

Biofortification:

An effective agricultural strategy for alleviating malnutrition

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Malnutrition is a global health issue and needs to be addressed with utmost urgency. In developing countries like India, the problem is even more serious and complicated. Improving the nutritional values of the staple crops can greatly help in improving the dietary intake of nutrients and thus reduce the problem of malnutrition to a great extent. Agronomic biofortification and genetic biofortification has been proven to improve the nutritional status of crops and can serve as a potential tool in ameliorating hunger and malnutrition.

Keywords: Agronomic biofortification, Anaemia, Hunger, Malnutrition

THE Sustainable Development Goal (SDG 2nd) of United Nations targets at achieving zero hunger by 2030. Though actions are being taken across the globe to alleviate malnutrition, still over 2 billion people are affected by malnutrition. Among 117 countries, India ranked 102nd in the global hunger index in 2019. With a global hunger index score of 30.3 India falls under “serious hunger” category. The global hunger index report also shows that India’s child wasting rate is extremely high at 20.8%. The data from National and Family Health Survey (2015-16) also shows the prevalence of malnutrition among children (Table 1). Considering this situation, hunger and malnutrition require immediate and foremost attention.

With the advancement of agricultural research and development in our country, India has been able to improve its productivity. However, with the growing population, increased demand and changing climate requires agriculture to be more productive, resource efficient and climate resilient. In addition to higher production, nutritional values of food must be given due emphasis

to reduce the problem of malnutrition and poor health. The dominance of high yielding cereals in the cropping system has resulted in a dramatic reduction in food diversity and micronutrient uptake. Out of 7,000 species ever cultivated by humans, currently only 30 plant species account for nearly 95% of the world’s food energy supply. Not only the numbers of food crop species in use but also genetic variation within many traditional cultivated food crops have declined. As dietary dependence is on few crops, hence the nutritional quality of these crops is of great importance to meet the nutritional need of the people feeding on them.

Under such a scenario the broad approaches that can help to alleviate the problem of malnutrition are: (i) Shift in dietary pattern towards more diverse and nutritionally rich foods, (ii) Increased intake of fortified food (rich in a particular ingredient in particular concentration), and (iii) Mineral Supplements (clinical intervention) and Biofortification (agronomic or genetic or a combination of both approach). Fortified foods and mineral supplements are often costly and poor people can hardly afford them.

Moreover, considering the existing narrow dietary diversity, biofortification seems to be a practical solution to the problem of malnutrition.

Biofortification

Biofortification is the process by which nutritional quality of food crop is improved through agronomic practices, conventional plant breeding or modern biotechnology. Considering the widespread malnutrition problem in India, biofortification holds a great significance. Biofortification can be achieved through agronomic or genetic biofortification (conventional breeding or genetic engineering) methods. Biofortification aims at improving nutritional quality by

Table 1. Prevalence of underweight, stunting, wasting and anaemia among children (under 5 years)

Problems	Children under age 5 years (%)
Underweight	35.7
Stunting	38.4
Wasting	21
Anaemia	58.4

Source: National Family Health Survey (NFHS) 2015-16

improving micronutrients, vitamins etc. and reducing antinutritional factors.

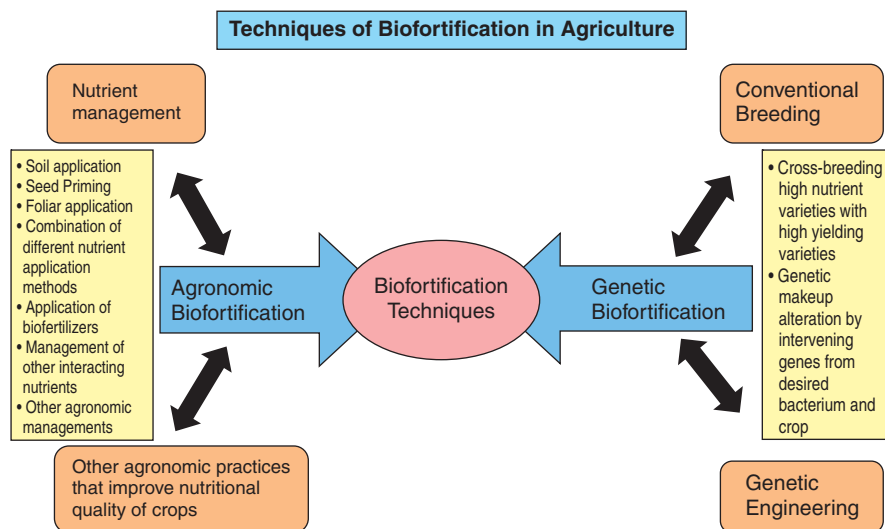
Agronomic biofortification

Under agronomic biofortification method, plants are supplied with desirable nutrients (through soil application method/seed priming/seed coating/root dipping/foliar application or any combination of these methods) to improve the concentration of that nutrient in the edible portion of the plant. However, to improve the concentration of one nutrient in grain (or any edible part) another nutrient or a combination of nutrients may be applied because one nutrient often interacts with other nutrient(s) in both soil and plant system, thus affecting their uptake, translocation (or retranslocation) towards grain, thereby deciding their final concentration in the edible portion of a crop. For example, increasing nitrogen fertilizer application of plant has been found positively improve shoot translocation and grain deposition of foliar applied zinc.

Agronomic biofortification is successful in improving micronutrient concentration in crops like rice and wheat. Considering widespread micronutrient deficiency in Indian soil, application of micronutrient can improve both productivities as well as nutritional quality of produce. However, the response in terms of productivity, as well as quality, may vary with crop (even vary from variety to variety), environment and management practices. Success of agronomic biofortification also depends on source, method, time and dose of nutrient application.

Research evidence suggest that application of micronutrient to crops like rice and wheat has been successful in improving productivity as well as grain micronutrient concentration of grain. Agronomic biofortification approach can help improving production, grain quality (i.e. micronutrient concentration) and can also reduce micronutrient deficiency in soil (when micronutrient is added to the soil).

The Harvest Plus project working on many countries have shown



encouraging results for agronomic biofortification. Considering the simplicity of the practice, agronomic biofortification practice can be adapted by farmers for producing nutritionally richer food.

Genetic biofortification

In genetic biofortification, plants are bred to develop biofortified varieties with better nutritional quality. Though genetic biofortification approach requires comparatively longer time and involves high cost, it is a sustainable way of alleviating malnutrition and ensures nutritional security.

In India, the Indian Council of Agricultural Research (ICAR) has started developing biofortified varieties as a sustainable and cost-effective measure of alleviating malnutrition. These biofortified varieties when integrated into our consumption system can enable countering hunger and malnutrition sustainably. The ICAR along with its collaborating partners have developed over a dozen varieties with improved nutritional qualities (Table 2). The varieties developed can be expected to have positive impact on human health. For example, wheat varieties, WB 02 and HPBW 01 are rich in zinc and iron, and can help in reducing deficiency in people feeding on them. As zinc deficiency and anaemia are very common especially among women, hence these varieties can be very helpful in solving such problems.

In addition to traditional breeding,

genetic engineering and transgenic approach are also used for developing biofortified variety. The classical example is that of Golden rice rich in vitamin A. Golden rice was developed by transforming rice with two beta carotene biosynthesis genes *psy* (phytoene synthase) from daffodil (*Narcissus pseudonarcissus*) and *crtI* (Carotene desaturase) from soil bacterium *Erwinia uredovora*. However, many countries do not allow the cultivation of transgenic crops for human consumption and thus its use has been limited.

Though the development of biofortified varieties takes longer time and involves high cost, once developed, such varieties can be grown for a very long period. Moreover, germplasms can also be shared within and across countries based on their environmental suitability. The large-scale production of biofortified varieties can greatly help in reducing hidden hunger and malnutrition, however, while developing such varieties care must be taken to take into consideration consumer preference.

Combining genetic biofortification and agronomic biofortification

Biofortified varieties are genetically superior in terms of a particular nutritional quality (or qualities) but their performance may be jeopardized under certain conditions. For example, a variety developed for high zinc grain may not perform to its full potential under an extremely zinc limited condition.

Table 2. Biofortified varieties developed with improved nutritional quality

Crop	Variety	Characteristics	Developed by
Rice	CR Dhan 310 (pure line)	Protein rich (10.3% protein in polished grain)	ICAR-NRRI, Cuttack
Rice	DRR Dhan 45 (pure line)	High in Zinc (22.6 ppm)	ICAR-Indian Institute of Rice Research, Hyderabad
Wheat	WB 02 (pure line)	Rich in Zinc (42 ppm) and Iron(40 ppm)	ICAR-Indian Institute of wheat and barley research, Karnal
Wheat	HPBW 01 (pure line)	High in iron (40 ppm) and Zinc (40.6 ppm)	PAU, Ludhiana under ICAR AICRP on Wheat and barley
Maize	Pusa Vivek QPM9 improved (Hybrid)	Country's first provitamin A rich variety, High in Provitamin A (8.15 ppm), lysine (2.67%) and tryptophan (0.74%)	ICAR-IARI, New Delhi
Maize	Pusa HM4 improved (Hybrid)	Contains 0.91% tryptophan and 3.62% lysine	ICAR-IARI, New Delhi
Maize	Pusa HM8 improved (hybrid)	Rich in Tryptophan (1.06%) and Lysine (4.18%)	ICAR-IARI, New Delhi
Maize	Pusa HM9 improved (hybrid)	Tryptophan (0.68%) and Lysine (2.97%)	ICAR-IARI, New Delhi
Pearl millet	HHB 299 (Hybrid)	High in Iron (73 ppm) and Zinc (41 ppm)	CCSHAU, Hisar in collaboration with ICRISAT, under ICAR-AICRP on Pearl millet
Pearl millet	AHB 1200 (Hybrid)	High in Iron (73 ppm)	Developed by VNMKV, Parbhani in collaboration with ICRISAT, under ICAR-AICRP on Pearl millet
Lentil	Pusa Ageti Masoor (Pure line variety)	Rich in iron (65 ppm)	ICAR-IARI, New Delhi
Mustard	Pusa Mustard 30 (pure line variety)	Low erusic acid (<2%)	ICAR-IARI, New Delhi
Mustard	Pusa double zero mustard 31 (Pure line variety)	Country's first canola quality Indian mustard variety Low erusic acid (<2%) in oil, Glucosinolate (<30 ppm in seed meals)	ICAR-IARI, New Delhi
Cauliflower	Pua beta kesari 1 (Pure line)	High α -carotene (8.0-10.0 ppm)	ICAR-IARI, New Delhi
Sweet Potato	Bhu Sona (pure line)	High α -carotene (14 mg/100g)	ICAR-CTCRI, Thiruvananthapuram, Kerala
Sweet potato	Bhu Krishna (pure line)	High anthocyanin (90 mg/100 g)	ICAR-CTCRI, Thiruvananthapuram, Kerala
Pomegranate	Solapur Lal (hybrid)	High iron (5.6-6.1 mg/100g), zinc (0.64-0.69 mg/100g) and vitamin C (19.4 -19.8 mg/100 g) in fresh arils	ICAR-National Research Centre on Pomegranate, Pune

Source: Yadava D.K., P.R. Choudhury, Firoz Hossain and Dinesh Kumar 2017. Biofortified Varieties: Sustainable Way to Alleviate Malnutrition. Indian Council of Agricultural Research, New Delhi

Under such condition combining agronomic biofortification with genetic biofortification can play an important role.

Benefits of biofortification

- Agronomic biofortification with micronutrients can help improving both productivity as well as nutrient status of food grains considering widespread micronutrient deficiency in Indian agriculture scenario.
- Genetic biofortification can help in ameliorating the problem of malnutrition in a sustainable manner over a long period. Moreover, recurrent costs are low as germplasms can be shared with other places or countries for growing.
- As nutrition plays an important role in the human physiology and growth, hence ensuring proper

nutrition in diet can help in reducing the cost of health care.

- Ensuring good health through nutritious food can help in maximizing the potential of human capital of the country.

Limitations

- The success of agronomic biofortification largely varies with management, crop (even varieties of a crop) and environment.
- Development of varieties are often time consuming and costly (though once developed can be used for a long time).
- Transgenic approach of developing biofortified variety of food crops is still a debate. For example, golden rice developed through genetic engineering is rich in vitamin A. However, it was not accepted by many countries, as many countries

are critical of genetically modified crops.

- Development of biofortified varieties may further lead to simplification of human diets and food systems.

The integration of biofortified food (which is nutritionally richer) to the food chain can help ameliorating the malnutrition issue to a great extent. This will not only improve health and wellbeing but also positively affect the economy through better utilization of human resources. It must be remembered that “good health comes from the farm, not the pharmacy”.

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