EVOLUTION OF ECO-AGRICULTURE SYSTEMS

Towards Climate Resilient Agriculture

Eco-agriculture is the need of the hour because of a fully integrated approach to agriculture, conservation and rural livelihoods, within a landscape or ecosystem. McNeely and Scherr (2003) have identified six sets of strategies that can advance the goals of Eco-agriculture:

- Creating biodiversity reserves that benefit local farming communities.
- Developing habitat networks in non-farmed areas of agricultural landscapes.
- Reducing land conversion to agriculture by increasing farm productivity.
- Minimizing agricultural pollution.
- Modifying the management of soil, water and vegetation to increase natural capital.
- Designing farm systems to mimic natural ecosystems.

EVOLUTION OF ECO-AGRICULTURAL PRACTICES

Panchagavya: These agriculture practices are traced back to Indus valley civilization. The eco-friendly organic liquid formulation made from products obtained from the cow is widely used. It is a fermented product made from milk, urine, dung, curd and clarified butter. This, added with other ingredients, has the potential to promote growth and provide immunity in the plant system.

Agnihotra system of agriculture: Agnihotra has its origin in the most ancient Vedic sciences of bio-energy, agriculture and climate engineering. This ancient Vedic farming technique promises an increase in crop yields with minimal input costs. The practice is used to treat the atmosphere, the soil, plants, pests and disease problems. Seeds were treated with cow's urine and Agnihotra ash. Through this process, seed-borne diseases were controlled. Agnihotra system of agriculture is still in use in various parts of India and rigorous amount of research is going on it.

Biodynamic agriculture: This alternative form of agriculture resembles that organic farming. It is based on the work of Rudolph Steiner, who suggested organic practices, green manures and crop rotations, and other steps such as paying attention to astrological calendars. A number of agronomic assessments have not supported claims of the methods' superiority, though there are national associations of biodynamic farmers in about ten countries.

Nutrient management with natural ways to restore soil nutrients such as bio-fertilizers, selection, cultivation and recycling of organic seeds can lead to good eco-agricultural practices

ABOUT THE AUTHOR

Dr Nutan Kaushik is Director General, Food & Agriculture Foundation, Amity University, Noida. She has been awarded various prestigious fellowships viz. USDA Cochran Fellowship, NFP Fellowship of Govt. of Netherlands, DBT CREST Fellowship, BIRAC BEST INNOVATION 2016 etc

Dr Kaushik's favourite stress buster is listening to Sufi music

Permaculture: This was introduced in 1929. The work of JR Smith was seminal for permaculture theory and practice. Permaculture is a design philosophy that focuses on creating ecological human ecosystems and food production processes that adhere to particular guidelines and principles. Permaculture can be applied to almost every site-specific ecological farming method. A permaculture agriculture system requires passive energy systems, safe on-site waste disposal, conserved and assured water supply, controlled fire, cold, excess heat and wind factors.

Organic farming: This was introduced in 1940 by Lord Northbourne. Organic farming is a production system that forbids or limits the use of synthetic fertilizer, pesticides, growth regulators and livestock feed additives. Crop rotations, crop residues, livestock manures, green manures, off-farm organic wastes, mechanical agriculture, mineral-bearing rocks and elements of biological pest control are used to preserve soil fertility, provide plant nutrients, control insects, weeds, and other pests. It also aims to minimize the wastage and pollution.

Reduced till/ Zero tillage agriculture: This was promoted by Edward H. Faulkner in the 1940s. It reflects an 80-year evolution that has gradually put into practice what soil scientists and farmers have long known – that mechanical tillage has negative effects on soil health, structure, and function, as well as disturbing and altering the soil. Tillage has some immediate benefits, the most immediate being easier crop establishment and then weed control. It has long-term negative effects on soil fertility and productivity, including loss of soil carbon, changes in soil organism populations (numbers, diversity, and activity), and soil erosion. As a result, a growing number of farmers are abandoning tillage, and more than 115 million hectares of agricultural land are now farmed without it. It includes conversational agriculture strategy of eco-agriculture that has eliminated the tillage.

Regenerative Agriculture: This has been in use since 1980s. It was introduced by Robert Rodale. It relies on nature's built-in ability to combat pests, improve soil fertility and boost productivity. It entails the need to continually regenerate the resources that the system necessitates. In practice, regenerative agriculture achieves these aims by using low-input and sustainable farming systems.

Bio-intensive agriculture: This was introduced by John Jeavons in 1999. It aims to attain maximum yields from the minimum area of land, seeking self-sufficiency and sustainability. This system uses open-pollinated seeds which can be naturally pollinated by insects or wind, rather than hybrids. It involves loosening the soil down to 24 inches, which helps with good aeration. Compost is used for the nourishment of crop, which also helps in holding water. Much of this system derives from traditional agricultural knowledge and practices. The consequences of dwindling crop production due to global warming and climate change can also be miti-

gated by bio-intensive farming.

All of the above systems have focused on maintaining the ecological balance.

INPUTS SUPPLIED IN ECO-AGRICULTURE PRACTICES

Nutrients management: Eco-agriculture practices focus on restoring and maintaining the soil's nutrient balance and revive fertility. Animal dung, forest leaf litter, bone meal, slaughter house waste, blood meal and green manures are essential organic sources for nutrient management and soil fertility. The quality of produce is determined by the nutrient content of the raw material and the composting process. Establishing the necessary levels of nutrients in each soil is required, and should be based on the specific needs of that soil. Biological services such as bio-fertilizers and other microbiological inputs have also received a lot of attention and are being widely promoted.

The other well-used approach to increase soil fertility is crop rotation. A well-designed crop rotation can increase the productivity of soil, control common root and stem diseases, control soil erosion and establish a sustainable environment. Management of crop residues is also an important approach to increase soil fertility and avoid soil damage.

Seeds: These are often overlooked as a fundamental part of our food and agricultural systems. Yet this tiny resource has enormous impact on how we farm and what we eat. Seed also has a big influence on the quality of our food, from its appearance to its taste and nutritional value. Seed has limitless potential for transforming our food system, particularly when combined with the principles that founded the organic movement – health and ecology. Plants that have been bred under organic and natural conditions have a higher chance of adapting to these production systems.

The challenges of eco-agriculture can be very different from those of traditional farming, where synthetic pesticides and fertilizer sources are widely used to combat pests, diseases, and other problems. The seed must be genetically diverse, lend itself to recycling and be certified organic. It must not be hybrid and never have been produced from genetic engineering nor contaminated with GMO.

Weed/Herb Control: This is the process of keeping or reducing the weed population and its development to a degree that doesn't causes economic damage to the crop while causing the least amount of pollution to the ecosystem. In eco-agriculture, good weed management entails creating conditions that prevent weeds from growing at the wrong time and in the wrong location, since that can cause serious problem for crop cultivation.

There is a need of complete sustainable eco-friendly weed management programme throughout the farming period. Weeds can be controlled by pathogen like fungi, bacteria, viruses and virus like agents. Among the classes of plant pathogens, fungi have been used to a larger extent than bacteria and virus or nematode pathogens. Bio-herbicides is a preparation of living inoculates of plant pathogens formulated and applied in a manner analogous to that of herbicide in an effort to control or suppress the growth of weed species.

Pests and disease management: In eco-agricultural practices, pest and disease management is a dynamic process that necessitates the incorporation of all management elements, such as the use of resistant varieties, biological diversity on the field, balanced feeding, a consistent supply of nutrients, and the use of preventive and curative measures. Maintenance of soil health and biological activity through timely incorporation of organic manures is also important for crop protection. Biofertilizers such as Rhizobium and Azotobacter assist in the mobilization of nutrients and the promotion of growth. Pathogens are unable to enter seeds because of the high microbial population surrounding them. Azotobacter produces a fungistatic complex that aids in the reduction of pathogen attack in soil. If preventive crop protection practices fail to sufficiently prevent economic losses, then it may be necessary to take curative actions which involve mechanical control with traps, sticky plates or hand picking, biological control with natural predators or antagonistic microbes and natural pesticides based on herbal preparations or other natural products.

Energy input: Human labour, draught animals and engine-driven machinery is commonly used for eco-agriculture. Operations involving planting, weeding, spraying, harvesting (horticultural commodities) requires human labour. Engine driven machinery and draught animals are used for ploughing, soil preparation, water lifting, pulling inputs and threshing. Improvements in energy efficiency can lead to ecological and economic win-win situations. The paradigm is shifting toward renewable energy resources in the eco-agricultural practices. These include solar energy, wind energy, micro-hydro energy and biomass energy. Solar energy is used in cold storage and wind energy is used for the operation of electric water pumps.

Water inputs: Good agricultural water management is important in eco-agriculture. Agricultural water management means using water in a way that provides crops and animals the amount of water they need, enhances productivity, and conserves natural resources for the benefit of downstream users and ecosystem services. Eco-agriculture aims at optimizing the use of on-farm resources and at a sustainable use of natural resources. Active water retention, water harvesting and storing of water are important practices which are being adopted.

Water retention reduces evaporation from the soil surface, preserving soil organic matter in the upper soil layers and, consequently, increasing water retention capacity of the soil. Water harvesting and storage refers to the collection of rainstorm-generated runoff from a particular area (a catchment) in order to provide water agricultural use. The water thus collected can either be utilized immediately, as for irrigation, or be stored in above ground ponds or in subsurface reservoirs, such as cisterns or shallow aquifers, for subsequent utilization.

Farmers' access to modern agricultural inputs is the backbone of every agricultural revolution. These above-mentioned methods apply modern science and technology within a theoretical and practical context. It incorporates ecological concepts and insights in order to make agriculture more profitable and sustainable. Nutrient management with natural ways to restore the soil nutrients such as bio-fertilizers, selection, cultivation and recycling of organic seeds can lead to good eco-agricultural practices. Sustainable eco-friendly weed control and maintenance of soil and plant health with bio-control agents for pest and disease management are also very crucial for maintaining smooth farming. Energy conservation and agricultural water management improvements will result in economic and ecological beneficial situations. These dynamic farming systems are a combination of agricultural and ecological experience that can be used to revise and alleviate the existing widespread tensions.

Acknowledgment: Funding from Asia Pacific Network, Japan is duly acknowledged.

- Dr Nutan Kaushik, Navdeep Singh Plaha, Ayushi Sharma