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# Making a Greener Revolution: A Nutrient Delivery System for Food Production to Address Malnutrition through Crop Science

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**Abstract** : During the 1970s, the Green Revolution basically used dwarfing genes in wheat and rice that allowed greater water and fertilizer efficiency which dramatically increased the cereal productivity and thus, increased human caloric intake of the developing world. However, having met caloric intake, there is a need to address the issues of malnutrition through a holistic food production system. For example Ca-deficient induced rickets was found in 9% of children in SE Bangladesh, illustrating the failure of that food production system to address this vital nutrient, calcium. A clinical trial has shown a minimum of increase in calcium intake of 250 mg Ca per child per day was enough to prevent rickets. In Bangladesh, a consortium of universities and other medical institutions and the International Center for Wheat and Maize Improvement (CIMMYT) has developed strategies to infuse calcium within the food delivery system. For treatment of ricketic children, a strategy was developed to use live and video drama to create community awareness of the production and/or consumption of high-calicum crops/food and calcium supplement added to the cooking rice (in this case, highly edible CaCO3 readily available throughout the country). Though this represents a very specific case study, this is a useful example of how collaboration based around crop science can address the 'hidden' hunger of malnutrition throughout the world.

**Key words** : Cereal production, Crop science, Malnutrition, Nutrients, Rickets.

The Green Revolution brought cereal production to the currently sustainable levels of self-sufficiency in much of South Asia. While most of the population's caloric intake is now adequate, as many as 50% of young children are malnourished in many places. Malnutrition takes on the form of vitamin or micronutrient deficiencies, such as zinc or iron, or stunting of body growth by the imbalance of nutrients which the current crop production systems are not providing. Fig. 1 illustrates that with increased population, cereal production has met, and even exceeded, dietary standards for most of the population. However, compared to cereals, pulses—an integral and historically significant dietary requirement—has fallen

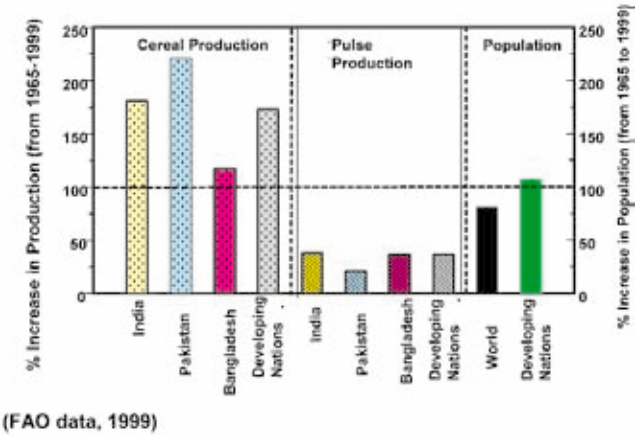


Fig. 1. Percent changes in cereal, pulse production, and population between 1965 and 1999 (FAO data, 1999).

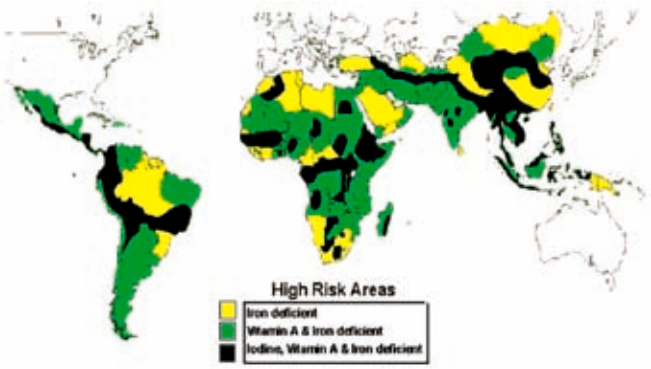


Fig. 2. Areas of the world having micronutrient deficiency risk (USAID).

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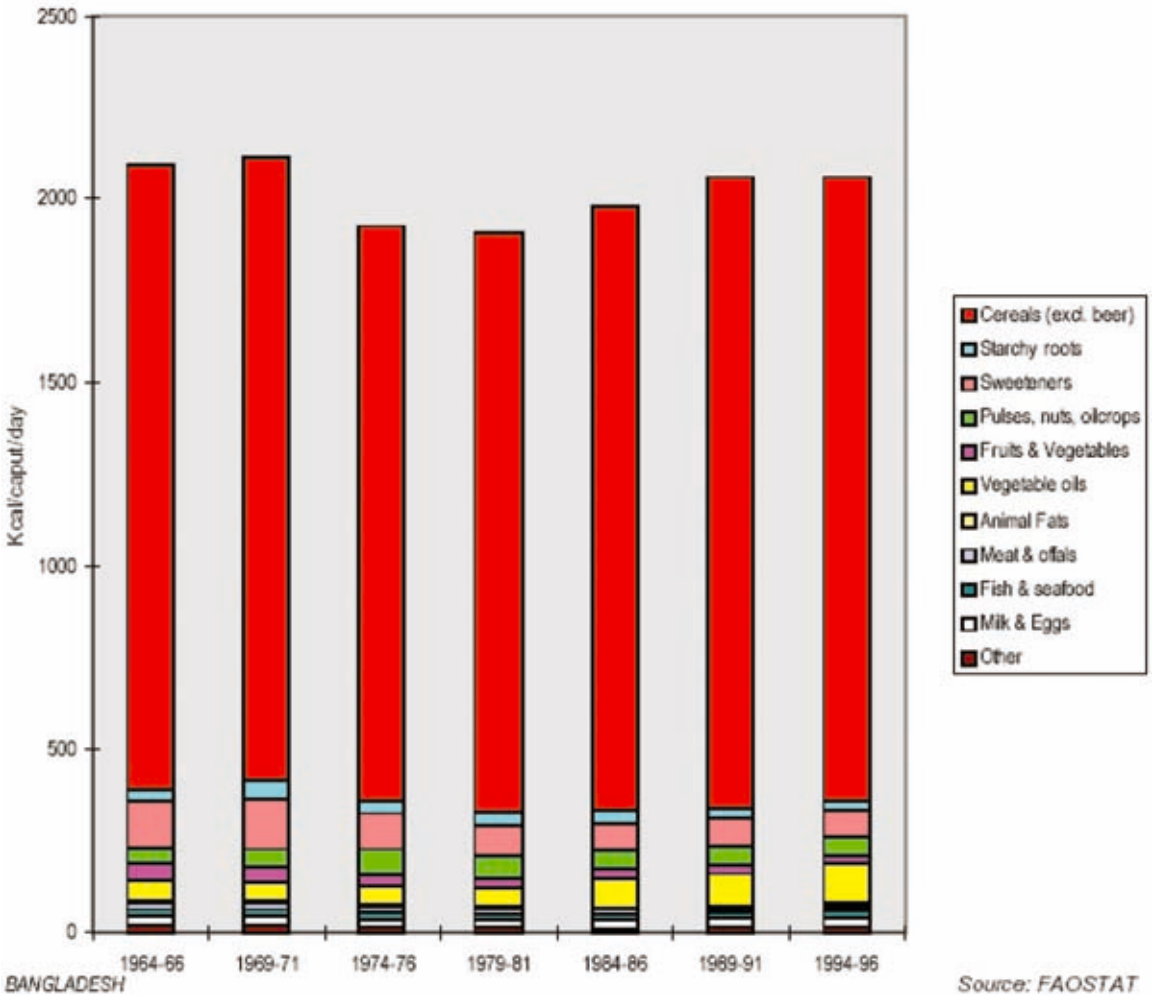


Fig. 3. Share of major food groups in Dietary Energy Supply Trends from 1964-66 to 1994-96 (FAO, 1999).

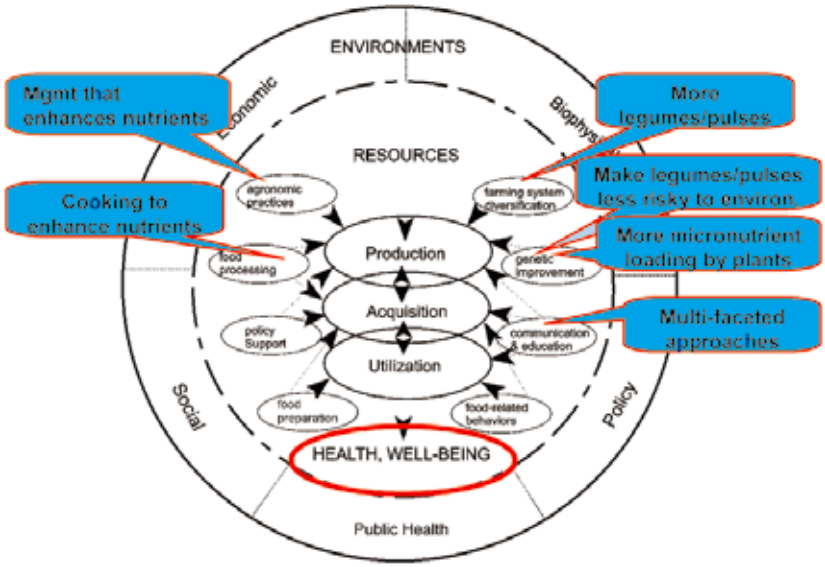


Fig. 4. Holistic food systems model for addressing food systems that deliver balanced nutrients to communities.

far short of meeting the communities' needs. Pulses satisfy much of the nutritional balance for a diet that would satisfy micronutrient and other deficiencies (Fig 2.) that are causing malnutrition rates to remain so high throughout the developing world.

In south-east (SE) Bangladesh, the debilitating disease, rickets, caused by calcium deficiency was discovered 12 years ago in children under 15 years of age (Combes, 2001; Hassan and Combes, 2002). Rickets was prevalent in 9% of the children surveyed. There are other areas of the world where Ca-deficiency induced rickets occurs (Thacher et al., 1999). Thus a study was conducted in Bangladeash to better understand the calcium supply of local diets and to determine the response of children to calcium supplements to the food supply. FAO data has indicated that between 1979/81 and 1994-96, the supplies of pulses, nuts and oil crops, starchy roots and sweeteners have decreased respectively by 23%, 18% and 16% (FAO, 1999) (Fig. 3).

## Materials and Methods

A nutritional survey was conducted in SE Bangladesh to determine the food intake and to measure the intakes of calcium in the diets of especially the mothers and children. The food intake over a twenty-four hour period was recorded for randomly selected communities. Simultaneously, a double blind feeding program was established among 200 children to determine the response of those children to calcium. Although these children had biochemical symptoms of the nutritional disorder rickets (elevated alkaline phosphatase), most did not exhibit the disabling weakening and bending of the bones. Three treatments were given: 1) a nutritious food supplement containing minerals and vitamins, but no additional calcium, 2) the same food supplement as (1) but with 50 mg calcium, and 3) the same food supplement above in (1) but with 250 mg calcium. The children were fed daily for 6 months. After the feeding period, their blood was sampled for alkaline phosphatase and X-rays taken of their joints.

## Results and Discussion

The survey determined that the communities lacked enough high-calcium foods in their diets to maintain adequate levels of calcium in their bodies (Institute of Child and Mother Health, 1998). This was true for all economic classes, all religious communities, and even with varying educational levels. In this area of Bangladesh there is little or no raising of cattle or livestock because the area is prone to cyclones and cattle are at risk of being swept into the ocean. Thus the population has no access to milk which is high in calcium. Further, the area is surrounded by mountains to the east, making communication with other Bangladesh communities difficult. As population numbers have grown, the land has been used for rice production, and there has not been a proportional increase in pulse production. Moreover, there is

Table 1. Foods readily available in SE Bangladesh that have high calcium for prevention and/or treatment of Ca-deficiency induced rickets in Bangladesh (USDA, 1997)

| Description | Weight (g) | Common Measure (usual consumption) | Ca Content (mg) per measure |
|---|---|---|---|
| Spinach, cooked, boiled, drained, w/o salt | 180 | 1 cup | 245 |
| Cowpeas, immature seeds, cooked, boiled, drained w/o salt | 165 | 1 cup | 211 |
| Okra (ladies' fingers) cooked, boiled, drained, w/o salt | 160 | 1 cup | 123 |
| Rice, white, long-grain, parboiled, enriched, dry | 185 | 1 cup | 111 |
| Mustard greens, cooked, boiled, drained, w/o salt | 140 | 1 cup | 104 |
| Chickpeas (garbanzo beans) mature seeds, cooked, boiled w/o salt | 164 | 1 cup | 80 |
| Papayas, raw | 304 | 1 papaya | 73 |
| Beans, snap, green, cooked, boiled, drained, w/o salt | 125 | 1 cup | 55 |
| Cucumber with peel raw | 301 | 1 large | 48 |
| Carrots, cooked, boiled, drained, w/o salt | 156 | 1 cup | 47 |
| Cabbage, cooked, boiled, drained, w/o salt | 150 | 1 cup | 47 |
| Bread white commercially prepared | 25 | 1 slice | 38 |
| Lentils, mature seeds, cooked, boiled, w/o salt | 198 | 1 cup | 38 |

inadequate transport of pulses from outside because of the difficulties in transport.

The double blind nutrition study showed that the lowest level of calcium used in this study was enough to prevent rickets in the majority of the children tested.

**1. Resulting community awareness and action programs**

Strategies were determined for supplementing calcium in the community's diets based on the survey and dietary supplement data.

Firstly, the soils were limed (soils in that region are acid sulphate soils) to test whether the various indigenous or improved crops and vegetables would take up more calcium. However, as calcium is an element used in the plant's biochemistry for bio-regulation, luxury consumption of calcium in plants is rare. More often calcium deficiencies limit plant growth or yields. Thus, liming was not the solution to raise calcium levels in the community, though it did increase productivity of most crops and vegetables.

Secondly, we identified local foods high in calcium and that, if eaten in greater quantities, would be sufficient in preventing rickets (Table 1). Thus foods such as cowpea, okra, pigeon pea, mungbean, small indigenous fish, and some indigenous leafy vegetables were able to contribute to the communities' calcium requirements. Use of milk products is an obvious but unaffordable solution.

The third strategy aimed at making the community aware of the link between diet and rickets was through live drama and a made-for-TV video drama. Using modern multimedia projectors, portable DVD players, rented generators and speakers available in every village, whole villages (even without electricity) can now view the 1-hour drama linking cause and effect. Because rickets disables young children permanently across all economic and religious classes in their communities and because these communities now better understand the causes of the disability, they have become highly motivated to prevent rickets. Responses indicate a great deal of knowledge about rickets and its prevention are imparted by using these dramas. Informal surveys indicate an increase in production and consumption of these high-calcium crops.

Lastly, an indigenous use of limestone usually added for chewing beetle nut was determined to be the best bioavailable and affordable source of calcium to supplement the calcium-delivery system of consuming more high-calcium crops. Thus, we determined that 1 g of $CaCO_3$ added to the cooking rice pot provided enough calcium per day for children to prevent rickets without affecting taste or color of the rice. Thus, embedded within the dramas and videos, we could mention not only food, but also the use of limestone in the rice pots to assist them in preventing rickets.

**2. A broader overview of a nutritionally balanced food system**

Fig. 4 illustrates a holistic food system for delivering a balance of nutrients to communities at risk of malnutrition. Although people are not positioned in this model, they represent the major change innovators. The example from Bangladesh shows that changes can be made at the system level, through a food system that addresses nutrients rather than simply caloric sufficiency. The key is crop science that finds local solutions and knowledge sharing, again at the local level.

## Conclusions

Informal surveys indicate that many households are now growing and consuming more high-calcium foods and including the addition of limestone in the rice pot based on the work conducted in the SE of Bangladesh. We believe that this 'rickets' model of empowering communities with a 'nutrient-delivery system' can be used elsewhere in communities throughout the world where malnutrition is a growing problem (Dagnelie, et al. 1990; Bhattacharyya, 1992; Bishop, 1999; Thacher, et al. 1999).

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