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# Provitamin A Maize Development: A Strategy for Fighting against Malnutrition in Nepal

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## Abstract

This review paper briefly highlights the importance, challenges and opportunities for adoption of provitamin A rich maize, and potential breeding strategies suitable in the context of Nepal. The biofortified maize with provitamin A could be the convenient, cheaper, and easily accessible source of vitamin A. It can provide a cheap and sustainable form of vitamin A for its deficiency prone communities. Unavailability of suitable maize varieties rich in provitamin A and insufficient nutrition education to the consumers are the major challenges for adoption of provitamin A maize. The introduction, development and commercialization of provitamin A rich maize varieties in collaboration with national and international scientists, CG centers, multinational companies, I/NGOs, government agencies, and private sectors can help to fight against vitamin A induced malnutrition in Nepal.

***Key words***: Provitamin A maize, Malnutrition

## Introduction

Malnutrition impairs an individual's ability to function resulting in poor work performance, reduced learning capacity and inadequately developed life skills thereby negatively affecting the quality of life and the socio-economic development of the country. According to MOHP (2006), the most common forms of malnutrition are protein energy malnutrition, iodine deficiency disorders, vitamin A deficiency (VAD), and iron deficiency anemia. Animals including human beings are unable to synthesize their own vitamin A and rely on dietary pro-vitamin A carotenoid pigments. Vitamin A deficiency occurs when the dietary intake of vitamin A is less than the body requirement or if the body cannot absorb vitamin A properly due to disease or infection. In comparison to young people, children are at a greater risk of death due to vitamin A deficiency because of poor functional immune system of children and unable to fight common childhood infections such as measles or diarrhea.

The provitamin A is the precursor of vitamin A where as retinol is the active form of it. Beta carotene is the most powerful precursor of vitamin A. The precursors of vitamin A have effects similar to the vitamin itself. Provitamin A is an antioxidant fighting against diseases by neutralising free radicals (unstable oxygen molecules). This antioxidant property reduces the risks of cancer, preventin-g bladder, mouth, larynx, lungs, breast, oesophagus and colon tumours. Vitamin A is essential for the normal functioning of the visual system and is required for growth, development, immune function, and reproduction. VAD can cause night blindness possibly leading to corneal blindness, as well as stunted growth among affected children (West, 1991; West and Darnton-Hill, 2008).

It also intervenes on the wound healing process and protects the skin against the sun for instance. It protects cerebral cells from damages linked to the age and reduces heart attack risks and cerebro-vascular accidents. Recommended Dietary Allowances (RDA) for vitamin A are given as mcg of retinol activity equivalents (RAE) to account for the different bioactivities of retinol and provitamin A carotenoids (Table 1).

### *Challenges for development and adoption of provitamin A maize*

The provitamin A carotenoids are sensitive to light and air. Sun drying or high-temperature drying of maize grain decreases the amount of carotenoids. The cooking methods of food preparation also results in some loss of provitamin A carotenoids. Therefore, the retention of provitamin A in maize kernels is essential which is influenced by genotype and environmental factors such as temperature, exposure to sunlight in the field and during post harvest handling. It is necessary to identify, introduce or develop new maize varieties rich in provitamin A that is adaptive to our agro-ecological niches and farmers' condition. It should also be economically potential.

The production of provitamin A crops will increase when communities accept to grow biofortified crops. Nutritional improvement at the cost of higher yields will potentially drag the adoption of provitamin A crops. Nutrition education is an important factor that affects the adoption and acceptability of biofortified crops (Tanumihardjo, 2008). If the mothers are educated about the importance of vitamin A, they will easily accept the biofortified crop (Chowdhury *et al.*, 2011). It is important for communities to be educated and convinced that the consumption of vitamin A enriched crop variety may result in improved nutrition and health (Tanumihardjo, 2008).

Limited research on biofortification, weak and inadequate physical infrastructure, laboratory for genetic engineering works along with poor extension mechanism also limit the research and dissemination of provitamin A enriched maize in Nepal. There is always risk of reluctance for consuming provitamin A maize without providing proper education to the consumers.

### *Opportunities of provitamin A maize*

Biofortification of staple food grains can be an effective way to provide essential nutrients to consumers whose diets rely heavily on these grains. The development of maize varieties that are biofortified with high concentrations of provitamin A carotenoids can be regarded as a key approach toward alleviating VAD (Pfeiffer and McClafferty, 2007). In the context of Nepal, provitamin A rich maize varieties can be demanding for food and feed in future.

National Maize Research Program (NMRP), Nepal has qualified human resources for developing new maize

**Table 1**. Recommended Dietary Allowances (RDAs) for Vitamin A

| Age | Male | Female | Pregnancy | Lactation |
|---|---|---|---|---|
| 0–6 months* | 400 mcg RAE | 400 mcg RAE | | |
| 7–12 months* | 500 mcg RAE | 500 mcg RAE | | |
| 1–3 years | 300 mcg RAE | 300 mcg RAE | | |
| 4–8 years | 400 mcg RAE | 400 mcg RAE | | |
| 9–13 years | 600 mcg RAE | 600 mcg RAE | | |
| 14–18 years | 900 mcg RAE | 700 mcg RAE | 750 mcg RAE | 1200 mcg RAE |
| 19–50 years | 900 mcg RAE | 700 mcg RAE | 770 mcg RAE | 1300 mcg RAE |
| 51+ years | 900 mcg RAE | 700 mcg RAE | | |

** Adequate Intake (AI), equivalent to the mean intake of vitamin A in healthy, breastfed infants.* (Source: IOM, 2001)

varieties. They can also contribute in the process of development, evaluation and dissemination of provitamin A maize varieties. Government of Nepal has increased the research funds substantially in recent years, increased collaboration with CIMMYT, multinational companies, I/NGOs and qualified manpower trained at foreign countries increased the scope of developing provitamin A maize varieties in our country Nepal.

## Strategy for provitamin A maize promotion in Nepal

### *1. Introduction, evaluation and dissemination*

In this breeding method, the introduced or existing genetic materials are tested under a series of trials; observation nursery (OBN) for two years, initial yield trials (IYTs) for two years, coordinated varietal trials (CVTs) for two years and coordinated farmer's field trials (CFFTs) for two years. In fast track breeding approach, plant breeders screen the introduced existing crop varieties, lines and/or accessions under OBN in the first year for one season. Then materials are tested directly in CVTs and CFFTs for two years. In the same year, the best materials can be screened from OBN in CFFTs. After testing materials in CVT and in CFFTs for two years, proposals are prepared and submitted to the national seed board for release. In this method, testing of materials in initial yield trial for two years is not necessary. Thus it takes only three years to release a variety instead of eight years in conventional method.

### *2. Breeding for provitamin A maize*

#### *a. classical methods*

Classical plant breeding uses crossing of closely or distantly related individuals to produce new crop varieties or lines with desirable properties. Plants are crossbred to introduce traits/genes from one variety or line into a new genetic background. In this approach the parent lines with high Provitamin A level are crossed over several generations to produce plants that have the desired provitamin A content along with desired agronomic traits.

#### *b. Molecular methods*

Marker assisted selection (MAS) is an indirect selection process where a trait of interest is selected, not based on the trait itself, but on a marker linked to it ( Ribaut and Hoisington, 1998). MAS is considered as a key approach for efficient breeding for high levels of provitamin A carotenoids in maize (Prasanna *et al.*, 2010). The use of marker-assisted selection (MAS) in breeding for provitamin A concentration in maize became possible after Harjes *et al.* (2008) published results of association mapping research, and PCR-based markers were subsequently developed to enable selection for favorable alleles of *LycE* (lycopene epsilon cyclase), a crucial gene that governs partitioning of alpha and beta carotene branches in the carotenoid biosynthetic pathway.

Generally the breeding strategy for developing provitamin A includes;

- Intra-population recurrent selection; it aims to compare the effectiveness of full sib vs. S1 recurrent selection for improving provitamin A.
- Conversion of white lines and yellow open pollinated varieties to enhanced pro-vitamin A content.
- Pedigree breeding; it is a technique that plant-breeders employ during inbreeding of biofortification of maize with provitamin A carotenoids.

## Conclusion

Among the various malnutrition problems, vitamin A deficiency is one of the serious dietary problems in Nepal. Development of maize varieties with increased pro-vitamin A carotenoids can provide a sustainable solution to eliminating vitamin A deficiency in the country. Therefore research should focus on biofortification of the identified crops like maize. The collaborative research led by scientist of NMRP in collaboration with CGIAR systems, other government agencies, private sectors and I/NGOs can tackle the malnutrition problems of Nepal through developing provitamin A maize varieties.

## References


Chowdhury, S., J. V. Meenashi , K. I. Tomlins and C. Owori 2011.“Are Consumers in Developing Countries Willing to Pay More for Micronutrient-Dense Biofortified Foods? Evi- dence from a Field Experiment in Uganda,” American Journal Agricultural Economics. ***93(1)***:83-97. http://dx.doi.org/10.1093/ajae/aaq121

Harjes, C. E., T. R. Rocheford , L. Bai, T. P. Brutnell , C. B. Kandianis , S. G. Sowinski, A. E. Stapleton , R. Vallabhaneni, M. Williams, E. T. Wurtzel , J. Yan and E. S. Buckler 2008. Natural genetic variation in lycopene epsilon-cyclase tapped for maize biofortification. Science **319 (5861):** 330-3. http://dx.doi.org/10.1126/science.1150255

IOM. 2001. Institute of Medicine, Food and Nutrition Board. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: National Academy Press; 2001.

MOHP. 2006. Ministry of Health and Population. Nepal Demohraphic Health Survey 2006.

Kathmandu, Nepal: Ministry of Health [Nepal], New Era and Micro International; 2007.

Pfeiffer, W. H. and B. McClafferty 2007. HarvestPlus: Breeding Crops for Better Nutrition.Crop Science 47(Supplement_3): S–88. Available at *https://www.crops.org/publications/cs/abstracts/47/Supplement_3/S-88 (verified 8 August 2011*).

Prasanna, B. M., K. Pixley, M. L. Warburton and C. X. Xie 2010. Molecular marker-assisted breeding options for maize improvement in Asia. Molecular Breeding. ***26(2)***: 339–356. Available at *http://www.springerlink.com/index/10.1007/s11032-009-9387-3* (verified 19 September 2012). http://dx.doi.org/10.1007/s11032-009-9387-3

Ribaut, J.M. and Hoisington, D. A. 1998. Marker assisted selection: new tools and strategies. Trends Plant Sci., 1998, ***3***:236–239. http://dx.doi.org/10.1016/S1360-1385(98)01240-0

Tanumihardjo, S. A. 2008. “Food-Based Approaches for En- suring Adequate Vitamin A Nutrition,” Comprehansive Reviews in Food Science and Food Safety. ***7(4)***: 373-381.

West, K. P. 1991. Dietary vitamin A deficiency: effects on growth, infection, and mortality. Food and Nutr. Bull. ***13(2)***.

West, K. P. Jr. and I. Darnton-Hill 2008. Vitamin A deficiency. In: Semba, R.D., M.W. Bloem (eds). Nutrition and Health in Developing Countries. Second edition. Humana Press. New Jersey, USA. http://dx.doi.org/10.1007/978-1-59745-464-3_13