



Home-based vegetable gardens and other strategies to overcome micronutrient malnutrition in developing countries

M.L. Chadha is the Director and M.O. Oluoch a Training Specialist at the Asian Vegetable Research and Development Center, Regional Center for Africa, Arusha, United Republic of Tanzania.

The world's population is projected to grow from 6.1 billion to 7.9 billion by 2025. Most of this growth will take place in cities, whose population in 2025 is expected to double to 3.4 billion. Poverty is persistent and widespread; approximately 1.2 billion rural people live on less than US\$1 per day. In the year 2000, there were 790 million people who went hungry. Despite progress on average per capita consumption of food (up 17 percent in the past 30 years to 2 760 kcal per day), people in 33 countries still consume fewer than 2 200 kcal per day. Although a combination of increased production and additional imports means that per capita consumption will increase to about 3 000 kcal per day by 2015, food insecurity and malnutrition will continue to persist because of problems with access and distribution. Despite steadily falling fertility rates and family sizes, the world

population is expected to grow and, by 2050, 84 percent of people will live in the countries that constitute the "developing" world (FAO, 1996).

The pressures from population growth and poverty contribute to severe malnutrition and continue to affect nearly half of the world's population. Some estimates indicate that more than 840 million people do not have enough food to meet their basic daily needs. Also alarming is that an 18 percent rise in the number of malnourished children is projected in Africa by 2020 (IFPRI, 2001). Over 2 billion people suffer from malnutrition in their diets (Gardner and Halweil, 2000), including protein-calorie deficiencies and micronutrient malnutrition. Such malnutrition prevents much of the world's population from reaching their full potential – mentally, physically or financially. It also contributes to higher death rates from heart disease, stroke and cancer (Khaw *et al.*,

2001). Many population groups subsist on diets based on staple plants that are lacking in diversity, which contributes to micronutrient deficiencies. This article focuses on vitamin A deficiency (VAD) and iron deficiency, which are among the deficiencies of greatest public health significance in the world today.

Vitamin A and iron deficiencies

Because VAD and iron deficiency disproportionately affect women during their reproductive years and children, they hinder both the development of

fatigue and reduced work capacity; and in pregnant women, anaemia may cause foetal growth retardation or low birth weight and is responsible for a large proportion of maternal deaths (Gillespie, 1998). The most popular approaches to addressing malnutrition are supplementation and the so-called “food-based strategies”, which include nutrition education and food fortification (Ruel and Levin, 2000). While supplementation strategies can be important in meeting acute micronutrient deficiencies, food-based strategies such as food fortification, nutrition education and home-gardening

production of leaf concentrates to extend the availability of seasonal fruits and vegetables throughout the year. Fortification programmes are often placed in this category and seek to add nutrients to commonly consumed foods. Iodine fortification of salt is perhaps the best-known fortification programme.

- *Increasing the intake of micronutrient-rich foods.* These approaches refer to nutritional education, communication, social marketing and behaviour change programmes to guide consumer food choices and to increase the

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individual human potential and national social and economic development. Almost one-third (about 250 million) of preschool children in developing countries are affected to some degree by VAD, which impairs growth, development, vision and the immune system, and in extreme cases leads to blindness and death (WHO, 1995; Sommer and West, 1996; UN ACC/SCN, 1997; United Nations, 2000). Iron deficiency, which leads to anaemia, is well recognized as the most common dietary deficiency in the world, even in developed countries, affecting mostly women of reproductive age and children (Gillespie, 1998). It is estimated that more than half of all pregnant women in the world and at least one-third of preschool children suffer from anaemia, and many more are iron deficient to some degree (UN ACC/SCN, 1997). Iron deficiency is harmful at all ages. In young children it impairs physical growth, cognitive development and immunity; during the school-age years it affects scholastic performance; in adulthood it causes

may potentially lead to longer-term elimination of micronutrient deficiencies.

Food-based strategies

Food-based strategies to address VAD and iron deficiency, which include food fortification, encompass a wide variety of interventions that aim to increase (1) the production and availability of and access to micronutrient-rich foods, (2) the consumption of foods rich in vitamin A and iron and (3) the bioavailability of these micronutrients in the diet. Examples of intervention methods include the following approaches.

- *Increasing the production of foods rich in micronutrients.* These strategies include agricultural programmes and policies to increase commercial production and programmes to promote home production of fruits and vegetables (school and home gardens), small livestock production and aquaculture (fishponds), and preservation and conservation techniques such as solar drying or

demand for micronutrient-rich foods. They also include education interventions targeted at specific age groups, such as the promotion of optimal breastfeeding and complementary feeding practices for infants and young children.

- *Increasing the bioavailability of micronutrients.* These include home processing techniques such as fermentation or germination to increase the bioavailability of certain micronutrients. Food preparation methods and food combinations within a meal are also methods used to increase bioavailability.
- *Plant breeding as a tool.* Plant-breeding technologies can also be included in food-based strategies because they can increase (1) the concentration of certain trace minerals and vitamins, (2) the bioavailability of micronutrients by reducing the concentration of anti-nutrient factors (inhibitors of absorption) or (3) the concentration of absorption promoters.

Food-based strategies are often described as a sustainable approach because the process empowers individuals and households to take ultimate responsibility over the quality of their diet through their own production of nutrient-rich foods and informed consumption choices. These strategies are said to be “the ideal long-term goal towards which society strives – provision of assurance of access to a nutritionally adequate diet achieved through diversity of food availability, wise consumer selection, proper preparation, and adequate feeding” (Howson *et al.*, 1998). Food-based strategies are also appealing because they can address multiple nutrients simultaneously, including dietary energy, proteins and various micronutrients, without the risk of antagonistic nutrient interactions or overload.

Vegetables as a component of food-based strategies

Many nutritionists and social scientists believe that the integration of food rich in micronutrients into the diet is the only

sustainable way to improve micronutrient status in the human body (Ali and Tsou, 1997). Vegetables are the most affordable and sustainable dietary sources of vitamins, trace elements and other bioactive compounds. They are the major source of most micronutrients and offer the only practical and sustainable way to ensure that micronutrients are supplied through the diet (see Table 1). Vegetables are a vitally important dietary component, not just a side dish to add flavour. Furthermore, vegetables can release and make available “bound” micronutrients in other staple crops for effective absorption from foods. The diversity of vegetables permits year-round production and forms the basis of a more balanced diet. Improved vegetable production and consumption is thus the most direct, low-cost method for many of the urban and rural poor to increase micronutrients in their diet.

Vegetable legumes as a protein source are recommended for populations with low-protein intakes. Leguminous crops can include mung bean, vegetable soybean or cowpea, depending on the

environment and palatability acceptance. Vegetables, especially tomatoes and leafy vegetables, serve as sources of vitamin A. In addition to the iron contained in vegetables, the high levels of vitamin C found in many vegetables will increase the efficiency of dietary iron absorption.

Recommendations to increase the intake of vegetables and fruits are supported by a wealth of epidemiological data, most of which are related to cancer incidence; nevertheless, the rate of vegetable consumption in many regions such as Asia and Africa remains very low. These regions also have severe problems in terms of micronutrient disorders, especially VAD and iron deficiency. Undoubtedly, the increase in vegetable consumption should be one of the primary approaches to combating nutritional disorders in these regions. Encouraging the planting and use of indigenous vegetables could play a role in increasing overall vegetable consumption.

Potential of indigenous vegetables to improve nutrition

The limited supply of vegetables, especially during the off-season, higher market price and lower appreciation or awareness regarding their consumption are key factors that limit the vegetable consumption rate in the developing world. A review of species shows that indigenous vegetables could make a positive contribution to world food production because they are well adapted to adverse environmental conditions and are generally resistant to pests and pathogens. Indigenous vegetables are generally uncultivated and underutilized. Tropical indigenous vegetables could be selected as a partial substitute for other cultivated commodities to alleviate nutrient deficiencies by extending production areas, increasing nutrient supplies, lowering the cost of production systems and complementing vegetable supplies during the off-season (Engle and Altoveras, 2000).

TABLE 1

Vegetables rich in vitamins and minerals, in decreasing order of quantity of nutrient

MICRONUTRIENT	QUANTITY	VEGETABLE SOURCE
Vitamin A	>2 000 international units	Amaranth, Malabar spinach, kale, kang kong, leaf lettuce and carrots
B vitamins	>17 mg	Legumes, taro and horseradish leaves
Vitamin C	>20 mg	Amaranth, Malabar squash, cabbage, kale, kang kong and bitter gourd
Calcium (Ca)	>20 mg	Amaranth, kang kong, head lettuce, leaf lettuce, kale, mustard, spinach, beans, onion, cabbage, turnip green and soybean
Iron (Fe)	>3 mg	Amaranth, kang kong, lettuce, spinach and chillies
Phosphorus (P)	–	Spinach, beans, lettuce, onions, tomatoes, cabbage, cauliflower, broccoli and collard greens
Iodine (I)	–	Onion, okra and asparagus
Protein	–	Mung bean, soybean and cowpea

SOURCE: Adapted from AVRDC, 1990.

Indigenous legumes can provide alternate cheap sources of protein and can alleviate protein malnutrition among lower-income families. Leafy indigenous vegetables are also rich sources of fibre, vitamins and minerals, and add diversity to the diet. Furthermore, they have been a traditional part of cropping systems in the past, especially in home gardens (Midmore, Niñez and Venkataraman, 1991). The cultivation, utilization and acceptability of indigenous vegetables do not usually pose problems, because they are familiar to the local population. Indigenous fruits and vegetables also have a longer shelf life than non-indigenous vegetables.

To evaluate the potential of indigenous vegetables in terms of production systems, it should be noted that these plants adapt easily to harsh or difficult environments. As such, the input required for growing them is lower compared with that for other crops. Fewer chemicals and pesticides are necessary because of their higher resistance to pathogens. Indigenous vegetable production would be advantageous for people living in lowland tropics with high population density. Basically, more labour and more complicated technologies are needed for commercial varieties of vegetables than for other crops such as cereals. Indigenous vegetables, on the other hand, can be grown less intensively, and will fit into farmers' production customs more easily in certain areas (Engle and Altoveras, 2000).

Regarding seasonality of vegetable production, off-season problems commonly occur with major crops. Tropical indigenous vegetables, on the other hand, can grow year round under conditions of high temperature and humidity. Therefore, indigenous vegetable production can compensate for low vegetable supply during the off-season, potentially helping to alleviate nutrition deficiency during this period.

AVRDC initiatives in combating malnutrition

The Asian Vegetable Research and Development Center (AVRDC) is an international centre with a mandate to work on vegetable crops, including vegetable legumes. The Center's Africa Regional Program (AVRDC-ARP) in Arusha, United Republic of Tanzania, serves as a bridgehead to extend AVRDC's mission into the African continent.

AVRDC has taken a particular interest in developing and promoting micronutrient-rich vegetables and in enhancing the bioavailability of nutrients, especially iron. At the Africa Regional Center, the evaluation and testing of a number of vegetable crops, such as tomato, mung bean, soybean, okra and a number of indigenous African vegetables, have generated promising results that are being promoted in selected countries in Africa. For example, AVRDC has developed tomato lines with 6 to 20 percent more beta-carotene than the normal tomato varieties. Not only is the tomato rich in beta-carotene and iron, but the bioavailability of these nutrients is also high (with or without cooking) (AVRDC, 1996, 2000). Recent work at AVRDC further shows that the tomato is one of the few vegetables that can enhance the bioavailability of iron in rice and mung bean (when rice or mung bean and tomato are mixed together). Experimental data have demonstrated that processed products such as tomato paste can also enhance the iron bioavailability of rice. Similarly, tomato can double the bioavailability of iron when cooked together with other cereal, tuber or legume crops (AVRDC, 2000). The improvement of tomato production to make it physically and economically accessible to target groups, such as women of reproductive age and children, can be an effective means of elevating nutritional levels of both vitamin A and iron in these groups.

When integrating micronutrient-rich foods into the diet, it is necessary to take into consideration the seasonal fluctuations in vegetable supply, which translate into seasonality in prices and ultimately consumption. Possible answers to the problem of seasonality proposed by AVRDC are diversification of the agricultural environment through the use of more vegetable species in school and home gardens, and use of sprouts or processed vegetables (AVRDC, 2002).

School and home gardens and vegetable sprouts

The goal of the AVRDC garden programme is to raise the productivity and quality of life of people in developing countries. One way to achieve this goal is to increase the nutritional status and income of people through research, development, training and extension of school, home and market garden technologies. For the past several years, AVRDC has been working towards this goal through nutrition-related garden activities. The Center has designed school and home gardens using a variety of vegetable crop species to provide a year-round vegetable supply. Growing vegetables in school and home gardens is the most direct way for many urban and rural poor families to improve their access to a variety of micronutrient-rich food.

One research project developed a school garden measuring 10 m x 18 m that provides 142 children with 1/2 cup (125 g) of vegetables per day throughout the school year. Similarly, it was shown that a garden plot measuring 16 m² in Indonesia, Thailand or the Philippines could supply a family of five (two adults and three children) with a significant percentage of the recommended dietary allowance of protein, calcium, iron and vitamins A and C. From three plots measuring 4 m x 1 m x 25 cm high, the daily vegetable yield is between 800 g and 1 000 g. Research on market gardens

showed that a plot measuring 10 m x 20 m, using only family labour, can increase income by approximately 30 percent for small farm families.

On the basis of knowledge gained through school- and home-garden research, it is now known that cultivation on a larger scale of a diverse array of vegetable species can be extended, including the planting of indigenous vegetables. Using sprouts is another way of making vegetables available in the off-season. Fresh sprouts contain higher levels of certain nutrients such as vitamin C and offer the added advantages that the processing is home based, and the seeds can be stored and sprouted easily during periods when vegetables are scarce.

Additional research needs

Food from plant sources is much more diverse than from animal sources. The diversification of indigenous vegetables can enhance palatability through the increase of dietary variety. However, dietary customs are culture-related. If consumers are unaware that certain vegetables are necessary for their daily requirements, those vegetables may easily be replaced by other foods such as cereals, meat or spicy crops. Thus, the promotion of vegetable consumption will become more difficult. The concept of the importance of vegetable nutrition to daily nutrient supplies needs to be supported by governments and should likewise be

acknowledged by farmers and consumers. Low yield is a further constraint hampering the utilization of indigenous vegetables. Low yield means low total nutrient supply. More research on uniformity and domestication of indigenous vegetables to improve yield and thus increase income would stimulate farmers' willingness to grow them. Research on variety selection and development of seed supply technology could also enhance the productivity of indigenous and other micronutrient-rich vegetables. With improved technology, growing vegetables can complement insufficient nutrient supply of current vegetable consumption.

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THE PRESSURES FROM POPULATION growth and poverty contribute to severe malnutrition and continue to affect nearly half of the world's population. Some estimates indicate that over 840 million people do not have enough food to meet their basic daily needs. Nutrition status is internationally recognized as a key indicator of national development. And a well-nourished, healthy workforce is a precondition for successful economic and social development. Agriculture is also a major source of income and employment for the world's poor. Thus, direct investment in improving nutritional status can result in a significant pay-off in raising labour productivity and incomes. National agricultural research, by enhancing a country's food production and productive capacity, can play a role in contributing to nutritional improvement.

While supplementation strategies can be important in meeting acute micronutrient deficiencies, food-based strategies such as food fortification, nutrition education and home gardening can offer longer-term elimination of micronutrient deficiencies. Vegetables, with their rich contribution of micronutrients, are important components of a healthful diet. Increased vegetable production could improve food security as well as offer income opportunities to small farmers, including women.

The Asian Vegetable Research and Development Center (AVRDC) is an international bureau with a mandate to work on vegetable crops, including vegetable legumes. The centre's Africa Regional Program (AVRDC-ARP) in Arusha, United Republic of Tanzania, extends AVRDC's mission into the African continent. AVRDC is working towards developing technologies to break the cycle of continuing poverty from generation to generation and reduce malnutrition problems through efforts in crop research and the application of vegetable gardening strategies. Improvements in vegetable production are making vegetables more affordable to families. The possibility now exists for greater food security for all.

Potagers familiaux et autres stratégies de lutte contre la malnutrition due aux carences en micronutriments dans les pays en développement

LES PRESSIONS DUES À LA CROISSANCE démographique et à la pauvreté sont facteurs de malnutrition sévère et touchent aujourd'hui encore près de la moitié de la population mondiale. Selon certaines estimations, plus de 840 millions de personnes ne peuvent subvenir à leurs besoins alimentaires quotidiens de base. L'état nutritionnel de la population est désormais considéré, à l'échelle internationale, comme l'un des indicateurs clés du niveau de développement national. Or, le développement économique et social n'est concevable que si la population active est en bonne santé et mange à sa faim. L'agriculture est aussi une source importante de revenus et d'emplois pour les populations pauvres du monde. En conséquence, les interventions visant directement l'amélioration de l'état nutritionnel peuvent avoir des retombées considérables sur l'accroissement de la productivité de la main-d'œuvre et des revenus. La recherche agricole nationale, en favorisant l'augmentation de la production vivrière et de la capacité de production des pays, peut aussi contribuer à l'amélioration de l'état nutritionnel des populations.

Si les stratégies de supplémentation alimentaire peuvent jouer un rôle important dans la lutte contre les carences aiguës en micronutriments, celles fondées sur l'alimentation comme l'enrichissement des aliments, l'éducation nutritionnelle et les potagers familiaux peuvent contribuer dans le long terme à l'élimination de ces carences. Les légumes, riches en micronutriments, sont des composantes majeures de régimes alimentaires sains. L'accroissement de la production maraîchère pourrait donc favoriser le renforcement de la sécurité alimentaire et l'augmentation des revenus des petits agriculteurs, notamment des femmes.

Le Centre asiatique de recherche et de développement dans le domaine des végétaux est un organisme international qui a pour mandat d'étudier les cultures maraichères, y compris les légumineuses. Le Programme régional pour l'Afrique du Centre, basé à Arusha (République-Unie de Tanzanie) a pour vocation de mener sur le continent africain la mission que s'est fixée le Centre. Le Centre œuvre à l'élaboration de technologies capables de briser le cycle ininterrompu de la pauvreté, qui se répète de génération en génération, et de réduire l'ampleur des problèmes liés à la malnutrition par le biais de recherches sur les cultures maraichères et de stratégies axées sur la création de potagers. Aujourd'hui, grâce à l'amélioration de la production maraichère, les ménages peuvent se permettre plus facilement d'acheter des légumes. Désormais, il est possible de renforcer la sécurité alimentaire des populations.

La horticultura familiar y otras estrategias para superar la malnutrición por carencia de micronutrientes en los países en desarrollo

LAS PRESIONES DERIVADAS DEL CRECIMIENTO demográfico y de la pobreza contribuyen a agudizar la malnutrición y siguen afectando a casi la mitad de la población del mundo. Algunas estimaciones indican que hay más de 840 millones de personas que no disponen de alimentos suficientes para satisfacer sus necesidades básicas diarias. El estado nutricional goza de reconocimiento internacional como un indicador clave del desarrollo nacional, y una mano de obra sana y bien alimentada es un requisito indispensable para conseguir un desarrollo económico y social satisfactorio. La agricultura es también una fuente importante de ingresos y empleo para la población pobre. Así pues, la inversión directa en la mejora del estado nutricional puede contribuir de forma importante a aumentar la productividad de la mano de obra y sus ingresos. La investigación agrícola nacional, al potenciar la producción de alimentos y la capacidad productiva, puede propiciar un mejor estado nutricional.

Si las estrategias de suplementación de la dieta pueden ayudar a resolver las carencias agudas de micronutrientes, las estrategias basadas en los alimentos, como el enriquecimiento de los alimentos, la educación nutricional y la horticultura familiar permiten eliminar de forma duradera las carencias de micronutrientes. Las hortalizas, con su importante aportación de micronutrientes, son componentes esenciales de una dieta saludable. El incremento de la producción de hortalizas podría aumentar la seguridad alimentaria y ofrecer oportunidades de ingresos a los pequeños agricultores, especialmente las mujeres. El Centro Asiático de Investigación y Desarrollo sobre las Hortalizas es un organismo internacional que se ocupa de la producción de hortalizas. El Programa regional para África que está llevando a cabo el centro en Arusha (República Unida de Tanzania) extiende su misión al continente africano. El Centro se está esforzando por desarrollar tecnologías que permitan romper el ciclo de pobreza permanente de una generación a la siguiente y reducir los problemas de malnutrición mediante una labor de investigación sobre cultivos y la aplicación de estrategias de establecimiento de huertos de hortalizas. Las mejoras introducidas en la producción de estos cultivos están permitiendo que resulten más asequibles para las familias. Ahora es posible aumentar la seguridad alimentaria para todos.