.88 ± 0.05
Little Millet	14.23 ± 0.45	08.92 ± 1.09	1.72 ± 0.27	2.55± 0.13	06.39 ± 0.60	65.55 ± 1.29	1449 ± 19	0.26 ± 0.042	0.05 ± 0.008	1.29 ± 0.02	6.03± 0.57
Kodo Millet	14.23 ± 0.45	08.92 ± 1.09	1.72 ± 0.27	2.55 ± 0.13	06.39 ± 0.60	66.19 ± 1.19	1388 ± 10	0.29 ± 0.054	0.20 ± 0.018	1.49 ± 0.08	1.49 ± 0.18
Foxtail Millet		12.30		4.30		60.09	331	0.59	0.11	3.20	
Barnyard Millet		06.20		2.20		65.55	307	0.33	0.10	4.20	
Proso Millet		12.50		1.10		70.04	341	0.41	0.28	4.50	

Table 2: Properties of Dietary Fiber and their impact on Health .

Function	Impact on Health	Millet
Water absorbing and bulking property	Energy diluents to formulate low calorie diets	All Millets
Increased transit time of food in the gut	Reduced risk of inflammatory bowel disease	Sorghum and Finger Millet
Bile acid and steroid binding	Hypocholestero-laemic activity and reducing the risk of cardiovascular diseases	Pearl Millet, Sorghum and Finger Millet
Retardation of carbohydrate absorption and impaired glucose tolerance	Management of certain type of diabetes	Sorghum, Pearl Millet and Finger Millet
Binding of toxins	As a detoxifying agent	Sorghum
Binding of divalent cations	Reduced bioavailability of Ca, Mg, Zn, Fe	Proso Millet and Foxtail Millet (unprocessed)

beneficial for heart health.

- Due to its high fiber content, it digests more slowly than other foods and releases glucose into the blood at a slower rate. This efficiently aids in keeping diabetic patients' blood sugar levels stable for a prolonged period of time.
- It is advised to consume pearl millet to treat stomach ulcers. Excessive stomach acid after eating is the most typical cause of stomach ulcers. One of the few meals, pearl millet, makes the stomach alkaline and prevents or lessens the effects of stomach ulcers.
- Because of its high magnesium content, pearl millet is beneficial at reducing migraine attacks as well as asthmatic patients' respiratory symptoms.

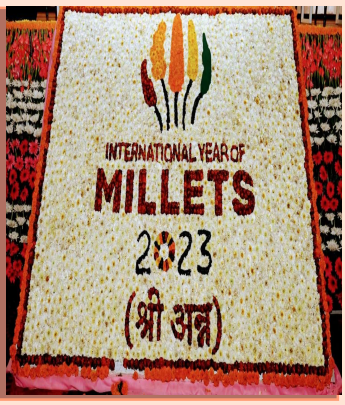
Finger millet:

- Due to the high fibre content and alpha amylase inhibitory capabilities of finger millet, which are known to limit starch digestion and absorption, diets based on this grain have demonstrated lower glycemic responses.
- Finger millet provided defence against mast cell activation, fibroblast activation, enhanced collagen production, mucosal ulceration, and epithelialization.
- Tryptophan, an amino acid found in ragi, reduces hunger and aids in weight management.
- Natural iron can be found in abundance in ragi. Consuming ragi benefits anaemia patients. Ragi can prevent undernutrition, degenerative illnesses, and early ageing if frequently taken.

Minor millets:

- Under conditions of high fat feeding, proso millet has been demonstrated to ameliorate the glycemic responses and insulin in genetically obese type 2 diabetic mice. As a result, millet grains may be helpful in both treating and preventing diabetes.
- Foxtail millets' aqueous extracts exhibit strong anti-hyperglycemic action.
- According to reports, barnyard millet, especially the dehulled types, is also good for type 2 diabetes since it has a low glycemic index (41.7) and is heat-treated.

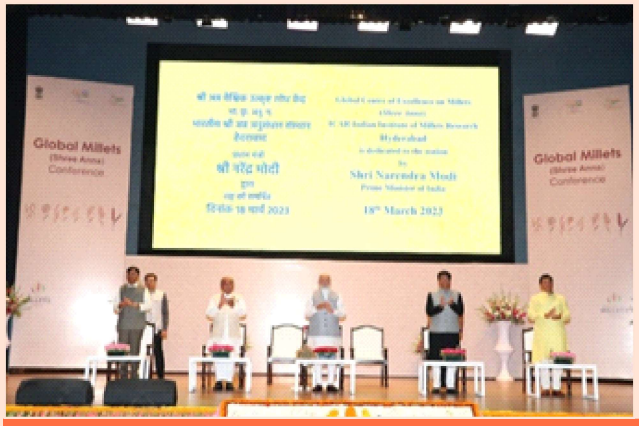
Global Millets (Shree Anna) Conference 2023



Dr. Shailesh Kumar Mishra

Hon'ble Prime Minister Shri Narendra Modi inaugurated the Global Millets (Shree Anna) Conference at Subramaniam Hall, NASC Complex, IARI Campus, Pusa, New Delhi on 18th March, 2023 at 11 A.M in the presence of Union Minister of Agriculture & Farmers Welfare, Shri Narendra Singh Tomar, besides Union Ministers Shri Piyush Goyal and Shri Mansukh Mandaviya and MoS Shri Kailash Choudhary. Visiting Ministers of other countries graced the inaugural function and gave messages for their countries. During the Inaugural ceremony, Prime Minister Narendra Modi also unveiled a customised postal stamp as well as a commemorative currency coin to mark the 'International Year of Millets' being celebrated in 2023.

Prime Minister Shri Narendra Modi digitally launched a Book on Millets (Shree Anna) Standards. Prime Minister also addressed the gathering on the occasion. A video on millets, which the government



named 'Shree Anna', was also released during the event, with the announcement of Hyderabad-based Indian Institute of Millets Research (IIMR) as the global centre of excellence.

Prime Minister Shri Narendra Modi said, "I am proud that India is leading the 'International Year of Millets'. Events like Global Millets Conference are not only necessary for Global Good but also a symbol of India's increasing responsibility for Global Good. It is a matter of great honour for us that after India's proposal and efforts, the United Nations declared 2023 as the 'International Year of Millets'. More than 75 lakhs farmers of India are virtually present with us in this ceremony today, which shows its importance".

Elaborating on benefits to small farmers, he said, "2.5 crore small farmers are directly related to millet. Our mission for Shree Anna is going to be a blessing for these small farmers. Shree Anna market will benefit them and the associated ecosystem. This will also

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strengthen the rural economy. Millets have also been selected for the One District One Product Scheme in 19 districts of the country. India is currently presiding over G20. Its motto 'One Earth, One Family, One Future' is also reflected in the International Year of Millets. Millets are also creating new jobs".

Union Agriculture Minister Shri Narendra Singh Tomar and his counterparts from six countries were present during the inaugural programme. Video messages from the Heads of State of Ethiopia and Guyana were also played during the inaugural ceremony. Union Agriculture Minister Shri Narendra Singh Tomar said, "As a result of the declaration of 2023 as the International Year of Millets by the United Nations on the initiative of Prime Minister Narendra Modi, the domestic and global demand for 'Shree Anna' has increased."

The year 2023 will witness a year-long campaign and several activities nationally and globally for increased adoption and promotion of millets. The two-day conference witnessed participation from dignitaries such as Dr Jaquelene Hughes, Director General, ICRISAT; Jong-Jin Kim, Assistant Director General & Regional Representative for Asia and Pacific, FAO; Kapil Dev, Cricketer; Geeta Phogat, Wrestler, Commonwealth Gold Medallist; Chef Thomas Gugler, President, World Association of Chefs, etc., alongside an esteemed audience of Padma Awardee farmers in physical as well as virtual mode. Mr. Menon, Sr. Sports Journalist and Mannava Srikanth, former Chief Selector, Indian cricket team also joined the session.

An Exhibition-cum- Buyer-Seller Meet (BSM) with a focus on millets was also held with the participation of more than 50 domestic and international buyers, importers, exporters and processors for the promotion of millets. The exhibition of more than 100 stalls showcased millets and millet-based ready-to-cook and ready-to-eat products by millet-based startups, exporters and live cooking sessions by various international and national chefs. The two-day conference also witnessed wider participation from Farmer Producer Organisations (FPOs)/ Farmers Self-Help Groups, Schools, Agri-Universities, Krishi Vigyan Kendras (KVKs), Gram Panchayats, Common Service Centres (CSC), Cooperative Institutions, Hotel Management Schools, Indian Embassies and Diaspora etc.

International Year of Millets:

Based on India's proposal, the year 2023 was declared as the International Year of Millets (IYM) by the United Nations General Assembly (UNGA). Also, in line with the Prime Minister's vision to make the celebrations of IYM 2023 a 'people's movement' and position India as the 'global hub for millets', all central government Ministries/Departments, States/UTs, farmers, start-ups, exporters, retail businesses and other stakeholders, are being engaged to promote and spread awareness about the benefits of millets (Shree Anna). The organization of Global Millets (Shree Anna) Conference in India is an important programme in this context.

The two-day global conference had sessions on all important issues related to millets (Shree Anna) like promotion and awareness of millets among producers, consumers and other stakeholders; millets' value chain development; health and nutritional aspects of millets; market linkages; research and development etc. The conference was attended by Agriculture Ministers of various countries, international scientists, nutri-

tionists, health experts, start-ups leaders and other stakeholders.

India aims to make IYM 2023 a people's movement for the overall benefit of the cultivator, consumer and climate. To take the momentum forward, India has taken a multi-stakeholder engagement approach by involving farmers, startups, exporters, retail businesses, hotel associations and various arms of the government in India and abroad to achieve the objectives of IYM 2023 and positioning India as the 'Global Hub of Millets'

Ministerial Round Table of Millets was held post-inaugural session of the Global Millets (Shree Anna) Conference held on March,18,2023 in New Delhi. Ministers from Guyana, Mauritius, Sri Lanka, Sudan, Suriname & Zambia; Permanent Secretary, Agriculture of Gambia & Maldives and Director General, Millets Initiative, Nigeria participated in the meeting. Union Minister of Agriculture and Farmers Welfare, Government of India welcomed the delegates attending the meet.

In his Opening Remarks at the Ministerial Round Table, Shri Narendra Singh Tomar highlighted India's role in Shree Anna promotion, being the largest producer and second largest exporter of millets in the world. During last 5 years, India is producing millets in the range of 13.71 to 18.02 million tonnes. In order to promote millets and meet the additional demand of millets, the Department of Agriculture and Farmers Welfare (DA&FW) is implementing a Sub-Mission on Nutri-Cereals (Millets) under National Food Security Mission (NFSM) in 212 Districts of 14 States since 2018-19. India exported 1,04,146 metric tonnes of millets during the export year 2022-23 (April to November) worth Rs. 365.85 crores. This export is bound to increase post-IYM celebration.

In his address, Shri Narendra Singh Tomar said the International Year of Millets (IYM) – 2023 will provide an opportunity to increase global production, efficient processing and better use of crop rotation and promote millets as a major component of the food basket. He added that the Ministry of Agriculture and Farmers Welfare is working in mission mode to increase millet production and consumption in collaboration with other Central Ministries, all State Governments and other stakeholders.

During the global conference, the MoU between WFP and the Government of India for cooperation between 2023-2027 was signed in the presence of Agriculture Minister Shri Tomar. During this, Mr. Manoj Juneja, Deputy Chief Executive Director, Management and Chief Financial Officer of UNWFP and Ms. Elizabeth Faure, WFP Representative and Country

Director in India were present. The MoU will be jointly implemented by the Department of Food and Public Distribution, Ministry of Agriculture and Farmers Welfare, Ministry of Women and Child Development, Ministry of Rural Development and the Ministry of Environment, Forest & Climate Change. Shri Tomar lauded the work of WFP in promoting food self-sufficiency and supporting governmental and global efforts to ensure long-term solutions to the challenge of hunger. He thanked the WFP for being a part of the Global Millets Conference and expressed the hope that the partnership between WFP and the Government of India will yield fruitful results to achieve our goals.

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