Journal of Namibian Studies, 35 S1 (2023): 2324-2339 ISSN: 2197-5523 (online)

Organic Farming And Its Self -Sustaining Capability: A Review

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Abstract

Organic farming ecosystem is the unit of the biosphere where the different organisms being interdependent on one another strive towards maintaining a balance in the input and output through their unique interactions. Biotic as well as the abiotic factors are synchronized in a way to maintain the optimum food chain and web that inculcates the healthy environment. The system is self-regulatory and self-reliant in terms of maintaining its own health by means of different nutrient and water cycles. The microbes that form the fundamental units in the organic ecosystem have the capability to increase their population and diversity as a result of the enriched soil health and availability of substrates. Although, there are several hurdles in the ways of farmers to adopt organic farming completely, like longer turnover period, hesitation in certifications, etc; yet framing of suitable policies by government along with incentivizing and making farmers aware could be a solution to switch the mind sets of farmers. For this, the concept of organic ecosystem and its bio-dynamics has to be very clear.

Key words: organic farming, self –regulatory, stability, sustainability, ecosystem.

Introduction

The concept of organic farming is not new but its definitions have several orientations that have not been clearly understood by the farmers at the ground level.

When the organic farming concept was brought in being, the motive was to use the local resources in the manner that it strives towards sustainability of the soil. Although by the definition of Lampkin (1991), organic agriculture is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators, and livestock feed additives, yet the confusion still lies about the beneficial impacts of organic farming over the variations in space and time dimensions and about the practicality and profitability of this theory which still questioned by the farmers as to when should they actually stop using the fertilizer at all with taking over by the use of completely nature bases local resources.

Green revolution in India, apart from successful increment in the yields due to indiscriminate use of chemicals, HYV's etc, had certain negative feedbacks too. The motive at that time was just to meet the rising food demand of growing population, reduce our dependence on the foreign markets and satisfy the Indian market with good economy. Sustainability and health of the soil were neglected, the repercussions of which we are facing today. With the continuous use of chemicals for nutrient and pest management, the soil chemistry has been abruptly disturbed, leading to loss in soil health and soil erosion. Land became adapted to the higher costly inputs years after years while the net productivity remained same or even lower. Soil erosion and land degradation has become frequent with increased siltation rates and loss in nutrients. Total cost of cultivation increased that led farmers to acquire loans along with attaining sub-optimal food quality that is not sufficient to meet the daily nutritious requirement. The question is, with this scenario, can we expect the farmers to all of a sudden switch to organic farming with completely avoiding the chemicals and attain the same increased yield? What is the possibility here and what should the farmer do? Even if the concept of organic farming is understood by the farmers, where is the problem lying to lag behind in getting the expected returns? Foods grown organically have been attaining popularity as well as demand in the market, especially amongst the health conscious society. And organic farming has been adopted by some few sections of the farmers turning them to adopt practices that are green and it also fetches them a good return. But how far the concept of organic farming has been successful? (Chopra et al., 2013).

According to Northbourne (2003), organic farming can be understood as 'an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity'. The concept of organic farming here describes the production system that is focused to enhance the factors (microbes, mineral content, organic matter etc) that improves physio-chemical as well as biological paradigms of rhizosphere. In this scenario, adding inputs to the land or managing the crop patterns are not only the concerns, but it becomes important to also understand the overall interactions and as a result consequences of our input addition or crop planning onto our land. It becomes important to understand the inter-relationship between different components. For an instance, under organic farming, on addition of composts or vermicompost, there is increment in organic stock, but its persistence into the soil depends on several factors like the soil status, diversity of microbes, kind of vegetation, weather etc. So, it is not a single factor that is deciding the increased fertility status of the soil but the set of components that interact together and frame an ecosystem that makes possible to attain a healthy soil (Schmidt et al., 2011). Thus the concept of organic farming is to consider the land as a whole ecosystem, wherein the components are not independently acting, but they are having negative consequences the moment any one of the individual component is impacted because of anthropogenic activities.

Ecosystem as a whole

"An ecosystem is an ecological unit, or a subdivision of the landscape, or a geographic area that is relatively homogenous and reasonably distinct from adjacent areas."- J.W. Marr (1961). An agro-ecosystem is the unit in which the different biotic components in association with the abiotic components (Bueren et al., 2002) interdependently work together to sustain the life of that unit and these inter relationships are strongly guided by the managerial activities of the farmer (Vandermeer, 1995; Almekinders et al., 1995) who also is an integral part of this ecosystem. Biotic components may be the plant or organisms that may have the inhibitory or beneficiary interactions amongst one another which together may or may not be impacted by weather interruptions. There lie the challenges to an organic farmer for managing and supporting all the above interactions at subsequent levels of the production system in such a balanced manner that the farm can utilize functions of ecosystem nurtured by the simulated agro-biodiversity, some of which includes: natural pest control through continuity of food web, nutrient re-cycling, and water cycle, soil preservation etc, for increased output, enhanced output stability, output quality and resource-use efficiency (RUE) (Southwood & Way, 1970; Altieri & Nicholls, 1999).

System is the set of components that interact with one another and any biasness with any one of the components may lead to the misbalance in the functionality of the entire system. In an organic ecosystem, management practices should also be based on the same concept; where our inputs are not only driven towards maximizing the net output but also towards the entire process of getting that output. The concept of organic farming is to develop a system that is stable, self- sustaining and self-regulatory (Johannes, 2001) where all the components have an important part to play. This kind of self-regulating and stable ecosystem is only possible when richness in biodiversity is sufficient to act as the barrier against the aberrations in the external environment or that is resistant enough to survive the external disturbances without the use of external inputs (Bueren et al., 2002). Organic farming is thus 'an ecological production management system that diversifies and populates soil flora and fauna; drives the biological cycles as well as soil biological activity' to enhance productive life of soil while decreasing the pressure onto environment.

Components of organic farming

Microorganisms, the integral part of soil, have major contributions in the kind of nutrient cycle regulated in an ecosystem. Efforts for nutrient management via organic farming consist of increasing soil microbiota that acts the basic framework for the other life-forms in that system. It becomes important to have the knowledge about the microbial features, structure and behaviours (driving the basic nutrient cycles) that are present into the farm-based resources like composts, FYM etc to estimate their potential impact on soil fertility (Ryckeboer et al., 2003). Manures like vermicompost possess the ability to enrich the soil microbial content where microbes either free-living or gut-associated, plays an important role in increasing both microbial activities and diversities in soil, on addition (Fracchia et al., 2006; Lazcano et al., 2008; Vivas et al., 2009). Presence of living cell-associated enzymes, e.g. dehydrogenase, ureases etc, that are the direct indicators of total activity of microorganisms, (Nannipieri et al., 2002) have been found to be augmented due to composting and vermicomposting (Saavedra et al., 2006), thereby, indicating the ability of these manures in nutrient, vitamins and hormones enrichment of soil. Similar other studies have indicated the development of beneficial microbial species on addition of manures in to soil that directly impact the nutrient availability in the rhizosphere, increase carbon stock, root respiration, biomass carbon: total carbon, and metabolic quotients, which indicate soil microbial activity and their interactions with other components in system (Pascual et al., 1997). Addition of organic amendments also has the supplementary effect of degrading the pesticide residues in soil because of the inclusion of non-indigenous microbes that act onto the specific hosts or pathogens and stimulate biodegradation and transformation (Fernández-Bayo et al., 2009). Also, the decomposition rates of chemicals like herbicides, insecticides and other synthetics have been studied in soil amended with vermicompost (Fernández-Bayo et al., 2009). Qualitative analysis of composts are however necessary before hand to avoid changes in soil pH over the due course of time as the wastes utilized for preparing the manures has a huge impact on the properties of the compost. Soil properties build up on addition of organic inputs such as water retention capacity, increase in micropores, increased colloidal structures etc which hold up the nutrients and soil microbiota progressing to healthy rhizospheres (Fig 1).

Comprising green manures and legumes in the cropping system is also positively correlated with the increased available nutrient contents near rhizosphere. Biological nitrogen fixation (BNF) due to the nodulated bacteria contributes to 40 to 70 Tg nitrogen y^{-1} (Herridge et al., 2008) that approximates to 50 percent of global N fertilizer production (Goyal et al., 2021) which can reduce the N requirement through the mineral fertilizers. Biofetilizers like Azotobacter, Azospirillium etc have also been studied to have been fixing the atmospheric nitrogen and convert it into plant available form of N (Tilak et al., 2005). Free living diazotrophs like Enterbacter spp. have been found to fix atmospheric nitrogen while producing phytohormones like Indole-acetic acid (IAA) that led to increased nitrogen uptake and improved root growth respectively (Panneerselvam et al., 2021). Therefore, BNF in soil constitutes an effective measure for sustainable soil N management, which complies with the principles of ecological health and security along with conservation of resources (Sofi and Wani, 2007)

Mulching, cover cropping and intercropping are the components of organic farming that have multidirectional benefits, as far as improving soil health is concerned. Mulching tend towards physical amelioration of soil, acting as a buffer for temperature changes in soil, and soil-moisture conservation (Montengro et al., 2013). In arid to semi- arid regions and steeply slopes to undulated lands, mulching can be an option to conserve the soil from erosion which becomes very common due to deficit in water, indiscriminate application of chemicals or increase in the sedimentation rates. Organic mulches has also been found to reduce the impact of salt toxicity on plant life-cycle and actively accelerate desalinization near root perimeters (29) while reducing the evaporation losses and retaining the soil moisture on the top layers which helps in diluting the salts (Chalker-Scott, 2007). Mulching with crop residues in crops such as rice grown under unsaturated, have been found beneficial in avoiding green house gas emissions with higher global warming potential (GWP) like N_2O as well as prevention of practices such as residue burning (Yang and Chang, 1997; Xu et al., 2004), specially in countries like India where rice dominates in major area. Considering the above reasons, mulching can be used under organic farming system as a means of saving water and reducing the irrigation requirements which would also be a means of saving the plants from different chemicals like herbicides and synthetic fertilizers.

Intercropping, a method of increasing the crop diversity over space and time dimensions possesses the potential to increase productivity of soil, higher economic returns, and resource use efficiency (Kaur et al., 2017). The ability to synthesize higher and more stable yields in a wide range of crop combinations (Lammerts van Bueren et al., 2003) can be exploited by the farmers as an alternative to intensive farming methods. Researchers have proven that intercropping is most productive when crops of different behavior, morphology, ontogeny (Fukai and Trenbath, 1993, Keating and Carberry, 1993) or different requirements are cropped for better optimization of resources and perception of solar radiation. Intercropping with crops such as green manures or legumes like this would be useful in decreasing the nitrogen requirement on land, limiting spaces for weed growth and discontinuing the insects pests life cycle. Intercropping has also found to be significantly effective in reducing the weeds by posing as physical barrier to the weed emergence, exerting resource competition onto weeds or by releasing allelochemicals which may inhibit the weed lifecycle (Arora et al., 2015; Seran and Brintha, 2010). Intercropping with cover crops can help in conserving soil while acting as live mulch, main condition being their compatibility with each other. Crops like Crotolaria sp., Raphanus sp. etc posses the allelopathic effects and as a result when used as cover crops have been found to negatively impact the growth and development of some weeds like B.pilosa.

Crop rotations with the crops of different behavior are very crucial part of managing the cropping system wherein, the nutrients and water cycle between soil and atmosphere is retained. Mono cropping onto a land increases the severity of weeds, insects and pests through the monotonous management systems over time and space dimensions where the farmers ultimately end up using indiscriminate synthetic inputs or intensive farming in order to attain same output. On the other hand, diversification of crops through crop rotations hinders with the ontogeny of weeds, insects and pests by destroying or removing their hosts. Thus, even though the environment is favorable, the absence of hosts fails the severity of the existing infestation. Also, in an organic farming system, the planning of crops should be done to balance the nutrient intake and release from the soil for e.g. deep rooted plant with shallow rooted plants; root nodulated plants with non-nodulated plants etc.

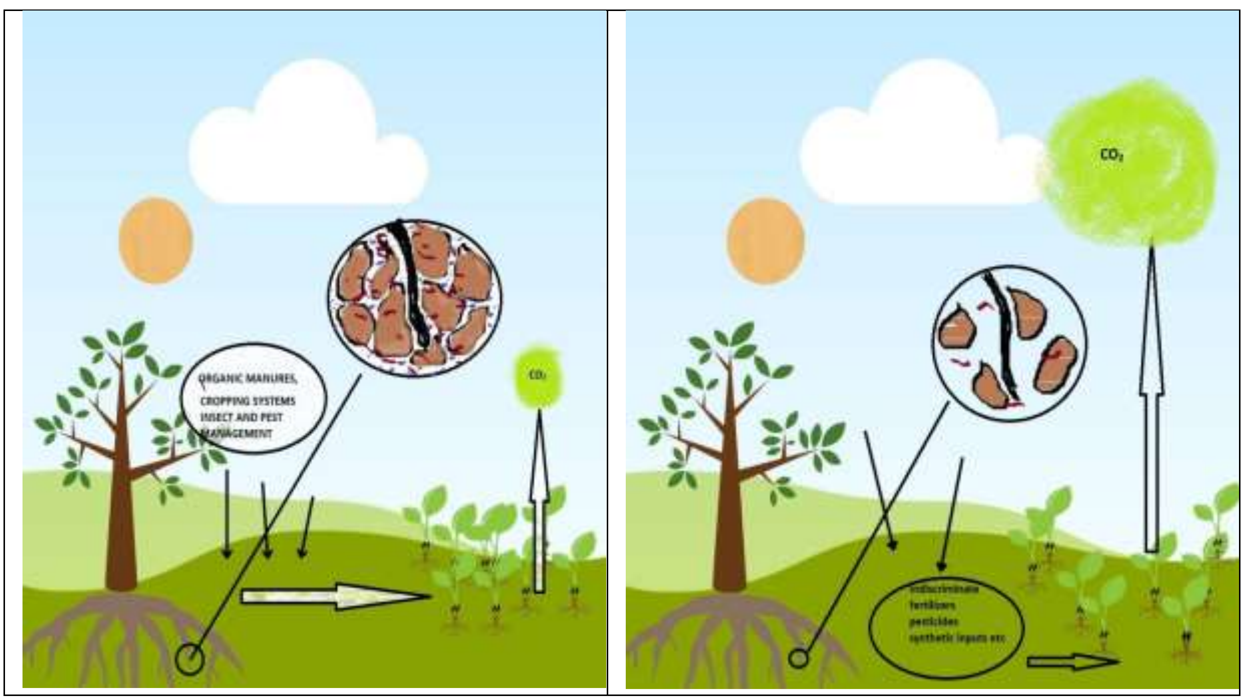

Fig1. A schematic diagram comparing the organic (left) and conventional (right) ecosystem. The various components of organic farming results in a promising

productivity along with the buildup soil physical, chemical and microbial attributes, with a relatively lesser release of greenhouse gases like CO_2. On the other hand, conventioanal farming, although has good productivity, but indiscriminate addition of synthetics and unplanned management lowers the soil physical, chemical and microbial properties.

Way forward towards organic ecosystem

One of the objectives of ecosystem study should be to find the patterns of decision-making and chains of behavioral that strongly guide growth and decline of ecosystem under any specific boundary conditions (Tsujimoto et al., 2018). Converging the management practices like land management, crop planning, cropping pattern, application of organic inputs and non-synthetics for plant sustainability and disease control can pave the way to frame the boundary of an ecosystem where the different biotic and abiotic components are able to build up their health and sustain thereby forming a strong framework against any external negative interactions. Organic ecosystem eliminates undesirable quantities of crop associates through stimulation of the self-regulatory and self-retaining capacity of agro-ecosystem as much as possible, via utilizing the capability of agro-biodiversity at different management levels (farm, crop species or variety level) within organic farming system (IFOAM, 2002). It maintains a biosphere where role of every organism is prominent and their working is to interact with the other organisms and sustain the overall health of the unit. In an organic ecosystem, microbial richness, as expected from the non-synthetic organic inputs, has a direct role in enhancing the soil health which in turn sustains the life of the plant allowing it to tolerate to climate aberrations. These plants have multiple ways to reverse the carbon flow and sequester carbon into soil as a result of plant-microbe interactions. Not only the organic carbon stock increases, but also the other nutrient cycles effectively work to bring about the changes in that ecosystem. For an example, lesser leaching losses can be expected on retention of the soil texture and increase in soil biota. Increase in the diverse forms of microbes impacted by increased decomposition of organic matters, strengthens the soil structure, nutrient availability and resistances to the plants for several diseases and pests (Barrios, 2007).

It has been noticed that plants become susceptible to the pests and diseases when they are grown in the environment that is unhealthy i.e. the nutrient deficit plants are more likely to be infected more. Frequent occurrence of diseases is correlated with the conditions like soil pH, high weed infestation, loss in soil fertility, absence or high water stagnation etc. On the other hand, organic ecosystem is the self- sufficient unit where the motive is to build the immunity of the plants that are resistant to the diseases. Increase in the abundance of microbial diversity, reduction in pathogens, use of the companion crops and natural resources are the other possible solutions to the disease management under organic farming.

Release of green house gases may be the other concern for scientists that may confuse whether to adopt organic farming or not. Global Warming Potential (GWP) of the 3 major green house gases that are mainly released from the agricultural soils is: 1 for CO_2, 23 for CH_4 and 296 for N_2O. Asian countries have been considered to be releasing the global warming gases like nitrous oxide and methane from the agricultural lands (FAO, 2018) majorly from the livestock or deforestation. Rice is one of the major staple foods in Asian countries and its cultivation is another major cause of release of these gases. N_2O release is associated in the soil system where nitrogen losses due to leaching, less nitrogen retention and denitrification are frequent. Reliance onto synthetic fertilizers for higher yields has been the cause of higher N_2O emissions (Peoples et al, 1995) to greater extent through the changes in the soil structure and as a result changes in the metabolic pathways of nitrogen in soil. Addition of the organic matter in soil is associated with increased enzymatic activities of the microbes that are able to release nitrogen eventually thus increasing the nitrogen in available forms near the rhizosphere. Organic matter acts as buffer with good absorbance of the nutrients and several enzymes that avoids leaching of the mobile elements like nitrogen. Similarly, carbon emissions have been associated with the crop residues burning, fuel burning, soil erosion due to continuous soil turnings and crops like waterlogged rice. The solutions to this are the crop diversification and conservation agriculture. When crops instead of burning, are used as mulches they help in not only in saving soil, fuel or water, but also effectively helps in minimizing the global warming gas emissions. Even crops like rice grown under unsaturated condition along with straw mulches have been found to release lesser GH gases like methane (23 GWP) (Xu et al., 2004) and carbon dioxide (Min and Rulik, 2020).

Conclusion

The rate of increase in the soil organic matter and there by conversion of a land into organic, varies with the different soil and climatic conditions. Further, there are many constraints in adopting organic farming, whether they are economical or social. Farmers continue to follow the conventional methods because they have advantage in terms of maximum output, easy pest management methods, effortless management practices etc even though these are the temporary benefitting practices that are compromising with sustainability of the soil. The way forward is to understand that in the long run, there is going to be two ways out, i.e. either keep following conventional methods where indiscriminate use of chemicals would also not be optimum to give the expected result, or, to follow the organic methods by using the local resources and with simple and scientific management practices with proper planning to have the same output but with the additional benefit of retained health of soil. To start over with, change in the mindset of farmers and framework of rigid policies by the government is required.

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