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STAKEHOLDER MEETING

Biofortification:
Linking Agriculture to Human Health and Nutrition

Agenda Item: **6c– Biofortification**

This item is for: Information [X] Discussion [ ] Decision [ ]

Proposed Action: None

Background: The attached note gives an overview of the micronutrient malnutrition problem and how biofortified crops can help address it. This is a background document to a presentation and discussion of biofortification in Parallel Session.

Comments:

Harnessing Agricultural Technology to Improve the Health of the Poor
Biofortified Crops to Combat Micronutrient Deficiency

Micronutrient malnutrition: The hidden hunger

Malnutrition affects nearly half the world's population. More than 840 million people do not have enough food to meet their basic daily needs. An estimated 2 billion people, who do have enough food, still suffer deficiencies in micronutrients. Mostly women and children in sub-Saharan Africa, South and Southeast Asia, and Latin America and the Caribbean, these people are at risk of disease, premature death, and lower quality of life as a result of nutritional deficiencies in vitamin A, iodine, and iron.

Reducing the cost of combating micronutrient malnutrition

There are principally three ways to fight micronutrient malnutrition: supplementation, fortification, and food-based approaches.

Current efforts to address problems of micronutrient malnutrition in the developing world have focused principally on providing vitamin supplementation for pregnant women and children under the age of 5 years and on the fortification of foods through postproduction industrial food processing.

Both supplementation and commercial fortification programs have made significant gains in combating micronutrient deficiencies, and the benefits are quite high compared to costs. One drawback to supplementation and fortification approaches, however, is that they incur the same recurrent costs year after year. By conservative estimates, these costs amount to US$50 million annually in South Asia alone, if all persons requiring treatment for vitamin A and iron deficiencies are to be reached.

Where adequate industrial infrastructure and well-established markets for food processing and delivery exist, food fortification has experienced great success in improving the micronutrient intake of vulnerable populations, particularly among the urban poor in developing countries.

This approach is especially effective in countries where the poorest people mostly purchase small amounts of processed foods to supplement their diets. Unfortunately, though, in the poorest developing countries, where the majority of the poor are dependent on their own produce for food, consumption of industrially processed foods is minimal.

Biofortified crops—varieties bred for increrased mineral and vitamin content—provide higher levels of micronutrients in the foods that the poorest people grow and consume daily. It can complement the other approaches by providing a sustainable and low-cost means of reducing the number of persons requiring treatment through supplementation and commercial fortification. Once the fixed investments are made in developing micronutrient-rich staple food crops at central research locations, recurrent costs are low, and benefits can be made available to all developing countries around the world.

A new paradigm for agriculture: Improving human health

Nutrition expert Dr. Gerald Combs of Cornell University in the USA argues that "improved health can be addressed by changing the paradigm for agriculture from that of only increasing production to one that marries production with improved health in sustainable ways."

Agriculture provides the nutrients that are essential for human life. That is why agricultural innovations offer the promise of sustainable solutions to nutritional problems. Breakthroughs in plant breeding and nutritional genomics promise to simplify and hasten the development of micronutrient-rich varieties and improve nutrient availability in current varieties. For example, advanced biotechnology tools, such as genome mapping and marker-assisted selection, now make it possible to identify, select, and transfer desirable traits, including those linked to high micronutrient content, from one variety to another.

The ability of crop research to screen for and improve the nutrient content of staple crops has been amply demonstrated in several cases:

- Iron-rich rice (IRRI)
- Quality protein maize (CIMMYT)
- High-carotene sweet potato (CIP)
- High-carotene cassava (CIAT)
- Zinc-efficient wheat (Adelaide University).

Preliminary research, funded by Danish International Development Assistance (Danida) and coordinated by IFPRI in collaboration with several Future Harvest centers, has aimed to determine the scientific feasibility of a plant breeding approach for improving the micronutrient content of staple crops. Recent findings of this work indicate that

1. Substantial useful genetic variation exists in key staple crops.
2. Breeding programs can readily manage nutritional quality traits, since most traits are highly heritable and simple to screen for.
3. These traits are stable across a wide range of environments.
4. Traits for high nutrient content can be combined with superior agronomic characteristics and high yields.

Now that the genes controlling high nutrient content have been identified for many staple crops, marker-assisted selection can be used to efficiently select and transfer genes for high content of desired micronutrients into new varieties. Researchers continue to examine the likely impacts of micronutrient-rich varieties on human nutrition—including nutrient bioavailability in the human body.

A multipartner consortium to develop biofortified crops

Given research results indicating that it is quite feasible to produce new varieties of staple crops with high micronutrient content, a consortium of institutions has been formed to develop and deploy biofortified crop varieties and demonstrate their impact in human diets. CIAT and IFPRI will coordinate the plant breeding, nutrition, and policy analysis activities to be carried out at eight CGIAR-sponsored Future Harvest centers and a range of developed and developing country institutions and NGOs (see the accompanying list of project participants and figure showing collaborative linkages). This consortium combines expertise in plant breeding, plant genomics, human nutrition, social behavior, and policy analysis in a common endeavor to use agriculture as a vehicle for improving human health through nutrition.

The consensus among plant scientists and other project members is that breeding of biofortified crops can begin to produce demonstrable results in the near term, achieving intermediate increases in micronutrient levels of up to 40 percent within the first 4 years. By the end of the project's third phase (year 10), increases are expected to be not less than 80 percent over current levels. Studies of factors affecting the bioavailability of increased micronutrients and measuring the nutritional impact of improved varieties will be conducted throughout the project to ensure the desired positive impacts on public health.

Initially, six staple crops for which prebreeding feasibility studies have been conducted are targeted for this biofortification approach: beans, cassava, maize, rice, sweet potato, and wheat. The project also includes prebreeding work to develop the knowledge base to enhance micronutrient content in an additional nine crops important in the diets of those suffering from micronutrient deficiencies: barley, cowpeas, faba beans, groundnuts, lentils, millet, pigeon peas, sorghum, and yams. As the feasibility of biofortifying these crops is demonstrated, additional funding will be sought to bring them into development and deployment.

What will be achieved?

Following is a summary of the objectives of the multipartner project to develop and deploy biofortified crop varieties:

Short term (1-3 years)

- Nutritionally optimal breeding objectives determined.
- Understanding of genotype-by-environment interactions, cultural and processing practices, and their effect on micronutrient content and bioavailability.
- In vitro and animal studies of bioavailability of enhanced micronutrients in promising lines.
- Genetics of high micronutrient levels understood and markers available to facilitate transfer of traits through conventional and/or novel means.
- High-yielding, adapted varieties with up to 40 percent higher micronutrient levels released to farmers and field and nutritional impact evaluations begun.

Medium term (4-6 years)

- Bioefficacy studies conducted to determine improved varieties' effects on micronutrient status of human subjects in test sites in Africa, Asia. and Latin America.
- New biofortified varieties adapted to specific regions of the developing world and showing highly desirable agronomic traits (e.g., drought resistance) released to farmers.
- Participatory breeding under way.
- Gene systems identified with potential for increasing nutritional value beyond traditional breeding methods.

Long term (7-10 years)

- Scaling up production and distribution of improved varieties with at least 80 percent increase in target micronutrients over current levels.
- Adoption of nutrititionally improved varieties on 1.5 million hectares per crop.
- Effective communications programs promoting consumption of nutritionally improved varieties under way.
- Nutritional impact studies undertaken to identify factors affecting adoption, impact on household resources, and health effects on individuals.
- Transgenic varieties produced at the experimental level crossed with high-yielding, adapted lines and screened for high micronutrient content.
- Experimental field testing of transgenic cultivars to ensure compliance with biosafety regulations.

Costs of the biofortification approach

The biofortification approach involves a set of one-time, fixed costs in developing breeding methodologies, breeding nutritional quality traits into current crop varieties, and adapting these varieties to diverse environments. No large, recurrent investments are required after nutritious varieties have been initially disseminated, and the costs do not increase with the number of people treated.

To achieve the full benefits of the plant breeding approach for poor people in developing countries will require an investment of up to US$1.4 million per year per major staple crop over 8-10 years. Varieties of six nutritionally enriched staple crops—beans, cassava, maize, rice, sweet potato, and wheat—would cover roughly 90 percent of the population at risk from micronutrient malnutrition in the developing world.

Diffusion of the micronutrient-rich varieties occurs through the same channels that have led to widespread use of CGIAR materials throughout the developing world.

Acceptance of micronutrient-rich varieties

A major advantage of improving the micronutrient content of staple crops is that the resulting varieties stand a high chance of being adopted by farmers in target regions.

These crops are already produced and consumed by the majority of poor households in the developing world. Because changes in mineral content need not alter the appearance, taste, texture, or cooking quality of improved staples, they should be fully acceptable to consumers and markets. Particularly where scientists can combine high micronutrient content with high yield, farmer adoption and market success of nutritionally improved varieties are guaranteed.

One way to ensure that nutritionally rich varieties are attractive to farmers is through participatory plant breeding. This approach integrates farmers' perspectives and preferences into the breeding process. Much experience suggests that in some situations participatory plant breeding can also be more cost-effective than conventional breeding.

Mechanisms for delivering micronutrient-rich varieties

One constraint of supplementation and fortification programs is that shortcomings in delivery often prevent them from reaching the poorest people. With micronutrient-rich varieties, in contrast, the delivery mechanism is built into the whole process, so that little intervention (and investment) is required once farmers have adopted the new seed. Micronutrient-rich seed can easily be shared and saved by even the poorest households.

To aid this process the Future Harvest centers can apply the considerable experience they have gained in building and promoting effective local seed systems and in helping restore seed systems following disasters.

Small farmer seed enterprises in particular will be crucial for disseminating seed of micronutrient-rich varieties among farmers. One proven way to promote the development of such enterprises and the dissemination of new seed is through local agricultural research committees.

Conclusion

Biofortification, or plant breeding to increase micronutrient content in food staples, is an obvious first step in building a food systems approach to reducing malnutrition. This approach addresses the root causes of micronutrient malnutrition, targets the poorest people, involves built-in delivery mechanisms, and is scientifically feasible and cost-effective. As part of an integrated food systems approach, it represents the best means for enabling rural households to improve family health and nutrition in sustainable ways.