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Biofortification- A novel tool to reduce micronutrient malnutrition

Rohini Bansode[1] and Sandeep Kumar[2]

[1]Department of Plant Biotechnology, Kerala Agricultural University, Thrissur 680656 India. [2]Centre for Environment Science and Climate Resilient Agriculture, Indian Agricultural Research Institute, New Delhi 110012 India

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Abstract

In current scenario, people are suffering from vitamins and minerals deficiencies which cause very serious constraint to human health and economic development. Malnutrition is widespread in the many developing nations and causes adverse effect on human health. Malnutrition is the cause of zinc, iron, provitamin A and iodine deficiency and one third of the world's population is at risk of these deficiencies. So, to tackle this problem, there is need for multiple complementary strategies to address key micronutritient deficiencis. To address this issue, biofortification is one of the promising strategies to enhance the availability of vitamins and minerals for people whose diets are dominated by micronutrient-poor staple food crops.

Keywords: Biofortification, malnutrition, micronutrient deficiency, zinc, iron, plant breeding, biotechnology, provitamin A

Introduction

Nutrition is a key for sustainable economic development and healthy diet is the one which satisfy human needs for energy and all essential nutrients (FAO 2004). Micronutrient deficiency is widespread in the industrialized countries, but also more so in the developing regions of the world. It can affect all age groups, but young children and women of reproductive age are found to be at more risk of developing micronutrient deficiencies. This deficiency not only cause adverse effects on human health and but at the same time it has the negative impact on economic development and productivity.

There are common forms of micronutrient malnutrition worldwide viz., iron, zinc, vitamin A and iodine deficiency. One third of the world's population in developing countries is greatly affected by these micronutrient deficiences. Among these four, the most prevalent is zinc and iron deficiency. It is found that more than 2 billion people are anaemic, below 2 billion have inadequate iodine nutrition and 254 million preschool-aged children are vitamin A deficient (Hotz and Brown, 2004). Various approaches are available to tackle the problem of micronutrient deficiency. One of them is the fortification of staple grain flours or processed foods with vitamins and minerals. This paper tries to highlight importance of biofortification and biofortified crops released with high nutritional content.

What is biofortification?

Biofortification is defined as the enhancement of micronutrient levels of staple crops through biological processes, such as plant breeding and genetic engineering (Bouis, 2002). It could be effective in deminishing the problem of malnutrition and the strategy that includes dietary diversification, supplementation, commercial fortification and other aspects. Biofortification could demonstrate to be a cost-effective and sustainable approach for alleviating micronutrient deficiency in developing countries where the majority of the poor households' diets are comprised of staple foods and where access to food supplements and commercially marketed fortified foods is limited.

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Table 1: Stages of biofortification (Winkler, 2011)

Discovery	1. Identify target population 2. Set nutrient target levels 3. Screen germplasm and gene
Development	4. Breed biofortified crops 5. Test performance of new crop varieties 6. Measure nutrient retention in crops 7. Evaluate nutrient absorption and impact
Dissemination	8. Develop strategies to disseminate seed
Outcomes	9. Improve nutritional status of target population

Biofortification of food crops

Staple crops including maize, beans, cassava, rice and millet are rich source of micronutrient content. Biofortified crop varieties are developed by plant breeding using selective breeding and/or genetic modification.

Conventional Breeding:

Plant breeding is an excellent tool to combat the problem of malnutrition with the use of varieties to develop new, productive and 'biofortified' crop lines for farmers to grow. These techniques are used to identify varieties with high amount of desired nutrients. Then this characteristic is transferred into cultivated varieties by crossing and individual plants were selected for those desired characteristics. Breeding approach can be used to develop biofortified varieties that enriched with high levels of micronutrients such as zinc or betacarotene etc. (Nestel *et al.*, 2006).

Genetic Modification

Biotechnology is one of the most promising tools that have shown to be most valuable in developed countries with enough amount of productivity. This technology has been used in the development of many insect resistant crop varieties using a protein from the *Bacillus thuringiensis* (Bt). Bt cowpea, Bt cotton, Bt maize and also herbicide resistant crops have been released and which have reshaped agricultural productivity of many developed countries. Crops that have been biofortified with higher levels of vitamins and minerals such as vitamin A, iron and protein are vitamin A rice, Golden Rice, biofortified beans, pearl millet, Maize and biofortified cassava with improved vitamin and mineral contents.

The progress has been made in the breeding of these important crops. Biofortified crops are released through HarvestPlus and its partners in Uganda (OFSP), Zambia (maize), Nigeria (cassava), the Democratic Republic of the Congo (DRC) (cassava and beans), Rwanda (beans), and India (pearl millet) (Table. 1).

Sweet potato

Orange flesh sweet potato contains high levels of betacarotene. Breeding programme started by by the International Potato Center (CIP) and National Agriculture Research and Extension System (NARES) mainly aims to improve the tastes and nutritional value. Mozambique and Uganda released high-provitamin A varieties in 2002 and 2007, respectively. These varieties are now being introduced in many parts of the world like Africa, South America and China. Reports show that 75% of the betacarotene is retained in the potato even after boiling in preparation for a meal (HarvestPlus, 2014a; Hotz, 2012; Jamil *et al.* 2012). Africans used to eat sweet potato which contains no vitamin A. Yields of orange flesh sweet potatoes are as high as those of the white sweet potatoes. Since 2009, eight African countries have released 31 orange flesh sweet potato varieties (HarvestPlus 2014d).

Maize

Maize breeding programme for improved Provitamin A started by the International Maize and Wheat Improvement Center (CIMMYT) and International Institute of Tropical Agriculture (IITA) in collaboration with NARES in southern Africa Biofortified orange

Maize with high provitamin A Carotenoid content was released in Zambia in 2012 which has shown great nutritional impact (Gannon *et al*. 2014).

Cassava

Cassava varieties *viz*., yellow or golden cassava is rich in high levels of beta carotene. These cassava varieties were released in Nigeria in 2013, where 100 million people eat cassava daily as staple food. Biofortified cassava (HarvestPlus, 2014d) has been shown significant increase in pro vitamin A (Talsma, 2014). These varieties are suitable to the African environment and resistant to cassava mosaic disease. Currently, more than 500,000 farmers have planted this cassava and further studies related to nutritional impact are ongoing.

Rice

Rice is main staple food for almost two thirds of the population plays an important role in Indian economy. Rice contains low nutritional value compare to other cereals. Therefore, rice alone can not meet the daily nutritional requirenment. So, there is a need to increase the nutritional value through biofortification. Biofortifed Rice varieties with increased zinc were released in Bangladesh in 2013. Also, Zinc content in biofortified rice is 30% more than traditional varieties (HarvestPlus 2014a).

Biofortified Pearl Millet

Pearl millet is one of the important staple crops in the states of Maharashtra, Rajasthan, Gujarat, and Uttar Pradesh. It is already being grown in Maharashtra and rich in iron and zinc content. Reports showed that breads made with this new pearl millet provide a significant amount of iron and zinc content (HarvestPlus, 2014d). Biofortified millet has shown the improved iron status of school-aged children (Beer *et al*. 2014). The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) carries out the pearl millet breeding research in collaboration with NARES and the private sector. The popular open pollinated variety (OPV) ICTP 8203 was improved to create the first biofortified variety, called ICTP 8203-Fe, which contains the full iron target and was officially released in 2013.

Beans

High iron content beans varieties are now being propagating in Rwanda, Uganda and the Democratic Republic of Congo. Five varieties of biofortified beans with higher iron contents were released in Rwanda in June 2012. Studies conducted previously showed that biofortified beans can improve iron status as compare to traditional varieties. Also, the UN's World Food Programme has purchased these beans for use in refugee camps with a view to improving iron intake among these nutritionally vulnerable consumers (WFP, 2014).

Table 2. List of biofortified crops released (Bouis *et al.,* 2013)

Crop	Nutrient	Countries of first release	Release year
Sweetpotato	Provitamin A	Mozambique, Uganda	2007
Beans	Iron, zinc	Rwanda, DRC	2012
Pearl millet	Iron, zinc	India	2013
Cassava	Provitamin A	Nigeria	2013
Maize	Provitamin A	Zambia, Nigeria	2012
Rice	Zinc, Iron	Bangladesh, India	2013
Wheat	Zinc, Iron	India, Pakistan	2013

Conclusion

This paper reviewed the outcomes of biofortification either by conventional breeding methods or by modern biotechnological tools. This serves as an ultimate tool which has gained an immense importance in global nutrition security. Therefore, biofortified crops can alleviate micronutrient deficiency which has significant role on the lives and health of millions of people.

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