

Enhancing productivity and nutrition with biofortified pearl millet cultivars

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Food, economic and nutritional securities are equally important to the resource poor farmers relying on pearl millet in marginal environments. Bio-fortified cultivars of pearl millet with higher iron (Fe) and zinc (Zn) content in the grain along with high grain yield are supposed to be the best solution in this context. With the concerted efforts of Indian Council of Agricultural Research (ICAR), Harvest Plus, ICRISAT and State Agricultural Universities, biofortified varieties and hybrids are available in pearl millet. The world first high-Fe pearl millet variety 'Dhanashakti' released in 2014 has 71 mg/kg Fe and 2.2 t/ha grain yield. The first set of biofortified hybrids (AHB 1200 Fe and HHB 299) released in 2018 had 73–77 mg/kg Fe, 39–41 mg/kg Zn with more than 3 t/ha of grain yield. With similar levels of grain yield, the second set of hybrids (RHB 233, RHB 234, AHB 1269, HHB 311) released in 2019–20 had 83–91 mg/kg Fe and 39–46 mg/kg Zn.

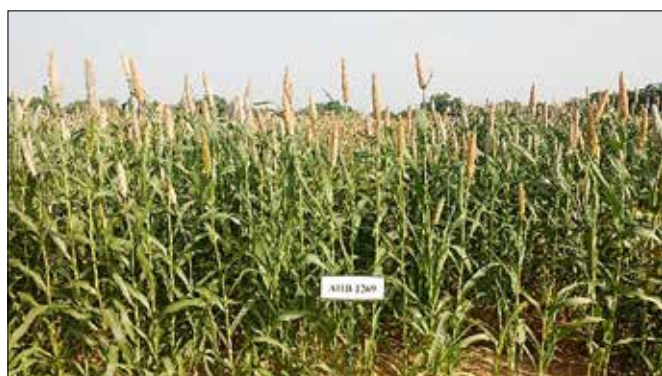
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MALNUTRITION due to micronutrient deficiency, especially with iron (Fe), zinc (Zn), vitamin A and iodine (I) is prevalent among the poor of southeast Asia and Africa, where, pearl millet [*Pennisetum glaucum* (L.) R. Br.] is grown in the harshest environmental conditions. Being a climate resilient crop, it is grown under adverse climatic conditions in the arid and semi-arid regions enduring high heat, marginal soils, poor inputs and drought besides being resilient to most biotic stresses. Pearl millet is the most widely cultivated staple food crop after rice, wheat and maize in India playing a vital role of addressing food and nutritional security in regions where other cereal crops can not be successfully grown. It is mostly consumed in the western Rajasthan and parts of Gujarat, where it is more than 50% of the total cereal consumption besides being consumed in other parts of Gujarat, Rajasthan, Maharashtra and Haryana.

Nutritional value of pearl millet

Pearl millet releases more energy (361 Kcal/100 g) on consumption as compared to rice (345 Kcal/100 g) and wheat (346 Kcal/100 g). The carbohydrate content of the grain amounts up to 62%. Pearl millet contains about 11.6% protein that is higher than rice, maize, sorghum and barley, and comparable to wheat. It has better essential amino acid composition and is a good source

of the sulphur containing amino acid, methionine. Due to its high total dietary fibre (11.2 g/100 g) and slow digestion, it is beneficial to non-insulin diabetic patients. It is a decent source of fat (5–7%) and fat-soluble vitamin E (0.2 mg/100 g). Regarding the fatty acid composition, pearl millet is a source of linolenic acid, the n-3 essential fatty acid that accounts for about 4% of the total fatty acids, compared to 0.9% in maize. The n-3 fatty acids play an important role in physiological functions like platelet aggregation, triglyceride reduction and better immune system. The grain is also a good source of vitamin A and B-vitamins, viz. thiamine, niacin and riboflavin. It is rich in minerals such as calcium (Ca), potassium (K), magnesium (Mg), manganese (Mn), Zn, Fe, and copper (Cu) as compared to corn with higher levels of phosphorus (P), being important for bone mineral matrix and adenosine triphosphate which is the energy booster in the body. Pearl millet is also rich in phytochemicals including phenolic acids; the ferulic and *p*-coumaric acids found in whole pearl millet, have several health beneficial properties including the ability to suppress the proliferation of certain type of tumour cells. Being gluten free, they are boon for patients with celiac disease. It is enriched with nutrients to mitigate malnutrition and hidden hunger and hence rightly designated as *nutri-cereal* (gazette of India, No. 133 dated 13 April 2018). Efficacy studies provide evidence that the



Biofortified variety (Dhanashakti) and hybrids (RHB 234, AHB 1269, HHB 311) of pearl millet

consumption of grains from biofortified varieties would provide bioavailable Fe to meet a fully recommended daily allowance (RDA) in children, adult men and 80% of the RDA in women.

Biofortification prioritization in breeding

However, the commercially released cultivars have low levels of Fe and Zn, though they have been improved for yield significantly over the landraces. Hence concerted efforts were made to breed for high Fe and Zn cultivars with good yield levels to address the food and nutrient needs of the resource poor population, since the entire breeding efforts of the public and private sector were geared towards hybrid development for higher grain yield owing to the availability of the cytoplasmic male-sterility system. The ICAR has endorsed the inclusion of the minimum levels of Fe and Zn that have to be bred into future varieties of pearl millet across the country. The All-India Coordinated Research Project on Pearl Millet decided on a minimum of 42 mg/kg of Fe and 32 mg/kg of Zn content. It is expected that the farmers may prefer cultivation of biofortified hybrids due to high nutrition in addition to higher grain and stover yields.

Biofortified varieties

Initially, the world first high-Fe pearl millet variety 'Dhanashakti' was developed by utilizing the intra-population variability within ICTP 8203, which is an early-maturing, large-seeded, disease resistant and high-yielding open-pollinated variety that has been under cultivation in India since 1990. Dhanashakti is officially released and notified by Central Variety Releasing Committee in 2014 for the cultivation in all pearl millet growing states of India. Based on national

testing trials, Dhanashakti had 71 mg/kg Fe (9% higher) and 2.2 t/ha grain yield (11% higher) compared to the original ICTP 8203. Hybrids of pearl millet with higher grain yield and high levels of Fe (>70–75 mg/kg) and Zn (>35–40 mg/kg) densities have been developed and released in India. Currently, India is growing >70,000 ha of biofortified pearl millet.

Biofortified hybrids

The first set of biofortified hybrids was AHB 1200 Fe and HHB 299, officially released at national level for A and B zones in collaboration with the agricultural universities of Maharashtra (VNMKV) and Haryana (CCSHAU) during 2018. These biofortified hybrids contained 73–77 mg/kg Fe and 39–41 mg/kg Zn. They are medium maturing having more than 3 t/ha of grain yield and 7 t/ha of fodder yield (Table 1). Apart from this, 'Phule Mahashakthi' was released for the state of Maharashtra.

The second set of hybrids was officially released at national level during 2019–20. The RHB 233, RHB 234, AHB 1269, HHB 311 were released in collaboration with agricultural universities of Rajasthan (SKNAU), Maharashtra (VNMKV) and Haryana (CCSHAU). These biofortified hybrids contained 83–91 mg/kg Fe and 39–46 mg/kg Zn. They are medium maturing having more than 3 t/ha of grain yield and 7 t/ha of fodder yield (Table 1).

In the current era, improving nutrition in staple crops through genetic biofortification needs focus as self-sufficiency in food quantity is attained. There is a need for premium price for biofortified grains and products in the market. This will enhance market opportunities for farmers and ascertain nutritional security in the

Table 1. Salient features of biofortified released pearl millet hybrids

Hybrid	Year	Bred at	Recommended area	Fe (ppm)	Zn (ppm)	Grain yield (kg/ha)	Fodder yield (q/ha)	Salient feature
HHB 311	2020	CCS HAU, Hisar	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra and Tamil Nadu	83	39	3173	72	Medium maturing, compact, conical ear heads, grey, hexagonal grains, resistant to major diseases and pest
AHB 1269Fe	2019	NARP, Aurangabad	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra and Tamil Nadu	91	43	3169	71	Medium maturing, resistant to downy mildew
RHB 234	2019	AICRP on PM, SKNAU, Jaipur	Rajasthan, Haryana, Gujarat, Punjab, Delhi, Maharashtra, and Tamil Nadu	84	41	3168	74	Medium maturing, greyish seed, resistant to major diseases and insect pest
RHB 233	2019	AICRP on PM, SKNAU, Jaipur	Rajasthan, Haryana, Gujarat, Punjab, Delhi, Maharashtra and Tamil Nadu	83	46	3157	74	Medium maturing, greyish seed, resistant to major diseases and insect pest
HHB 299	2018	CCS HAU, Jodhpur	Rajasthan, Haryana, Gujarat, Punjab, Delhi Maharashtra and Tamil Nadu	73	41	3274	73	Medium maturing, compact panicle, greyish hexagonal shape grains, resistant to major diseases and insect pests
AHB 1200 Fe	2018	NARP, Aurangabad	Rajasthan, Gujarat, Haryana, Punjab, Delhi, Maharashtra, Telangana, Andhra Pradesh and Tamil Nadu	77	39	3170	70	Medium maturing, long cylindrical panicle, resistant to downy mildew, resistant to stem borer, highly responsive to fertilizers

future. Biofortified cultivars being developed through conventional breeding do not face the possible challenge of food regulations and consumer acceptance and can be easily marketed.

SUMMARY

Combining the yield and micronutrients in pearl millet hybrids has been successful with the collaboration of national and international breeding programmes. As a result, 6 biofortified hybrids has been released at

national level since 2018 with comparable grain and fodder yields to commercially grown hybrids. Apart from this, one widely adapted variety, ICTP 8203 is available to the farming community. These biofortified cultivars have comparable yields to commercially grown hybrids and need to be widely cultivated for bringing nutritional security in the marginal areas, where the crop is the sole option of living to the farmers.

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Drought-tolerant rice Swarna Sukha Dhan for rainfed upland ecology of Uttar Pradesh

A drought- tolerant rice variety Swarna Sukha Dhan (RCPR 16, IET 24692) was notified and released for cultivation under drought prone rainfed upland ecology in Uttar Pradesh. RCPR-16 (IET 24692) has recorded yield advantage of 11.48 and 19.63% over NDR 97 (best check) and Shusk Samrat (local check) respectively. Swarna Sukha Dhan is a short duration (110–115 days), high-yielding (3.5–4.0 tonnes/ha), and multiple-stresses (drought, diseases and insect pest) tolerant with desirable cooking quality traits. Quality wise IET 24692 showed high hulling (78.4%), milling recovery (70.9%), head-rice recovery (68.4%), medium slender grain type with intermediate amylose content (22.32%) and alkali spreading value (ASV=4.0). It has GC content (49 mm) with very occasionally chalky and medium slender grains indicating good cooking quality.



Source : ICAR Annual Report 2021-22