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The Prospects of Organic Agriculture and Yield Improvement in the 21st Century

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ABSTRACT
Agriculture was practiced for thousands of years without the use of inorganic or artificial chemicals or synthetic substances. Artificial fertilizers were first created during the mid-19th century. These early fertilizers were cheap, powerful, and easy to transport in bulk. Advances occurred in chemical pesticides in the 1940s, leading to the decade being referred to as the 'pesticide era'. Even though these new agricultural techniques, were beneficial in the short term, had serious longer term side effects such as soil compaction, erosion, and declines in overall soil fertility, along with health concerns about toxic chemicals entering the food supply and affecting lives of millions. In order to remedy these problems soil biology scientist began to seek ways to remedy the side effects in the late 1800s and early 1900s, while still tried to maintain higher production. Organic agricultural systems/farming originated as early as 20th century in reaction to rapid changing farming practices. It continues to develop by various organic agriculture till today. It relies on fertilizer of organic origin, such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control,, mixed cropping and the fostering of insect predators are encouraged. Generally, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. Naturally occurring pesticides such as pyrethrin and rotenone are permitted, while synthetic fertilizers and pesticides are generally prohibited; even though, some synthetic substances such as copper sulfate and elemental sulfur are allowed. Generally, modified organisms, nanomaterials, human sewage sludge, plant growth regulators, hormones, and antibiotic used in livestock management are prohibited. Organic farming is advocated now due to its sustainability openness. Cost - effectiveness, self-sufficiency, autonomy/independence, health, food security, food safety and protection for the extinction of some vegetables and food crops by the application of chemicals and some synthetic fertilizers to the soil. It also responds to site specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promotes ecological balance, conserves soil biodiversity and maintain long - term soil health. It is a small but powerful step towards constructing the framework for healthy, highly nutrient – inclusive, efficient and sustainable food production systems in the 21st century.
Keywords: Organic, pesticide era, green manure, sustainable.

INTRODUCTION

Agriculture was practiced for thousands of years without the use of artificial chemicals. Artificial fertilizers were first created during the mid-19th century. These early fertilizers were cheap, powerful, and easy to transport in bulk. Similar advances occurred in chemical pesticides in the 1940s, leading to the decade being referred to as the 'pesticide era' These new agricultural techniques, while beneficial in the short term, had serious longer term side effects such as soil compaction, erosion, and declines in overall soil fertility, along with health concerns about toxic chemicals entering the food supply. In the late 1800s and early 1900s, soil biology scientists began to seek ways to remedy these side effects while still maintaining higher production.

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. Organic farming continues to be developed by various organic agriculture organizations today. It relies on fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control, mixed cropping and the fostering of insect predators are encouraged Helga, W. *et al* (2013). In general, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. For instance, naturally occurring pesticides such as pyrethrin and rotenone are permitted, while synthetic fertilizers and pesticides are generally prohibited. Synthetic substances that are allowed include, for example, copper sulfate, elemental sulfur and Ivermectin. Genetically modified organisms, nanomaterials, human sewage sludge, plant growth regulators, hormones, and antibiotic use in livestock husbandry are prohibited. Reasons for advocation of organic farming include advantages in sustainability openness, self-sufficiency, autonomy/independence, health, food security, and food safety. Organic farming is a form of agriculture that relies on techniques such as crop rotation, green manure, compost and biological pest control. Organic farming uses fertilizers and pesticides but excludes or strictly limits the use of manufactured fertilizers, pesticides, plant growth regulators such as hormones, livestock antibiotics, food additives, genetically modified organisms, human sewage sludge, and nanomaterials. Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements, an international umbrella organization for organic farming organizations established in 1972

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972. Organic agriculture can be defined as:

an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones.

Since 1990 the market for organic food and other products has grown rapidly, reaching $63 billion worldwide in 2012. This demand has driven a similar increase in organically managed farmland that grew from 2001 to 2011 at a compounding rate of 8.9% per annum. As of 2011, approximately 37,000,000 hectares (91,000,000 acres) worldwide were farmed organically, representing approximately 0.9 percent of total world farmland, Gold, Mary (2014).

International Federation of Organic Agriculture Movements

Organic farming methods combine scientific knowledge of ecology and modern technology with traditional farming practices based on naturally occurring biological processes. Organic farming methods are studied in the field of agroecology Danielle T. (2018). While conventional agriculture uses synthetic pesticides and water-soluble synthetically purified fertilizers, organic farmers are restricted by regulations to using natural pesticides and fertilizers. An example of a natural pesticide is pyrethrin, which is found naturally in the Chrysanthemum flower, Paull, John (2011). The principal methods of organic farming include crop rotation, green manures and compost, biological pest control, and mechanical cultivation.

These measures use the natural environment to enhance agricultural productivity: legumes are planted to fix nitrogen into the soil, natural insect predators are encouraged, crops are rotated to confuse pests and renew soil, and natural materials such as potassium bicarbonate and mulches are used to control disease and weeds. Genetically modified seeds and animals are excluded.

While organic is fundamentally different from conventional because of the use of carbon based fertilizers compared with highly soluble synthetic based fertilizers and biological pest control instead of synthetic pesticides, organic farming and large-scale conventional farming are not entirely mutually exclusive. Many of the methods developed for organic agriculture have been borrowed by more conventional agriculture. For example, Integrated Pest Management is a multifaceted strategy that uses various organic methods of pest control whenever possible, but in conventional farming could include synthetic pesticides only as a last resort.

The USDA defines organic agriculture as "a production system that is managed to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity."

More specifically, organic farming entails:

- Use of cover crops, green manures, animal manures and crop rotations to fertilize the soil, maximize biological activity, maintain long-term soil health and also aid in the use of biological control. Crop rotations and other techniques to manage weeds, insects and diseases.
- Emphasis is also geared towards biodiversity of the agricultural system and the surrounding with emphasis on environment.
- Using rotational grazing and mixed forage pastures for livestock operations and alternative health care for animal wellbeing.

"Organic agriculture is also production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved..." USDA.

Organic production is defined by the United State Department of Agriculture (USDA) as a set of practices that comply with the USDA's Agricultural Marketing Service (AMS) National Organic Program (NOP) regulations and in larger practice, encompasses a whole system approach to farming that integrates biological, cultural and mechanical practices to foster nutrient cycling, ecological balance and conserve biodiversity, and, provide a wealth of benefits to the environment by:

- using cover crops, manure and conservation tillage to build soil health and reduce erosion
- promoting biodiversity by mixed species plantings and rotations
- using biological control to minimize exposure to synthetic pesticides and fertilizers
- promoting the well-being of livestock by minimizing hormones and antibiotics and using alternative health care, and
- focusing on renewable resources, soil and water conservation and other management practices that enhance ecological balance.

Crop diversity: Organic farming encourages Crop diversity. The science of agroecology has revealed the benefits of polyculture (multiple crops in the same space), which is often employed in organic farming. Planting a variety of vegetable crops supports a wider range of beneficial insects, soil microorganisms, and other factors that add up to overall farm health. Crop diversity helps environments thrive and protects species from going extinct.

Soil managements: Organic farming relies heavily on the natural breakdown of organic matter, using techniques like green manure and composting, to replace nutrients taken from the soil by previous crops. This biological process, driven by microorganisms such as mycorrhiza, allows the natural production of nutrients in the soil throughout the growing season, and has been referred to as *feeding the soil to feed the plant*, Watson C.A. *et al* (2002). Organic farming uses a variety of methods to improve soil fertility, including crop rotation, cover cropping, reduced tillage, and application of compost. By reducing tillage,

soil is not inverted and exposed to air; less carbon is lost to the atmosphere resulting in more soil organic carbon. This has an added benefit of carbon sequestration, which can reduce greenhouse gases and help reverse climate change.

Plants need nitrogen, phosphorus, and potassium, as well as micronutrients and symbiotic relationships with fungi and other organisms to flourish, but getting enough nitrogen, and particularly synchronization so that plants get enough nitrogen at the right time (when plants need it most), is a challenge for organic farmers. Crop rotation and green manure ("cover crops") help to provide nitrogen through legumes (more precisely, the *Fabaceae* family), which fix nitrogen from the atmosphere through symbiosis with rhizobial bacteria. Intercropping, which is sometimes used for insect and disease control, can also increase soil nutrients, but the competition between the legume and the crop can be problematic and wider spacing between crop rows is required. Crop residues can be ploughed back into the soil, and different plants leave different amounts of nitrogen, potentially aiding synchronization, Horne, Paul Anthony (2008). Organic farmers also use animal manure, certain processed fertilizers such as seed meal and various mineral powders such as rock phosphate and green sand, a naturally occurring form of potash that provides potassium. Together these methods help to control erosion. In some cases pH may need to be amended. Natural pH amendments include lime and sulfur, but in the U.S. some compounds such as iron sulfate, aluminum sulfate, magnesium sulfate, and soluble boron products are allowed in organic farming.

Mixed farms with both livestock and crops can operate as ley farms, whereby the land gathers fertility through growing nitrogen-fixing forage grasses such as white clover or alfalfa and grows cash crops or cereals when fertility is established. Farms without livestock ("stockless") may find it more difficult to maintain soil fertility, and may rely more on external inputs such as imported manure as well as grain legumes and green manures, although grain legumes may fix limited nitrogen because they are harvested. Horticultural farms that grow fruits and vegetables in protected conditions often rely even more on external inputs.

Biological research into soil and soil organisms has proven beneficial to organic farming. Varieties of bacteria and fungi break down chemicals, plant matter and animal waste into productive soil nutrients. In turn, they produce benefits of healthier yields and more productive soil for future crops. Fields with less or no manure display significantly lower yields, due to decreased soil microbe community. Increased manure improves biological activity, providing a healthier, more arable soil system and higher yields, Paull, John (2006).

Weed management: Organic weed management promotes weed suppression, rather than weed elimination, by enhancing crop competition and phytotoxic effects on weeds. Organic farmers integrate cultural, biological, mechanical, physical and chemical tactics to manage weeds without synthetic herbicides.

Organic standards require rotation of annual crops, meaning that a single crop cannot be grown in the same location without a different, intervening crop. Organic crop rotations frequently include weed-suppressive cover crops and crops with dissimilar life cycles to discourage weeds associated with a particular crop. Research is ongoing to develop organic methods to promote the growth of natural microorganisms that suppress the growth or germination of common weeds.

Other cultural practices used to enhance crop competitiveness and reduce weed pressure include selection of competitive crop varieties, high-density planting, tight row spacing, and late planting into warm soil to encourage rapid crop germination.

Mechanical and physical weed control practices used on organic farms can be broadly grouped as:

- Tillage - Turning the soil between crops to incorporate crop residues and soil amendments; remove existing weed growth and prepare a seedbed for planting; turning soil after seeding to kill weeds, including cultivation of row crops;
- Mowing and cutting - Removing top growth of weeds;
- Flame weeding and thermal weeding - Using heat to kill weeds; and
- Mulching - Blocking weed emergence with organic materials, plastic films, or landscape fabric.

Some critics, citing work published in 1997 by David Pimentel of Cornell University, which described an epidemic of soil erosion worldwide, have raised concerned that tillage contribute to the erosion epidemi. The FAO and other organizations have advocated a 'no-till' approach to both conventional and organic farming, and point out in particular that crop rotation techniques used in organic farming are excellent no-till approaches, David R (2008) and Green (2008) A study published in 2005 by Pimentel and colleague, Pimentel, et al. (2005) confirmed that 'Crop rotations and cover cropping (green manure) typical of organic agriculture reduce soil erosion, pest problems, and pesticide use.'

Some naturally sourced chemicals are allowed for herbicidal use. These include certain formulations of acetic acid (concentrated vinegar), corn gluten meal, and essential oils. A few selective bioherbicides based on fungal pathogens have also been developed. At this time, however, organic herbicides and bioherbicides play a minor role in the organic weed control toolbox, Martin, H. (2018).

Over centuries of civilization, raising of animals and growing plants have always been an organic practice. Chemicals were presented in the agricultural industry only in the 20th century. Yet, the adverse health effects that these chemicals can have, both on the soil and the crops, are pushing farmers to accept the traditional, organic farming methods.

Organic farming uses biological materials and avoids synthetic substances. This helps to maintain ecological balance and soil fertility and subsequently reduces wastage and pollution. This type of farming depends on the ecologically balanced principles of agriculture such as crop rotation, green manure, organic waste, minerals, biological pest control, and rock additives. The consequences of shifting to such practices are huge, and the switch needs a holistic approach to address the challenges and make the most of opportunities in the agriculture industry, Horne, Paul Anthony (2008).

According to the analytics experts at Quantzig, "Organic farming is a small but powerful step towards constructing the framework for healthy, highly nutrient-inclusive, efficient and sustainable food systems."

Benefits of organic farming in the agricultural industry

Nutrient-rich food: Organic farms are preferably managed and nurtured using sustainable practices. Hence, food crops produced organically are filled with nutrients such as minerals, vitamins, enzymes, and other micro-nutrients as compared to those from conventional farms that use chemicals for cultivation. Crops from conventional or commercial farms have a reasonably lower nutrient content, as most of the nutrients get wrecked by the use of harmful chemicals that are used to keep the produce fresh and pest-free, Paull, John (2006).

Enhances soil nourishment: Organic farming efficiently addresses soil management. Organic farming procedures such as inter-cropping techniques, crop rotation, and the widespread use of green manure can even help with farming on damaged soil that is subject to corrosion and salinity, Watson C.A. *et al* (2002). The absence of chemicals in organic farming promotes the existence of microbes, which raises the nourishment of the soil. This, in turn, guarantees that the crop remains nutrient-rich.

Organic farmers must consider how the various components of their system - rotations, pest and weed management, and soil health - will maintain both productivity and profitability. This section outlines the major principles incorporated into organic farming systems as opined by Ingram, M. (2007).

Rotations: Although practices vary from farm to farm and region to region, at the core of any successful annual organic farming system is the crop rotation. According to "Cereal-Legume Cropping Systems: Nine Farm Case Studies in the Dryland Northern Plains, Canadian Prairies, and Intermountain Northwest," productive rotations:

Enhance soil conservation and build soil organic matter; Provide weed, disease and insect control;
Enhance water quality and conservation, biological diversity and wildlife habitat; and
Ensure economic profitability for the farming system.

As the main management tool for all aspects of the farming system - including weeds, pests, insects, soils, and crop production - a well-planned rotation is more than the sum of its parts, addressing the connections between all of those factors. For example, successful rotations, according to "Switching to a Sustainable System" by Fred Kirschenmann:

Include the use of cover crops to provide fertility, control weeds and provide habitat for beneficial insects;

Have a diversity of plant species to encourage natural predators, discourage pest and disease build-up, and minimize economic and environmental risk;

Provide a balance between soil conservation and crop production by adding organic matter to the soil to both supply nutrients and improve soil quality properties such as water infiltration and water holding capacity; and

For soil borne-disease control in organic systems, many growers use composts, long known as effective plant pathogen suppressants. Rotations also are important for decreasing pathogen populations, as most pathogens are plant specific. In general, rotating the crop, planting resistant varieties, and adding organic matter have all been shown to reduce the incidence of soil-borne diseases:

Organic Systems Make Good Economic Sense: Organic farmers are often the first to admit that as they were transitioning to organic systems, their yields declined. Many studies have shown that, initially, a decline in yields occurs during the conversion to organic production.

However, once the transition period has passed - usually in three to five years - organic crop yields often rebound to within 90 to 95 percent of conventional yields, according to an Organic Farming Research Foundation review of comparative studies as reported by Gillman J. (2008).

Perhaps even more important, once the farming system has been certified, price premiums for organic crops, added to the reduced production costs, help boost profitability as presented on Table 2 below.

TABLE 2. ORGANIC AND CONVENTIONAL PRICES FOR FIELD CROPS 2000-2002

	2000		2001		2002	
Production System	**Organic**	**Conventional**	**Organic**	**Conventional**	**Organic**	**Conventional**
Corn ($/bushel)	$3.51	$1.86	$3.01	$1.89	$3.96	$2.13
Soybeans* ($/bushel)	$13.02	$4.73	$12.29	$4.43	$12.29	$4.93
Spring Wheat ($/bushel)	$5.72	$2.82	$5.75	$2.96	$5.54	$3.47
Oats ($/bushel)	$2.00	$1.17	$2.00	$1.42	$3.64	$1.89

* Clear Hilum, cleaned

Prices of Crops Products Grown Organically in the Northern Plains and Upper Midwest'. Economics Commentator, South Dakota State University. #437, April 4, 2003.

Culled from South Dakota State Univeristy, U.S., on 17th July, 2018.

For many organic farmers, equivalent yields are not necessarily the goal. "High yields are not always connected to profitability," said Wende Elliott. On her farm, she expects a 37.5 percent operating profit margin, largely due to lower input costs and a premium price for organic poultry, hay and row crops.

How organic farming makes good economic sense. In 2001, his organic corn and soybean yields were only 90 percent of conventional yields as reported by Gillman J. (2008), yet the organic corn fetched $4.70 bushel compared to $2.10 for conventional. The soybean price disparity was even larger - conventional soybeans went for $3.80 per bushel, while organic livestock feed beans brought $10.50 per bushel and organic food grade beans $15 a bushel, Lotter, D. (2003).

Ed Fry, who farms 400 acres of grain and has 240 milk cows in Chestertown, Md., points out in a marketing fact sheet from Rodale that while his corn yields were comparable in 2000, his total production costs were lower for organic corn - $1.79/bushel versus $2.23 for conventional. The labor per acre was higher in his organic corn, but because the organic corn fetched $4 a bushel versus $2.50 for the conventional, he didn't need to farm as many acres for the same amount of profit.

In organic dairy operations, a similar principle of reduced production and higher profits applies. When Vince Foy and Debbie Yonkers of North Danville, Vt., converted their 70 Jersey cows to organic, their

milk production decreased by 10 to 15 percent, but their gross income increased from $125,000 to $165,000. Moreover, they cut their debt-to-cow ratio in half.

In fact, said Lisa McCrory, dairy technical assistance coordinator for the Northeast Organic Farming Association of Vermont (NOFA-VT), "organic dairy producers almost always reduce their production numbers, due to management changes such as feeding the animals less grain." And even though the price of organic grain is higher, other costs such as veterinary bills, fertilizer and labor decrease, improving net income.

A statewide study conducted in Vermont by the Northeast Organic Dairy Producers Alliance showed that although milk production was lower in the organic systems, the organic producers received an average net return of $477 per cow per year compared to the conventional average of $255 per cow.

"Looking beyond production and making decisions based on profitability and the bottom line makes good business sense," McCrory said.

While more research is needed on the economics of transition, the long-term economic viability of established organic systems is quite positive. A 1999 Wallace Institute review of six midwestern land-grant university studies found:

Organic grain and soybean production systems are "competitive with conventional production systems." In fact, with current market premiums, producers of organic grain and soybeans earn higher profits than conventional growers.

Without a price premium for organic crops, half of organic systems were still more profitable than the conventional systems. Those systems less profitable than conventional quickly surpassed the conventional systems when organic premiums were figured in, Brinton W, et al. (2004).

In cases where organic systems were more profitable without price premiums, it was generally due to lower production costs, higher net returns due to the types of crops in the organic systems, and better performance of the organic systems under drought conditions or in drier areas.

Production costs tend to be lower in established organic systems because of reduced input costs.

One exception to this, perhaps, is labor. Organic farming systems are often more labor intensive because of increased time spent managing weeds and monitoring pests. Labor costs, however, can be measured in different ways.

"If a farmer views his/her time spent on the farm in terms of its opportunity costs, e.g., what he or she could be earning off the farm, labor costs for organic farming are higher than conventional," said Jim Hanson, extension economist in the Department of Agricultural and Resource Economics at the University of Maryland. "However," he added, "for those farmers who don't view off-farm income as an alternative source of income the labor costs between the two systems are similar." Martin, H. (2018).

In a forthcoming study to be published by Hanson, he found that family labor was about 30 to 40 percent higher in an organic mid-Atlantic grain operation than in a conventional one, but hired costs were equivalent between the two systems.

Production costs also vary by region, climate and production system. For example in humid areas, pest and weed control measures can raise costs.

A recent study in a corn-soybean system in Iowa found costs of conventional production were only slightly higher than organic. The organic farms had lower fertilizer and pesticide costs, but higher seed and machinery costs.

However, in a Sustainable Agriculture Research and Education (SARE), SARE-funded project that compared organic and conventional apple production across California, Sean Swezy, formerly a researcher at the University of California and now director of UC-SAREP, found production costs of organic apples 10 to 25 percent higher than conventional ones in the coastal fresh market systems due to labor and material costs. However, statewide, the organic systems were determined to be commercially profitable.

Finally, in a SARE-funded potato study in Idaho comparing 18 conventional and organic farms, the average material costs were lower in the organic and the labor costs higher, but overall there was no significant difference in fixed and variable costs, SARE, Conference/ presentation materials (2014)

Organic livestock systems often cost less, thus can be a viable option for beginning farmers or those who have trouble raising capital, because those systems do not require elaborate or expensive housing. Poultry, for example, can be raised on pasture using inexpensive, easy-to-build structures.

As with any successful business, good management is essential. "I've discouraged some farmers from going organic if they were already struggling with their conventional farm and not ready to embrace the mind shift involved in transitioning to organic," said Brad Brummond, the extension agent from North Dakota who specializes in organic production. "Conversion is a learning process, not a fix for a failing conventional farm."

SUMMARY AND CONCLUSION

Africa has the largest restoration opportunity of restoration of the degraded lands which is more than 700million hectares into arable organic farming. It can also make agriculture more sustainable through improved soil health, restoring its fertility by growing cover crops and green manure. Also as defined by (FAO, 2001) that, organic agriculture is "A holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system"

Generally, also, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. But, naturally occurring pesticides such as pyrethrin and rotenone are permitted, while synthetic fertilizers and pesticides are generally prohibited; even though, some synthetic substances such as copper sulfate and elemental sulfur are allowed. In a broad sense, modified organisms, nanomaterials, human sewage sludge, plant growth regulators, hormones, and antibiotic used in livestock management are prohibited. Organic farming is advocated now due to its sustainability openness. Cost - effectiveness, self-sufficiency, autonomy/independence, health, food security, food safety and protection for the extinction of some valuable vegetables and food crops by the application of chemicals/herbicides and some synthetic fertilizers to the soil. It also responds to site specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promotes ecological balance, conserves soil biodiversity and maintain long - term soil health. It is a small but powerful step towards constructing the framework for healthy, highly nutrient – inclusive, efficient and sustainable food production systems in the 21st century especially in Africa.

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