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 used basically 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, the emerging malnutrition, the luxury of having met caloric intake, must be addressed through holistic food production that addresses the whole nutrient delivery system that does not allow for malnutrition. In SE Bangladesh, Ca-deficient induced rickets with a prevalence of 9% among the children was found, illustrating the failure of that food production system to address this vital nutrient, calcium, in their diets. 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. CIMMYT Bangladesh within a consortium of universities and other medical institutions has developed strategies to infuse calcium within the food delivery system of that area. This is the example of how CGIAR and university collaboration can use crop science to address the 'hidden' hunger of malnutrition through a food production system based on nutrient delivery. Though this represents a very specific case study, expansion of such strategies and methodologies can address some specific malnutrition throughout the world.

Media summary

Growing malnutrition in the world represents the luxury of having met caloric intakes by the Green Revolution. Paradigms must shift from 'cereal production' to 'nutrient delivery systems.'

Key Words

Cereal production, malnutrition, rickets, crop science, nutrients

Introduction

The Green Revolution brought the levels of cereal production to currently sustainable self-sufficiency in much of South Asia. South Asia's strong rice-wheat cropping systems give credence to this fact. However, within the luxury of having met most of the population's caloric intakes, malnutrition among children is well above 50% 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 that the current crop production systems are providing. Figure 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 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 SE Bangladesh, a debilitating disease caused by calcium deficiency was discovered 12 years ago in children under 15. Rickets, though referred in the dictionary as 'the Englishman's disease' for lack of sunlight for the body to produce Vitamin A, was found with a prevalence rate of 9% among the children. It was determined to be caused by calcium deficiency, i.e. insufficient calcium consumed in their diets

(Combes, 2001; Hassan and Combes, 2002). There are other areas of the world where Ca-deficiency induced rickets occurs (Thacher et al., 1999).

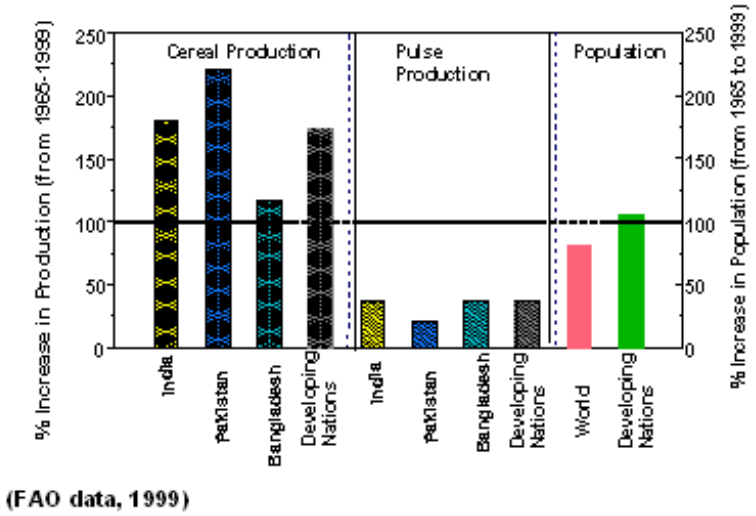

Figure 1. Percent changes in cereal, pulse production, and population between 1965 and 1999 (FAO data, 1999).

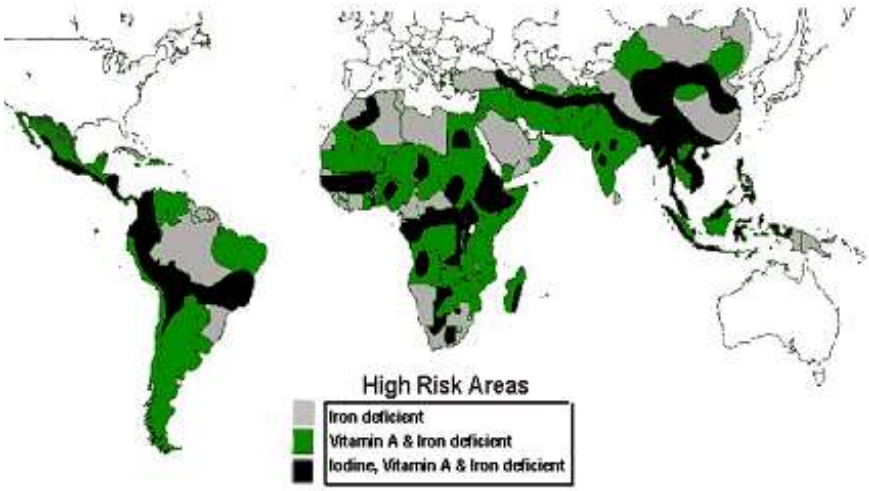

Figure 2. Areas of the world having micronutrient deficiency risk (USAID).

Methods

An intensive nutritional survey was conducted to determine the food intake and to measure the intakes of calcium in the diets of especially the mothers and children. Twenty-four hour food intakes were recorded for randomly selected communities in SE Bangladesh. Simultaneously, a double blind feeding program was established among 200 children for determining the response of those children to calcium. These children had biochemical symptoms (elevated alkaline phosphatase) but most had not expressed 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) that same food supplement above but with 50 mg calcium, 3) that 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

The survey determined that the calcium intake of those communities lacked enough high calcium foods to maintain adequate levels of calcium in their bodies (Institute of Child and Mother Health, 1998). Though this was true for all economic classes, all religious communities, and even with varying educational levels—many were not consuming enough Ca-rich foods in their diets. SE Bangladesh has always been prone to cyclones, preventing cattle or livestock-raising (they are swept into the ocean during the tidal waves). Population has grown significantly for this area and as they are surrounded by mountains to the east, communication with other Bangladesh communities is difficult and thus, imports of other pulses normally consumed elsewhere.

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.

Resulting Community Awareness and Action Programs

With the correct 'diagnosis' of the community's problem of not producing, accessing, and consuming calcium rich foods and knowing that 250 mg extra calcium per day per child would solve the problem of rickets, strategies were determined for supplementing calcium in the community's diets. Experiments using limestone were conducted (soils in that region are acid sulphate soils) to test whether more calcium would be taken up with the various indigenous or improved crops and vegetables. 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 to the communities, though it did increase productivity of most crops and vegetables.

Secondly, we tried to identify local foods high in calcium and are already consumed that if eaten in greater quantities, would be sufficient in preventing rickets. Cowpea, okra, pigeonpea, mungbean, small indigenous fish, some indigenous leafy vegetables were all tested for their calcium contents and were determined to be able to contribute to the communities' calcium requirements. Use of milk products are an obvious but unaffordable solution.

Thirdly, using live drama and a made-for-TV video drama, we empowered communities with the knowledge of the causes and prevention of rickets. Because rickets disables young children permanently across all economic and religious classes in their communities and because these communities see these disabilities, they have become highly motivated to prevent rickets. Using modern multimedia projects, portable DVD players, and rented generators and speakers available in every village, whole villages even without electricity can view the 1-hour drama. 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 beetlenut 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 the use of limestone in the rice pots to assist them in preventing rickets.

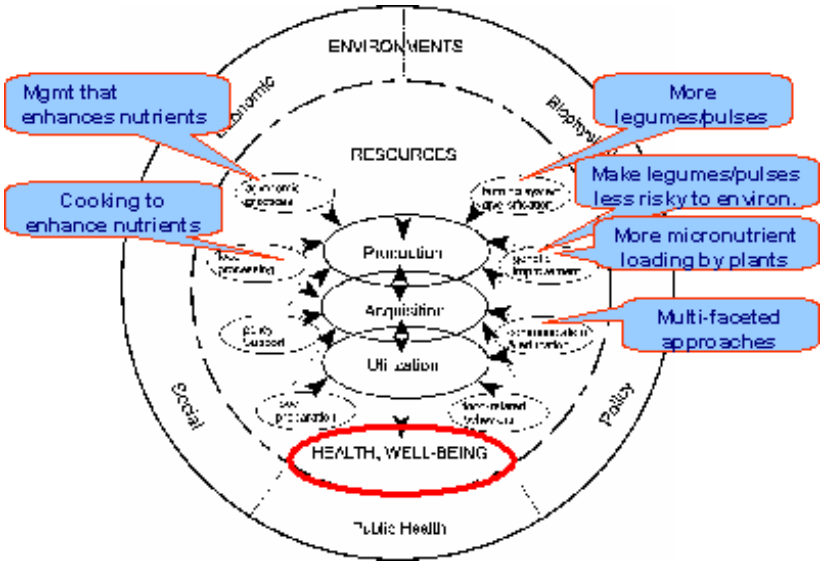

Figure 3. Holistic food systems model for addressing food systems that deliver balanced nutrients to communities.

Figure 3 illustrates the holistic food systems which can be nutrient delivery systems for communities at risk to malnutrition. Though people are not positioned in this model, they represent the major change innovators that can make changes to the system, with its goal being good health and well-being of the communities through a food system that addresses nutrients rather than simply caloric sufficiency.

Conclusion

Though not formally assessed, informal surveys indicated that many households are growing and consuming more high-calcium foods and including the addition of limestone in the rice pot. 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 (Bishop,1999; Bhattacharyya, 1992; Thacher, et al. 1999; Dagnelie, et al. 1990).

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