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Can science and technology feed the world in 2025?

M.S. Swaminathan

M.S. Swaminathan Research Foundation, Taramani Institutional Area, Chennai 600113, Tamil Nadu, India

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Abstract

By 2025 the global population will exceed 7 billion. In the interim per capita availability of arable land and irrigation water will go down from year to year while biotic and abiotic stresses expand. Food security, best defined as economic, physical and social access to a balanced diet and safe drinking water will be threatened, with a holistic approach to nutritional and non-nutritional factors needed to achieve success in the eradication of hunger. Science and technology can play a very important role in stimulating and sustaining an Evergreen Revolution leading to long-term increases in productivity without associated ecological harm.

Keywords: Green revolution; Evergreen Revolution; Village knowledge centers; Sustainable solutions; Rural–urban parity index

1. Introduction

A combination of improved genetic cultivars, appropriate agronomic and fertilizer practices, irrigation facilities and assured and remunerative marketing opportunities led to the birth of the green revolution in many parts of Asia. The green revolution, defined as a commodity-centered increase in productivity, achieved by changes in plant architecture, improved harvest index and photoperiod insensitivity, resulted in the growth rate in food production exceeding the growth rate in population. Recent deceleration in food production growth rates due to a combination of adverse meteorological, ecological and marketing factors (sometimes referred to as the ‘‘fatigue of the green revolution’’) poses a fresh challenge; to reverse this decline and ensure that there is adequate food for the growing population.

Food security has three dimensions, namely: (1) endemic hunger caused by poverty-induced under- and malnutrition; (2) hidden hunger caused by the deficiency of micronutrients like iron, iodine, zinc and vitamin A in the diet; and (3) transient hunger caused by natural calamities or civilian conflicts. Real food security, however, must not only increase the availability of needed food grains in the market, but also economic, social and physical access to a balanced diet, clean drinking water, environmental hygiene and primary healthcare. The United Nations Millennium Development Goal is to bring down the number of children, women and men going to bed hungry from 850 million to about 425 million by 2015. A review conducted in 2005 to assess progress made during the first 5 years of this millennium suggests that even this modest goal is not being achieved.

By 2025, the world population is likely to exceed 7 billion with about 2 billion tonnes of food grains needed to meet the needs of this population. Achieving this level of production is not likely to be too difficult since there is a large untapped production reservoir available in countries like India, even with technologies currently on the shelf. If these technologies can be transferred to farmers' fields through appropriate packages of services and public policies, the food needs in physical terms can be met. However, even today the food security challenge is not just increasing production but providing jobs or livelihoods which can lead to economic access to food, and in achieving needed production increases without further environmental pollution. In general, where there is work, there is money and where there is money there is food. Therefore, it becomes important to look at agriculture not only as a food-producing machine, but also as an important source of livelihood generation both in the farm and non-farm sectors.

The persistence of widespread under- and malnutrition in many developing countries arises from policies which fail to recognize that the farming population, including landless agricultural labor, constitutes the majority of consumers. Unfortunately, the term, ‘‘consumer’’ seems to cover only the urban population in the minds of the policy makers. Enhancing small farm productivity and profitability will make a major contribution to reducing hunger and poverty. This in turn will

E-mail addresses: swami@mssrf.res.in, msswami@vsnl.net.

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depend on the ability to assure remunerative prices for farm produce.

In industrialized countries, farmers constitute 2–4% of the population. The per capita income of farmers is high both because of the size of the farm and the extensive support extended by governments. These farmers are technology, capital and subsidy rich. Public policies concurrently promote conservation, cultivation, consumption and commerce. Extensive support is given to promote conservation farming. The collapse of the Doha round of negotiations in agriculture is an indication that farming cannot survive in industrialized countries without substantial support from public funds to ensure its economic viability.

What then is the future for farmers and farming in developing countries? The following four areas need urgent and integrated attention: technology, training, techno-infrastructure, and trade. Upgrading of technology, ecology and management of small farms is the need of the hour.

2. Technology

Technologies that will enhance land, water and labor productivity and that will allow an increase in long-term productivity without associated ecological harm are urgently needed (Table 1). The smaller the farm, the greater is the need for marketable surplus in order to a generate cash income. A small farm can lend itself to higher productivity and profitability, provided the farmer is enabled to overcome handicaps arising from lack of capital and credit, and access to appropriate technologies, inputs and remunerative markets. The Green Revolution must be extended to the small farm and confer the power and economies of scale on small producers, both in the production and post-harvest phases of farming. Without this mounting debts will continue to affect them. Cooperative farming, service cooperatives, stakeholder companies, formation of compact production and processing estates by self-help groups and farmer-centric contract farming can all contribute to improvement in the economics of small holdings and thereby foster improved management.

At the production end, there is need for integrating more frontier technologies including biotechnology, information and communication technologies, and renewable energy technologies. New agricultural technologies like genomics and information technology, together with improved agronomic management, should form the cornerstone of increased agricultural productivity and profitability of small farms both in irrigated and rain-fed areas, as well as in problem soils and coastal areas. Recombinant DNA technology has already resulted in the breeding of crop varieties possessing tolerance to salinity and drought as well as to serious biotic stresses caused by the triple alliance of pests, pathogens and weeds. We must also emphasize their use in the development of more nutrient efficient varieties. It is however essential for each country to have a professionally- and socially-credible National Biotechnology Regulatory Authority. The bottom line for any biotechnology policy should be the safety of the environment, the well being of farming families, the ecological and economic sustainability of farming systems, the health and nutritional security of consumers, the safeguarding of home and external trade, and the biosecurity of the nation. Biotechnology does not imply only genetically modified organisms (GMOs). Non-GMO applications are many, such as tissue culture to multiply elite germplasm, bio-fertilizers, bio-pesticides and bio-remediation of groundwater, as well as marker-assisted breeding. In the case of GMOs, safe and responsible use should be ensured. Organic farming procedures permit the use of varieties developed by marker-assisted breeding.

Bio-energy based on pyrolysis and gasification of biomass can be a decentralized source of energy. Bio-fuels also offer scope wherever ecological and economic conditions are favorable. Biomass is an under-utilized resource. ‘‘Bio-parks’’ can be promoted in every block to convert the available biomass into a range of products, including energy and manure.

Conservation farming and green agriculture are the pathways to an ‘Evergreen Revolution’, defined as increasing productivity in perpetuity without associated ecological harm. The greatest problem with applying conservation agricultural concepts in dryland areas is the lack of adequate quantities of crop residues. The removal of crop residues for alternative uses accelerates the already fast decline of soil organic matter content in dryland farming. Long-term sustainability of dryland soils may be significantly enhanced by reduced tillage that leaves more crop residues on the soil surface. ‘Green’ agriculture involves the development and adoption of environmentally friendly technologies like integrated nutrient supply and integrated pest management.

Besides enhancing soil fertility and soil organic matter, the need for the economic and efficient use of water cannot be overemphasized. The average yield of cereals can be increased by 30–60% annually in dryland farming areas by increasing crop

Table 1
Steps in the Evergreen Revolution, defined as increasing productivity in perpetuity without associated ecological harm

Component	Description
Organic agriculture	Cultivation without any use of chemical inputs like mineral fertilizers and chemical pesticides
Green agriculture	Cultivation with the help of integrated pest management, integrated nutrient supply and integrated natural resource management systems
Eco-agriculture	Based on conservation of soil, water and biodiversity and the application of traditional knowledge and ecological prudence
Effective microorganism agriculture	System of farming using effective microorganisms
White agriculture	System of agriculture based on substantial use of microorganisms, particularly fungi
One-straw revolution	System of natural farming without ploughing, chemical fertilizers, chemical pesticides and herbicides