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Rival Assessment of Organic and Conventional Agriculture Based on Farmers' Perspectives and Preferential Choices - A Review

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***Abstract* — Scientific literatures on organic and conventional agricultural systems are mostly two sided; wholly supporting one system while disregarding the other and vice versa with a few open-minded comparisons between the two. Clear similarities and differences exist in both and should not be ignored at rival assessment of their potentials especially when making general recommendations for farmers. Choosing wholly between or combining the two systems has to base on farmers' different preferential choices which, in reality, is more complicated but promising than some literatures present. In this review, it is argued that the choice of choosing between both systems depends on the individual farmer's fondness. High yields, depending on several factors; genetic, environmental and selected management practices are attainable in both systems. Herein, the assessment on yield, managerial skills, nutrient content of produce, environmental effects and sustainability reveals choosing between both systems can depend on individual farmers' preferences.**

***Keywords* — Preferential Farming Choice, Farmers Choice of Practice, Organic vs Conventional Farming, Agricultural Systems**

I. Introduction

The consistent rise in world's population has always posed several questions of how to meet future food supply (Tilman et al., 2002) considering the inevitable roles of food to sustaining human lives. With the world's estimated population increase of between nine and eleven billion in 2050 (Cohen, 2003), more areas of agricultural land being grabbed for non-agricultural purposes such as building, recreation and waste disposal (McRae and Burnham, 1981), increasing poor soil fertility arising naturally due to soil type (Herrmann et al., 1994), artificially due overuse of soil followed by poor management practices (Masse et al., 2011) especially in Africa and some parts of Europe and South America coupled with the possible threats of global warming to soil fertility status (Kirschbaum, 1995), meeting the estimated world's food supply in future needs special attention. Previous decade assessments revealed almost one third of the world's agricultural land has been abandoned due to erosion and degradation (Kendall and Pimentel, 1994; Pimentel and Giampietro, 1994). The question of efficient agricultural systems that will ensure adequate food supply in lesser land area while posing minimal or no negative effects on the environment has been a debating topic between organic and conventional systems (Drinkwater, 1995; Eltun et al., 2002; Gabriel et al., 2006; Halberg et al., 1995; Marinari et al., 2006; Pimentel et al., 2005;). All foods are produced through agricultural practices; crop and animal productions. Most agricultural practices are either organic, conventional or combination of both in different scales; large, medium or small. Farmers often choose production systems due to economic (Bruckmeier et al., 1994; Svensson, 1991 in Fairweather, 1999), environmental (Dubgaard and Sorensen, 1988; Svensson, 1991), nutritional (Svensson, 1991) and other preferential ideologies (Wilier and Gillmour, 1992). Nonetheless, there are no restrictions on what system of production to choose from (Fairweather, 1999).

According to the definition given by the IFOAM in September 2005, organic agriculture is a production system that sustains the health of soils, ecosystems and people. It subsequently relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. This is in agreement with the definition given by FAO/WHO Codex Alimentarius Commission, 1999 as the entirety of production management system that supports and improves the health of agro-ecosystem; biodiversity, biological cycles, and soil biological activity. Fertilizers of organic origin including green manure from crop residues and weeds, composted animal dung, and bone meal (as calcium source), and cropping systems such as crop rotation and intercropping to organically add nitrogen to the soil, are its typical practices (Dakora and Keya, 1997). Conventional agriculture, also known as non-organic agriculture, is contrary to organic agriculture in practice. It, thus, involves the use of synthetic chemicals; significant amount of chemical fertilizers, pesticides, other external chemicals, and high energy input to maintain nutrient supply to plants, control pests and diseases and supply other necessities for optimum crop and animal production. Therefore, external inputs to replenish and meet the demands of optimum yields are applicable where necessary as a typical practice. This clearly indicates both organic and conventional practices significantly differ with regards to inputs sources; openly external (conventional) and strictly internal (organic). It has always been debated if organic agriculture can meet the world's food demand (De Ponti et al., 2012) considering the future estimated population increase. Some literatures argue both organic and conventional practices with regards to yields (Eltun et al., 2002; Halberg, et al. 1995; Pimentel et al., 2005; Stanhill, 1990), rapid technological innovation (Dalgaard et al., 2001; Pimentel et al., 2005; Seufert et al, 2012), fertility (Eltun et al., 2002; Kirchmann et al., 2009; Palm et al., 1997, Pimentel et al., 2005), external energy inputs (Dalgaard et al., 2001), environmental effects

(Eltun et al., 2002; Gabriel et al., 2006; Pimentel et al., 2005), nutrient contents of produce (Warman and Havard, 1997; Warman and Havard 1998; Worthington, 2001) and management skills (Pang and Letey, 2000). Similarities and differences exist between the two systems; organic agriculture causes less leaching of nutrients (Drinkwater et al., 1995), less expensive to practice (Personal observation), higher sustainability (Palm et al., 1997), higher carbon storage (Drinkwater et al., 1995), lesser erosion impact (Reganold et al., 1987), lesser groundwater contamination (Kreuger et al., 1999; Mäder et al., 2002), and improved soil biodiversity effects (Bengtsson et al., 2005; Mäder et al., 2002). Conventional agriculture has better weed management (Chiverton and Sotherton, 1991), pest management (Winston, 1999), increased yield (Warman, 2005), less nutrient management skills demands and large scale production encouragement (Oral communication). These indicate both practices can be advantageous when properly harnessed.

However, if the question of which practice between organic and conventional farming is better, should be properly addressed, "none or both" will suit in best, as each practice depends on farmers' preferences. The management practices and the yield result based on these preferences may look different than what many scientific scholars expect. In this review, it is argued that the choice of choosing between both systems depend on the individual choices. High yields, depending on the selected management practices, are attainable in both systems, and bothcan be practiced in both developing and already developed countries of the world.

II. Fertility and Yield Assessment Effects

Like the saying goes, "plants give back what is given them" indicating that yield depends on soil fertility. The fertility of agricultural soils can only be maintained over a long period if the already used plant nutrients are replaced with equivalent amounts. Badgley et al. (2007) reported organic agriculture to have the potential of meeting the global food supply after comparing the yields of over 290 global datasets through a yield ratio of organic to non-organic for both already developed and developing countries. Improvements in food production through intensified single component farm system, addition of a modern productive element to the farm, efficiency in water and land use that subsequently leads to increased cropping intensity, enhanced per hectare yields of staples through the newly introduced regenerative elements into farm systems and enhanced biodiversity; new locally suitable crop varieties and animal breeds have been reported in organic practice (Pretty et al., 2003). Additionally, overall increased water use efficiency, better soil health and fertility, and pest control with minimal or zero-pesticide use which ensures food security were reported in organic agriculture, thus, a system with higher yield potential. High nutrient indicating factors such as cation exchange capacity, carbon, nitrogen and extractable phosphorus, calcium, magnesium, manganese, zinc and boron have be-en observed in soils with compost (as organic practice) compared to inorganically fertilized plots at the twelfth year of production (Warman, 2005). Stanhill (1990) reported higher yields of organic produce than conventional systems with organic practice being resistant to year-to-year variability in yield, climatic change and conversion effects after comparing over 200 (both crop and animal production) yields of organic and conventional farming systems. According to Poudel et al. (2002), organic system has greater aboveground weed biomass at harvest compared to conventional system. But these results are not fixed and the conditions under which they were obtained are heterogeneous, thus, contrasting results have been observed in similar conditions. Assessment of relative value of crop output, net returns, energy intensiveness, and labour requirements in organic farming requires more intensive research work (Klepper et al., 1977). Through meta-dataset analysis of over 360 published organic–conventional comparative crop yields, De Ponti et al. (2012) reported that organic yields of individual crops are on average of 80% to conventional. Kitchen et al. (2003) reported biomass and grain production of wheat in organic farming systems to produce significantly less biomass than the conventional farming systems at late tilling in both the moderate and marginal rainfall areas. Though grain yield was variable, it was also significantly lower in the organic farming system for 11 of the 14 comparisons. Crop yields have been observed to be 20 percent lower in the organic systems, compared to conventional systems (Mäder et al., 2002). Contradictory observations in nitrogen use efficiency between conventional and organic agriculture exists. For instance, Torstens son et al. (2006) reported better nitrogen use efficiency from inorganic fertilizers than in green manures as organic fertilizers in combination with cover crops. A twelfth year comparison between compost and inorganic manuring effect on the fresh weight yields showed that the compost treatment non-significantly yielded higher quantities of carrots, peppers, onions and tomatoes, and significantly higher yields for green- and yellow-beans. However, on same plot and same production season, cauliflower and Brussels sprouts yields were higher in the inorganic manure plots (Warman, 2005); indicating different crops perform differently under same fertility condition. In some practices, the yield reduction experienced with integrated and ecological cropping system, relative to conventional cropping, is often smaller for forage crops and potatoes than for cereals (Eltun et al., 2002).

The naturalness of nutrient sources is no guarantee of superior quality and that promotion of organic principles does not improve the supply and recycling of nutrients but excludes other more effective solutions for nutrient use in agricultural systems (Kirchmann et al., 2009). For instance, organic practice leads to nitrogen deficiency in high nitrogen demanding crops which might lead to leaching due to the carryover of un-mineralized organic manure and accumulation of mineralized nitrogen after crop uptake if supplied in excess to meet the crop demands (Pang and Letey, 2000); this takes over two years to cover the yield differences due to nitrogen limiting after. Average crop yields assessment over a twelve-year period in four agricultural management systems viz. corn, soybean, and winter wheat 3-yr rotation under conventional, no-till, low-input, and organic management in four times rotation revealed yields in the organic system were significantly lower in the corn and winter wheat phases of the rotation compared to the other three management systems (Smith et al., 2007). Long term adequate application of inorganic fertilizer maintains the levels of soil pH, total nitrogen, organic carbon, cation exchange capacity and exchangeable calcium but decreased carbon to nitrogen ratio, cation exchange capacity and exchangeable magnesium values ofthe soil (Singh and Balasubramanian, 1979), thus, good indicators for soil fertility. Nitrogen turnover and its efficiency was assessed in sixteen conventional and fourteen organic private farms with mixed animal and crop production and significant differences in nitrogen surplus at the farm level of 242 kg N/ha conventional compared to 124 kg N/ha of organic dairy farms respectively with a strong dependent on stocking rate were observed Halberg, et al. (1995). A demonstration has revealed that yield and soil fertility are superior in conventional cropping systems under cold-temperate conditions in an eighteen-year old trial under poor nutrients condition due to lack of nitrogen, yield-limiting in organically grown crops were recorded (Kirchmann et al., 2007). It is possible to consistently achieve higher yield with a fewer external inputs through intensification system in rice production. For instance, Uphoff (2003) achieved about two times double the world's average yield without any external inputs; a pure organic system. Palm et al. (1997) reported combining both organic and inorganic fertilizers have advantages; increased nutrient recovery was recorded in the combined nutrient source compared with inorganic fertilization alone. According to Drinkwater et al. (1995), it is nearly impossible to distinguish between the fruit yield and arthropod pest damage levels of organically and conventionally managed production practices. Warman and Havard (1997) reported no differences in the analysis of a 3-year old yield of the carrots and cabbages produced organically and conventionally. Badgley et al. (2007) evaluated the amount of nitrogen provided via fixation by leguminous cover crops often used as fertilizer in organic farming in both temperate and tropical agro-ecosystems and found these legumes to be efficient at fixing similar nitrogen amount compared to the synthetic fertilizer used in non-organic farming. Under good management, low-input organic cropping systems can be as productive per unit of land as conventional systems (Posner et al., 2008). Warman and Havard (1998) observed the analysis of the three years of data to show that the yield of the potatoes was not affected by treatments. Clark et al. (1999) observed that organic and low-input systems in tomato production can produce yields similar to conventional systems if the yields limiting factors such as weed and nitrogen dynamics which are difficult to manage and put under control are under adequate control. It has been demonstrated that the long-term use of compost can produce similar yields for most crops such as carrots, peppers, onions, tomatoes, cauliflower and Brussels sprouts in compost-amended and conventionally-fertilized soils (Warman, 2005). No significant differences were observed in the corn yield between organic rotation and conventional monoculture practice (Poudel et al., 2002).

Therefore, nutrient use efficiency resulting from good soil fertility management can subsequently increase similar yields, higher or lower yield in both organic and conventional agriculture depending on the type of crop produced. This assessment reveals soil fertility can be adequately improved in both organic and conventional practices depending on wide range of management and environmental factors. Higher yields are likewise achievable, thus, farmers can adhere to any practice of their choice depending on the different preferences.

III. Management Skills Demand

Like the good old saying goes "good management, good yield, and subsequent bumper harvest" (anonymous). Under good management practices; crop types and growing conditions, the yields of organic systems can be compared to conventional yields. But making organic agriculture sustainable food production system requires fully understanding the factors that limit yields (Seufert et al., 2012). Management skills play a vital role in the final yield of produce irrespective of organic and conventional system. Herein, management skills entail to what practices were observed, how and when they were observed; the technical knowhow. Changing from conventional to organic system is always followed by a yield loss depending on climatic conditions and edaphic (soil) factors. Differences in the swapping time might reduce yield in the beginning till a usual yield is attained. Based on collected data from Danish organic and conventional mixed dairy farms, Halberg and Sillebak (1997) reported the yield difference estimate of 21–37 percent in grain crops and 12–18 percent in fodder beets and grass/clover. In organic production systems, longer rotation management practices from four years up with more diverse crops was observed to reduce seed bank populations and abundance of important annual broadleaf weed species (Teasdale et al. 2004). A tree legume such as *Sesbaniasesban* in a single year through leaf pruning, can add significant amount of nutrients (N, P, K, Ca, and Mg) per hectare; which subsequently ensures sustainability in agro-forestry and alley cropping systems, and can boost cereal crop production (Dakora and Keya, 1997). About 20% production inefficiency in organic farming was observed from poor management practices in crop production (De Ponti et al., 2012); most of poor yield effects arise from poor management practices (Pimentel et al., 2005). The presence of weed that results to competition accounts for lower crop yields in the organic and low-input systems over some years as observed by Clark et al. (1999) due to poor management practice. It was suggested that developing cost-effective fertility and weed management alternatives can improve nitrogen dynamics and weed management, indicating the potentials

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of the right management practices. Liebhardt et al. (1989) reported 25% less corn grain yields in organic systems compared to conventional in the first four years of a five years comparison trial, and similar yield on the fifth year. Another report has it that weed competition and insufficient nitrogen were the yield limiting factors in organic corn yields during the first fourth year; improved practices increase yield. From the fourth year after establishment of organic practices in a previously conventional managed land, inputs of carbon, phosphorus, potassium, calcium and magnesium were higher in the organic and low-input systems resulting from manure applications and cover crop incorporations. This finding indicates that, through good management skills, organic and low-input farming result in important increases in soil organic carbon and larger pools of stored important nutrients that are influential for long-term fertility maintenance (Clark et al., 1998). Crop rotation involving legume and cereal monocultures is significantly more sustainable than intercropping; the most dominant cultural practice in the continent (Dakora and Keya 1997), thus, biological nitrogen fixation can be constrained by several factors such as environmental, nutritional and cropping systems. As a result of complex interactions between several factors; system components and fertility management skills, organic farming demands a long-term integrated approach to achieve production efficiency rather than the more short-term practices commonly practiced in conventional agriculture (Watson et al., 2002); a discouraging factor in choosing organic practice, perhaps. Smith and Gross (2006) observed higher biomass and annual variability of weed in the organic system compared to conventional system. More knowledge and skill on the part of farmers and initially more labour per hectare are required, coupled with labour intensity remuneration by achieving higher returns for labour (Uphoff, 2003); labour saving. Easier practice for one farmer might be a harder one for another farmer and vice versa. For instance, Stanhill (1990) reported more difficulties in organic agriculture compared to the conventional. A farmer who uses machines and external inputs on a commercial production base can easily get all work done by these machines – an easier practice. Therefore, a farmer can choose between the two practices depending on management skills – a preferential choice.

IV. Nutrient Contents of Produce

Comparison between organic and conventional foods revealed, there is no evidence organic and conventional foods differ in nutrient contents except nitrate content. Warman and Havard (1998) observed there was no difference between treatments in the vitamin C or E contents of the corn kernels, same was observed in the analysis of the three years data on potatoes for vitamin C content. Warman and Havard (1997) reported no differences in the analysis of a 3-year old vitamin content of the carrots and cabbages produced organically and conventionally. Some reports have it that organic and conventional fruits and vegetables may inconsistently differ in terms of sensory qualities (Bourn and Prescott, 2002). On the contrary, some findings strictly insist the produce of one type of practice is better in one system than the other. For instance, organic vegetables and fruits were reported to contain more minerals, vitamins, proteins and carbohydrates than conventional vegetables, and can possibly benefit human health compared to conventional produce (Brandt and Mølgaard, 2001). Comparisons of analyses of archived samples from conventional and organic production systems demonstrated statistically higher levels ($P < 0.05$) of quercetin and kaempferolaglycones in organic tomatoes. Additionally, ten-year mean levels of quercetin and kaempferol in organic tomatoes [115.5 and 63.3 mg g-1 of dry matter (DM)] were 79 and 97% higher than those in conventional tomatoes (64.6 and 32.06 mg g-1 of DM), respectively, with the levels of flavonoids increased over time in samples from organic treatments, whereas the levels of flavonoids did not vary significantly in conventional treatments (Mitchell et al., 2007). Worthington (2001) observed differences in the nutrient content of organic and conventional crops. Thus, he reported that organic crops contained more vitamin C, iron, magnesium, and phosphorus amount and less nitrates amount than conventional crops. He added that there is better quality and a higher content of nutritionally significant minerals with lower amounts of some heavy metals in organic crops compared to conventional ones. Leclerc et al. (1991) observed the β-carotene and vitamin B1 content to be higher in carrots and the dry matter and vitamin C in the celeriac grown with organic fertilizer compared to conventional, with a decreased level of nitrate in the celeriac. However, most of these reports have non-homogenous assessment methodology for these crops, thus, rendering the findings less standard. Some reports have it that experiment, alone, may or may not affect the quality and the nutritional value of produce; the nutritional contents and qualities of crops can be affected by several factors such as Genetics; plant crop and cultivar (Asenjo, 1962), environmental; soil type, soil structure, manure application method, manure type, light, temperature, precipitation, management practices, inputs (Asenjo, 1962; Hornick, 1992; Rendig, 1984; Somers and Beeson 1948) and post-harvest practices; maturation time, processing, storage facilities and transportation means (Asenjo, 1962; Hornick, 1992; Salunkhe and Desai 1988; Somers and Beeson 1948). Since these factors were never put into consideration in investigations where differences were reported, it is still unclear to make strong conclusions that these differences emanated from either organic or conventional practice.

V. Environmental Impacts and Sustainability

Different techniques of organic farming have been in use as far back as 6000 years with a major objective of sustaining food production while conserving soil, water, energy, and biological resources. Higher soil organic matter, higher soil nitrogen content, lower fossil energy inputs, comparable yields to conventional systems, conservation of soil moisture and water resources under drought conditions have been reported (Pimentel et al., 2005). Sustainable intensification was reported to reduce the need for irrigation water by about half and diminished the requirements for capital and seed (Uphoff, 2003). According to Drinkwater et al. (1995), nitrogen mineralization potential, microbial, parasitoid abundance, and diversity were observed to be higher in organically managed farms than in conventional farms. Organic methods consume less fossil energy and cause less soil erosion compared to conventional farming (Lockeretz et al., 1981), and have positive effects on biodiversity; species richness and abundance (Bengtsson et al., 2005). Integrated farming results in the least environmental harm and seems more profitable (Eltun et al., 2002). Drinkwater et al. (1998) reported organic residues to maintain soil fertility, which subsequently ensures diversity in cropping sequences which further increased soil carbon and nitrogen, sustained production, and environmental quality. Biodiversity assessment by Gabriel et al. (2006) has shown that organic farming makes the greatest contribution to total species richness at both inter fields and inter regions scale due to environmental heterogeneity. Farmers can grow a variety of plants together to promote biodiversity diversification and ward off pests and pathogens (Altieri and Nicholls, 2012). According to Poudel et al. (2002), organic system has advantage of lower potential risk of nitrogen leaching from lower nitrogen mineralization rates which subsequently improves agricultural sustainability and environmental quality while maintaining similar crop yields compared to conventional. Pang and Letey (2000) reported; to meet the nitrogen demand of high nitrogen crops through organic supply, excessive nitrogen supply, which is challenging and could lead to leaching, will be ensured – a huge environmental risk factor. Nitrogen loss of over 200kg per hectare per annum under integrated production system, due to nutrient mismanagement, has been reported (Granstedt, 1995). Intensive production systems with high external inputs poses adverse effects on the environment due to losses of nutrients from fertilizers and manures to water bodies and uncontrolled release of gases to climate change (Gregory et al., 2002). The application of herbicides in conventional farming systems will, by their nature, decrease weed abundances, and subsequently cause deleterious effects on insects and birds, depending on these plant species (Chiverton and Sotherton, 1991). Similarly, the use of pesticides will not only decrease pest insects but also the predators that feed upon them (Winston, 1999). Insecticides have been reported reduce the diversity and biomass of predatory insects (Relyea, 2005). No doubts, these effects are disadvantageous to the environment due to their cause of loss in varieties, which arise from intensification. Mulder et al. (2003) confirmed functional diversity decreases with increasing management intensity. Similarly, the use of pesticides will not only decrease pest insects but also the predators that feed upon them (Winston, 1999). However, intensive production; mostly seen in conventional practice, results into nutrient run-off and can be managed through a good cropping system such as mixed farming with less cropping intensity (Eltun et al., 2002). Conventional agriculture is not a sustainable practice, but can be made sustainable and ecologically sound by through supplementing some traditional organic farming techniques (Pimentel et al., 2005). However, some scientific findings have it that nutrient leaching between conventional and organic farming does not significantly differ (see Aronsson et al., 2007), albeit organic farming reduces leaching by up to 30%. Crop rotation; a management practice than can be observed in both organic and conventional systems, involving legume and cereal monocultures is significantly more sustainable than intercropping; the most dominant cultural practice in the continent (Dakora and Keya, 1997). Though organic farming has less chances of adversely affecting the environment, conventional practice can still be managed in an environmental friendly way to reduce nutrient leaching (Aronsson et al., 2007).

VI. Summary and Conclusions

Meeting the world's food demand in future based on the exponential population increment without threatening the environment and human health is possible and can be achieved through both organic agriculture and lenient conventional agriculture. To answer the question properly, one has to consider the benefits between organic or conventional practice hence human health and the environment is not at risk while optimum food production is ensured. The similarities and differences between organic and conventional agriculture, specifically on crop production, is somewhat explored herein, whereas the farmers option to choose between the practices is preferential. This assessment reveals apart from environmental impacts and sustainability, the options of choosing between organic and conventional agriculture can be co-weighed in terms of fertility management, yield assessment, management skills and nutrient contents of the produce. With less doubts, the greatest factor of choosing between the two practices is "farmers' preferences". Further assessments based on direct information obtained from the farmers should be carried out to reveal how these farmers (not the scientific scholars), see both production systems.

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