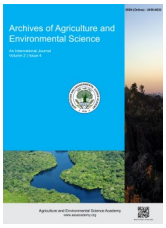
Archives of Agriculture and Environmental Science 6(3): 367-372 (2021)
https://doi.org/10.26832/24566632.2021.0603016

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



REVIEW ARTICLE

A review on use of agrochemical in agriculture and need of organic farming in Nepal

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ARTICLE HISTORY

Received: 02 July 2021
Revised received: 08 September 2021
Accepted: 18 September 2021

Keywords

Climate Change
Conventional farming
Organic farming
Pesticides
Sustainability

ABSTRACT

The growing use of chemical pesticides haphazardly and their harmful influence on ecosystem and human health highlight the necessity for safe and sustainable organic production in our time. The article reviews a general overview of organic farming; the impact of organic farming on soil health and climate mitigation in comparison with conventional farming practice in Nepal. The article identifies the problems and possibilities of organic farming to resuscitate the pesticide-dominated conventional practice in Nepal. Organic farming now has been embedded in the natural agriculture policy in Nepal. Organic farming benefits in terms of environmental protection along with better living health. Various governmental and non-governmental bodies, farmers, and individuals are working to promote organic farming in Nepal. With the increase in awareness of health and environmental concerns, the adoption of organic agriculture and the demand for organic agricultural products is increasing. It holds a great prospect in countries like ours where an integrated crop-livestock system is still prevalent in many parts of the country. As a result, an organic farming system in Nepal must be thoroughly investigated and supported through proper regulations and tactics. It is urged to supplant pesticide-based conventional farming with organic farming that leads towards agricultural sustainability for the upcoming generation.

Citation of this article: Makaju, S., & Kurunju, K. (2021). A review on use of agrochemical in agriculture and need of organic farming in Nepal. *Archives of Agriculture and Environmental Science*, *6*(3), 367-372, https://dx.doi.org/10.26832/24566632.2021.0603016

INTRODUCTION

Organic farming can be described as a system of management and agricultural production that is a combination of a high level of biodiversity with environmental practices that help to conserve natural resources and has rigorous standards for animal welfare (Youmatter, 2019). International Federation of Organic Agriculture Movements (IFOAM) explains "Organic farming as a production system which sustains the health of soils, ecosystems, and people. It depends on the ecological process, biodiversity, and cycles adapted to the local scenario, rather than the use of chemical inputs which carries adverse effects to the environment". Organic farming mostly focuses on using natural materials in agricultural practices and discarding the use of any kinds of chemical fertilizers and pesticides which degrades the fertility of the land (Vogt, 2007). Initially, excess use of the chemical fertilizers gives increasing production of the land but as time passes the production capacity of land decreases and may finally meet to zero. Organic farming helps to produce nutritious, quality, and safe food products along with maintaining ecological balance and sustainability (SASEC, 2020). Presently organic farming has emerged as a reaction to the industrialization of agriculture and it is focused on environmental and social problems (Prajuli *et al.*, 2020). Organic farming delivers overall advantages over conventional agriculture is being one of the heated topics. Reganold and Wachter (2012) claim that organic farming system is more profitable and environmentally friendly while (Connor and Mínguez, 2012) claims that organic farming is future sustainable food systems. Explanation of (Seufert and Ramankutty, 2017) in the latest review on the costs and benefits of organic farming in its present form and conclude that, on the positive side, organic farming provides higher biodiversity and improves soil and water quality per unit area, enhanced profitability and higher nutritional value.

The common sentence "Nepal is an Agricultural Country" is being overused and unjustified sentence used for a decade. The problem of brain-drain and muscle-drain escalating in the tandem is just being dull work which is not the best part for the existing agriculture system in Nepal. Presently the unemployment rate of Nepal is skyrocketing forcing an enormous number of people to select foreign nations for employment temporarily or permanently. The earthquake which occurred in 2015 has affected the socio-economic, political, and environmental atmosphere (Prajuli *et al*., 2020). Organic Farming is a very common farming practice in the Nepali agriculture sector. Over a century, farmers of hills and mountains are following traditional farming which is by default organic. Many of the traditional Nepalese farmers do not know that their traditional farming practice is similar to organic farming.

In Nepal, there is an increasing trend of using inorganic chemicals, terminator seeds and adopting high input technologies. The increasing pace of population growth and demanding cash income to run the household forced farmers to increase the agriculture production including food which caused farmers to adopt modern farming technologies. Many reports have claimed that there are huge harmful effects on human as well as animal health along with the environment due to the unbalanced and excessive use of chemical fertilizers and pesticides (Tamang *et al*., 2013). Presently organic farming movement has grabbed a success when measured in land area, several farms, products, sales, organic farming are creating stunning growth over the past few decades. Before the 1980s, the number of organic farms globally was negligible according to Lockeretz in Organic farming: An International History (Lockeretz, 2007). Much scientific research has justified many claims about organic farming and food in terms of reduced fossil energy consumption, reduced exposure to pesticides, improved soil, and water quality, protection of biodiversity but the questions remain about the organic farming net effect on greenhouse gas emissions, including Carbon dioxide, Nitrous oxide, and methane and their impact on climate change relative to conventional farming (Clark, 2020).

CHEMICAL PESTICIDES, FERTILIZER, AND THEIR NEGATIVE IMPACTS

The word pesticides grab a huge range of compounds which includes insecticides, herbicides, rodenticides, fungicides, molluscicides, nematicides, plant growth regulators, and others. Among all the compounds, organochlorine (OC) insecticides are used successfully in controlling the number of diseases such as malaria and typhus which were completely banned by technologically advanced nations after the 1960s. The introduction of several insecticides like organophosphate in the 1960s, carbamates in the 1970s, pyrethroids in the 1980s as well as the introduction of various herbicides and fungicides in the 1970s-1980s contributed greatly to pest control and agricultural output. The history of the use of chemical pesticides is not too old. On 1952s, chemical like Paris green, gammexane and nicotine was introduced first time in Nepal which was imported from the USA to control malaria (Sharma *et al*., 2013). Usually pesticides must be lethal to the targeted pest rather than not targeted pest species including human beings, birds, and animals. The rampant and unmanaged use of synthetic chemicals under the proverb, "if little is good, a lot more will be better" has created an enormous negative impact on human beings as well as other life forms (Aktar *et al*., 2009).

In most the developed countries, organochlorine pesticides are banned for both agricultural and domestic use but they are still being used in developing countries like Nepal. Organochlorine pesticides of the first-generation were reported to be environmentally persistent, remain on soil and sediments for a long period, and accumulates in non-human organisms with devastating toxic effects at the population level (Köhler and Triebskorn, 2013). Organochlorine residues are also transferred to the food chain which carries harmful impacts on human beings. Usually, most of the pesticides are broad-spectrum and kills both the target as well as not target organisms. The toxic action of chemical pesticides is not restricted to target pests and toxicity is also exerted on non-target similar organisms causing huge damage to the biodiversity and ecosystems health. Organochlorine has impacted enormously on top predators of terrestrial food chains, like a bird of prey and are accumulated in adipose tissue of animals and humans, being transferred to a newborn with milk fat and act as an endocrine disruptor (EEA, 2013). Organophosphates were also reported as highly toxic to the arthropods which include insects but also shrimp, crabs, and other crustaceans, and also to vertebrates. Pyrethroids also harm on insects and vertebrates. Other chemical compounds such as herbicides have shown effects on the central nervous system of mammals (Singh *et al*., 2016).

Huge intoxication of farmers, rural workers, and their families has occurred during the application of pesticides and was documented in reports entitled "poisoning and effects of synthetic chemicals on human health". Globally each year unintentional poisoning kills about 355,000 people and such poisoning is usually associated with excessive exposure and inappropriate use of toxic chemicals (WHO, 2012). In many reports, dispersion of pesticides residues in the environment and mass killing of non-human biotas such as bees, birds, amphibians, fish, and small mammals are included (Paoli *et al*., 2015). Early reports and structured incident reporting system has helped bring sound regulations for pesticides applications, including the dosage of the chemical to be used and the best periods for the application of those pesticides (Hester and Harrison, 2017). The compounds such as hexacyclohexanes (HCH), chlordane, and toxaphene applied in the agricultural fields in the south USA were volatilized and transported by atmospheric processes, condensed in cooler climates, and were deposited from the atmosphere onto the Great Lakes in Canada (Li and Jin, 2013). Recently introduced and more degradable pesticides like chlorpyrifos, parathion, isoproturon and mecroprop have been detected in river waters of Spain (Moreno-Gonzalez and Leon, 2017). In surface waters, residues of new chemical pesticides show an opposite concentration trend with concentrations often increases over

the years such as for glyphosate (Portier *et al*., 2016). This is one of the worrisome topics because of the widespread presence of chemical residues on natural resources such as water for human consumption including ground-level water and water for aquaculture activities.

The use of excess chemical fertilizer on agricultural land carries adverse effects on waterways which are caused due to the chemical runoff of the excess fertilizer. Deposition of excess fertilizer in water causes depletion in the oxygen content of water. The living organisms of the water body use up oxygen left which results in the death of the organism. Chemical fertilizer contains a high amount of nutrients such as nitrogen, potassium, phosphorous, etc. Over application of those fertilizers to plant can cause leaves to turn yellow or brown, damaging the plant and reducing the crop yield. This condition is defined as chemical leaf scorch. Leaf scorch leads plants to wither and may cause the plant to die. Unmanaged and unplanned use of chemical fertilizer can contribute to the release of greenhouse gases such as carbon dioxide and nitrous oxide into the atmosphere. This effect is brought by the use of a greater amount of chemical fertilizer than the amount absorbed by plants. According to the National Oceanic and Atmospheric Administration (NOAA), Climate Monitoring and Diagnostic Lab, the excess amount of greenhouse gases is being trapped in the atmosphere may contribute to the increased surface temperature of land and ocean. Excess use of chemical fertilizer can lead to soil acidification due to a decrease in the amount of organic matter in the soil. Nitrogenous fertilizer applied in the soil with a large amount and for a longer period damages the topsoil, resulting in reduced crop yields. Sandy soils are very much prone to soil acidification than clay soils. Clay soils carry the ability to buffer the effects of excess chemical fertilization. Excess and continuous use of chemical fertilizers on soil depletes the soil of essential nutrients which results in foods produced from those soil contains fewer amount vitamins and minerals. According to the data provided by the U.S Department of Agriculture Nutrient Data Laboratory, foods that are grown in the soils that were chemically fertilized for longer period were found to have less magnesium, potassium, and calcium content (Hunt, 2020).

According to (Savei, 2012), chemical fertilizers usually contain phosphates, nitrate, ammonium, and potassium salts. A large majority of heavy metals such as Hg, Cd, Hs, Pb, Cu, Ni, and Cu are present on fertilizers and these all elements are well known to cause soil degradation. The different research finding shows that effects of chemical fertilizers on the soil are not immediately obvious, because the soil contains strong buffering power due to its composition. Soil structure is one of the major components which is degraded by fertilizer use. On explanation of (Savei, 2012) the use of industrial fertilizer like $NaNO_3$, NH_4NO_3, KCl, K_2SO_4, NH_4Cl is one of the causes of deterioration of soil structure. Decrease in soil pH is caused due to continuous use of acid-forming nitrogen fertilizers (Moebius-Clune *et al*., 2011). Again (Savei, 2012) also reported in a research carried out in the province of Rice in Turkey with one-way ammonium sulfate fertilizer application to tea which gave a result that increasing acidity of soils and 85% of the cultivated land had dropped the pH below 4 and also the report identified that high application of large amounts of potassium fertilizer was found to disrupt the balance of nutrients preventing plants from receiving necessary nutrients for growth and development of a plant.

ORGANIC FARMING: FEEDS THE SOIL

Soil formation is a story of rocks and minerals which is broken down into smaller and smaller pieces. Soil organic matter is a glue that helps to provide structure to all those smaller particles, prevents soil compaction, and supports sound root growth. According to the researchers of Rodale institute each pound of carbon on the soil can retain up to 40 lbs of water. (Biernbaum, 2012) Soil that we cultivate today is affected by many anthropogenic pressures, such as loss of soil organic carbon (SOC), nutrient depletion, soil compaction, and heavy metal deposition (Smith *et al*., 2016). A high level of SOC is one of the key characteristics of soil fertility which helps to promote soil structure, aeration, water holding capacity, chemical buffering capacity, soil microbial activity, plant root development, and continuous release of plant nutrients through mineralization. According to the global review of (Gattinger *et al*., 2012), soils with an organic cropping system have a significantly higher level of SOC content than those with conventional systems.

Organic farming helps to improve soil fertility and also builds both nutrient and carbon stocks (IFOAM, 2008). Organic farming builds, maintain, and replenishes the soil health than conventional farming (RI, 2011). Soil fertility means more than just providing plants with macro and micronutrients on organic farming. Plants, soil organic matter (SOM), and soil biology are highly considered ineffective soil fertility management. Organic farming is decorated to enhance soil fertility and to achieve numerous goals. Some sound goals include the protection and improvement of soil physical condition which supports healthy plants and soil-dwelling organisms and also increase the ability to resist and recover from stress like flooding or aggressive tillage, maintains soil buffering capacity to minimize environmental degradation caused by soil loss or soil failure to filter nutrients or degrade harmful compounds, increases water and nutrient use efficiency by increasing biological fixation and retention of needed nutrient by reducing their loss from the system to the extent possible. Organic farming usually aims to maintain nutrients in organic reservoirs or in bioavailable mineral forms instead of just supplying nutrients through frequent fertilizer additions which are achieved by cycling nutrients through organic reservoirs. Soil fertility is usually improved by organic matter management and not through input substitution. (Wander, 2020)

ORGANIC FARMING: MITIGATION OF CLIMATE CHANGE

Climate change is one of the biggest challenges in the present world. Organic farming provides a system that helps to reduce environmental impacts. One of the primary objectives of organic farming is also climate change mitigation, conversion to organic agriculture can contribute to the reduction of greenhouse gas

emissions. It also helps in maintaining the ecosystem, improving biodiversity on farmland, conserving soil fertility, reducing eutrophication, water pollution, and improving food security. Global emissions from agriculture and livestock have increased from 4.7 billion tons CO_2 in 2001 to more than 5.3 billion today and calculation gives that the increase is more than 14%. Organic farming helps to mitigate climate change by reducing greenhouse gas emissions. There is the presence of a direct correlation between nitrous oxide emissions and the number of nitrogen fertilizers used on the farming land. Nitrous oxide emissions from the farming land account for almost 60% of agricultural emissions globally. This is particularly worrisome because the impact of 1 kilo of nitrous oxide on warming the atmosphere is nearly about 300 times greater than the impact of 1 kilo of carbon dioxide. Here organic farming does not permit to use of synthetic nitrogenous fertilizer, instead, organic farming focuses on establishing closed nutrient cycles, minimizing loss via runoff, volatilization, emissions, and nitrogen levels on organic farms tend to be lower per hectare than on conventional farming which can lead to sustainable climate-friendly production that delivers enough food. Organic farming also fights global warming by storing carbon in the soil. Many management practices followed by organic farming such as minimum tillage, returning crop residues to the soil, the use of cover crops, crop rotation, and greater integration of nitrogen-fixing legumes help to increase the return of carbon to the soil which favors productivity and carbon storage. Simply this can be taken as more carbon in the soil means less carbon in the atmosphere (IFOAM, 2018).

A meta-analysis which was published by (Skinner *et al.*, 2014) revealed that organic farming generated a lower amount of N_2O emissions from the soil per unit area but not per unit yield and they calculated that organic farming yields would need to increase by 9% just to match the emissions per unit output from conventional farming. From the available data, they reported that rice cultivation gave higher methane emissions for organic compared to conventional management on a yield basis. After some years, (Skinner *et al.*, 2019) reported based on findings from a field study at the DOK (Bio-dynamic, Bio-Organic, Konventionell) long term cropping system comparison trial in Therwil, Switzerland, over for 571 days during which they compare greenhouse gas emissions (GHGs) from the soil of five different crop production systems. They majorly focused on emissions of N_2O and CH_4 because according to the authors, more than half of the total amount of GHGs emissions come from agriculture. They reported on a per hectare basis there is a 40% reduction in nitrous oxide emissions in organic farming compared to non-organic farming.

ORGANIC FARMING IN NEPAL: PROBLEMS AND PROSPECTS

More than one-third of the Nepalese population is engaged in farms. However, only a portion of agriculture is organic. The 15th Five Year Plan (FY: 2020-2024) of the government of Nepal describes "High and sustainable production and productivity" as one of the long-term national goals among the ten. Organic Agriculture in Nepal is a good hope and need for sustainability (CBS, 2018). Since most of the farmers of Nepal still practice indigenous farming, it holds the prospects of economic empowerment through organic farming. Most of the farmers in Nepal hold subsistence farming integrated with livestock, either due to scarcity of chemical fertilizers and/or they are unaware of chemical fertilizers. Although the application of chemical fertilizers expanded after the 1980s primarily in the terai and hilly regions, these inputs are not easily accessible to most of the farmers in the hilly and Himalayan regions (Pokharel and Pant, 2009). Since most of the farmers in Nepal practices minimum use of inorganic fertilizers and pesticides and have easy access and availability of farmyard manure and local resources to make organic fertilizers and pest control products from plant and animal products, it provides better conditions for a potential increase in organic farming in different regions of Nepal (Burlakoti *et al.*, 2012). Moreover, organic farming requires high labor input comparing to traditional and modern farming methods. Thus, in Nepal, where unemployment is one of the major issues, organic farming can be an attraction. Eco-tourism can be also promoted through organic farms (Bhatta *et al.*, 2009)

However, for the development and promotion of organic agriculture, there seems to be an insufficient emphasis on it at the program level. Average consumers of Nepal are price-oriented; they choose inorganic products over organic products due to the higher prices of organic products. Lack of awareness about the organic products, quality, and availability, lack of proper market are facilities are the problems at marketers and consumers levels (Bhatta *et al.*, 2009). Adequate production of organic products and the business volume for market sale are still unnoticeable.

The main constraints at the producers' level are poor technical skills in managing the farmland, insufficient organic technology to support production, lack of research on processing and certification, poor investment capacity, small and fragmented land holding, and less risk-bearing capacity, etc. Due to the combination of the above factors, the problems in organic farming have been worsening coupled with the negative effect of climate change such as uneven and untimely rainfall, drought, gradual temperature rise, lack of conservation farming practices, and so on. This has resulted in decreasing production and productivity. The situation demands low external-input eco-friendly agriculture technologies, particularly organic agriculture, which can be a viable option for sustainability in Nepal (Shova manandhar's blog, 2010).

About 11,852 ha (0.3% of total agricultural land) of land in Nepal is managed under organic agriculture farming by 1622 organic growers. (FiBL and IFOAM, 2020) It was9,789 ha (0.23% of total agricultural land) of land under organic farming practiced by 1470 organic growers in 2010 (IFOAM, 2012). The figure clearly shows that there is very slow progress in organic farming in Nepal. It progressed by 0.07% over for a decade. The Nepalese government (Ministry of Agriculture and Livestock Development, Nepal Agricultural Research Council, AFU) and non-government sectors, farm organizations, and cooperatives

are working on organic farming in Nepal (Bhatta *et al.*, 2009). In 2020, the initiation of the founding "Organic Farming Promotional Centre" was held under the Ministry of Agriculture and Livestock Development (Atreya *et al.*, 2020). The organic product certification process was implemented under the formulation of the national standard of organic agriculture production and processing in 2007. However, it has not been implemented well in the country (Bhatta and Doppler, 2011; Bhat, 2009). The national certifying body like Organic Certification Nepal (OCN) Nepal offers internationally accredited inspection and certification services to local operators (Khanna and Tripathee, 2018). Similarly, national network organization such as Nepal Permaculture Group (NPG), Organic World and Fair Future (OWF), Organic Village, etc. are actively working in the promotion and marketing of organic products. Some international certification organizations such as NAASA (Australia), ECOCERT (France), One Cert Asia (USA), IMO (Switzerland), control Union (Netherlands), CertAlletc, are also actively involved in the certification of organic agricultural products in Nepal, with their agents. (Khanna and Tripathee, 2018; Pokharel and Pant, 2009). Most of all local governments of Nepal are concentrating on organic farming. Karnali province has been declared for working mainly on organic farming and organic products (Atreya *et al.*, 2020).

According to the study done by (Banjara and Poudel, 2017), "A separate organization having proficient manpower, adequate resources and effective management need to be built for organic agriculture. Government should especially focus on 3 main sectors of organic agriculture that includes: i) Software: establish Research Education, Training, promotion of knowledge and information, ii) Hardware: to access organic fertilizer, seeds, land, storage, lab, transportation, auction market etc. and iii) Market: coordination between and within the national and international market for the greater sells and better price. Strengthening these 3 sectors, organic agriculture can be sustained which can aid the growth of Nation." – Basanta Ranabhat, Chairman, Organic Certification Nepal Pvt. Ltd (Nepal Govt. approved national organic certifying agency in Nepal). Dr. Yubakdhoj G.C – "Director - General, Department of Agriculture, Ministry of agriculture, Nepal" pointed out need for the production of organic fertilizer and pesticides in Nepal. According to him, "Agricultural diversification plays a vital role in economic development. Organic agriculture is suitable in the Nepalese scenario and proves to be beneficial for the Nepalese farmers from the socio-economic perspective as well (Banjara and Poudel, 2017).

Conclusion

Organic farming is an urgent requirement in today's era. It helps in balancing soil health, conserving agricultural biodiversity, reducing greenhouse emissions, maintaining minimal or zero pesticide residues, gradually increasing production over time, and improving food security; thus maintaining a healthy agricultural system. Organic farming holds a greater prospect in Nepal. It will be easier to adopt organic farming since it is a simple modification of traditional/ indigenous farming which is still in practice in many parts of the country. Chemical fertilizers, insecticides, genetically modified organisms, and plant growth regulators are replaced with botanical and bio-pesticides, green manure, livestock wastes, kitchen, and field degradable wastes. Therefore, The Nepal government should have strong policies and strategies such as a clear long-term vision, a sustainable organic model, easy access to the certification process, market system, premium prices of organic products, the establishment of the organic industry, import and export process of organic products, and so on. Organic farmers and the organic sector must foster the culture of intensive learning and communication about new ideas and innovative techniques, as well as a strong atmosphere of inclusivity in innovation. Nepal must now place a higher priority on the organic sector to ensure its long-term viability.

ACKNOWLEDGEMENT

Here the authors are grateful and like to thanks all the friends and family who supported in writing this paper.

Conflict of interest

Here the authors declare there is no conflict of interest in the publication of the paper.

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