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Biofortification in Horticulture

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Introduction

In the past years agricultural system and research in developing countries mainly concentrated on production rather than nullifying the nutritional point. This approach has resulted in a rapid rise in micronutrient deficiency in food grains, thereby increasing micronutrient malnutrition among consumers. However, now is the high time when agriculture should concentrate on a new paradigm that will not only focus on food production, but deliver better quality food as well. Introducing biofortified staple crops with increased nutrition content can therefore have a very big impact, as the strategy relies on improving an already existing food supply (Nestel *et al*., 2006). Biofortified staple foods may not deliver equally high levels of minerals and vitamins per day, compared to supplements or fortified food products, but they can increase micronutrient intake for the resource-poor people who consume them daily, and therefore complement existing approaches (Bouis*et al*., 2011). In general human being requires diverse and well-balanced diet, containing complex mixture of both macro and micro nutrients in order to maintain optimum health, this includes 17 minerals and 13 vitamins are essential micronutrients. Also Soil micronutrient deficiencies limit crop productivity and nutritional quality of foods, which together affect nutrition and human health. Biofortification is a feasible and cost-effective means of delivering micronutrients to populations that may have limited access to diverse diets and other micronutrient interventions. The prime objective of biofortification is the nutritional enrichment of crops to address the negative economic and health consequences regarding vitamins and mineral deficiencies in human beings that can have a measurable impact on nutritional status.

The term biofortification refers to nutritionally enhanced food crops with increased bioavailability to the human population that are developed and grown using modern biotechnology techniques, conventional plant breeding, and agronomic practices. As fruits and vegetables are the sources of carbohydrates, and are needed for providing energy to the body, including the nervous system and brain. These foods also provide significant amounts of dietary fiber that helps to improve digestive function and lower the risk for high cholesterol, heart disease, obesity, and diabetes. These are the store house of natural vitamins (vitamin A, folate, vitamin C, etc.), minerals, such as iron (Fe), zinc (Zn), selenium (Se), iodine (I), and potassium (K), which act as antioxidants that help to limit cell damage from free radicals. Numerous early studies revealed that there is a strong link between eating fruits and vegetables and protection against cancer. Therefore, the presence of fruits and vegetables in the diet make it complete and balanced. Fruits and vegetables have rich sources of genetic diversity for micronutrients, and hence they are highly amenable for biofortification through conventional and marker-assisted breeding programs of crops for combating malnutrition problem.

Micronutrients in Human Nutrition:

Over two billion people around the world suffer from“hidden hunger” or micronutrient deficiencies. Theydo not get enough micronutrients from the foods they eat to lead healthy, productive lives. Micronutrients are vitamins and minerals such as vitamin A, zinc, and iron. Although they are only required by the body in very small amounts, they are essential to good health and preventing illness. Many of the symptoms of micronutrient deficiencies cannot be seen such as lower IQ, lower resistance to disease, and fatigue.

Strategies for Biofortification

- **Agronomic Biofortification:**The success of agronomic biofortification mainly depends upon the mobility of mineral elements in the soil and in plants. Zinc, (foliar applications of Znso4), Iodine (Soil application of iodide or iodate), Selenium (as selenate) are the most suitable micronutrients for agronomic biofortification. In fruit and vegetable, mineral concentration was effectively increased by synthetic metal chelators such EDTA- Fe- and Zn-chelates. Foliar application is the quick and easy method of nutrient application to fortification of micro nutrients (Fe, Zn, cu, etc.) in plants. Also mycorrhizal associations have been noticed to increase the concentrations of Fe, Se, Zn, and Cu in crop plants. AM-fungi increase the uptake and efficiency of micronutrients like Zn, Cu, Fe, etc.

- **Conventional plant breeding:** Since the previous 40 years, traditional breeding has mostly emphasised yield traits and resistance breeding, with less emphasis on nutritional aspects, which has resulted in a decline in nutrient status in the existing varieties. Fortification with essential vitamins, antioxidants, and micronutrients is getting more interest as a consequence of recent advancements in traditional plant breeding. There must be sufficient genetic variation in cultivars' concentrations of β-carotene, other functional carotenoids, iron, zinc, and other minerals that makes it possible for the selection of breeding materials that are nutrient-dense. This genetic variation is necessary for conventional breeding to increase the micronutrient content of staple foods. Fe and Zn levels and up to a 6.6-fold variation has been reported in beans and peas. Apparently, this genotypic variation is generally more reduced in tubers and in fruits (e.g. Fe, Zn, Ca and Mg concentrations in strawberry differed less than 2-fold.
- **Genetic engineering:** Genetic engineering offers a viable alternative for improving the concentration and bioavailability of micronutrients in the edible crop tissues when there is insufficient variation among genotypes for the desired character/trait within the species or when the crop itself is not suitable for conventional plant breeding (due to lack of sexuality; for example, bananas).Golden rice, which was developed to produce beta-carotene or provitamin A in the edible part of the grain, was one of the first biofortified crops. Since then, other crops have experienced comparable triumphs, providing us with a variety of foods fortified with carotenoids as well as crops fortified with other micronutrients like vitamin Eand folate. In the same way this approach is also being applied to other crops, including maize, orange, cauliflower, tomato, yellow potatoes and golden canola etc.

Biofortified Varieties in Horticulture

- **Pomegranate:** Solapur lal (Hybrid) developed by ICAR-National Research Centre on Pomegranate, Pune are suitable for adaption in semi- arid parts of country. This hybrid rich in iron content (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 in comparison to 2.7-3.2 mg/100g, 0.50- 0.54 mg/100g and 14.2-14.6 mg/100g, respectively in popular variety Ganesh.

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- **Sweet Potato:** Bhu Krishna and Bhu Sona developed by using pure line breeding at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala. Variety Bhu Krishna rich in anthocyanin content (90.0 mg/100g) in comparison to popular varieties which have negligible anthocyanin content along with dry matter content 24.0-25.5%, starch: 19.5% and total sugar: 1.9-2.2%. This variety also exhibit salinity stress tolerance. Similarly variety Bhu Sona rich in high β-carotene (14.0 mg/100 g) content as compared to 2.0-3.0 mg/100 g β- carotene in popular varieties along with 27.0-29.0% dry matter content, 20.0% starch and 2.0-2.4% total sugar content.
- **Cauliflower:** Pusa Beta Kesari 1 (Pure line variety) developed by ICAR-Indian Agricultural Research Institute, New Delhi. This variety contains high β-carotene (8.0-10.0 ppm) in comparison to negligible β-carotene content in popular varieties.
- **Lentil:** Pusa Ageti Masoor (Pure line variety) developed by ICAR-Indian Agricultural Research Institute, New Delhi for Uttar Pradesh, Madhya Pradesh, Chhattisgarh region. This variety contains 65.0 ppm iron as compared to 55.0 ppm iron in popular varieties.

Conclusion

Traditional agricultural practices can partly enhance the nutritional content in plant foods but biofortification is a practice of nutrient fortification into food crops using agronomic, conventional and transgenic breeding methods to provide a sustainable and long term strategy to address negative impacts of vitamin & nutrient deficiencies. Biofortification works have been practiced in on several horticultural crops like Pomegrnate, Cauliflower, sweet potato, lentil, etc. several conventional and transgenic varieties have been released, while additional varieties are in the pipeline. In the future, mineral and vitamin deficiencies are expected to be more threatening, and biofortification strategy is a potential tool for supplying naturally fortified food to those who have limited access to commercially marketed fortified foods, which are more easily accessible in cities. This method is useful for addressing malnourished populations in relatively remote regions throughout the world.

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