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GUEST EDITORIAL

From Green Revolution to Evergreen Revolution: Pathways and Terminologies

The major scientific pathway of the green revolution of the late 1960s was productivity enhancement of cereal grains, particularly wheat and rice. A quantum jump in the productivity and production of wheat and then rice transformed the image of India as a 'begging bowl' to 'bread basket'. Today, nearly 40 years later, the 'green revolution' is aptly recognized as 'forest or land saving agriculture'. If the yield improvement associated with the green revolution in wheat and rice had *not* taken place, India by now would have had to convert nearly 80 million hectares of forest land to produce the current level (~207 million tons) of harvest of food grains. The green revolution that raised the ceiling to yield also reinvigorated the entire agricultural production machinery in the country. In particular, it restored self-confidence in India's agricultural capability.

The term 'green revolution' was coined by William Gaud in 1968 to describe the enhanced photosynthetic activity of the green pigment, chlorophyll, leading to more grain production. This involves not only effective utilization of solar energy and carbon dioxide from the atmosphere, but also water and several nutrients, particularly nitrogen, phosphorus and potassium from the soil. The plant type also matters since several traditional tall varieties of cereal crops 'lodge' under the weight of their grain-filled, dense panicles that are produced when the soil is enriched with high doses of fertilizers and water. The logic, therefore, was to shorten the plant height *without* reducing the panicle length. The use of Mendelian genetics helped in developing dwarf and semi-dwarf varieties of wheat and rice. These dwarf plant types efficiently utilized the externally applied chemical forms of nitrogen, phosphorus and potassium, as also irrigation water and produced much larger quantities of grains because of a higher harvest index. Thus, the pathway for the green revolution involved genetically altered plant forms (i.e. dwarf and semi-dwarf), application of high doses of chemical fertilizers and copious irrigation. However, their luxuriant growth attracts a variety of pests, and therefore, chemical pesticides need to be periodically applied. In addition, they were also selected for photoinsensitivity, so that they can be fitted into multiple cropping sequences.

In January 1968, even before the term green revolution was coined, M. S. Swaminathan in his Presidential Address to the Agricultural Sciences Section of the Indian Science Congress drew attention to the adverse consequences of the excessive applications of chemical fertilizers, pesticides and irrigation using groundwater, without adequate drainage, on soil structure and health. He cautioned against practising exploitative agriculture keeping in view only the short-term gains. He made a plea for adherence to the scientific principles of soil and plant health management in order to sustain the benefits of enhanced productivity over long periods. Unfortunately, the culmination of the benefit of free electricity to the farmers to draw groundwater for irrigation, absence of legumes in the crop rotation, and indiscriminate application of chemical fertilizers and pesticides led to the degradation of soil and water. The damage to the ecological foundations essential for sustainable advances in productivity led to the onset of a fatigue in the green revolution.

Lessons drawn from the green revolution are that steps taken towards productivity enhancement should concurrently address the conservation and improvement of soil, water, biodiversity, atmosphere, renewable energy sources, etc. Keeping these in focus, the goal of 'evergreen revolution' – for achieving higher productivity in perpetuity was developed. What this means is a system of agriculture that involves sustainable management of natural resources and progressive enhancement of soil quality, biodiversity and productivity. The evergreen revolution will be triggered by farming systems that can help to produce more from the available land, water, and labour resources without either ecological or social harm. Wilson (*The Future of Life*, Alfred A. Knoff, NY, 2002) observes that Swaminathan's evergreen revolution is the best available option to increase agricultural productivity to feed the growing millions of humans, while at the same time conserving the rest of the life as well on our planet.

The goal of 'evergreen revolution' (productivity advance in perpetuity without accompanying ecological harm) necessarily involves pathways which do *not* adversely affect soil health, water quality, biodiversity, atmosphere and

renewable energy sources. In this context, several approaches have been proposed ranging from organic farming to varying levels of combinations of traditional and modern scientific methods to transform the green into an evergreen revolution.

The International Federation of Organic Agriculture Movement (IFOAM) has defined **organic agriculture** as 'all agricultural systems that promote the environmentally, socially and economically sound production of food and fibres' (www.ifoam.org). Four principles govern the identification of organic agriculture. The first is the *principle of health*, which emphasizes that health of all living systems and organisms, from the smallest in the soil to human beings are mutually dependent. The second is the *ecological principle* which stipulates that organic agriculture should be based on living ecological systems and cycles, should work with them, and help sustain them. The third is the *principle of fairness* directing that the organic agriculture should be built upon relationships that ensure fairness, equity, respect, justice in the human–human relations and the relations between humans and other living beings. It stipulates that farm animals are provided with conditions and opportunities of life that accord with their physiology, innate behaviour characteristics and well-being. The fourth is the *principle of care* which stipulates that organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. Here, the precautionary approach for decision making recognizes that, even when the best scientific knowledge is used, there is often a lack of knowledge with regard to future consequence and to the plurality of values and preferences of those who might be affected. The emphasis is on precaution and responsibility, and not on risk assessment which is considered as a narrow notion based on narrow scientific or economic appraisal. *Hence, it does not permit use of any chemical agents (i.e. fertilizers, pesticides, etc.) or transgenic crops in the schedule of organic farming*. The organic certification process is a rigorous one, and consequently, even a very slight deviation from or compromise with the stipulations in the production of organic foods results in their outright rejection. In many countries, certification is covered by legislation, and commercial use of the word organic, outside of the certification framework, is illegal.

Green agriculture is a system of cultivation with the help of integrated pest management, integrated nutrient supply and integrated natural resources management systems. This is widely practised and promoted in China. Green agriculture does not exclude the use of minimum essential quantities of mineral fertilizers and chemical pesticides.

McNeely and Scherr describe (*Ecoagriculture: Strategies to Feed the World and Save Wild Biodiversity*, Island Press, Washington, 2003) how increased agricultural diversity can enhance habitat for wild species, and how strategies to enhance wild biodiversity can build on the beneficial effects of many wild species for agricultural production and sustainability. **Eco-agriculture** aims at mutually reinforcing relationships between agricultural productivity and conservation of nature. Innovative eco-agriculture approaches can draw together the most productive elements of modern agriculture, new ecological insights and the knowledge that local people have developed from thousands of years of living in harmony with nature. Eco-agriculture is defined as an approach that brings together agricultural development and conservation of biodiversity as explicit objectives in the same landscapes.

Teruo Higa (*An Earth Saving Revolution*, Sunmark Publishing, Tokyo, 1994) narrates the amazing gains in agricultural productivity by the application of **Effective microorganisms** (EM). The rice cultivation described by him involves direct planting without any tilling and weeding. It cuts the costs of agricultural chemicals and artificial fertilizers by one fifth. Untreated cowdung forms bulk of the fertilizer. In the initial period (the first and second year), the rice yields were lower but in the fourth year, the production level had even slightly surpassed the standard yield level of modern agriculture. Besides being benign to ecosystems, the EM-agriculture improves the quality of fruits and reduces the cost of external inputs by about one-fifth.

White agriculture is a system of agriculture based on a substantial use of microorganisms, particularly fungi. The concept of white agriculture took shape in 1986 in China. *White* refers to the white-coated scientists and technicians performing high tech processes to produce food directly from micro-organisms or to use them to augment and improve green agriculture.

One-straw revolution is a system of natural farming proposed by Masanobu Fukuoka. Its four principles are: (i) *No* cultivation (no ploughing or turning the soil), (ii) *No* chemical fertilizer or prepared compost, (iii) *No* weeding by tillage or herbicides (weeds play a part in building soil fertility; they need to be controlled, but *not* eliminated), and (iv) *No* dependence on chemicals or poisonous pesticides.

The future of Indian agriculture depends upon our ability to enhance the productivity of small holdings without damage to their long-term production potential. Transforming green revolution into an evergreen revolution using one or more of the several pathways described here will usher in a win-win situation for both farmers and ecosystems. Crop–livestock integration and introduction of stem nodulating legumes or pulse crops in the rotation will facilitate the building up of soil fertility. Instead of placing the above-mentioned six approaches to sustainable agriculture in different compartments, it will be prudent to develop for each farm an ever-green revolution plan based on an appropriate mix of the different approaches which can ensure both ecological and economic sustainability.

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