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Circular Agriculture via Integrated Farming Systems

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INTRODUCTION

Circular agriculture is a novel form of sustainable agriculture, which focuses on the effective use of natural resources through resource recycling, reduced wastage, efficient nutrient use and integration of various agricultural enterprises within a production cycle. The adoption of IFS allows the integration of various types of agricultural production like crop farming, livestock, fishery, horticulture, agroforestry, cultivation of mushrooms, bee keeping and utilization of renewable energy technologies. The adoption of such an approach helps in promoting resource recycling, reducing dependency on exogenous inputs, enhancing profit from farms, improving sustainability and making the farms resilient to the impacts of climate change. The current paper aims at discussing circular agriculture using integrated farming systems.

Agriculture plays a crucial role in ensuring food security and livelihood of the farmers across the world. However, traditional agricultural practices heavily depend on synthetic fertilizers, pesticides, fossil fuels, and extensive monoculture systems leading to soil degradation, biodiversity loss, water contamination, greenhouse gas emissions and reduction in profitability from farms. Growing concerns related to climate change, resource depletion and environmental degradation have necessitated the development of sustainable models of agriculture.

Circular agriculture can be said to be a very promising technique through which the circular economy concepts have been integrated in agricultural production. Instead of following the linear process of "take-produce-dispose," circular agriculture follows the principle of "reduce-reuse-recycle," where any waste produced from agricultural production is made useful instead of being treated as waste.

An Integrated Farming System (IFS) is among the most realistic approaches to achieve circular agriculture. An IFS involves the scientific integration of various farm businesses such that the waste produced by one farm business is used as raw material for another, thus establishing a sustainable production system.

Concept of Circular Agriculture

Circular agriculture is a sustainable form of agriculture, which seeks to reduce the amount of resources used, recycle nutrients and organic materials, reuse the agricultural waste, restore the ecological function, reduce environmental pollution and increase the sustainability of agricultural systems. The main goal of circular agriculture is to boost the efficiency of agricultural production through minimizing the waste and conserving the natural resources. This is unlike conventional agriculture, where all the agricultural wastes are treated as waste and have no use whatsoever.

Integrated Farming Systems (IFS)

Integrated Farming System (IFS) is a science-based strategy that utilizes two or more complementary agricultural operations in the same farm for the purpose of improving productivity, economic viability and sustainability. IFS involves integrating field crop production, horticultural crops, dairy farming, goat and sheep farming, poultry, duck farming, fishing, piggery, mushroom growing, vermicomposting, biogas generation, beekeeping, agro forestry, azolla cultivation, silk worm rearing and fodder production in an integrated farming system. In this strategy, the output or the waste produced in one farming operation becomes the input of another farming activity.

Principles of Circular Agriculture by Integrated Farming System

Resource Recycling

Resource recycling is one of the key principles of circular agriculture. In lieu of disposing of the wastes produced in agriculture, they are recycled to useful products on the farm. The residue left after harvesting crops is used as feed for livestock, while animal dung is processed in biogas plant to produce renewable energy. The biogas slurry from biogas plant is used as organic fertilizer, residue from crop is composted to add nutrients to soil, fish pond sludge is used to provide nutrients to crops and poultry litter is used to make vermicompost. The recycling of resources eliminates the problem of waste disposal and increases farm efficiency.

Nutrient Cycling

The principle of circular agriculture ensures continuous nutrient cycle in the agricultural system. Important plant nutrients like nitrogen, phosphorus, potassium, carbon and micronutrients are added to the soil through the use of compost, farm yard manure, crop residues, green manure and biogas slurry.

Diversification

The next principle of IFS is diversification. Farmers diversify their agricultural activities from using only one kind of crop to crops, livestock, fisheries, horticulture, and beekeeping. Diversification decreases production risks, guarantees constant income, provides better employment chances, and makes farms more resistant to climatic and market unpredictability.

Water Use Efficiency

Water use efficiency is reached through recycling water for various farm activities. The water from fish ponds may be used for watering crops due to the presence of nutrients necessary for plants in this water. Rainwater harvesting, drip irrigation, sprinkler irrigation, and mulching provide additional ways to make water usage more efficient.

Utilizing Renewable Energy

Circular agriculture promotes the use of renewable sources of energy like biogas, solar-powered irrigation systems, solar dryers, solar fencing, and biomass energy.

Mushroom Farming

Through mushroom farming, agricultural wastes like rice straw, wheat straw, maize stover, and sugar cane trash are utilized to cultivate edible mushrooms. Once harvesting is done, the used mushroom growing substrate is used as compost or livestock feed.

Components of Circular Agriculture

Crop Production

Crop production serves as the basis of integrated farming system. Residues from crop production are not considered waste but used as animal feed, compost, mushroom cultivation substrate, mulch and bio-char. Legumes are also grown in such systems to enrich soils biologically with nitrogen due to nitrogen fixation.

Livestock

Livestock is an essential part of circular agriculture as they produce milk, meat, manure, urine and even draft power. Manure is one of the main sources for making farm yard manure, vermicompost, biogas and other organic fertilizers.

Fisheries

Fish ponds have multiple roles in integrated farming system. First of all, they are fish producers. Also they can store water for irrigation, facilitate nutrients recycling, and produce nutrient-enriched pond sediments that increase soil fertility. There are also integrated fish-duck farming systems where ducks naturally fertilize ponds and eat aquatic plants and insects.

Poultry

Poultry farms contribute to circular agriculture as they produce eggs, meat and organic manure. Poultry litter is particularly nitrogen-rich and is great for compost production and fish ponds fertilization.

Vermi-composting

In vermi-composting, the organic waste is converted into organic manure through the activities of earthworms. The raw material sources for vermi-compost include animal dung, crop residues, vegetables, and kitchen waste. Vermi-compost helps in enhancing soil structure and microbial activity along with improving the nutrient status of the soil.

Generation of Biogas

The source materials of biogas plants include animal dung, poultry litter, pig manure, and crop residues. Biogas plants produce clean cooking gas and electricity while the leftover nutrient rich slurry is used as an excellent organic fertilizer.

Agro-forestry

Agroforestry involves planting trees in combination with agricultural crops and livestock. Trees act as the source of timber, fruits, fuel wood, carbon sequestration, soil conservation, increased biodiversity and shading effect. Leaf litter generated by the trees also enriches soil with organic matter.

Beekeeping

Beekeeping contributes to circular agriculture by improving crop pollination and producing valuable products such as honey, beeswax, royal jelly, and propolis. Enhanced pollination significantly increases crop yield and quality while generating additional farm income.

Flow of Resources in Circular Agriculture

Within an integrated farming setup, there is constant flow of resources from one enterprise to another. The residue of the crops is fed to the livestock, the dung from the livestock is utilized in the biogas plant, the biogas slurry is made into compost and organic manures, and the manures are used back in the crop field. Likewise, the sludge of fish ponds is added to the agricultural lands to enhance their fertility, while the litter of poultry birds is made into vermicompost.

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