

Biofortified crops to combat hidden hunger

On the occasion of the International Women's Day (8 March 2018), Prime Minister Narendra Modi launched the National Nutrition Mission and Pan India Expansion of 'Beti Bachao, Beti Padhao', covering all the 640 districts of the country. The National Nutrition Mission is timely in the context of widespread malnutrition prevailing in India. It is therefore important to accelerate our efforts in achieving a malnutrition-free India. This requires concurrent attention to three major types of hunger, viz. calorie deprivation, protein hunger and hidden hunger caused by the deficiency of micronutrients. It is equally important that agriculture, nutrition and health come together in a synergetic manner.

World over, about 2 billion people suffer from deficiencies of various micronutrients such as vitamin A, vitamin C, folic acid, iron, iodine, zinc, etc. In India alone, it is estimated that around 600–700 million of the current human population of about 1300 million people suffer from various micronutrient deficiencies.

India has been tackling the three different forms of hunger since the time of its independence in August 1947. Primary attention during the 1950s and 1960s was to fight and overcome the deficiency of cereal grains in the country. Since these provide the much needed calories on a daily basis, inadequate intake results in 'caloric hunger'. Thanks to the Green Revolution, India is now producing sufficient quantities of wheat, rice, maize, etc. Enhancement of the productivity of cereal grains through the Green Revolution was achieved primarily through Mendelian genetics and breeding. As of now, the country has quite satisfactorily overcome 'caloric hunger' by enactment of the National Food Security Act 2013. This Act ensures legal right to food possibly with home-grown cereals. Over 70% of India's population of 1.30 billion can overcome caloric hunger by this Act. Hence, caloric hunger is no longer an issue of desperate concern. Subsequently, deficiency in the intake of protein in the diet received due attention. Pulses, milk, meat, poultry and fish are appreciable sources of protein; of which pulses are relatively easier to produce in larger quantities. Further, pulses are more readily affordable by economically weaker sections of the society. Above all, significant number of people in India are largely vegetarians. The cultivation of pulses was successfully promoted through

the launching of 'Pulse Panchayat' by the M. S. Swaminathan Research Foundation (MSSRF), in Tamil Nadu. Fortunately, pulse crops fix their own nitrogen, and do not need copious irrigation. The pulse crops are thus climate-resilient.

The third type of hunger caused by deficiency of micronutrients in the diet, such as vitamin A, vitamin B12, vitamin C, iron, iodine and zinc is referred to as 'hidden hunger', since it is not felt readily as in the case of caloric and protein hunger. The hidden hunger exerts extreme adverse effects on human health especially in children. In a plea for a global grid of genetic gardens of biofortified crops (*Curr. Sci.*, 2016, **111**, 965), one of us (M.S.S.) has cited the 2016 Global Nutrition Report of the International Food Policy Research Institute (IFPRI), Washington, USA and brought out that malnutrition exerts multiple adverse impacts on human health and quality of life. Children are the worst victims and hence, there is an urgent need to adopt a life-cycle approach in terms of nutrition intake with special emphasis on the first thousand days in a child's life.

One approach to overcome micronutrient malnutrition has been the production and consumption of biofortified crops. Developing through Mendelian breeding orange-fleshed sweet potato rich in vitamin A is an example. The developers won the 2016 World Food Prize. As of now, zinc-rich rice and wheat, iron-rich beans and pearl millet, vitamin A-rich sweet potato, cassava and several other crops have already been developed. As against these biofortified crops developed by traditional Mendelian breeding, vitamin A-rich 'Golden Rice' is a product of genetic engineering (i.e. molecular breeding).

Ever increasing number of revelations on the 'unintended effects' of genetically engineered crops suggests the need for more basic research. Further, genetic, toxicological and environmental impact assessment studies have raised serious concerns on health and environmental safety. These aspects have been briefly discussed recently (Swaminathan, M. S. and Kesavan, P. C., *Curr. Sci.*, 2018, **114**(8), 1585; Kesavan, P. C. and Swaminathan, M. S., *Sci. Cult.*, 2018, **84**(3–4), 89–95). More importantly, as of now the genetically modified crops are not preferred in many countries. Consequently, there are effectively only the two following methods of promoting

the cultivation and consumption of biofortified crops. One is to identify the naturally biofortified crops rich in one or more micronutrients which provide remedies to nutritional maladies. *Moringa oleifera* (drumstick) is a good example to overcome iron deficiency. Second, increasing micronutrients content through traditional Mendelian breeding is readily acceptable, as has been done in India to develop iron-rich pearl millet and in Bangladesh zinc-rich rice.

An important point to bear in mind is that the predominant dietary intake of people in different geo-climatic regions varies in the dietary content of specific micronutrients. Consequently, the people of a given region suffer from specific nutritional maladies. The Farming System for Nutrition (FSN) designed by one of us (M.S.S.) involves cultivation of agri-horticultural crops naturally biofortified with specific micronutrient(s), the deficiency of which results in a nutritional malady. This approach involves providing agro-horticultural remedies to nutritional maladies. The FSN has been elaborated by Swaminathan and his research associates (*Agric. Res.*, 2014, **3**, 193–203).

FSN is unique in combining the social, ecological and economic dimensions of 'sustainable agriculture', which in the Indian context involves eco-friendly farming by millions of resource-poor, small and marginal farmers, and also enhancing farm-based rural livelihoods. FSN is ideally suited for the resource-poor, small and marginal farmers to raise a variety of agri-horticultural crops naturally biofortified with one or more specific micronutrients. While providing fruits and vegetables to alleviate micronutrients deficiency in a given region, these farmers could get increased remuneration (i.e. better prices) than what they would receive from traditional subsistence farming. Further, the corporate style of 'monoculture' factory-farming aimed at producing large quantities of a specific commodity for food processing would not be compatible with farming a variety of biofortified crops. Even more ideally, the FSN is almost tailor-made for smallholder family farms. That in turn would augment income-generation to the rural farming families. In particular, the favourable economic and gender impact on women farmers (who have no legal right to land and hence loans from the banks) is likely to be significant. 'Feminisation of poverty' in the rural areas could be fought with FSN.

What is now essential is that crop scientists and nutritionists should identify as many numbers of agri-horticultural crops suitable for cultivation in a given agro-climatic region and bring these to the knowledge of the local farmers. It is towards this goal that one of us (M.S.S.) has suggested the setting up of 'genetic gardens of biofortified crops'. He has also suggested that it is important to promote nutrition literacy among both farmers and consumers. Furthermore, genetic gardens should have different sections based on particular micronutrients. Thus, there will be a vitamin A section, iron and iodine

section, etc. By walking through the garden, farmers can identify the crops they can introduce in their farming system to address specific micronutrient deficiency.

Another important point relevant to the success of the National Nutrition Mission is that genetic gardens of biofortified crops greatly supplement the 'Zero Hunger' challenge declared by the UN Secretary-General Ban Ki-moon in 2012; the term 'Zero Hunger' refers not just to 'caloric hunger', but also to 'hidden hunger'.

Economic and social access to balanced diets and clean drinking water should receive overriding priority for realizing the vision for a new India. Urban and peri-urban horticulture can play a particularly important role both from the point of view of enhancing availability of fruits and vegetables, and for making them available at affordable prices. Genetic gardens of biofortified crops can also become part of the urban agriculture revolution. The other aspect needing greater attention is the spread of FSN, since agriculture is the predominant occupation of over 50% of the population. Mainstreaming a nutrition dimension in the prevailing farming systems is the fastest way of overcoming hidden hunger. The National Nutrition Mission will be successful if we are able to integrate crop husbandry with the donors of protein and micronutrients.

However, it is of paramount importance that resource-poor small farmers should be given necessary economic incentives to adopt FSN. This involves adoption of three following aspects:

- Provision of minimum support price to the farmers.
- Public procurement (by Government) of the biofortified agri-horticultural produce. *The Hindu Business Line* (23 April 2018) has reported that in 2016–17, the total procurement of pulses was 1.47 million tonnes, against production of 23.13 million tonnes. It is true for several crops other than rice and wheat.
- Public distribution of the biofortified crops – it may be a good idea to include in the mid-day meal menu prepared using biofortified crops

As emphasized at the International Women's Day programme, the highest priority in overcoming malnutrition should go to women and children below 1000 days in age. From what has been proposed here, there is a need for the Central and the State Governments to develop appropriate policies for implementation of the above three integrated steps (i.e. appropriate pricing, procurement and distribution).

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