Gloria Maria Winnie, International Journal of Advances in Agricultural Science and Technology,
Vol.5 Issue.8, August- 2018, pg. 140-145 ISSN: 2348-1358
Impact Factor: 6.057
NAAS Rating: 3.77

ADOPTION OF SUSTAINABLE AGRICULTURAL PRACTICES FOR THE SOCIAL-ENVIRONMENTAL AND ECONOMIC EQUITY: A REVIEW

Gloria Maria Winnie
Dept. of Botany, St. Berchmans College Changanacherry, Kottayam, Kerala, India

Abstract

There is an urgent need to match food production with increasing world population. However, the struggle to achieve food security should be carried out keeping in mind the soil and the environment in which the living things survive. The mission of increasing food grain production somehow stands achieved. But it accompanied a series of problems related to the environment and natural resources. Sustainable agriculture integrates three main goals. They are environmental health, economic profitability and social-economic equity. Sustainable agriculture is a big challenge and its success lies in new approach to accomplish the goals of growing crops and raising livestock with minimal environmental pollution. Techniques in sustainable agriculture are cover cropping, mixed cropping, crop rotation, conservation tillage, making use of microbial interactions, bio-intensive integrated pest management, aquaponics and integrating livestock and crops. This work was an attempt to discuss the objectives, benefits and techniques used in sustainable agriculture.

Keywords: sustainability, agriculture, environment, economy

1. Objectives

- To understand the objectives and benefits of sustainable agriculture.
- To investigate the methods or techniques used in sustainable agriculture.

2. Methodology

This is a review article that discuss, reviews and summarizes and available scientific literature from different databases.

3. Introduction

As the world's human population continues to increase, the demands placed upon agriculture to supply future food will be one of the greatest challenges facing the agrarian community. In order to meet this challenge, a great deal of effort focusing on the soil biological system and the agro-ecosystem as a whole is needed to understand better the complex processes and interactions governing the stability of agricultural land.(Khan M. S *et al*., 2007)Many agricultural methods result in low biodiversity in farmed areas and inefficient uses of natural resource because of widespread herbicide and pesticide use. Impractical soil management leads to erosion and destruction of soil biota. These raise the need of sustainable agriculture

Today, the drive for productivity is increasingly combined with a desire for sustainability. Sustainable agriculture can be seen as a new way forward for conserving resources and enhancing productivity to achieve the goals of agriculture. (Abrol I.P. and Sunita Sangar., 2006) It is an integrated system of production practices that will last over long term.

Objectives of sustainable agricultural practices are to satisfy human food needs, enhance environmental quality, make the most of non- renewable energy sources, sustain economic viability and enhance quality of

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life. That is, it emphasizes productions that are profitable, environmentally sound, energy efficient and improve the quality of life for both farmers and the public.

However potential benefits of this practice are, it is economically sustainable, environmentally sound and it socially sustainable. Agricultural sustainability means it preserve the quality of soil, water, and air. It cooperates with and is modeled on natural systems. Economic sustainability means it provides a secure living for farm families, it provides a secure living to other workers in the food system, and it provides access to good food for all. Social sustainability means, it supports communities.

4. Techniques of sustainable agriculture

4.1 Cover cropping

The major contribution of cover crops to agricultural systems is probably long-term soil protection and fertility enhancement, particularly on erodible land. Erosion prevention and soil stabilization is probably the highest priority for maintaining a sustainable agriculture by the use of cover crops.(Teasdale, J. R. 1996)according to Lu *et al*., 2000 a cover crop is a crop planted primarily to manage soil erosion, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agro-ecosystem. Legumes and grasses are extensively used as cover crops. Cover crops can also suppress weeds, provide suitable habitat for beneficial predator insects, and act as non-host crops for nematodes and other pests in crop rotations.

The choice of cover crop depends on whether the primary purpose is to nitrogen to the succeeding crop and reduces nitrogen fertilizer use, to reduce NO_3^-leaching or to improve soil properties. Legume cover crops can fix nitrogen symbiotically from the atmosphere and supply it to the succeeding crop. Thus cover crops increase the nitrogen cycling in the soil. Nitrogen mineralized from the incorporated cover crops residues can substitute part or all of the commercial nitrogen fertilizer needs of the succeeding crop. (UM Sainju and BP Singh., 1997)

4.2 Crop rotation

Crop rotation is the method of planting different crops in the same area at different crops in the same area at different times of the year or at different years.

There are many advantages attributed to crop rotation. This method reduces pesticides and herbicide use. Pest reproductive cycles are interrupted with the change in crops, preventing their number from growing rapidly because pests cannot build up populations due to periodical rotations. Weed insect, crop disease cycles are broken by the use of cropping sequences that reduce the need of pesticides. Crop rotation also reduces the use of fertilizers or commercial nitrogen since crops like legumes can naturally restore nitrogen and other nutrients. Crop rotations help in the reduction of the amount soil erosion, water runoff and also improve the soil tilth. (RH Higgs *et al*., 1990)

4.3 Mixed cropping

Mixed cropping, also known as polyculture, inter-cropping, or co-cultivation. It is a type of agriculture that involves planting two or more plants simultaneously in the same field, interdigitating the crops so that they grow together.

According to HM Paulsen *et al*., 2006 agricultural advantages of mixed cropping are gained by biological effects like light competition, offering weed-suppressing capacities or by diversification of plant covers to break development cycles of pests. ie, the increase in vegetational complexity can interfere with host-plant location of crop pests. Another advantage over monocultural practices is that, even if one of the crops fail, the same field might still produce other crop successes. In addition the practice provides a rich biodiverse environment, fostering habitat and species richness for animals and insects such as butterflies and bees.

In a study conducted by Daellenbach GC *et al.*, 2005 on plant productivity in cassava-based mixed cropping systems concluded that there was an increase tuber yield. That is increase in productivity and soil cover compared to monocropping.

4.4 Bio-intensive integrated pest management

Bio-intensive integrated pest management incorporates ecological and economic factors into agricultural system. Integrated pest management comes under biological control of pests and it involves the use of other living things that are enemies of a pest in order to control it. Sometimes, it encompasses a full spectrum of biological organisms and biologically based products including pheromones.

Integrated pest management process includes various stages such as proper identification pest damage and responsible pests, pests and host life cycle biology, monitor the environment for pest populations, establish action threshold, choose an appropriate combination of management tactics and finally to evaluate the results.

The benefits of implementing bio-intensive integrated pest management include reduced chemical input costs, reduced on-farm and off-farm environmental impacts and more effective and sustainable pest management.

4.5 Integrating livestock and crops

Half the world's food comes from farms that raise both. Animals pull ploughs; their manure fertilizes crops and also can supply post-harvest residues to livestock. Animal agriculture is an integral part of food production systems using lands and products not usable by humans for the production of human food and making useful contributions to crop rotations and soil conservation.(J W Oltjen and J L Beckett., 1996)In this system manure from livestock is commonly used as a fertilizer. Manure is an important source of nitrogen and other nutrients. Joint application of manure and inorganic fertilizers and manipulation of the relative amounts and times of application can synchronize nitrogen release and availability in the soil with demand for and uptake by crop plants. It is found to be one of the most productive approach, combining the short-term benefits of inorganic fertilizer with the long-term value of manure. (Murwira K H *et al.*, 1995)Methane was extracted from manure and paunch material which was used to power the slaughterhouse and for local household energy which replaced the cutting of trees for firewood. Liquid manure slurry was turned into compost for crop production. So it can be said that crop and livestock farming complement each other.

According to Mark C. Eisler and Michael R. F. Lee., 2014, the lure of high productivity has led to ill-advised schemes to import livestock to places where they are genetically unsuited. But it is better to raise regionally appropriate animals.

4.6 Aquaponics

Aquaponics is an evolving closed-system food production technology that integrates recirculating aquaculture with hydroponics. In principle, aquaponics is the combination of aquaculture and horticulture within a single recirculating aquaponic system provides a sustainable approach. (Kloas W *et al.*, 2015)

It is the agricultural system where plants and fish are nurtured and grown together. In this constructed ecosystem water must be retained and recirculated instead of allowing it to drain off. As a result wastage of water can be avoided. Integration of nitrifying bacteria improves the sustainability by converting the fish waste to plant nutrients and the system simultaneously producing two cash crops (Richard V. Tyson *et al.*, 2011)

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4.7 Conservation tillage

Tillage is defined as the mechanical manipulation of the soil for the purpose of crop production affecting significantly the soil characteristics such as soil water conservation, soil temperature, infiltration etc.

In conventional tillage farmers use machines like a plough or disc to turn over and loosen the soil after harvest. This can leave the soil exposed to rain and wind, which can sometimes lead to erosion of the topsoil that is needed to grow a crop. Conventional tillage makes the soil serve as a source rather than a sink of atmospheric pollutants and thus is not sustainable and environmentally friendly.

But in conservation tillage crop residues are distributed evenly and left on the soil surface. The principle of conservation tillage involves maintenance of surface soil cover through retention of crop residues, so that it helps to prevent soil erosion and therefore add organic matter while protecting the soil from erosion. (M A Basuri *et al*., 2015)

Conservation tillage increases the ability of soil to store carbon while simultaneously enriching the soil. It improves soil water infiltration, thereby reducing erosion and water and nitrate runoff. It also reduces leaching of nutrients due to greater amounts of soil organic matter to provide binding sites. (Rattan Lai., 1989) In a study conducted by Sharma Peeyush *et al.*, 2006 it was found that conservation tillage minimizes soil disturbance, encourages build-up of organic material, preserves the soil structure, increases biodiversity and conserves soil water. Lower intensity of tillage leaves organic mulch at the soil surface, which reduces run-off, increases the surface soil organic matter promoting greater aggregate stability which restricts soil erosion. This suggests that tillage exerts impact on the soil purposely to produce crop and consequently affects the environment. This method gives a lot of potential benefits to meet our goals.

4.8 Making use of microbial interactions for sustainable agriculture.

Maintenance of diverse and functional microbial communities and plant- microbe interactions are essential for sustainable ecosystem. (Kumari Anju *et al*., 2014) The beneficial influences of microorganisms on plant growth include nitrogen fixation, acquisition and uptake of major nutrients, promotion of shoot and root growth, disease control or suppression and improved soil structure. The microorganisms are the best natural resources and their contribution is beyond practical calculation. Some of the commonly promoted and used beneficial microorganisms in agriculture worldwide include *Rhizobia*, *Mycorrhizae*, *Azospirillum*, *Bacillus*, *Pseudomonas*, *Trichoderma*, *Streptomyces* species etc. These beneficial microorganisms can help to improve agricultural production worldwide. (Vadakattu V.S.R. Gupta., 2012)

Mycorrhizae: The symbiotic association of plants and arbuscular mycorrhizal fungi has been widely recognized for the benefits it provides with nutrient transport and uptake. Acquisition of mineral nutrients, defense against abiotic and biotic stresses, water relations in symbiotically associated plants are the primary benefits of arbuscular mycorrhiza.

Nitrogen fixing bacteria: Nitrogen fixation is one of the essential beneficial biological processes for the economic and environmental sustainability of agriculture. Biological nitrogen fixers have long been a component of many farming systems as a source of nitrogen for agriculture. (Peoples M B *et al*., 1995) 'Diazotrophy', the ability to fix atmospheric nitrogen catalyzed by the enzyme nitrogenase, is distributed the diverse groups of bacteria. Principal nitrogen fixers are free-living soil bacteria like *Azospirillum*, *Azotobacter*, *Beijernickia*, *Derxia*, *Bacillus*, *Klebsiella*, *Chromatium*, *Rhodospirillum*, *Clostridium*, *Methanococcus* etc and also free living cyanobacteria like *Anabaena*, *Nostoc* etc.

Plant growth promoting rhizobacteria (PGPR): Bacteria colonizing roots that elicit shoot and root growth are referred as plant growth promoting rhizobacteria. It is recommended for improving plant growth and disease control both in agriculture and horticulture. These rhizobacteria can promote root and shoot growth either by producing plant hormones or secondary metabolites, controlling diseases, induction of systemic resistance or through changing physicochemical interactions with plants. (Vadakattu V.S.R. Gupta., 2012)

Phosphate solubilizing microorganisms: Compared with other macronutrients, phosphorus is least mobile. Phosphate solubilizing microbes could play an important role in supplying phosphate to plants in amore ecofriendly and sustainable manner. Several strains of bacterial and fungal species have been investigated for their phosphate solubilizing capabilities. (He Z L *et al*., 1997) Some of the examples of phosphate solubilizing bacteria are *Escherichia intermedia*, *Enterobacter asburiae*, *Serratia phosphoticum*, *Azospirillum brasilense*, *Actinomadura oligospora*, *Aerobactor aerogenes* etc and fungi such as *Fusarium oxysporum*, *Alternaria teneius*, *Curvularia lunata*, *Chaetomium globosum*, *Humicola insolens*, *Paecilomyces occidentalis*, *Sclerotium rolfsii*, *Trichoderma viridae*, *Torula thermophila*, *Schwanniomyces occidentalis* etc. (Sharma S B *et al*., 2013)

5. Conclusion

Sustainable agriculture is an integrated strategy and a profitable way of producing high quality food and fiber that protects and renews the natural environment, builds local economies, and enhances the quality of life of farmers and society as a whole. The objectives of sustainable agriculture are environmental health, economic viability, also social and economic equity. The primary benefits of sustainable agriculture are environmental preservation, protection of public health, upholding animal welfare and economic profitability.

Soil management practices influence crop productivity. Changes in tillage, residue management, cropping patterns and rotation practices induce major shifts in the species richness and help to minimize the use of pesticides and herbicides which in turn minimize the environmental pollution. Maintenance of diverse and functional microbial communities is essential for sustainable ecosystems. Integration of livestock with agriculture is also found to an efficient sustainable practice. It is concluded that the techniques used are eco-friendly, enhance the environmental quality and can meet the human food need.

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