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# Improving human nutrition through agriculture: The role of international agricultural research. Conference summary and recommendations

Howarth E. Bouis

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## Abstract

*This paper reports the conference recommendations for priorities for future research and follow-up actions. It also summarizes the paper presentations and key points made by participants during the course of the conference. It includes partial transcripts of invited remarks made by several participants who were not asked to submit research papers. With respect to research, participants recommended continued efforts on breeding for nutritionally improved crop varieties, evaluation of the impact of the Consultative Group on International Agricultural Research (CGIAR) activities on nutritional outcomes, and new work on communication and outreach related to nutrition. Interdisciplinary research collaboration with non-CGIAR partners in these three broad areas was stressed. The need for a shift in emphasis from protein–energy malnutrition to micronutrient malnutrition was recognized. With respect to institutionally related follow-up actions, formation of an interdisciplinary task force was recommended to implement a process for development of a multidisciplinary common conceptual framework describing agriculture–nutrition linkages, which could then be used for evaluating integrated approaches to nutrition improvement; and to seek approval from the CGIAR Technical Advisory Committee for a system-wide initiative on human nutrition that would include partners from outside the CGIAR. Progress since the conference is reported.*

## Introduction

A primary objective of this final chapter in the conference proceedings is to report the results of the group discussions—identification of research gaps and recommendations for priorities for future research

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and follow-up actions—which took place on the last day of the conference. In this context, it also useful first to summarize and highlight key points made by participants during the course of the conference.

## Summary of Consultative Group on International Agricultural Research (CGIAR) research related to human nutrition and outside perspectives on that research

### An overview of agriculture–nutrition linkages and micronutrient malnutrition: institutional and disciplinary perspectives

On the first morning of the conference, the First Lady of the Philippines, Dr. Luisa P. Ejercito Estrada, gave the keynote address on “The Political Commitment to Improving Nutrition” to open the conference. At the end of the morning session, four persons gave invited remarks on “Perspectives from Outside the CGIAR.” Following are selected excerpts from these presentations and from several of the papers, which help to motivate a summary of key points made during this morning session follow.

#### *Luisa P. Ejercito Estrada, First Lady of the Philippines*

As a medical doctor, I am committed to helping save lives and improving the health of people. As First Lady, I am often moved especially to improve the health and quality of life of our poor citizens. I fully support our President in his fruitful undertakings, more specifically in providing health and medical services to poor families and communities. One of my regular projects is to bring medical and relief missions throughout the country, particularly to poor communities that are not reached by the regular public health and medical centres. The “Wheat Flour Fortification with Vitamin A Project” was one of the first major activities of the Estrada administration in its first 100 days.

There is certainly no doubt that agriculture has to be listed as a viable input in the campaign against micro-

nutrient malnutrition. After all, agricultural crops and products are what provide the basic micronutrients needed for nutrition and better health. To achieve this, two basic strategies should logically be pursued. First, breed and develop more nutrient-dense crops, especially rice, corn, and root crops. Second, promote and encourage the production of micronutrient-rich food products, including livestock, poultry, fish, and certain vegetables and fruits, especially those that can be easily raised in backyards and community gardens.

**Muhiuddin Khan Alamgir, State Minister for Planning, Bangladesh**

Bangladesh's Constitution has recognized "raising of the level of nutrition and improvement of public health" as "among primary duties" of the state. The usual perception that nutrition status cannot be improved without prior income generation and poverty reduction was *not* given operational significance. Based on experience in the recent past in application of direct health and nutritional measures, the programmes taken up underscored the need for simultaneous approaches covering all relevant areas and long- and short-term activities. In all these, emphasis has been on coordinated actions instead of vertical and stand-alone programmes. The role given to agriculture in this Policy and Plan of Action is thus vital, complementary, and cohesive. An important component is an approach integrating public food security support and agricultural extension services with the health- and nutrition-related programs (deworming and immunization, for instance).

In pursuing these programmes in the field of agriculture, cooperation and support from international research institutions are called for in a number of areas. They include improvement of food grain quality with more digestible protein, integrated plant nutrients and soil quality, higher photosynthetic efficiency, nitrogen fixation by non-legumes, development of stress-tolerant strains of seeds, management of soil and plant nutrients based on balanced use of organic nutrients, and genetic engineering and technology as of special importance.

**Barbara Schneeman, Assistant Administrator for Human Nutrition, US Department of Agriculture–Agricultural Research Service (USDA-ARS), and Eileen Kennedy, Deputy Under Secretary, Research, Education, and Economics, US Department of Agriculture**

The first era of research in the United States emphasized increasing yield, using the development of germplasm and production methods to provide sufficient food (a parallel in international development is the Green Revolution). The second era has brought efficiency into focus, using technology and research innovations to maximize output and minimize inputs. The third era is emerging and focuses, not only on

yield and efficiency, but includes the quality and safety of our food production system, which includes nutritional value of food and insuring the quality of our environment.

Our systems must move beyond a focus on simply producing enough food to address fundamental issues of how to make the food system better able to meet the nutritional needs of consumers and contribute to sustainable environmental quality. Technology, derived from research on biological systems, genetics, and consumer needs, will drive this new era of development. The research challenge is great—we must sustain our achievements in yield and efficiency while improving the quality and safety of the food system.

Success in this third era will be determined by multidisciplinary research efforts and this effort is where more specific collaboration between the CGIAR and USDA will be essential. ARS has been experimenting with these multidisciplinary partnerships for at least 60 years—they are essential for designing viable solutions. More and more agricultural research will be called upon to not simply address nutrient deficiencies, but, from the point of view of the consumer, to promote health.[1]

**Yang Weimin, Director, Agriculture and Social Sectors Department (East), Asian Development Bank**

The Bank is proud of its annual commitment to support research through the CGIAR institutes, because the research relates to core Bank objectives: first, reduction of poverty by raising the productivity of staple crops and the household incomes of poor farmers and by lowering consumer prices for the poor working classes, especially in urban areas. Second, environmental protection, by paying special attention to the rational use of water resources in agriculture and the natural resource management of fragile ecosystems, such as forests, coastal, and upland habitats. Third, economic growth. A recent Bank review of the future prospects for rural Asia stressed the critical role of agricultural research and biotechnology to support social stability, integrate food markets, and promote rising incomes as rural and urban Asia become increasingly interlinked.

It seems to us that the issue of dietary quality and dietary diversification cannot simply be left to the market, where income dictates effective demand. The poor will be left behind. Their quality of life will improve disproportionately if agricultural research and technology produce seeds that will enrich the micronutrient content of affordable staple foods, especially rice.

**Robert Bertram, Office of Agriculture, US Agency for International Development (USAID)**

Our agency has been associated with the effort to bring agriculture and nutrition closer together for many

years. USAID supports agricultural research for three reasons: alleviation of hunger, increasing incomes and creating economic growth, and protecting the environment and conserving natural resources.

We recognize that these three objectives are interdependent.... But fundamentally, I would argue that it is the first objective—hunger, pervasive, chronic, food insecurity—that is the strongest factor generating support and interest from a development agency like USAID. What we are really talking about is human welfare—what it takes for people to live a healthy, productive, and even happy life. This is where nutrition comes in—the linkages among diet, health, and human development. We want to ensure that our investment in agricultural research leads to the most positive outcome for people. The issues that we are going to discuss this week are at the heart of this human connection to agriculture. A workshop such as this ensures that nutritional objectives remain squarely on the screen of agricultural researchers and the CGIAR in particular. At the same time, we hope that agricultural interventions will remain important arrows in the quiver that nutritionists consider when thinking how best to solve a problem.

**Per Pinstrup-Andersen, Director-General, International Food Policy Research Institute (IFPRI)**

What is different now 15 years after the last CGIAR-wide meeting on nutrition?... New and more powerful plant-breeding techniques are available today. The use of biotechnology is a much-debated and highly visible topic.... Our understanding of the nature of human nutrition problems is more complex. Micronutrient deficiencies are high on the public health agenda, alongside energy. Food-production, environmental, and human nutritional and health systems are increasingly strained as a consequence of population growth and the closing of the land frontier. Consequently, in finding solutions to problems that arise within these systems, it is more difficult today to ignore interdependencies among these systems. [2]

**Barbara Underwood, President, International Union of Nutritional Sciences**

Sustaining the progress that has been achieved will depend on underpinning the medical model with food-based approaches, which address multiple nutrient and phytochemical needs for optimal health. Agriculture by investing in the green revolution can rightly be credited for its contribution to reducing food shortages and the protein–energy malnutrition problem. A similar opportunity exists now for agriculture to invest in developing more micronutrient-dense staple crops, while not neglecting continued research on livestock and small animals, fish, vegetables and legume production. Education and awareness of the public is also crucial. The public must not be considered only

the “target” of imposed interventions. Civil society must become engaged in the process.[3]

**Ross Welch, Plant Physiologist, Plant, Soil, and Nutrition Laboratory, US Department of Agriculture–Agricultural Research Service, and Robin Graham, Professor, Department of Plant Science, University of Adelaide\***

Forging linkages among agriculture, nutrition, and health is necessary to nullify the adverse effects of past policies for global agriculture, nutrition, and national development that have fostered only short-term, unsustainable solutions to starvation, malnutrition, underdevelopment, and high human fertility rates. To do so would be to support a new paradigm for agriculture—the food systems paradigm—an agriculture that aims not only for productivity and sustainability but also for better nutrition, important objectives for the entire human race.[4]

**Lawrence Haddad, Director, Food Consumption and Nutrition Division, International Food Policy Research Institute (IFPRI)**

By way of income generation and food price reduction, it is clear that agricultural research has contributed to significant reductions in malnutrition. Food availability has improved in no small part due to agricultural research, despite rapid population growth in developing countries and severe constraints to increased production through land expansion. The question the participants at this conference must ask themselves is, “Can agriculture—helped by agricultural research—do even more?”[5]

## Summary of opening session

The opening session laid out the broad policy environment for the presentations and discussions to follow. The following key trends and conditioning factors are noted:

1. There has been a shift in focus away from protein–energy malnutrition to micronutrient malnutrition.
2. Cereal prices, adjusted for inflation, have fallen substantially over time as a result of the Green Revolution.
3. More powerful plant-breeding techniques are being developed, including but not restricted to biotechnology.
4. There is a better understanding of and increasing appreciation for the significance of interdependencies among nutrition, health, how food is produced and processed, what food is produced, and the environment.

\* The paper by Welch and Graham [4] was not presented at the conference but is included in this volume to provide a plant scientist perspective along with those of a nutritionist and an economist.

5. The problem of nutrition, and micronutrient malnutrition in particular, has the attention of government leaders and donor agencies.

The following points of agreement on policy are noted:

6. There is much that can be and must be done now to reduce malnutrition among the poor without waiting for increases in income, although higher incomes help to reduce malnutrition; targeting women through better education, among other means, is a key element.
7. Fortification and supplementation programmes are part of the answer to micronutrient malnutrition, but so is improved dietary quality; agriculture has been an important element of the strategy for addressing protein–energy malnutrition in the past (although protein–energy malnutrition persists) and will be an important element of the strategy for addressing micronutrient malnutrition in the future.
8. Greater integration of agriculture into the mix of policies for reducing malnutrition will require a greater degree of interdisciplinary communication and coordination among government, non-profit, and private agencies.
9. The required degree of coordination cannot be achieved without strong political support; securing this political support will depend in turn on public education about the costs of malnutrition and the benefits that agriculture and other interventions can provide.

The following points of disagreement as to degree are noted:

10. The extent to which the interdependencies cited in point 4 and collaboration and coordination cited in point 8 can be successfully addressed, as a practical matter.
11. The usefulness of pursuing “partial” solutions, while foregoing a holistic, food systems approach. A partial solution might include, but is not restricted to, treating single-nutrient deficiencies.

The conference recommendations indicate quite clearly the need for development of a common conceptual framework as a basis for better understanding and communication, research collaboration, and programme and policy coordination among disciplines.

### CGIAR research on staple food crops

In the first morning session, enthusiasm was expressed for incorporating agricultural strategies into the mix of interventions for reducing malnutrition. The next 17 papers in the proceedings present evidence on various aspects of one such strategy: breeding for nutritionally improved, micronutrient-dense staple food crops.

Bouis et al. provide the general arguments underpinning such a strategy, which are reproduced here:

The combining of benefits to human nutrition and agricultural productivity, resulting from breeding staple food crops that are more efficient in the uptake of trace minerals from the soil and that load more trace minerals into their seeds, results in extremely high *ex ante* estimates of benefit–costs ratios for investments in agricultural research in this area. This finding derives from the confluence of several complementary factors:

- » The rates of micronutrient malnutrition are high in developing countries, as are the consequent costs to human welfare and economic productivity.
- » High trace mineral density in seeds produces more viable and vigorous seedlings in the next generation, and efficiency in the uptake of trace minerals improves disease resistance, agronomic characteristics that improve plant nutrition and productivity in trace-mineral-“deficient” soils.
- » A significant percentage of the soils in which staple foods are grown are “deficient” in these trace minerals, which has kept crop yields low. In general, these soils in fact contain high amounts of trace minerals. However, because of chemical binding to other compounds, these trace minerals are unavailable to staple crop varieties presently used.
- » The adoption of nutritionally improved varieties by farmers can rely on profit incentives, either because of agronomic advantages on trace-mineral-deficient soils or incorporation of nutritional improvements in the most profitable varieties being released.
- » Because staple foods are eaten in large quantities every day by the malnourished poor, the delivery of enriched staple foods (fortified by the plants themselves during growth) can rely on existing consumer behaviour.
- » The benefits from relatively small investments in agricultural research may be disseminated widely, potentially accruing to hundreds of millions of people and millions of acres of croplands.
- » Breeding advances are derived from initial, fixed costs, with low recurring costs, and thus tend to be highly sustainable as long as an effective domestic agricultural research infrastructure is maintained.[6]

The three basic breeding strategies are to increase nutrient density, reduce antinutrients or inhibitors, and increase promoting substances. Papers by Gregorio et al. [7], Monasterio and Graham [8], Beebe et al. [9], Bänziger and Long [10], Cakmak et al. [11], Graham and Rosser [12], Chavez et al. [13], and Maziya-Dixon et al. [14] investigate the first strategy—that of increasing nutrient density for iron, zinc, and  $\beta$ -carotene in rice, wheat, maize, beans, and cassava. The topics addressed are the degree of genetic variability in these nutrients, the stability of genotype–environment interactions, and the genetics of high nutrient density. In general, genetic variability is sufficiently high and genotype–environment interactions are sufficiently

moderate that breeding for high nutrient density is deemed feasible and worthwhile. What data are available on genetics suggests that breeding for high levels of  $\beta$ -carotene, in particular, would be relatively easy.

The evidence on agronomic aspects of the breeding strategy, then, is very favourable. In fact, for rice, a high-yielding, disease-resistant, aromatic variety, already in the International Rice Research Institute (IRRI) testing programme, was serendipitously discovered—after a high correlation was found between the high-iron trait and aroma. Initial tests indicate that this rice delivers up to 80% more iron after milling than standard modern varieties.

A remaining question critical to the eventual success of the breeding strategy is the degree to which the extra iron and zinc in high-mineral-concentration seeds is bioavailable to humans. Papers by Welch et al. [15], King et al. [16], and Haas et al. [17] directly address this question, using increasingly realistic, but increasingly expensive, methodologies to test bioavailability. Welch et al. used a rat model. A small number of human subjects consuming single-food test meals were examined in a laboratory setting by King et al. Both of these studies used radiolabelled grain, the cost of which limits the amount of grain that can be used. Feeding trials of a relatively large sample of human subjects in the Philippines eating “normal” meals along with high-iron rice are planned by Haas, del Mundo, and Beard. The available evidence, although promising, is not yet definitive.

The second strategy, that of reducing antinutrients, is discussed in the paper by Raboy [18], who has pioneered the development of low-phytic-acid lines of maize and other cereals. The advantage of this strategy is that bioavailability may be increased simultaneously for a range of trace minerals. A disadvantage is perhaps a negative effect on productivity in phosphorus-deficient soils, although this aspect still requires additional research. As already mentioned, breeding for increased levels of trace minerals improves plant nutrition and productivity. The effects of breeding for higher levels of  $\beta$ -carotene are not expected *a priori* to be either positive or negative, although this issue has not been studied in depth. Breeding for higher levels of  $\beta$ -carotene changes observable consumer characteristics (colour), requiring consumer education, effects which are not an issue for breeding for lower phytates or increased trace minerals.

Hagenimana and Low [19] forego plant-breeding altogether, which results in considerable savings in terms of money for breeding research and the time it takes for their intervention to reach consumers. They follow a strategy of selecting improved orange-fleshed sweet potatoes that are already high in  $\beta$ -carotene; they implement a nutrition education programme to convince rural women to switch away from production of presently preferred white sweet potato varieties over

to the orange-fleshed varieties. The design of their education programme is key to the success of their strategy. A similar approach could also be taken with maize, cassava, and wheat, since high- $\beta$ -carotene lines already exist [12].

Vasal [20] discusses the history of the quality protein maize (QPM) breeding programme at the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) that predated efforts to breed for micronutrient density. Because of the initial trade-off between high-lysine and lower yields and undesirable consumer characteristics associated with high-lysine content, breeding of high-yielding, high-lysine lines with desirable consumer characteristics has been a long and arduous, but eventually successful, process. Livestock that consume QPMs thrive, making combined production of QPM and livestock profitable. Apart from relieving protein constraints to better human nutrition (e.g., provided in maize-weaning foods in parts of Africa), lysine (a sulphur-containing amino acid) may improve the bioavailability of minerals in human diets.

These first 15 papers concentrate on the use of conventional breeding or selection techniques. The final two papers, by Datta and Bouis [21] and Phillips [22], discuss the application of biotechnology to improving the nutritional quality of food staples. The potential benefits to consumers are great; some nutrition-improvement objectives may be met through biotechnology that cannot be addressed using conventional techniques. Other nutrition objectives may be met more quickly at lower cost once techniques are further refined. Nevertheless, use of conventional breeding and biotechnology should be seen as complementary techniques, which eventually can be used in tandem for maximizing a range of desirable nutritional characteristics in the same crop.

In getting plants to fortify themselves through plant-breeding, is it optimal to treat only single nutrient deficiencies, when better public health requires better provision of multiple mineral and vitamins? Indeed, this question may be raised of most conventional fortification and supplementation strategies in place today. Graham and Rosser [12] raise the possibility of nutritional synergies to be attained by simultaneously breeding for enhanced levels of iron, zinc, and  $\beta$ -carotene. This is seen as a high-priority research area involving feeding trials to identify the optimal breeding strategy that would maximize gains to nutritional improvements.

#### **CGIAR research on livestock, fish, vegetables, and other non-staple food crops**

Breeding for nutritionally improved staple food crops is only one relatively narrow, although apparently high-payoff, activity in the broad spectrum of agricul-

ture–nutrition linkages. This is brought out clearly by Haddad [5] in his conceptual framework, which provides examples of CGIAR research in a number of diverse areas: the time-allocation patterns and decision-making power of women, who are the primary care providers for children and other family members; nutrient losses during processing and preparation of food; health environmental effects of agricultural production; income generation for those engaged in agriculture; the effects on diets of changes in food prices and on own-consumption of producers whose cropping patterns have changed; and the effects of changing work patterns on nutrient and energy needs.

It is in this broader context that the eight papers presented on the afternoon of the second day of the conference should be seen. Eight papers cannot cover the entire spectrum of topics. Nor, as is pointed out later in the final plenary discussion on the third day, does stock-taking of CGIAR research at this conference cover all work that is being done by the CGIAR related to nutrition. Several, but not all, of the papers are commodity-focused, as are the mandates of the individual centres where the authors work. These papers demonstrate an impressive range of research activities related to human nutrition encompassed by CGIAR centres.

Ali and Tsou [23] and Fassil et al. [24] discuss a broad spectrum of centre-wide nutrition-related activities that are undertaken by the Asian Vegetable Research and Development Center (AVRDC) and the International Plant Genetic Resources Institute (IPGRI). The AVRDC has given a high priority to the human nutrition impacts of its research on vegetables. Some of these activities might well have been described in the previous section of these proceedings—breeding for nutrient-dense genotypes and testing bioavailability. However, vegetables are considered to be inherently rich sources of vitamins and minerals. Efforts to increase their consumption should have a beneficial impact on micronutrient status. Other agronomic-related research activities involve not only increasing vegetable yields and lowering unit production costs, but also finding ways to extend growing seasons and reduce the extreme seasonality in vegetable prices.

Socio-economic research has also been undertaken to analyse vegetable consumption patterns and the factors that drive these patterns. A model is proposed for assigning economic values to various nutrients contained in foods, values which in turn point the direction in which resources should be invested for maximizing nutrition benefits. Indeed, the model is used for assigning priorities for AVRDC research.

Cardwell [25] and Abd El Moneim et al. [26] describe plant-breeding activities of the International Institute of Tropical Agriculture (IITA) and the International Center for Agricultural Research in the Dry Areas (ICARDA) that are directed not at micronutri-

ent deficiencies but at reducing compounds that are detrimental to health in other ways—mycotoxins in maize in the case of Cardwell's research and a neurotoxin in grasspeas that can cause irreversible paralysis in the case of the research by Abd El Moneim et al. Although plant-breeding research is one approach being followed by the IITA to address the mycotoxin problem in maize, farmer participatory methods are also used to improve storage practices to reduce levels of mycotoxins in grains. In addition, an epidemiological study is under way to examine the effect of exposure to aflatoxin in maize-based production systems on the growth of children and on the immune response to vaccination.

A primary reason why the prevalences of micronutrient deficiencies are high in developing countries is that meat, dairy, and fish consumption is low. These products are highly desired but expensive. Not only are minerals and vitamins present at higher concentrations in meat, dairy, and fish products, but they are more highly bioavailable than minerals and vitamins contained in plant foods. Moreover, consumption of these products in the same meal with plant foods improves the absorption of minerals from plant foods. Ahmed et al. [27] and Prein and Ahmed [28] report on ongoing research related to human nutrition at the International Livestock Research Institute (ILRI) and the International Center for Living Aquatic Resources Management (ICLARM). Although ILRI and ICLARM activities that have led to growth in the supply of livestock and fish products can be presumed to have had substantial beneficial nutritional impacts on consumers, past research at these centres apparently has not given high priority to measuring these nutritional effects in the search for ways to enhance nutritional impacts.

Effects on dietary quality and other aspects of household resource allocation decisions are still being analysed. ICLARM research on measuring nutritional impacts is equally in its formative stages. A few studies have looked at the effects of projects on fish consumption itself but have not taken the further step of measuring impacts on the overall diet and then the impact of diet on measures of nutritional status.

The Bouis study in Bangladesh [29] of the nutritional effects of adoption of improved vegetable varieties and polyculture fish pond production is one of the first not only to measure the impacts of adoption on household income and food consumption, but also to link individual diets to blood haemoglobin, a proxy measure for iron status. By surveying both adopting households and a carefully selected sample of comparable non-adopting households, a reasonable assessment can be made of the impact of adoption on micronutrient status. The impact is small, primarily because the incomes of adopters are highly diversified. Although both technologies are apparently highly profitable, they as yet do not constitute

the major income-earning activity. Also, most of the extra production of these micronutrient-rich foods is sold—to the benefit of consumers. This is shown by regression estimations that link consumption of various foods to measurable impacts on blood haemoglobin.

Smitasiri [30], who has worked extensively on the promotion of food-based interventions for nutritional improvement through communication and education, commenting on the CGIAR presentations, argues that the cost of animal and fish products is simply too high for the poor, but that micronutrient-rich vegetable sources are well within their purchasing power. She points out that education and promotion are essential elements for successful food and nutrition interventions—education of the poor, education of various groups in the community, and education of the public at large.

Once resources are invested in food-based strategies, many operational issues, such as those raised by Smitasiri, arise as how best to optimize nutritional impacts. It may well be that the research should not concentrate on adopting households, but rather on the much larger number of poor consumers who benefit through lower food prices.

#### **Merging agricultural strategies with existing supplementation, fortification, and dietary diversification programmes**

Whereas the presentations reviewed above involved, for the most part, CGIAR scientists talking about contributions that their research could make to improving nutrition, there was a need to inform CGIAR scientists about the strengths and drawbacks of existing strategies and to discuss how agricultural strategies could be integrated in the present mix of interventions in a complementary way. The three broad types of interventions currently being emphasized to address the problem of micronutrient malnutrition are supplementation, fortification, and dietary diversification through nutrition education. There was a general consensus among the participants that no one particular type of intervention, including agricultural strategies, was the lone solution to the problem.

#### **An in-depth case study of the Philippine micronutrient strategy**

##### *Overview of Philippine policies and programmes*

Presentations were given by Corazon Barba [31], director of the Food and Nutrition Research Institute, on an overview of Philippine nutrition programmes, by Alex dela Cuadra [32] of the Department of Health on supplementation programmes in the Philippines, by Florentino Solon [33], director of the Nutrition Center of the Philippines, on fortification programmes, and

by Elsa Bayani [34], director of the National Nutrition Council, on food production and nutrition education policies, projects, and programmes. These four presentations were followed by shorter talks by six speakers representing various stakeholder organizations involved in various aspects of fighting micronutrient malnutrition. Brief excerpts from their remarks are given below.

Bayani provides a useful summary of the four initial presentations:

For the past six years, universal supplementation of vitamin A and selective supplementation of iodine using iodized oil capsules has provided immediate, although short-term, relief from micronutrient deficiencies. We have shown how such an effort can be mounted successfully through a National Micronutrient Day, but with the participation of national governmental agencies, local governmental units, local and international NGOs, the business community, and the people themselves. We have learned valuable lessons along the way, lessons that helped develop a more efficient system for procuring and distributing supplies, and more effective schemes of mobilizing participation to the activity. We have also shown that micronutrient supplementation can be integrated with other routine services of the health-care system. Micronutrient supplementation will continue to be an important intervention to address micronutrient malnutrition, shifting from a universal supplementation policy to a targeted one, within the next decade.

We have likewise set in motion actions to ensure that foods fortified with vitamin A, iron, and iodine will be available and accessible to the public, especially the nutritionally needy. Such actions range from technology development to technology testing, to market studies and clinical trials. Thus, today, we have a wider array of fortified foods in the market: iodized salt, iron-fortified rice, and vitamin A-fortified flour, sugar, margarine, cheese, milk, snack foods, instant noodles, and juice drinks, among others. Bringing fortified foods to the truly nutritionally needy, possibly through the mandatory fortification of staples like rice, flour, sugar, and cooking oil with iron and vitamin A, is a major challenge. We also need to further increase the demand for iodized salt, calling for the implementation and enforcement of a salt iodization law. [34]

#### **Corporate perspective: Benjamin Ynson, Genie Food Corporation**

Snack foods. They are the most controversial products on the market shelves today. On the one hand, they make you feel guilty to eat them. On the other hand, you have to have them. Should we ban them? Or could we reform them? We at Genie Foods believe that it is possible to re-engineer so-called junk foods and make them into a far better product, as close as possible to multivitamin tablets. We were able to enhance our snack product, which is the first snack to be approved by the Department of Health. It is fortified with vitamin A, iron, and iodized salt.

**Consumer perspective: Jamie Manuel, National Consumer Affairs Council**

The National Consumer Affairs Council, created under the Consumer Act of the Philippines, is mandated to improve the management, coordination, and effectiveness of consumer programmes not only in governmental agencies but in non-governmental agencies as well. October was declared Consumer Welfare Month by the President. This is the time when concerted efforts are made to assert consumer rights. During this month there are several agencies conducting seminars in coordination with our office on the topic of food safety that includes nutrition. We have also, through the assistance and advice of the Department of Education, adopted a programme to integrate the concept of consumer education in the curricula of public, elementary, and secondary schools, including private institutions.

**University perspective: Demetria Bonga, University of the Philippines at Diliman**

Academia has a cadre of technical people who can help rationalize and promote national nutrition intervention programmes such as the ones already discussed. We are recognized as a partner in discussions of policies and issues related to nutrition.

First, in the conduct of research work, universities can evaluate the extent of utilization of fortified foods and keep track of trends through time. The Department of Health plans to phase out supplementation. When should that happen? We don't know. We have to monitor the extent to which fortified foods are being consumed. For example, what is happening in the rural areas where micronutrient malnutrition is more severe? At the moment, fortified foods are more available in the urban areas. It is necessary to test whether fortified foods perform well in clinical trials. Academia can also assist in this. We need to know the extent to which fortification has reduced the prevalences of specific micronutrient deficiencies.

Second, universities have experts in mass communication who can design effective information dissemination campaigns for fortified foods. They can also help to develop appropriate information materials on fortified foods using a range of media outlets.

**Cost-effectiveness: Dyezebel Dado, Department of Health**

Initiated in 1993, the Philippine National Vitamin A Supplementation Program (NVASP) is one of the oldest, most mature, and most comprehensive of its kind. Originally the NVASP was to be maintained for three years. With the programme now entering its sixth year, the government is wavering in its commitment to continue financing. We conducted a cost-effectiveness analysis of NVASP and a hypothetical programme of vitamin A fortification of wheat flour to see what policies might work best or how they could be modified.

The effectiveness indicator used for the fortification programme was the number of people who consumed less than 70% of the recommended daily allowance of vitamin A. The analysis found that fortification is more than twice as cost-effective in reducing inadequate vitamin A intake as is the NVASP. However, fortification alone does not appear to be adequate. At what is considered the maximum acceptable fortification level, there would still be 2.2 million Filipino children aged 12 to 59 months (29%) who would have inadequate vitamin A intake.

An investigation of the cost-effectiveness of geographically targeted supplementation programmes covering urban areas, rural areas, and the poorest rural areas reveals that maintaining a universal supplementation programme in urban areas and only the poorest rural areas would reduce the total vitamin A programme (supplementation and fortification) costs by 30% and reduce the number of Filipino children with inadequate vitamin A intake to 900,000 (12%). These results suggest recommendation of a strategy that combines fortification and supplementation.

**NGO Perspective: Naida Pacsion, Chairperson, KAIN**

KAIN is a coalition of 14 local and international non-governmental organizations (NGOs) that work together on nutrition issues.

The goals of KAIN are to serve as a coordinating body for nutrition-related activities among NGOs in the country; to enhance the capability of member NGOs in the areas of programme planning, management, and institution-building; and to provide technical assistance to national and local governments, other NGOs, and people's organizations for nutrition-related interventions.

The NGO-government partnership works well, because the NGOs have close links with the grass-roots people—links that government agencies cannot have. NGOs have a proved capacity to mobilize communities. We have flexibility and the capacity to test innovative approaches without the burden of bureaucracy. We can pilot test programmes, find ones that work, and then bring them to the government for institutionalization.

**International aid perspective: Nancy Haselow, Helen Keller International**

Micronutrient malnutrition is a multifaceted problem that rarely stems from a single cause. Like the problem, the solution requires a multifaceted approach if we are to make sustainable strides towards reducing micronutrient malnutrition in countries, in communities, in families, among those most at risk and vulnerable. The solution requires that we forge alliances, build partnerships, and join forces with other stakeholders to use relevant research findings to design, test (pilot and evaluate), and implement a mix of effective interven-

tions that can all combine to alleviate micronutrient malnutrition.

International agencies can contribute to this end by translating academic research into pilot strategies for scale-up once proved to be effective. In this regard, nutrition research findings from the vitamin A supplementation impact studies (conducted in Indonesia, Nepal, India, etc.) were used to advocate for further investigation into the extent of vitamin A deficiency within many countries, which in turn provided fuel to convince policy makers to develop policies and national programmes to control vitamin A deficiency. Innovative interventions to control vitamin A deficiency, such as universal supplementation during National Immunization Days, home gardening reinforced with nutrition education, and social marketing of various fortified foods, developed and tested within the context of one country, have been adapted for use to other countries.

#### ***Integrating Agriculture into the Philippine Strategy***

Juliano [35] pointed out that the Philippine agricultural research system already collaborates with the International Rice Research Institute (IRRI) on the development of high-iron rice in areas of mutual interest and expertise, particularly in the field testing of the lines developed at IRRI. High, stable grain yield is required of lines if they are to receive approval for release. If lines are to be released for their superior nutritional content, then higher levels of micronutrient content and demonstrable bioavailability need to be established. Castillo [36] spoke about the need for a broader collaborative effort between IRRI and national scientists that would reach well beyond the government agricultural research institutions.

#### **Micronutrient policies, programmes, and strategies in other parts of the world**

The Philippine micronutrient programme reflects to some degree the opportunities and constraints faced by governments throughout Asia. Presentations were next made summarizing micronutrient policies, programmes, and strategies in Africa and Latin America. Historical experience and comparisons were also discussed for developed countries.

##### ***Sub-Saharan Africa***

In general, Africa lags behind Asia in the range of interventions being implemented and the length of time that they have been in place. Smith [37] emphasized the lack of trained personnel and other infrastructure. Supplementation programmes started in earnest after the 1992 International Conference on Nutrition. More recently, there has been an increase in the rate of coverage of vitamin A supplementation of children under five years of age, due to the integration of vitamin A

capsule distribution into national immunization days. Food fortification was initially not considered a front-line approach because of the lack of infrastructural facilities, but it is now getting a close look.

Micronutrient intervention efforts have only begun to exploit the untapped potential of the existing food systems, for example, the dissemination of high- $\beta$ -carotene sweet potatoes discussed by Hagenimana and Low [19]. There is a growing movement to involve women in intervention programmes.

##### ***Latin America***

Bressani [38] points out that a key distinguishing feature of Latin America is that 75% of the population is already classified as urban, and that this proportion is projected to rise to 82% by 2025. Because markets for processed foods are more developed in urban than in rural areas, fortification has a comparative advantage in Latin America relative to other regions. Indeed, most past interventions discussed involve fortification. Successful salt iodization programmes are the most widespread, followed by fortification of sugar with vitamin A; fortification of wheat with thiamine, riboflavin, niacin, and folic acid; and fortification of margarine. Breeding for nutritionally improved foods, which may be viewed as a fortification strategy (getting plants to fortify themselves), therefore is also applicable to this region.

##### ***Europe–Norway***

Eide [39] begins with a global perspective. Community nutritionists today understand nutrition as the complex interaction between a broad set of biological and societal processes. There is, however, a communication gap between nutritionists outside the laboratory and contemporary plant breeders for micronutrient content that may risk reducing the concept of nutrition to “nutrients in agriculture.” Recent efforts by the Norwegian Ministry of Agriculture to promote “whole-food-chain thinking” are described, including the participation of the consumer in setting goals of agricultural policy to promote food and nutritional security.

#### **Micronutrient interventions and strategies: Implications for CGIAR research**

In general, there is relatively little recognition of the *indirect* effects of agricultural research, which can be considerable. Increasing the aggregate supply of a particular micronutrient-rich food, and so *ceteris paribus* lowering its price in the market, will increase consumption. This applies both to investments in long-term increases in supply and to efforts to dampen seasonal fluctuations in prices of vegetables, fruits, and other foods through improved storage and marketing infrastructure, increased interregional and even inter-

national trade, and breeding of varieties that grow in the off-season.

Moreover, the role of agriculture is not just a matter of providing nutrients, as pointed out by Barth Eide [39] and as is clear from Haddad's [5] conceptual framework. Better health and better child care are the direct inputs that are also required. Health and child care, in turn, are affected at one level by how and what foods are produced, and at another level, by innumerable characteristics of the natural resource base and the cultural, political, and economic system of the society in which the agricultural sector is embedded. Therefore, many levers for influencing nutrition outcomes are available to agricultural policy, agricultural projects and programmes, and agricultural research.

### **Recommendations for priorities for CGIAR research and follow-up action**

On the third day of the conference in an initial plenary session, five speakers were invited to give their views on a subset of these questions of their own choosing. Excerpts from their remarks are given below. During the break-out sessions, each of the four research-question groups was asked to identify at least three priorities for research and one specific follow-up action. Each of two institutional-question groups was asked to identify at least three follow-up actions. The groups could add, delete, or modify questions as they chose.

The following suggested questions were posed to the break-out groups:

#### **Research agenda 1: Increasing the supply of foods rich in bioavailable nutrients**

1. Does CGIAR research related to specific crops, fish, and animal products have more potential for improving nutrition than others?
2. To what extent do producers of vegetables, fish, and livestock products consume their own produce and so improve the nutritional status of family members?

#### **Research Agenda 2: Consumer aspects of plant-breeding and nutrition education**

1. How crucial is nutrition education as a complementary activity to plant-breeding?
2. What is the scope for developing consumer demand for more nutritious genotypes of specific crops which are identifiable, say by an orange or yellow colour, but which may be more expensive in the market, or which may be less preferred because of their colour?

#### **Research agenda 3: Policies and programmes that may indirectly impact nutrition: The interface of economic factors and nutrition outcomes**

1. What is the role of agricultural investment and price policies in improving nutrition?
2. Providing better-quality diets through agriculture, and raising farm productivity and lowering food prices in the process, provides a range of nutrients and benefits to rural households in a number of ways not directly related to nutrition, e.g., by raising household income. Supplementation and fortification programmes have narrower objectives and typically provide only one nutrient. Is it possible to compare these broad strategies in terms of their cost-effectiveness or benefit-cost ratios? If not, how can the best mix of interventions to improve nutrition be identified?

#### **Research agenda 4: The impact of the Green Revolution on micronutrient malnutrition**

1. Has the Green Revolution improved or worsened micronutrient malnutrition?
2. How has the Green Revolution changed the diets of the poor? Cereal prices are lower. In some countries, non-staple food prices are higher. What are other major factors (e.g., population growth and urbanization) that have influenced present diets?
3. Are modern varieties of the same crop more or less nutritious than traditional varieties, with respect to their contents of trace minerals and vitamins, phytate and other antinutrients, sulphur-containing amino acids, and other promoters?

#### **Institutional issues 1: Intra-CGIAR coordination of research activities related to human nutrition**

1. Should the CGIAR take on the explicit objective of improving human nutrition? Are there compelling reasons for doing this, e.g., cost-effectiveness relative to supplementation and fortification? What are the constraints to doing so, e.g., funding? Do CGIAR plant breeders already have enough breeding objectives without having to worry about nutritional quality? Will this slow down progress in achieving other breeding objectives? Will the international nutrition community recognize the CGIAR as an important partner in fighting malnutrition?
2. Who should pay for plant-breeding with a nutritional objective? Should this (new) objective be taken on entirely by traditional CGIAR funding sources? Can some of the funding burden be shared with bilateral and multilateral organizations that fund nutrition interventions?
3. Should a formal Intercentre Initiative on Human Nutrition be created within the CGIAR?

## Institutional issues 2: CGIAR collaboration with external organizations

1. What institutional arrangements would work best for providing human nutrition expertise (i.e., interdisciplinary collaboration) to the CGIAR?
2. In breeding for nutritionally improved staple food crops, how should collaboration with national agricultural research centres, in developing and developed countries, be arranged?
3. In breeding for nutritionally improved crops, is collaboration with university researchers crucial in this endeavour?
4. Is there a collaborative role with the private sector in developing and disseminating staple food crops with improved nutritional content?

### Excerpts from invited comments during plenary session before break-out groups

#### *Milla McLachlan, World Bank*

On first reading, I was dismayed that the questions posed for the break-out groups were extremely cautious and very tentative. These were asking us again to consider *whether* we should be incorporating agriculture into strategies for nutritional improvement, and not *how* to do this. Fifteen years after the first CGIAR-wide meeting on human nutrition, we should be asking bolder questions. Upon further reflection, I thought that this may be due to the admirable caution of a scientist, or a sober response to the experience that they, as agriculturalists, have had with us, as nutritionists.

Before directly addressing some of the break-out group questions, I will start with two brief “don’ts.” First, please don’t ask permission of the nutrition community, or wait for the nutrition community to welcome you to do something to improve nutrition. Rather do what needs to be done. We have seen a retreat away from food-based approaches over the last couple of years. The medical model has become very strong in nutrition and in the training of nutritionists. There has been a fair and legitimate disillusionment with food-production programmes that have nutritional improvement as a stated goal at the outset, but then never again think about nutrition or measure nutrition, so that there is never any impact on nutrition. Many food-related nutrition projects and nutrition education programmes have been too diffuse and have not focused on the improvement of the nutritional status of particular vulnerable groups, such as women and children. Therefore, there has been a quest for projects that directly address the nutritional problems of these groups.

Second, don’t tinker at the margins. It is not good enough for the CGIAR system and agriculturalists just to spend what little money is available to see what

can be done. Either take incorporation of nutritional concerns seriously and spend the resources that are required, or state publicly that the resources and/or the inclination to improve nutrition are not there, and that you will stick to the narrower objective of increasing production, or other objectives. It seems to me that the commitment of the CGIAR and agriculturalists to fighting food insecurity should be comprehensive—it should address food availability, access to food, and utilization. Food security without nutrition security seems to me to be a hollow victory.

I would like to challenge the CGIAR to pursue a bold, visionary “Agriculture for Human Nutrition Initiative.” This may be undertaken at the regional level, or throughout the CGIAR system, or by key CGIAR centres linking with national nutrition and agricultural research partners; this is for future discussion.

However, such an initiative would involve four essential elements:

1. Agreement on a conceptual framework so that we are all working from the same understanding of the causes and consequences of malnutrition and the several pathways through which agriculture influences nutrition; we need to spend some time identifying priority pathways and, before that, agreeing on the criteria for selection of priority pathways.
2. Development of indicators to measure the impact of agricultural strategies on nutrition, not just outcome indicators but intermediate indicators as well.
3. Links between policies or programmes, agricultural research, and nutritional outcomes need to be made explicit from the beginning; partnerships must be an integral part of this initiative; development of methodologies and institutional arrangements for doing this can draw on CGIAR experience with other cross-cutting issues, such as gender and the environment.
4. This initiative must be sold to nontraditional funders that have a primary focus on poverty and health; it must be exciting, it must be new, and it will require an investment in communication, marketing, and fund-raising.

#### *Mahiul Haque, Bangladesh Rice Research Institute*

The Bangladesh Rice Research Institute (BRRI) has now released a total of 38 improved rice varieties. This year total production is about 30 million tons of rice, which is enough to also feed the poor. I have selected particular questions to answer that are relevant to BRRI’s institutional mandate:

1. Do breeders have enough breeding objectives already without having to worry about nutrition objectives? Will working on nutrition objectives slow down reaching other breeding objectives? Over the past 30 years, we have had much success

in Bangladesh in increasing the supply of rice by introducing and continuously improving modern varieties of rice. It is now time to look into the nutritional quality of grains. From our institutional point of view, we are ready to include nutritional quality as one of our breeding objectives.

2. Who should pay for plant-breeding with a nutrition objective? This is a difficult question. Since the output can be directed towards different regions of the globe, this should be shared by the CGIAR, by national agricultural research institutes, and organizations that fund nutritional interventions.
3. In breeding for nutritionally improved food crops, how should collaboration between the CGIAR, national agricultural research centres, and universities be organized? As far as BRRI is concerned, the existing system of collaboration between national agricultural research centres and international centres can be used. Universities may be included in the collaboration to evaluate what has been accomplished.
4. What is the scope for developing consumer demand for crops that are more nutritious but that may be more expensive to market or that initially may be less desirable because of their colour? When the rice endosperm will be yellow because of vitamin A, we will have to wait and see, but I don't think that it will be a problem in our society.

Finally, I have some personal observations to make. The germplasm collection in our research institute consists of 7,500 lines, including local landraces. Using the genetic variation in this collection, we have been very successful in increasing production. If we had been motivated before, we could have made progress in achieving the objectives of more iron, zinc, or vitamin A in rice. It is better late than never.

**Gerald Combs, Cornell University, United States**

Food plays important social, cultural, and economic roles in every society; but always it remains the (usually sole) source of nutrients. Therefore, nutritional status and, to a great extent, health, depend on access to, quality of, and diversity in food supplies. Perhaps it is the very personal nature of food use that allows these issues often to be overlooked amid efforts to enhance economies, alleviate poverty, and improve public health; but, in fact, these are the very issues that connect food to health outcomes.

Efforts to alleviate malnutrition in the developing countries have been targeted toward increasing supplies of macronutrients (in particular, energy and protein) and a few micronutrients (vitamin A, iron, and iodine), because deficiencies of these nutrients have been or are responsible for the ill-health of millions of people, a fact that has been well documented. That notwithstanding, it is true that millions of people in poor countries are also malnourished with respect

to other vitamins (riboflavin, folate, and vitamin B<sub>12</sub>) and minerals (selenium, calcium, copper, and probably chromium and boron). Although few programmes have addressed these latter deficiencies, none have undertaken to implement recent findings of great public health relevance in poor countries: the cancer-preventive effect of selenium; the heart-protective effects of folate, vitamin E, and perhaps copper; the antidiabetic effect of chromium; and the reduction of bone loss by boron. Somehow, contemporary nutrition knowledge is not being translated into programmes in the developing world.

*The need for a new approach.* Trans-disciplinary and trans-sectoral efforts are called for that address food systems in holistic ways, i.e., from the production, acquisition, and utilization of foods to the biophysical, economic, social, public health, and policy environments in which those activities are carried out. Whereas agricultural success has historically been measured in terms of yields and costs, food-systems approaches would also include measures of impacts on human nutritional status and health, as well as environmental, economic, and social sustainability.

*Implications for the CGIAR.* The improvement of diets (and, thus, health) is implicit in any effort to increase food production and/or decrease food production costs. If that is, indeed, the case for the CGIAR, then the relevant question is *not* whether the CGIAR should undertake the improvement of human nutrition as part of its agenda but, rather, whether it should make that goal explicit. In other words, should the CGIAR adopt what I have called the "new paradigm" for agriculture? Who is better positioned than the CGIAR, with its resident multidisciplinary expertise and its existing and potential network of collaborating researchers in various national agricultural research centres and research universities, to lead such an effort productively?

Making the new paradigm an institutional value would not mean creating a new programme; instead, it would mean using that paradigm to rethink and to link existing programmes. It would mean that CGIAR efforts would need to go beyond those that would target mainly crop yields and production costs, to link those outcomes with consumer accessibility and nutrient content and bioavailability. Such food-systems-based approaches would not be focused *only* on major crops; instead, they would consider *cropping systems* (including livestock) and their abilities to support balanced human nutrition in sustainable ways. The core strategies for doing this were laid out by an international expert consensus conference in 1995 and include items already on the CGIAR agenda: increasing the diversity of cropping systems, particularly with respect to indigenous fruits and vegetables and to pulses; developing "micronutrient-efficient" cultivars of major staple crops; improving the use

of micronutrient- (iron and zinc) rich cereal brans; reducing phytates in staple grains and developing heat-stable phytases for use as food ingredients; improving means of measuring micronutrient bioavailability; standardizing data on food nutrient and phytochemical compositions; and developing models for integrated, small-scale farming systems.

If the global goal is to find ways to make the food systems of the world provide the nutrient needs of healthy human populations, then it is a highly relevant question to ask, "If not the CGIAR, then who will do this?"

**Xiao Yang, Zhejiang University, China**

*Agricultural strategies are low cost and of great benefit to the poor.* Since micronutrient malnutrition mainly occurs in the developing countries, we should find cheaper and economically acceptable ways to solve this problem. Although there have been some programmes for improving grain quality in China, no breeding programmes have been conducted to increase micronutrient concentrations and trace mineral availability related to human nutrition.

Micronutrient supplements are available in markets in China. Supplementation or fortification has a narrow objective, most often supplying only one micronutrient. These products are unavailable to the majority of the population, especially the poor population in rural areas. In contrast, agricultural approaches address a broad range of nutrients and may reach a broader population. Therefore, it is increasingly important and critical to link agricultural practices to improving human micronutrient nutrition. Since 25% of the world population resides in China, where there is widespread micronutrient malnutrition, it would be important to give China high priority in this effort.

**Joseph Hunt, Asian Development Bank**

*Agricultural research as a public investment.* How does agricultural research make valid claims on public finance? Economists think of agricultural research as creating public goods. There are at least four ways in which this is done:

1. Plant-breeding produces better nutrition for all through increased food supplies and lower food prices. It also reduces poverty. When micronutrient enhancement is involved, plant-breeding performs both functions. Not only does it improve anthropometry, but it contributes to sustained development, and the capacity to apply learning throughout life.
2. Through dissemination of research, creation of new information affects behaviour and decisions. This affects policy dialogue. It provides evidence-based impacts that can be built into programmes that integrate agriculture, health, and nutrition.

3. New information also affects messages that go into training, public education, and all forms of media.

4. Quality assurance and food safety are integral to agricultural research.

*Broadening the framework for economic analysis.* We want to broaden the framework of economic analysis beyond cost-benefit analysis. These are topics for further discussion.

1. Better nutrition has direct and indirect effects on productivity. The direct effects are mainly through wages and increased capacity to work. The indirect effects are through cognition and capacity to learn.
2. We need to look closely at the way we measure losses and benefits from better nutrition, so that we have a common currency for discussing these effects at all levels and across disciplines. We have to be able to compare such diverse effects as deaths averted, effects on wages and household income, and impact on cognition. Measures such as currency and disability-adjusted life years (DALYs) are currently being used.
3. Use of marginal costing to compare plant-breeding with other types of nutrition interventions is persuasive. Plant-breeding and conventional fortification could become important means to broadly reduce the prevalences of micronutrient deficiencies. Other interventions can then target those who still suffer from deficiencies.

*Windows of opportunity in the life cycle.* There are critical vulnerability points that we might think of as windows of opportunity in the life cycle, where agriculture might make a critical contribution. Eventually we want to link CGIAR objectives to sustained health over the life cycle, whereby public nutrition becomes an objective of the CGIAR, and in which generational and intergenerational effects are recognized.

1. Nutritional interventions and nutrition education for good practices at the birth of their first children targeted at adolescent girls can have a real effect on their probability of surviving in good health and of having better-nourished children.
2. Links between low maternal body mass index and low birthweight are quite important. Not only are low-birthweight children more likely to die early, they have a higher susceptibility to chronic diseases later.
3. Complementary feeding or breastfeeding issues are quite important and could be addressed through plant-breeding.
4. Chronic undernutrition affects the quality of life and productivity of future generations.
5. Links between gender-sensitive approaches and food health care should be emphasized.

*Investment partnerships.* We should think of a regional investment-planning model that builds broad

partnerships for regional investment to sustain both agriculture and health as interwoven parts of the same problem. This process will help to define, through a demand-driven process, the roles of both the CGIAR and of donors.

## Group recommendations

Following are the recommendations reported in plenary session that came out of the six break-out discussions. A summary of these six sets of recommendations is attempted in the final section of this paper.

### Group 1. Increasing the supply of foods rich in bioavailable nutrients. Rapporteur: Samson Tsou, AVRDC

1. Make better use of CGIAR germplasm banks by generating and disseminating information on nutritional characteristics, such as mineral and vitamin content and bioavailability of those minerals and vitamins. Bioavailability would be determined through simple but reliable methods that are either currently available from nutritionists or are to be developed by nutritionists.
2. Undertake a multicentre, integrated agricultural systems approach project, including impact assessment methodologies, targeted at improving the adequacy of several micronutrients. The strategy would include agricultural production, post-harvest processing, and application of nutritional, economic, and social sciences.
3. Breeding for higher micronutrient density and for consumer acceptance of staple and non-staple foods should be a high priority for the CGIAR centres.

#### *Follow-up activity*

Take steps to acquire capacity to implement the first recommendation.

### Group 2. Consumer aspects of plant-breeding and consumer education. Rapporteur: Suttalak Smitasiri, Mahidol University, Thailand

1. Technologies developed by CGIAR centres should be developed in line with end-user perceptions of desired characteristics—those of farmers, traders, and consumers. This will facilitate consumer education later on.
2. Undertake comprehensive nutrition communication promotion programmes at two levels: at the public level and targeted at poor groups. Importantly, this requires an evaluation component to check that messages are being effective.
3. Undertake programmes to improve the public

trust in agricultural innovations. These would include studies to assess the perceptions of several groups (e.g., the general public, professionals, policy makers, and the private sector). Public attitudes towards agricultural innovations are presently negative. Public relations activities should be undertaken to build trust.

#### *Follow-up activity*

IFPRI should form a multidisciplinary task force (including social scientists, nutritionists, agriculturalists, and other stakeholders) to implement these three steps. Issues related to agriculture–nutrition linkages should be discussed at future CGIAR-wide meetings

### Group 3. Economic factors that influence nutritional outcomes. Rapporteur: Mahabub Hossain, IIRRI

#### *Information gaps*

1. Much information is available on health and nutrition and on economic policies and agricultural development strategies, but there are few data sets and studies that link the two.
2. Existing cost-effectiveness studies of various nutritional interventions focus too much on short-run impacts. There is a need to incorporate sustainability issues and long-run impacts in these studies.

#### *Recommendations for research*

1. Assessment of the impact of international agricultural trade on agricultural programmes, price policies, and nutritional outcomes.
2. Studies linking nutritional outcomes with agricultural and infrastructural development programmes and policies.
3. Assessment of the impact of crisis situations on nutritional outcomes, including the development of indicators for surveillance systems.

#### *Follow-up activity*

To accomplish this, there is a need for multidisciplinary collaboration and research partnerships. Institutional mechanisms must be found to foster linkages with nutritionists in the planning process and then to link with extension services and NGOs to implement any technologies that are developed.

### Group 4. Impact of the Green Revolution on nutrition. Rapporteur: Britta Ogle, Swedish University of Agricultural Sciences

1. The CGIAR needs to consider the ethics of *not* incorporating nutrition into its research agenda. Safety and quality are important elements of better nutrition. New and different agricultural technolo-

- gies always change diets and thus change the nature of health and nutritional problems, even perceptions of what are good diets.
2. A common conceptual framework between disciplines is needed to come to agreement on research priorities. This cannot be done at the global level, but it has to go down at least to the country level. A key issue is: How bioavailable are the nutrients that we seeking to bring more of into the system?
  3. Research is needed on the genetic diversity of wild varieties, landraces, and modern varieties. How have the changes in the nutritional content of modern varieties impacted nutrition?

#### *Follow-up activity*

The first two recommendations are overriding follow-up actions that have to set the scene. Developing the proposed framework can be the basis for beginning a process of interdisciplinary communication.

#### **Group 5. Intra-CGIAR coordination of research.**

**Rapporteur: Robert Bertram, USAID**

#### *Follow-up activities*

1. Undertake a more comprehensive stock-taking of CGIAR research activities related to human nutrition.
2. Secure approval from the CGIAR Technical Advisory Committee of a system-wide initiative related to human nutrition. This would involve developing a conceptual framework. This should include partnerships outside of the CGIAR, especially with human nutritionist organizations. IFPRI should take the lead.
3. Secure approval of human nutrition as a theme for International Centres Week (held annually).
4. Report on CGIAR breeding activities related to improving nutritional quality at crop science society meetings.
5. Report on CGIAR human nutritional research activities at the Administrative Coordinating Committee/Sub-Committee on Nutrition (ACC/SCN) meetings.
6. Tap into nontraditional sources of funding for activities related to human nutrition. This includes newly formed foundations and funding windows of present CGIAR donors that are not usually utilized.

#### **Group 6. CGIAR collaboration with external organizations. Rapporteur: Barbara Schneeman, US Department of Agriculture**

#### *Principles for successful collaboration between disciplines*

1. A shared vision; identification of where there are overlapping objectives.
2. Recognition of comparative advantages and strengths; clearly defined roles for each partner.

3. Trust, understanding, and mutual respect are necessary.
4. Equal relationships; avoidance of tokenism.
5. Nutrition is an outcome in which all disciplines can have a stake.

#### *Preconditions that would facilitate outside collaboration*

1. Development and acceptance of a framework for analysis and application of agriculture–nutrition linkages.
2. Statement by the Technical Advisory Committee that the CGIAR will take nutritional impacts into consideration in its decisions and research activities.
3. A shift from a commodity focus to a food-systems focus. Such a shift demands both internal and external collaboration.
4. A dialogue between CGIAR centres and national agricultural research centres is important to define what approach would be taken.

#### *Follow-up activities*

1. Improve outside awareness of CGIAR activities through participation of CGIAR in meetings of professional societies. This would also increase the awareness of CGIAR scientists about possibilities for outside collaboration.
2. Information about CGIAR activities should be included in university education and training programmes; nutrition focus at International Centers Week and other CGIAR meetings; linking CGIAR information to various Internet sites; field trips for cross-training (e.g., bringing plant scientists to a health clinic to observe clinical signs of micronutrient deficiencies).
3. A CGIAR steering committee on agriculture–nutrition linkages should be created to interface with the ACC/SCN.
4. Case studies of successful interdisciplinary programmes could be used to highlight the benefits of interdisciplinary research.

#### **Plenary discussion**

After the group recommendations for research were presented, the floor was opened for discussion. A number of diverse topics were raised. Comments could be categorized into two groups. The first group were those comments that followed up on the recommendations presented above with specific ideas for promoting agriculture–nutrition interventions in a broad sense, or the breeding strategy more narrowly. The other set of comments touched on gaps in the workshop discussions and recommendations, for example, not enough discussion on topics such as labour and gender issues, nutritional problems other than micronutrients, linkages with the health system, and persons with disabilities.

### Post-conference activities: Summary of recommended CGIAR research and extension/outreach activities

During the relatively short time remaining for plenary discussion, no attempt was made to summarize the recommendations of the six working groups. This is attempted below.

#### Related to breeding for nutritionally improved crops

1. Characterize lines in germplasm banks for nutritional characteristics
2. Undertake the next steps for breeding for nutritionally improved varieties with acceptable consumer characteristics.

#### Related to evaluation of the impact of CGIAR activities

3. Assess the impact of agricultural programmes and policies, agricultural trade, and economic crises on nutritional outcomes, including development of appropriate indicators.
4. Further evaluate genetic diversity of wild varieties, landraces, and modern varieties; draw out implications for past nutritional impacts of modern varieties.

#### Related to extension/outreach

5. Implement nutrition communication and promotion programmes directed at the malnourished poor.
6. Implement public relations programmes directed at the general public to improve trust in agricultural innovations.

#### How research should be structured and organized

7. Develop a multidisciplinary, common conceptual framework.
8. Use agricultural systems approaches to identify and prioritize interventions.
9. Conduct participatory research to ensure that variety releases are consistent with end-user perceptions of desired characteristics, including consumers and traders (not only farmers).
10. Undertake outside collaboration with nutrition and communications institutions and other disciplinary perspectives, including NGOs and extension services, as required.

#### Recommended follow-up activities

11. Form an interdisciplinary task force organized by the IFPRI, composed of members from inside and outside of the CGIAR, which would:

- » identify and implement a process for development of a multidisciplinary, common conceptual framework describing agriculture–nutrition linkage, which could be then used for evaluating integrated approaches to nutrition improvement;
  - » evaluate the feasibility of implementing a strategy for nutrition promotion and communication, including consideration of the ethics of not incorporating nutrition explicitly into its research agenda;
  - » undertake a more comprehensive stock-taking of CGIAR research activities related to human nutrition;
  - » secure approval of human nutrition as a theme for International Centres Week;
  - » seek approval from the CGIAR Technical Advisory Committee for a system-wide initiative on human nutrition which would include partners from outside the CGIAR;
  - » interface with the ACC/SCN and report on CGIAR activities at the annual meetings of the ACC/SCN;
  - » seek ways to have CGIAR research related to human nutrition incorporated into university training programmes (case studies of successful interdisciplinary programmes could be used to highlight the benefits of interdisciplinary research); link information about CGIAR activities to various Internet sites; facilitate field trips for disciplinary cross-training (e.g., visits of agriculturalists to health clinics to observe clinical manifestations of malnutrition; visits of nutritionists to agricultural research stations).
12. CGIAR scientists should seek opportunities to report on CGIAR research activities related to human nutrition at professional meetings of various disciplines. This would improve awareness of CGIAR activities, and CGIAR scientists would become more informed about the possibilities for outside collaboration.
  13. Seek to tap new donors and sources of funding for activities related to human nutrition. This would include newly formed foundations and funding windows not presently utilized of present CGIAR donors.

### Final reflections

Given the large number of diverse linkages between agriculture and nutrition, in some sense a disproportionate number of presentations focused on breeding for nutritionally improved crops. Indeed, it is revealing that every one of the six break-out groups recommended some variation on an activity that involved a broad overview of agriculture–nutrition linkages: developing a common conceptual framework, taking an integrated agricultural systems approach, and the

need for multidisciplinary collaboration and research partnerships. The presentations might have been more evenly distributed across various linkages. Certain specific linkages were only mentioned.

In part, the skewed distribution of presentations reflected the stock-taking objective of the conference. To some degree, it represents what the CGIAR has been doing. More importantly, perhaps, this also reflects the tension between initiating research and planning research. Taking a systems approach and attempting to carefully evaluate a number of alternatives has clear potential benefits and inherent appeal to those engaged in research, but it is not without risks: (1) the risk of never reaching interdisciplinary consensus as to the optimal strategy, either because of the complexity of the system or because the principles of successful interdisciplinary collaboration developed by

break-out group 6 are not followed; (2) the risk of coming to a consensus but not being able to manage the institutional coordination required by recommended actions; and (3) the risk that the final recommended actions, when implemented, will turn out to be themselves flawed. With these risks fully in mind, the first steps have been taken to initiate the proposed planning exercise, as described above.

The CGIAR Micronutrients Project has made it through the first two types of risk. It is on the verge of facing the third type of risk—finding out if it really works after all in feeding trials planned to begin shortly after this volume is published. If the breeding strategy is successful, then it will give impetus to other efforts to link agriculture to nutrition that may have little to do with plant-breeding per se, but that may have payoffs that are equally high.

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## Erratum

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In the article “Red palm oil in the maternal diet improves the vitamin A status of lactating mothers and their infants” by L. M. Canfield and R. G. Kaminsky (*Food Nutr Bull* 2000;21(2):144–8), please substitute the following for reference 17 on page 148:

17. Canfield LM, Liu Y, Kaminsky RG, Castillo C, Zavala G, Garner C, White K, Pagoaga E. Supplementation of mothers with red palm oil increases serum vitamin A of the breastfed infant. *FASEB J* 1997;7:2280.