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INFLUENCE OF ENVIRONMENTAL IMPACTS OF ORGANIC FARMING IN BIHAR (INDIA)

Deepak Kumar Gupta*, Dr. Rana Vikram Singh**, Dr. Bibhuti Dutta Singh***

*Research Scholar,Faculty of Science,Zoology,Jai Prakash University,Chapra,Saran,Bihar-841301

**Associate Professor, Faculty of Science,Zoology,Jagdam College,Chapra(Saran),Bihar-841301

***Faculty of Science, Zoology, Dayanand Anglo Vedic Postgratuate College,Siwan,
Jai Prakash University,Chapra,(Saran),Bihar-841301

Abstract: **Organic agriculture means a process of developing a viable and sustainable agro-ecosystem.Organic agriculture is a production system that aims at sustaining healthy soils, ecosystems and people by prohibiting the application of synthetic pesticides and fertilisers in crop production and by emphasising animal welfare in livestock breeding. This article shows that organic agriculture is characterised by higher soil quality and reduced nutrient or pesticide leaching compared to non-organic agriculture, but that positive effects on biological control services or emission of green-house gases are less evident. Yield gaps between organic and non-organic agriculture are on average 20%, but vary between crops and regions. Given the environmental risks that are associated with intensive, non-organic agriculture, farming practices should be modified to decrease risks. Organic agriculture can be more friendly but individual farming practices need improvement to meet the demands of a growing human population. Further growth of the organic farming sector will contribute to reduce the negative environmental impact of agriculture.**

Keywords: **Organic Agriculture, Ecosystem, Fertilizers, Livestock Breeding, Green-house Gases, Environmental impact ,etc.**

1. INTRODUCTION

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices in the state of Bihar. Organic agriculture continues to be developed by various organic organizations today. Organic agricultural methods are regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM). Organic agriculture, as defined by the International Federation of Organic Agriculture Movements (IFOAM), is a 'production system that sustains the health of soils, ecosystems and people'. According to IFOAM, 'It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects … combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved'. The origins of organic agriculture date back to the end of the nineteenth century, when pioneers of organic agriculture reacted to the negative environmental consequences of intensified agriculture between world wars. Today's standards of organic agriculture reflect these ideas by prohibiting applications of synthetic pesticides and fertilizers in crop production and emphasising animal welfare in livestock breeding.

The popularity of organic agriculture partly stems from the increasing awareness about negative effects of intensive, non-organic agriculture, including human health risks due to pesticides and a limited long-term sustainability due to, for example, the development of resistances to pesticides. A total of 82 countries had 43.1 million hectares of agricultural land under organic certification in 2013, which constitutes an almost fourfold increase compared to that in 1999. This acreage accounted for approximately 1% of the total share of agricultural land worldwide (Willer and Lernoud, 2015).

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The following key aspects of the Influence of Environmental Impact of organic agriculture are addressed in this article compared to non-organic agriculture:-

(1) Pest and disease control

(2) Crop pollination

(3) Organic matter decomposition

(4) Soil quality

(5) Ground and surface water

(6) Climate and air

(7) Production of Food and its quality

(1) PEST AND DISEASE CONTROL

Plant pests, including animals (mainly invertebrates), pathogens (viruses, bacteria and fungi) and weeds, cause losses of up to 40% in major crops worldwide (Oerke, 2006). Pest control is often accomplished by pesticide applications and the use of genetically modified organisms in non-organic agriculture. In organic agriculture, these approaches are prohibited (with the exception of selected organic pesticides) and farmers are limited to practices that directly affect pest populations negatively (e.g.tillage) or improve crop and non-crop habitats to promote natural enemies of pests (for further details. Beneficial organisms that suppress pests include specialised parasitoids, generalist predators and pathogens. Populations of resident natural enemies can be promoted by habitat management (conservation biological control) and such measures may lead to higher levels of pest control (Birkhofer et al., 2008). The control of animal pests by ground-running and vegetation compared to intensive, non-organic agriculture. Results on the biological control of animal pests by parasitoids do not support this positive effect of organic agriculture, and parasitism rates can even be lower in organic viticulture. Arable weeds are the most severe pests in field crops (usually controlled by herbicides under conventional agriculture) and seed predators act as antagonists of weed growth. In organic farming, major insect pest are important role in crop damage. Fig.(a) Black Stink Bug (*Proxys punctulatus*), Fig.(b)Locus (*Locosta migratoria*),Fig.(c)Brown Stink Bug (*Halyomorpha halys*),Fig.(d) Army Worm,A larval form of *Spodoptera fruqiperda*,*Fig.(e)* A Paddy Pest *((Leptispa pygmaea)* .

FIG: -(A) BLACK STINK BUG (*Proxys punctulatus)*

FIG:- (B) LOCUS *(Locosta migratoria)*

FIG;-(C) BROWN STINK BUG (*Halyomorpha halys)*

FIG:- (D) ARMY WORM, A LARVAL FORM OF *Spodoptera frugiperda*

FIG:- (E) A PAADY PEST (***Leptispa pygmaea)***

The major control of pests by different process:-

(1) Biological pest control

(2) Cultural Control

(3) Trap cropping

(4) Pesticides

(5) Fumigation

(6) Sterilization

(2) CROP POLLINATION

Many animals visit flowers to find food resources, predominantly pollen and nectar, and when animals move between flowers they transfer pollen grain and support plant reproduction. Animal pollination, mostly by bees and other insects, has been estimated to benefit 76% of the world's leading crops and contribute to 35% of the global crop production (Klein et al., 2007). Organic agriculture can support crop pollination both in terms of quantity and quality, for example, in strawberry (Andersson et al., 2012).

Andersson et al. (2012) found higher pollination success. Potted strawberry plants at organic farms compared to non-organic farms, with 45% of the paddy fully pollinated at organic farms compared to only 17% at non-organic farms. The underlying mechanism is most likely that organic agriculture often benefits pollinator diversity and abundance through higher plant diversity and absence of pesticides (Tuck et al. 2014). Studies about effects of organic farming on pollination of crops on a field scale, however, are lacking and the effect of organic farming on pollination services depends on the landscape context (Brittain et al., 2010). Different agents are responsible for transfer of pollen grains for production of wild variety of crops. The different agencies of pollination **(1)** Biotic agencies of pollination **(2)** Abiotic agencies of pollination.

Table 1: Agents of Pollination/Description and its Example:-

S.No.	AGENTS OF POLLINATION	DESCRIPTION AND ITS EXAMPLE
1.	**Entomophily**	Entomophily or insect pollination is a form of pollination whereby pollen of plants, is distributed by insects. Example:-Invertebrates and Vertebrates
2.	**Ornithophily**	Ornithophily or bird pollination is the pollination of flowering plants by birds. Example:-Hummingbirds and Crow

3.	**Cheiropterophily**	Cheiropterophily is the pollination by bats. Example:-Bats
4.	**Malacophily**	In these cases pollinating agents are snails and slugs. Land plants like Chrysanthemum leucanthemum and water plant like Lemnashow malacophily. Example:- Snails and Slugs
5.	**Myrmecophily**	Myrmecophily is the term applied to positive interspecies associations between ants a variety of other organisms such as plants ,other anthropods and fungi. Example:- Ants
6.	**Necrocoleoterophily**	Necrocoleoterophily is the pollination by Carion beetle. Example:-Carion beetle
7.	**Psychophily**	Psychophily is the pollination by butterfly.Example:- Butterfly
8.	**Cantharophily**	Cantharophily is the pollination by bettle. Example:- Bettle

(3) ORGANIC MATTER DECOMPOSITION

Nutrient cycling is primarily driven by micro-organisms, but soil fauna also contributes to the breakdown of organic matter in agricultural fields. Certain agricultural practices that are commonly, but not exclusively, used in organic agriculture utilise litter decomposition services directly to improve nutrient availability to crop plants (e.g. adding crop residues or cultivating legumes in the crop rotation). Empirical studies on decomposition services indicate that both higher and lower rates of litter decomposition can be observed in organic compared to nonorganic agriculture. A higher decomposition rate is usually explained by larger populations of soil organisms under organic agriculture (Tuck et al. 2014). Lower rates are explained by the higher N content and therefore more rapid decomposition of plant litter under the application of synthetic fertilizers in non-organic agriculture (Scheller and Joergensen, 2008). Fig. (a) Organic farming plot and showing decomposition of organic material.

FIG :- OGANIC FARMING PLOT AND SHOWING DECOMPOSTION OF ORGAN MATERIAL

(4) SOIL QUALITY

Agricultural land use and the ongoing intensification of agriculture pose severe risks for soil degradation worldwide Soil nutrients, microbial communities, soil erosion and physical properties are all affected by agricultural management, with potentially severe consequences for human societies (Setala et al., 2014). Soil organic matter/soil organic carbon are managed via the application of organic fertilizers (e.g. manure, slurry or compost), mulches or crop residues and crop rotations (e.g. including legumes with nitrogen (N) fixation) under organic agriculture replacing the application of mineral fertilizers in intensive, non-organic agriculture. There is good evidence that organic agriculture leads to higher soil organic matter content and soil carbon stocks compared to non-organic agriculture. These results partly reflect the fact that organically managed fields often receive external carbon input at higher rates and that diverse crop rotations are more common compared to non-organic agriculture (Leifeld et al., 2013; Leithold et al., 2015).

Organically managed soils can have significantly higher soil carbon content even if organic fields do not receive manure(Marriott and Wander, 2006), or if both organic and non-organic fields receive manure over long periods (Birkhofer et al., 2008). Positive effects of organic agriculture are also evident for N content and microbial parameters (biomass and activity) compared to non-organic agriculture. Available phosphorous (P) and potassium (K) contents, however, are less consistently affected by organic agriculture. Among the most important physical properties of agricultural soils are aggregate stability, water-holding capacity and bulk density. These properties contribute to the resistance of soils versus structural degradation and reduced nutrient leaching. Soil physical quality is often higher under organic agriculture, a fact that contributes to the often lower soil erosion in comparison to non-organic agriculture. Higher abundances of arable weeds and increased competition with crop plants may, however, also lead to the risk of high soil erosion in organic agriculture due to reduced crop plant densities.

(5) GROUND AND SURFACE WATER

Water leaches through agricultural soils and takes (primarily) nitrate with it, causing N losses from arable fields and associated environmental problems (e.g. eutrophication). Levels of nitrate leaching in organic agriculture have been reported to be lower or equal to levels under non-organic management per unit area, but higher per unit product. Higher nitrate leaching in non-organic agriculture is usually related to larger N inputs, reduced use of cover crops or higher stocking densities. Major difficulties with studying effects of farming systems on leaching are the seasonal and inter-annual variation in rainfall and N mineralisation processes. Nutrient budgets in organic agriculture rarely show surplus P, so that P leaching from organically managed arable land is of limited concern.

The poor recycling of P and the strict regulation of potential P source constitute one of the main challenges in organic agriculture. The main sources of environmentally critical pesticides that contaminate water are synthetic herbicides, and organic agriculture does not contribute to these negative impacts on the environment. Pesticide leaching in organic agriculture would be limited to organic pesticides. These chemicals can have severe local consequences for non-target soil organisms (e.g. copper sulphate), but nothing is known about potential leaching of such substances (Shepherd et al., 2003).

(6) CLIMATE AND AIR

The emission of green-house gases (GHGs) from agriculture contributes to global warming. Nitrous oxide is produced during nitrification and de-nitrification processes in soils that are fertilized with synthetic fertilisers. Organic agriculture contributes to Nitrous oxide emissions due to the production, storage and application of manure and due to the decomposition of green manure crops in the rotation. Studies observed higher Nitrous oxide emissions in organic dairy and crop farming in the Chapra (Bihar) compared to non-organic agriculture. In general, Nitrous oxide emissions are lower per unit area in organic agriculture, but higher per unit product. Studies on the emission of carbon dioxide as another important GHG also show higher emissions in organic agriculture per unit product , but lower emissions per unit area compared to non-organic agriculture. Methane emissions in agriculture are the result of complex interactions between fodder type, livestock species and livestock numbers in animal breeding. Methane emissions per unit livestock decrease with increasing production intensity and this should result in higher methane emission per unit in organic livestock breeding. The major reviews about GHG emissions conclude that GHG emissions are lower in organic agriculture or not different from non-organic agriculture if considered per unit area, but that organic agriculture may lead to higher emissions if considered per unit product (Mondelaers et al., 2009; Skinner et al., 2014; McGee, 2015).

(7) PRODUCTION OF FOOD AND ITS QUALITY

Global food production needs to account for the increasing future demand for food. It is therefore not surprising that there is an ongoing debate about the ability of organic farming to feed the global human population in future agriculture (Avery, 2007; Ponisio et al., 2015). Organic agriculture, on average, produces lower yields than non-organic farming yield gap on average approximately 80% to non-organic production, Ponisio et al., 2015), but with pronounced differences between crops and regions. One of the major arguments against the promotion of organic agriculture as the dominant form of agricultural production focuses on the additional demand for land if yield gaps between organic and non-organic agriculture cannot be closed. This aspect is alarming as fertile arable land is finite and large areas of agricultural land are already lost due to soil erosion, exploitation and conversion (e.g. urbanisation, Setala et al., 2014). Consumers primarily buy organically produced food because of food safety concerns with conventionally produced food (e.g. due to pesticide residues) and, to a lesser extent, because they perceive such products as healthier (e.g. due to vitamin content, Illukpitiya and Khanal, 2016). There are indications that crop and dairy products from organic agriculture are safer and healthier. Lower pesticide residues (crop) or antibiotic content (meat), cadmium concentrations and higher antioxidant, vitamin C, mineral, poly-unsaturated fatty acid and nutrient contents have been reported for organically produced food (Baranski ´ et al., 2014). The measured differences, however, are not necessarily biologically relevant for human health and underlie several additional factors that act on food quality independent of the farming system (Mulet, 2014). In organic livestock farming, for example, product quality is rather controlled by farm-specific management decisions instead of overarching regulations for organic agriculture (Sundrum, 2001).Fig.(a) A healthy irrigated cabbage (*Brassica oleracea*),Fig. (b) A plot of green vegetable, irrigated organic farming. Fig. (c) A healthy irrigated plot of paddy (*Oryza sativa*).Fig.(d) A healthy irrigated plot of Mustard (*Brassica nigra*).

FIG;-(A) A HEALTHY IRRIGATED CABBAGE *(Brassica oleracea*)

FIG:-(B) A PLOT OF GREEN VEGETABLE; IRRIGATION OF ORGANIC FARMING

FIG:- (C) A HEALTHY IRRIGATED PLOT OF PADDY (*Oryza sativa)*

FIG:-(D) A HEALTHY IRRIGATED MUSTARD (*Brassica nigra*)

2. CONCLUSIONS

It is difficult to find a consensus between promoters and opponents of organic agriculture. Challenges in organic agriculture include the cost-effective supply of crops with plant nutrients with limited requirements for additional land to supply nutrients. The current situation of nutrient supply in organic agriculture is often not optimal, as livestock and crop production are spatially decoupled, which increases the need for transportation of nutrients between farms (Foissy et al., 2013). There is also a considerable inflow of plant nutrients to organic agriculture from non-organic farms (Nowak et al., 2013). Certified organic products require a high price premium. Lower productivity compared to non-organic agriculture and reduced governmental subsidies in the future may increase prices even further. These developments may lead to equity issues between richer and poorer parts of human societies (Reddy, 2010). Improvements to the security of food supply, such as the reduction of food wastes or changes in human consumption habits, need to contribute to these future challenges. It is also important to be aware of the major challenges that intensive, non-organic agriculture pose for human societies: several pesticides in the past and recently have been identified as severe risk to human health. Agricultural pests are known to develop resistance against these substances, which challenges the long-term sustainability of chemical pest control strategies. Among the most promising improvements to increase yields in organic agriculture improved crop rotations, mixed cropping strategies and options to promote the provision of ecosystem services from agricultural and semi-natural land (Niggli, 2015). As a compromise between the lower yields in organic agriculture and the environmental problems from intensive, non-organic agriculture, researchers have proposed two ways of blending philosophies at different spatial scales. At the field scale, it has been suggested to alter regulations for organic agriculture to allow for a larger range of options in pest control and plant nutrient management (Stewart et al., 2013). These suggestions (partly labelled 'conventionalisation' of organic agriculture) have raised criticism as they are not necessarily in accordance with the principles of agroecologically based crop management in organic agriculture (Barberi, 2015).

However, even under the existing regulations, organic agriculture is not always in accordance with the principles outlined by the IFOAM (Darnhofer et al., 2010). At larger scales, Reganold and Dobermann (2012) suggested that a mix of different farming approaches in agricultural landscapes may be best suited to provide food and reduce negative environmental impacts. Given the beneficial effects of organic agriculture and the low acreage that is currently certified worldwide, further growth of the organic farming sector can most likely contribute to reduce the negative environmental impact of agriculture. To address the global demand for food, fuel and fibre, individual practices in organic agricultural have to be improved and integrated management systems have an important role in future agriculture (Reganold and Wachter, 2016).

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REFERENCES

[1] Andersson GKS, Rundlof M and Smith HG (2012) Organic farming improves pollination success in strawberries. PLoS One 7: e31599.

[2] Arnhold S, Lindner S, Lee B, et al. (2014) Conventional and organic farming: soil erosion and conservation potential for row crop cultivation. Geoderma 219: 89–100.

[3] Avery A (2007) 'Organic abundance' report: fatally flawed. Renewable Agriculture and Food Systems 22 (4): 321–323.

[4] Baranski M, ´ Srednicka-Tober D, Volakakis N, ´ et al. (2014) Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. British Journal of Nutrition 112

[5] Barberi P (2015) Functional biodiversity in organic systems: the way forward? Sustainable Agriculture Research 4 (3): 26.

[6] Birkhofer K, Bezemer TM, Bloem J, et al. (2008) Long-term organic farming fosters below and aboveground biota: implications for soil quality, biological control and productivity. Soil Biology and Biochemistry 40 (9): 2297–2308.

[7] Birkhofer K, Arvidsson F, Ehlers D, et al. (2016) Organic farming affects the biological control of hemipteran pests and yields in spring barley independent of landscape complexity. Landscape Ecology 31 (3): 567–579.

[8] Bos JF, de Haan J, Sukkel W, et al. (2014) Energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands. NJAS-Wageningen Journal of Life Sciences 68: 61–70.

[9] Brittain C, Bommarco R, Vighi M, et al. (2010) Organic farming in isolated landscapes does not benefit flower-visiting insects and pollination. Biological Conservation 143: 1860–1867.

[10] Van Bruggen AH, Gamliel A and Finckh MR (2016) Plant disease management in organic farming systems. Pest Management Science 72 (1): 30–44.

[11] Clark MS, Horwath WR, Shennan C and Scow KM (1998) Changes in soil chemical properties resulting from organic and low-input farming practices. Agronomy Journal 90 (5): 662–671.

[12] Darnhofer I, Lindenthal T, Bartel-Kratochvil R, et al. (2010) Conventionalisation of organic farming practices: from structural criteria towards an assessment based on organic principles. Agronomy for Sustainable Development 30 (1): 67–81.

[13] Diekötter T, Wamser S, Wolters V, et al. (2010) Landscape and management effects on structure and function of soil arthropod communities in winter wheat. Agriculture, Ecosystems & Environment 137 (1): 108–112.

[14] Domínguez A, Bedano JC, Becker AR, et al. (2014) Organic farming Fosters agroecosystem functioning in Argentinian temperate soils: evidence from litter decomposition and soil fauna. Applied Soil Ecology 83: 170–176.

[15] Erhart E and Hartl W (2010) Soil protection through organic farming: a review. In: Lichtfouse E (ed) Organic Farming, Pest Control and Remediation of Soil Pollutants, pp. 203–226. Dordrecht: Springer.

[16] Foissy D, Vian JF and David C (2013) Managing nutrient in organic farming system: reliance on livestock production for nutrient management of arable farmland. Organic Agriculture 3 (3–4): 183–199.

[17] Gattinger A, Muller A, Haeni M, et al. (2012) Enhanced top soil carbon stocks under organic farming. Proceedings of the National Academy of Sciences 109 (44): 18226–18231.

[18] Geiger F, Bengtsson J, Berendse F, et al. (2010) Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland. Basic and Applied Ecology 11 (2): 97–105.

[19] Illukpitiya P and Khanal P (2016) Consumer perception of organic food and product marketing. In: Nandwani D (ed) Organic Farming for Sustainable Agriculture, pp. 315–324. Cham: Springer International Publishing.

[20] Jonason D, Smith HG and Birkhofer K (2013) Landscape simplification promotes weed seed predation by carabid beetles (Coleoptera: Carabidae). Landscape Ecology 28 (3): 487–494.

[21] Klein AM, Vaissiére BE, Cane JH, et al. (2007) Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biological Sciences 274 (1608): 303–313.

[22] Leifeld J, Angers DA, Chenu C, et al. (2013) Organic farming gives no climate change benefit through soil carbon sequestration. Proceedings of the National Academy of Sciences of the United States of America 110 (11): E984.

[23] Leithold G, Hülsbergen KJ and Brock C (2015) Organic matter returns to soils must be higher under organic compared to conventional farming. Journal of Plant Nutrition and Soil Science 178 (1): 4–12.

[24] Letourneau DK and Bothwell SG (2008) Comparison of organic and conventional farms: challenging ecologists to make biodiversity functional. Frontiers in Ecology and the Environment 6 (8): 430–438.

[25] Marriott EE and Wander M (2006) Qualitative and quantitative differences in particulate organic matter fractions in organic and conventional farming systems. Soil Biology and Biochemistry 38 (7): 1527–1536.

[26] Mondelaers K, Aertsens J and Van Huylenbroeck G (2009) A meta-analysis of the differences in environmental impacts between organic and conventional farming. British Food Journal 111 (10): 1098–1119.

[27] Mulet JM (2014) Should we recommend organic crop foods on the basis of health benefits? Letter to the editor regarding the article by Baranski et al. ´ British Journal of Nutrition 112 (10): 1745–1747.

[28] Munro TL, Cook HF and Lee HC (2002) Sustainability indicators used to compare properties of organic and conventionally managed topsoils. Biological Agriculture & Horticulture 20 (3): 201–214.

[29] Navntoft S, Wratten SD, Kristensen K, et al. (2009) Weed seed predation in organic and conventional fields. Biological Control 49 (1): 11–16.

[30] Niggli U (2015) Sustainability of organic food production: challenges and innovations. Proceedings of the Nutrition Society 74 (1): 83–88.

[31] Nowak B, Nesme T, David C, et al. (2013) To what extent does organic farming rely on nutrient inflows from conventional farming? Environmental Research Letters 8 (4): 044045.

[32] Ponisio LC, M'Gonigle LK, Mace KC, et al. (2015) Diversification practices reduce organic to conventional yield gap. Proceedings of the Royal Society of London B: Biological Sciences 282 (1799).

[33] Reganold JP and Dobermann A (2012) Agriculture: comparing apples with oranges. Nature 485 (7397): 176–177.

[34] Reganold JP and Wachter MW (2016) Organic agriculture in the twenty-first century. Nature Plants 2: 1–8.

[35] Rusch A, Delbac L, Muneret L, et al. (2015) Organic farming and host density affect parasitism rates of tortricid moths in vineyards.Agriculture, Ecosystems & Environment 214: 46–53.

[36] Scheller E and Joergensen RG (2008) Decomposition of wheat straw differing in nitrogen content in soils under conventional and organic farming management. Journal of Plant Nutrition and Soil Science 171 (6): 886–892.

[37] Birkhofer K, et al. (2014) Urban and agricultural soils: conflicts and trade-offs in the optimization of ecosystem services. Urban Ecosystems 17 (1): 239–253.

[38] Shepherd M, Pearce B, Cormack B, et al. (2003) An assessment of the environmental impacts of organic farming. A review for DEFRA-funded Project OF0405.

[39] Skinner C, Gattinger A, Muller A, et al. (2014) Greenhouse gas fluxes from agricultural soils under organic and non-organic management–a global meta-analysis. Science of the Total Environment 468: 553–563.

[40] Stewart BA, Hou X and Yalla SR (2013) Facts and myths of feeding the world with organic farming methods. In: Lal R and Stewart BA (eds) Principles of Sustainable Soil Management in Agroecosystems, pp. 87 108. Boca Raton: CRC Press.

[41] Sundrum A (2001) Organic livestock farming: a critical review. Livestock Production Science 67 (3): 207–215.

[42] Sudarsan Biswas M, Ali N, Goswami R, et al. (2014) Soil health sustainability and organic farming: a review. Journal of Food, Agriculture & Environment 12 (3&4): 237–243.

[43] Tuomisto HL, Hodge ID, Riordan P, et al. (2012) Does organic farming reduce environmental impacts?–a meta-analysis of European research. Journal of Environmental Management 112: 309–320.

[44] Wang S, Li Z and Fan G (2012) Soil quality and microbes in organic and conventional farming systems. African Journal of Microbiology Research 6 (24): 5077–5085.

[45] Willer H and Lernoud J (2015) The world of organic agriculture: Statistics and emerging trends 2015.

[46] Winqvist C, Bengtsson J, Aavik T, et al. (2011) Mixed effects of organic farming and landscape complexity on farmland biodiversity and biological control potential across Europe.

[47] Abbot LK and Manning DA (2015) Soil health and related ecosystem services in organic agriculture. Sustainable Agriculture Research 4 (3): 116.

[48] Anderson RL (2015) Integrating a complex rotation with no-till improves weed management in organic farming. A review. Agronomy for Sustainable Development 35: 1–8.

[49] Crowder DW and Reganold JP (2015) Financial competitiveness of organic agriculture on a global scale. Proceedings of the National Academy of Sciences 112 (24): 7611–7616. Finckh MR, van Bruggen AHC and Tamm L (2015) Plant diseases and their management in organic agriculture. St. Paul: The American Phytopathological Society.

[50] Gomiero T, Paoletti MG and Pimentel D (2008) Energy and environmental issues in organic and conventional agriculture. Critical Reviews in Plant Sciences 27 (4): 239–254.

[51] Kremen C and Miles A (2012) Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. Ecology and Society 17 (4): 40.

[52] Mäder P, Fliessbach A, Dubois D, et al. (2002) Soil fertility and biodiversity in organic farming. Science 296 (5573): 1694–1697.

[53] Reeve JR, Hoagland LA, Vilalba JJ, et al (2016) Organic farming, soil health, and food quality: considering possible links. Advances in Agronomy. 137: 319–367

[54] Sandhu HS, Wratten SD and Cullen R (2010) Organic agriculture and ecosystem services. Environmental Science & Policy 13 (1): 1–7.

[55] Smith LG, Williams AG and Pearce BD (2015) The energy efficiency of organic agriculture: a review. Renewable Agriculture and Food Systems 30 (3): 280–301.

[56] Tittonell P (2014) Ecological intensification of agriculture– sustainable by nature. Current Opinion in Environmental Sustainability 8: 53–61.