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Food Quality: Comparison of Organically and Conventionally Foodstuffs under Different Nutrient Management in Agricultural Systems

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Abstract

The purpose of this review paper is to understand how information revealed on organic foodstuffs are influenced by conventionally and organically nutrient management and perceived organic knowledge drive consumer trust and attitudes towards organic foodstuffs in different agricultural systems. Currently, there is uncertainty about the degree of difference in nutrient composition between conventionally and organically produced foodstuffs. Organic foodstuffs are those that are produced according to specified standards, which, among other things, control the use of chemicals and medicines in crop and animal production, and emphasize protection of the environment. Recently published non-systematic reviews comparing nutrient composition of organically and conventionally produced foods have come to contrasting conclusions. Some have reported that organically produced foodstuffs have higher nutrient content than conventionally produced foodstuffs, while other reviews have concluded that there were no consistent differences in nutrient content between production methods. This review study incorporates critical factors based on related theories and study, including the growing methods either by conventionally or organically and the consumer trust to develop a more comprehensive model for better understanding of consumer organic choice behavior. The reviewed research findings have provided implications and additional contributions to the existing theories for the development of the organic foodstuffs for better quality in agricultural systems.

Keywords: Food quality; Organic farming; Conventional farming; Nutrient management; Consumer choice.

Introduction

Food quality itself is very difficult to define as it depends, to a certain extent, on one's personal tastes and priorities. During last decades the consumer trust in food quality has drastically decreased, mainly because of the growing ecological awareness and several food scandals like Bovine Spongiform Encephalopathy **(BSE)**, dioxins and bacterial contamination. It has been found that intensive conventional agriculture could introduce contaminants into food chain, first of all nitrates and nitrosamines, residues of pesticides, antibiotics and growth hormones. Consumers started to look for safer and better controlled foods, produced in more environmentally friendly, authentic and local system. The prime requisite is the promotion of health of the soil-plant-environment system to be free from economic exploitation under overuse and abuse of the input as if with impunity [1].

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Organically produced foods are widely believed to satisfy the above demands, providing better environment and higher nutritive values. Several research studies conducted in many European countries have partly confirmed this opinion. Organic crops contain fewer nitrates and nitrites and fewer residues of pesticides than conventional ones. They contain as a rule more dry matter, more vitamin C and B-group vitamins, more phenolic compounds, more exogenous indispensable amino acids and more total sugars; however the level of β carotene is often higher in conventional plant products. Organic crops contain statistically more iron, magnesium and phosphorus, and they have usually better sensory quality. Vegetables, potatoes and fruits from organic production show better storage quality during winter keeping. Farm animals from organic herds show less metabolic diseases like ketosis, lipidosis, arthritis, mastitis and milk fever. Small experimental mammals (rats, rabbits) fed organically grown feed show better health and fertility parameters. However, there are also some negatives: plants cultivated in organic system have as a rule 20 % lower yield than conventionally produced crops. Milk and meat yield is also lower in organic animal production, partly because parasitic afflictions are more frequent.

Several important problems need to be investigated and settled in coming years: environmental contamination of the organic crops (heavy metals, polychlorinated biphenyls **(PCBs),** dioxins, and aromatic hydrocarbons), bacterial and fungi contamination (Salmonella, Campylobacter, mycotoxins). Last but not least, the impact of the organic food consumption on human health and well being still remains unknown and needs explanation. Hence, with intensification of cropping and use of chemical fertilizers, the supplementary and complementary roles of organic materials are being strongly felt for retaining soil productivity [2], and improving crop yield with better food quality.

Among the various factors responsible for high productivity and quality of crops, fertilizer management is considered to be an important one. Nutritional status is an important factor in quality at harvest and post harvest life of crops. Fertilizer application schedule vary widely among growers which depends upon soil type, cropping history and soil test results. Deficiencies, excesses or imbalances of various nutrients are known to result in disorders that can limit the quality of the crops. To date, fertilization recommendations for fruits and vegetables have been established primarily for productivity goals, not as diagnostics for good flavor quality and optimal postharvest life. Keeping these points in view, literature has been surveyed and the review has been grouped as follows.

Application of organic and inorganic fertilizer on crop yield and crop quality

Response of different crops to application of organic and inorganic fertilizer

Growth and yields of crops grown in organic and conventional production systems can be equivalent. During the ‘‘organic transition’’ period, defined under US national organic standards as the first 3 years after switching from conventional to organic management, crop yields are often reportedly lower than in conventional systems [3]. Yields may eventually increase [4], but the expectation of initially lower yields can be ‘‘a strong deterrent to those farmers who may wish to make such a change [3]’’. However, the vegetable fields under organic production in California produced yields equal to those under conventional production [5,6].

Tomatoes require nutrient elements such as N, P, K, Mg, Ca, Na and S for good production. These nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity [7]. The use of organic manure, e.g. poultry dropping and ruminant dung has improved agricultural productivity in West African countries. Organic manure helps to improve the physical condition of soil and provides the required plant nutrients. Organic manure also enhances cation exchange capacity and acts as a buffering agent against undesirable soil pH fluctuations. Numerous reports [3,8] recommend 9-18 tons/acre of manure for good tomato yield. Application of broiler litter at the rate of 15 ton/ha, N at 40 kg/ha, P at 30 kg/ha and K at 30 kg/ha gave higher growth and fruit yield [9]. Tomato can also be supplied with a combination of compost and mineral N fertilizers to improve fruit yield [10].

A study on conventional and alternative farming systems for tomatoes [11] over 4 years indicate that organic and low-input agriculture produce yields comparable to conventional systems. Nitrogen availability was the most important factor limiting yield in organic systems, and can be satisfied by biological inputs.

Long-term research in Pennsylvania has also demonstrated little difference in yields between conventional and organic production systems [12]. It was reported that yields were higher in fields under organic production than conventional production in the second year in Tomato-sweet corn cropping system [13]. Conventional maize–tomato plots, however, had significantly lower yield than the organic and transitional plots [14]. It was reported that organically grown tomato crops can achieve similar marketable yields compared to conventionally produced crops [15]. In prior research, Kahu et al., 2009 reported that yields from organic cultivation were significantly higher than those of control plot.

The adoption of the new practices brought, however, the need for comparison between low-input against conventional systems. In addition, recovering the principles and mechanisms that operate in the nature to be utilized as replacement for the traditional input, will only be achieved if a broad base of knowledge of the complex relationships between organisms and their relationship with the environment is available [16,17]. To that effect, interdisciplinary studies are needed to verify whether or not the sustainability of the agroecosystems can be achieved. Although the development of ecologically sound agriculture systems is rapidly emerging as a priority, few research papers have detailed the effects and interactions of the new proposed practices.

Tomato cropping is an excellent model for comparisons between the conventional and the organic systems for reasons like the intense use of agricultural input and the risk of contamination of consumers, farmers and ground water by agrochemicals [5]. In an interdisciplinary study, Drinkwater et al., 1995, evaluated several agronomical and ecological indicators in the organic and conventional tomato cropping systems in California **(USA)**, and concluded that biotic agents are essential to make up for the absence of synthetic input. However, the involved mechanisms are much more complex than a mere replacement. For example, soil fertility management practices affected C and N dynamics and, as a consequence, also affected pathogen-host relationships and plant-herbivores interactions through community level mechanisms.

Creamer et al. (1996) compared in two locations the conventional, integrated, organic and no-input systems tomato cropping systems; the last three systems were associated to a cover crop. The number of fruits and flower clusters were higher in the conventional system during the initial assessments, becoming equivalent to the other systems later. No differences were observed with regard to the occurrence of pests and diseases among the treatments. In one of the regions, there was greater accumulation of plant dry matter and higher tomato yield in the conventional system than in other treatments, which represented greater economic gain. In the other region, however, no differences were observed among the systems. The differences between regions were associated with soil type and climate and, demonstrated the need for more studies to be carried out under different conditions.

Vermicompost into either peat–perlite or coir–perlite mixtures also improved plant growth significantly compared to that in an unamended medium. Even when tomato plants were fertilized with mineral nutrients, their growth in different potting mixtures was less than in vermicompost amended soil, suggesting that factors other than nutrient availability were responsible for growth. Vermicompost applied to tomatoes cultivated in the field also increased yields [18]. Nutrient management plays a key role in improving crop yield with maintenance of soil fertility for sustainable production in intensive cropping. The treatments with optimal dose of fertilizer application i.e. chemical fertilizer, CF100, vermicompost, VC100 and VC50 + CF50 were statistically at par and they were significantly superior to suboptimal dose of VC with other organic sources, in increasing yield of both tomato and sweet corn [19,20].

In terms of overall vegetable yield, several studies have shown that organic production is comparable to conventional and low-input systems [21]. Examples include: carrots, lettuce, tomatoes [22], cabbage (Warman and Harvard, 1997), and peppers [23]. When conventional growing did come out ahead in terms of yield, organic and low-input systems had enhanced microbial biomass and activity, water-holding capacity, increased mobile humic acids, water infiltration rates, pools of phosphorous and potassium, and increased soil organic matter [24].

Use of organic manures as a means of maintaining and increasing soil fertility has been advocated [25,26]. Animal manures, when efficiently and effectively used, ensure sustainable crop productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields [27]. Manures are usually applied at higher rates, relative to inorganic fertilizers. When applied at high rates, they give residual effects on the growth and yield of succeeding crops [28]. Improvements of environmental conditions as well as the need to reduce cost of fertilizing crops are reasons for advocating use of organic materials [29]. Organic manures improve soil fertility by activating soil microbial biomass [30]. Application of manures sustains cropping system through better nutrient recycling [31]. Manures provide a source of all necessary macro- and micro-nutrients in available forms, thereby improving the physical and chemical properties of the soil [32]. The vermicompost (VC)-based treatments registered lower soil available macronutrients (N, P and K), but higher organic carbon and micronutrient (Fe, Mn, Zn and Cu) as compared to CF treatment at the end of two years cropping system. Inclusion of BF in VC-based treatment was more promising in increasing the microbial count by three fold as compared to the CF treatment. Organic fertilizer application, therefore exhibited potential in soil health in acid lateritic soil of the subtropical climate [19,20].

Soil fertility is a major overriding constraint that affects all aspects of crop production [33]. Inorganic fertilizer was advocated for crop production to ameliorate low inherent fertility of soils in the tropics. In addition to being expensive and scarce, the use of inorganic fertilizer has not been helpful in intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrient imbalance [34,35]. The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide [36]. Large quantities of organic wastes such as poultry manure are available especially in urban centers and are an effective source of nutrients for vegetables such as tomato [37]. Soil fertility status varies considerably with different ecological zones. In fact, even in the same zone, there are micro-differences in soil characteristics. The crop yield response to organic waste is highly variable and depends on the types of wastes, crop type and species, soil type and climate conditions [37].

A few studies have reported differences in soil properties between transitional and established organic systems [38,5], but it was not clear whether these differences were responsible for any yield differences. Yield data consistent with the soil-quality hypothesis have been published [4]. However, yield trends with years of organic management are not always positive (Stan hill 1990). More importantly, previous controlled and replicated tests of the soil-quality hypothesis, as opposed to uncontrolled comparisons among commercial farms, have involved comparisons among different years. Any positive trends could therefore reflect improvements in crop management, rather than improving soil quality. For example, changing to a shorter-season maize variety following a green manure crop (Liebhardt et al., 1989) or changing from direct seeding to transplanting of tomatoes [4], could be responsible for the reported yield increases during the organic transition. Organic agriculture has been described by USDA National Organic Standards Board as "an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity" [39]. It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. Organic agriculture has existed since the beginning of farming. Conventional agriculture started as a result of World War I ammunitions with the introduction of inorganic fertilizers and synthetic insecticides [21].

Organic agriculture employs a combination of the best methods of traditional agriculture and modern technology. Present- day organic growers use tried and tested practices, such as crop rotation, growing a diversity of crops, planting cover crops and green manures (Karkanis et al., 2007). At the time, most organic production systems include use of modern equipment, improved cultivars, and new technologies such as drip-irrigation [40]. In contrast to "conventional agriculture", organic farming relies on preventive rather than corrective practices.

Manure is an organic matter used as fertilizer in agriculture. Manure has proved to be very beneficial for the soil because it contains a rich and wide range of minerals and nutrients. It provides abundant amounts of the three main chemicals that plants require- N, P, and K. Importantly, it also contains many of the micro-nutrients (trace elements) [41]. The second benefit of manure is that it improves the composition of the soil. It contains both animal waste and straw (or sometimes sawdust). Data obtained by other researchers [42-44] clearly demonstrated the beneficial effects of manure on the yields of crops (cotton, sweet maize, maize, wheat).

Sweet maize is a fairly heavy feeder and soil fertility is critical for high yield (Fernandez Santos et al., 1992). The low yield in other maize varieties grown in Nigeria has been partly attributed to depletion of organic matter and soil nutrients [45]. Obi and Ebo (1994) observed that the top soils of south eastern Nigeria are predominantly very fragile and delicate and as a result suffer rapid decline in fertility after cultivation. Poultry manure (PM) is an excellent organic fertilizer as it contains both macro and micro nutrients in available forms during mineralization. In contrast to organic fertilizer, it adds organic matter to soil which improves soil structure, soil aeration, nutrient retention, soil moisture holding capacity and water infiltration [41 and 46].

The use of manure and mulching are two of the basic cultivation techniques of organic agriculture [47]. Moreover, emerging evidence indicates that integrated soil fertility management involving the judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints [48]. Combined organic/inorganic fertilization both enhanced C storage in soils, and reduced emissions from N fertilizer use, while contributing to high crop productivity in agriculture [49].

Effect of organic and conventional nutrient sources on crop quality

Crop quality is an important factor in agricultural farming system. Tomatoes have been reported to be an important source of antioxidants such as lycopene, phenolics, and vitamin C in human diet [50-53], and have been linked with reduced risk of prostate and various other forms of cancer, as well as heart diseases [54,51,55,56]. There is growing debate as to whether growing vegetables and fruit crops under organic management systems will lead to higher concentrations of lycopene and other secondary metabolites compared to growing these crops under conventional systems [57,58].

A more recent study found significantly higher levels of lycopene and other microconstituents in tomatoes grown on an organic farm versus a conventional research station when tomatoes were evaluated on a fresh matter content basis [59]. Premuzic et al. (1998) reported that the fruits of tomatoes grown on organic substrates, such as vermicompost, contained significantly more Ca and vitamin C and less Fe than those grown in hydroponics media, but no differences were found in concentrations of P and K.

Toor et al. (2006) [60] reported that mean ascorbic acid content in tomatoes grown using chicken manure and grass-clover mulch was 29% higher than in the tomatoes grown using the mineral nutrient solutions. Worthington (1998) [61] reviewed 34 studies, published over the previous 50 years, and observed that organic crops had lower nitrate levels in 61% of the studies and higher vitamin C levels in 58% of the studies. Woese et al. (1997) [57] also observed that there was strong evidence for lower concentrations of nitrate in organic vegetables and higher levels of vitamin C among organic potatoes and leafy vegetables. Vermicompost at full dose increased ascorbic acid, beta carotene, total soluble solids and color value compared with its half dose along with other organic sources (crop residue and biofertilizer). The potential exists to improve tomato fruit quality through a better nutrient management, whether it is conventional, organic or a combination of both [19-20].

Masamba and Nguyen (2008) [62] reported that significant differences were observed in Valencia oranges which showed higher vitamin C content in organic Valencia oranges as compared to conventional ones. A study on effect of cultivation practices on fruit quality and antioxidant capacity showed that blueberry fruit grown from organic culture yielded significantly higher sugars (fructose and glucose), malic acid, total phenolics, total anthocyanins, and antioxidant activity than fruit from the conventional culture [63]. Palit et al. (2008) [64] reported that organic fertilization produced higher polyphenol in tea than inorganic fertilization, which has shown greater antioxidant properties. Juroszek et al. (2009) [15] reported that there was significantly higher total phenolics and ascorbic acid content under organic management. Stracke et al. (2009) [65] reported that antioxidant capacity was higher in organically produced apples than in conventionally produced fruits. Bourn and Prescott (2002) [66] and Brandt and Molgaard (2001) [58] reported that nutritional quality of conventionally and organically produced vegetables demonstrate inconsistent differences with the exception of higher levels of ascorbic acid (vitamin C) and less nitrate in organic products. Sousa et al. (2005) [67] reported that organically grown cabbage had higher total phenolics content than conventionally managed cabbage.

In comparing the results of organic versus conventionally cultivated plant products, review papers suggest that organic fruits and vegetables often have lower protein and carotene content [68], lower pesticide residue levels, and lower nitrate content [57,69] than conventionally grown fruits and vegetables. In contrast, organically produced fruits and vegetables often contain higher concentrations of ascorbic acid [70,71] and higher contents of defense related secondary metabolites [58]. However, a recent review paper pointed out contradictory findings related to the levels of secondary metabolites in organic versus conventionally produced crops and stated that it is premature to conclude one production system is superior to the other with respect to nutritional composition [69].

On the basis of the carbon (C)-nitrogen (N) balance theory, it has been argued that organic fertilizers are not as powerful in promoting plant growth and development as mineral fertilizers; the plant thus allocates more resources to synthesizing carbon-containing compounds such as organic acids and polyphenolics rather than nitrogen-containing compounds such as protein [69]. However, well-managed organic tomato crops can be as vigorous as well-managed conventionally produced tomato crops [15]. In addition, it has been argued that by limiting or prohibiting the use of synthetic pesticides, organic production methods cause plants to devote greater resources toward the synthesis of their own chemical defense mechanisms [69] such as polyphenolics, higher levels of which have been reported for pak choi after flea beetle attacks (Young et al., 2005). However, the application of sublethal doses of synthetic herbicides can cause plant stress in conventionally produced crops as well, so one should not automatically assume that plants grown conventionally are subjected to lower levels of stress than organically grown plants [69].

Sweet maize (Zea mays L. saccharata Strut.) mostly grown in the United States, East Asia and some European countries, has become popular among the elites in African countries [73]. It is distinguished from other maize varieties by its delicious taste, high sugar content when in the milk or immature state and by its wrinkled, translucent kernels when dry. Sweet maize is usually eaten in the immature state as a fresh vegetable; boiled, steamed or roasted. When cut from the cob, it can be used in a wide variety of vegetable mixtures, soups or stew and for canning purposes. At optimum market maturity stage, sweet maize contains 5-6% sugar, 10-11% starch, 3% water soluble polysaccharides, 70% water, moderate amounts of protein, vitamins A and K [73].

Corn contains anthocyanins or carotenoids, and phenolic compounds which are phytochemicals synthesized in the plant by secondary metabolism; although these compounds are considered nonnutritive, interest in antioxidant and bioactive properties has increased due to their health benefits [74,75].

Kernel sweetness in Sweet Corn is the most important quality factor in consumer satisfaction, followed by tenderness and colour of kernels, and sweetness is closely related to sucrose, fructose, glucose and total sugar concentration [63,76,77]. Asami et al. (2003) [78] reported that ascorbic acid concentrations of organic and sustainably grown and frozen corn were 52.4 and 66.7% higher, respectively, than conventionally grown and frozen corn.

Although consumers in North America consume sweet corn because of its taste, it can be a good source of both vitamins C and E and some essential minerals. The following references deal mostly with the production of compost-amended corn, particularly field corn, with little emphasis on its food quality. In one of the few studies where plant quality was considered, Lockeretz et al. (1981) [79] discussed feed corn production as a consequence of organic or conventional crop management. These authors found that the conventionally produced corn was higher in crude protein and two amino acids; the organically grown corn was higher in lysine and four other amino acids. Between organic and mineral sources of fertilizer application, ascorbic acid and total phenolics content of sweet corm were higher in organic nutrient management. The ascorbic acid was higher by 133%inVC100 and 37%inVC50+CF50 compared to mineral (CF100) treatment [80].

Olsson et al. (2006) [81] also found that the ratio of ascorbate to dehydroascorbate was significantly higher in the organically cultivated strawberries. The extracts from organically grown strawberries had a higher antiproliferative activity for both HT29 cells and MCF-7 cells than those from the conventionally grown fruit. Thus, the organically grown strawberries might have a higher content of secondary metabolites than the conventional strawberries.

Weibel et al. (2000) [82] showed that internal fruit quality of organic apples was either similar or slightly better than that of conventional fruit. Additionally, they did not find significant differences in fruit total vitamin C content between the two production systems. Magkos et al. (2003) [83] also stated that little or no hard evidence of differences in vitamin content and no significant differences with respect to minerals could be identified. Comparable total polyphenol content and similar antigenotoxic potential were found in organically and conventionally grown apples [84]. A compilation of overall effect of organic vs. chemical nutrient management on crop quality is presented in table 1.

Table 1: Effect of organic vs. chemical nutrient management on quality of different crops.

Crop	Effect (Positive, Negative and Indifferent)	References
Tomato	Positive	[57-60]
	Indifferent	[5]
Corn	Positive	[78]
	Negative	[79]
Potato and leafy vegetables	Positive Indifferent	[57] [Srikumar and Ockerman (1990)
Cabbage	Positive	[67]
Fruits and vegetables	Positive	[70,71]
	Indifferent	[83]
Valencia oranges	Positive	[62]
Blueberry	Positive	[63,82]
Apple	Positive	[65]
Strawberries	Positive	[81]
Tea	Positive	[64]

Table 2: Comparison of polyunsaturated fatty acids contents in organic and conventional foods.

			Compounds contents			
References	**Study design**	**Compounds analyzed**	**organic**	**conventional**	**Units**	**Statistical comparison**
García-González et al. 2014	16 samples of extra virgin olive oil of 4 Spanish cultivars taken from cooperative societies.	palmitic acid, palmitoleic acid, oleic acid, linoleic acid, linolenic acid, arachidic acid.	0.28 ± 0.06	0.28 ± 0.07	Means ± SD of PUFAs in mg kg-1	No differences in PUFA content
Samman et al. 2008	59 certified organic and 53 conventional oils purchased from markets in Sydney. Edible oils considered: Coconut oil (1), Olive oil (2), Canola oil (3), Mustard seel oil (4), sesame oil (5).	palmitic acid, palmitoleic acid, oleic acid, linoleic acid, linolenic acid, arachidic acid.	(1) 2.63 ± 0.86 (2) 10.59 ± 3.26 (3) 25.73 ± 9.08 (4) 46.07 ± 0.45 (5) 48.2 ± 1.09	3.86 ± 0.46 12.09 ± 9.6 29.51 ± 0.53 28.21 ± 13.79 44.18 ± 3.8	Means ±SD % of PUFA on total fatty acids content	No differences in PUFA content
Anastasopoulos et al. 2013	Virgin olive oil (Koroneiki variety) produced in Messinia, Peloponnesus, Greece from different harvesting periods: season 2000(1) and 2004(2).	palmitic acid, palmitoleic acid,oleic acid, linoleic acid,linolenic acid,arachidic acid.	(1) 77.43 ± 1.95 (2) 79.25 ± 0.18	77.90 ± 1.40 79.05 ± 0.18	Means±SD% of PUFAs on total content	Higher PUFA content in organic olive oil
Rouphael et al. 2015	Perilla plants grown under conventional and organic farming in a typical Mediterranean area such as Southern Italy,season 2005.	palmitic acid oleic acid linoleic acid linolenic acid stearic acid	6.3 13.5 14.7 61.9 1.9	6.3 13.9 14.6 61.6 1.9	Means% of PUFAs on total content	No differences in PUFA content

Table 3: Comparison of essential amino acids contents in organic and conventional foods.

			Compounds contents			
References	**Study design**	**Compounds analyzed**	**organic**	**conventional**	**Units**	**Statistical comparison**
Rohling and Engel, 2010	Three maize cultivars grown in the season 2004 at two locations. The same procedure was repeated in the season 2005.	histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine	numeric data not reported.	numeric data not reported.	-	No differences in essential amino acids content
Mader et al. 2007	Wheat (Triticum aestivum L.) grown in a 21 year agrosystem comparison in central Europe	histidine isoleucine leucine lysine methionine phenylalanine threonine tryptophan valine	47.2 23.1 34.6 67.1 26.3 13.5 45.9 31.0 11.4 42.8	46.6 22.8 35.4 67.0 25.4 13.3 46.4 30.5 10.8 42.8	means g kg−1 total protein	No differences in essential amino acids content

Maggio et al. 2008	Tubers harvested on July, 2003. Six potatoes, collected from each plot, treated and analyzed	histidine isoleucine leucine lysine methionine phenylalanine threonine tryptophan valine	104.9 14.8 11.8 36.6 16.7 16.0 24.5 10.6 34.1	98.5 17.1 15.1 38.4 16.7 19.2 24.0 11.2 37.3	mg 100g-1 fresh Weight	Only threonine is in significant higher levels in organic tubers
Pieper and Barret, 2009	Processing tomatoes of the same cultivar (Lycopersicon esculentum var. AB2) grown and harvested in season 2006 (1)and 2007(2) from three commercial growers in California.	Phenylalanine Histidine Methionine Lysine Threonine	(2) 1.41 ± 0.27 0.56 ± 0.09 0.10 ± 0.02 0.68 ± 0.10 0.76 ± 0.15	(1) 1.81 ± 0.28 0.78 ± 0.14 0.15 ± 0.03 0.89 ± 0.17 1.15 ± 0.28	g kg−1 fresh weight	No differences in essential amino acids content

Table 4: Comparison in minerals and vitamins content in organic and conventional foods.

			Compounds contents			
References	**Study design**	**Compounds analyzed**	**organic**	**conventional**	**Units**	**Statistical comparison**
Gastol et al. 2013	66 fruit and vegetable fields (36 farms) producing organic and conventional crops	Cu, B, Fe, Mn, Zn, Ni, Pb, Cd, Ca, P, Mg, S, Na	Numeric data not shown	Numeric data not shown	-	Higher amounts in organic product
Colla et al. 2002	10 years of organic and conventional management practices on soil chemical properties, processing tomato yields and fruit mineral composition	N,P,K,Ca,Mg, Na	Numeric data not shown	Numeric data not shown	-	Organic fruit contain higher amounts of Ca and P
Laursen et al. 2011	Samples of winter wheat,spring barley, faba bean, and potato(1), obtained from field trials undertaken in 2007 and 2008 at three different Danish geographical locations.	K Mg P S Ca Fe Mn B Zn Cu Mb Sr Na	(1) 2.28 ± 0.24 0.11 ± 0.01 0.24 ± 0.03 0.16 ± 0.01 180 ± 67.4 21.0 ± 7.66 6.16 ± 1.01 4.46 ± 0.46 11.6 ± 0.77 5.30 ± 0.99 0.35 ± 0.07 0.75 ± 0.20 69.3 ± 16.0	2.08 ± 0.16 0.11 ± 0.01 0.21 ± 0.04 0.15 ± 0.01 206 ± 78.4 20.0 ± 7.57 6.19 ± 0.90 4.57 ± 0.51 10.1 ± 0.51 4.31 ± 0.78 0.21 ± 0.02 0.91 ± 0.26 48.7 ± 15.4	mg kg-1	No differences in mineral levels
Gorenjak et al. 2012	52 samples of lettuce, conventional and organic, from 15 different areas of northeast Slovenia.	Nitrate/nitrite concentration	1258 ± 1018.3	1359 ± 960.6	mg kg-1 fresh weight basis	Nitrate levels higher in conventional foods
Ismail and Fun, 2003	5 types of green vegetables grown organically and conventionally selected based on popular consumption among Malaysian market.	vitamin C	124.80	114.70	mg 100 g-1	No differences in vitamins content
[82]	Apples (Golden delicious cv) harvested of 5 pair of organic/ conventional fruit farms with similar micro climate, soil condition and planting system.	P Vitamin C	Numeric data not shown Numeric data not shown	Numeric data not shown Numeric data not shown	-	No differences in vitamin C content

Table 5: Comparison of polyphenols contents in organic and conventional foods.

			Compounds contents			
References	Study design	Compounds analyzed	organic	conventional	Units	Statistical comparison
[82]	Apples harvested of 5 pair of organicconventional fruit farms with similar micro climate, soil condition and planting system.	flavanols,cinnamon acids, phloretinglycosides, quercetinglycosides	only statistical result reported	only statistical result reported	-	Higher levels of phenolics in organic food
[63]	Organic and conventional samples of blueberry collected from 5 certified organic farms in New Jersey.	anthocyanins: delphinidin 3gal. delphinidin 3-glu. cyanidin 3-gal. delphinidin 3-ara. petunidin 3-gal. petunidin 3-glu. petunidin 3-ara. malvidin 3-gal. malvidin 3-gluc. malvidin 3-ara.	171.59 69.77 29.22 93.53 184.86 127.13 95.70 303.03 303.35 227.12	41.74 24.64 14.24 37.00 75.26 79.00 66.70 289.38 184.92 199.62	µg g-1	Higher levels of anthocyanins in organic food
Carbonaro et al. 2002	Peaches (1) and pears (2), either grown on tilled soil (of the same age, 5 years), obtained from the Istituto Sperimentale per la Frutticoltura (Ciampino, Rome).	Caffeic acid chlorogenic acid catechol α-tocopherol ɤ-tocopherol tocopherolquinone caffeic acid chlorogenic acid catechol α-tocopherol ɤ-tocopherol tocopherolquinon	(1) 2174.50 ± 198.20 2655.30 ± 171.20 - 0.57 ± 0.01 0.37 ± 0.01 1.34 ± 0.03 (2) 865.1 ± 43.8 3020.7 ± 235.4 401.4 ± 110.3 0.71 ± 0.05* 0.68 ± 0.15 2.0 ± 0.10	2451.9 ± 126.4 2053.2 ± 145.0 - 0.65 ± 0.02 0.46 ± 0.01 1.80 ± 0.27 674.2 ± 50.5 959.1 ± 100.9 557.1 ± 143.2 0.58 ± 0.03 0.68 ± 0.09 1.43 ± 0.30	PPO activity (unit min-1/100 g f.w.) µg 100 g-1 fresh weight PPO activity (unit min-1/100 g f.w.) µg 100 g-1 fresh weight	Higher levels of polyphenolics in organic peach and pear
Lombardi-Boccia et al. 2004	Yellow plums,conventio nally or organically grown in the same farm (Fruit FarmingInstitute, Rome, Italy).	caffeic acid trans-p-cumarico acid ferulic acid chlorogenic acid neo-chlorogenic acid myricetin quercetin kaempferol	22.6 ± 1.05 8.9 ± 0.32 9.3 ± 0.42 37.5 ± 2.94 46.0 ± 6.9 1.1 ± 0.1 30.2 ± 0.8 0.6 ± 0.2	20.6 ± 1.23 8.5 ± 0.34 8.0 ± 0.63 25.2 ± 1.25 52.0 ± 2.76 0.9 ± 0.2 19.6 ± 1.2 1.7 ± 0.3	mg kg-1 fresh weight	Higher polyphenols content in conventional plums
Gastol et al. 2013	66 fruit and vegetable fields (36 farms) producing organic and conventional crops.	Total polyphenols	Data not shown	Data not shown	-	No differences in polyphenols content
Valverde et al. 2015	2 varieties of broccoli grown over 2 years (1), (2) in a splitplot factorial system comparison trial.	Total phenolics total flavonoids	(1) 345.70 ± 51.30 16.60 ± 6.90	290.80 ± 3.90 10.20 ± 1.80	mg 100 g−1 fresh weight	No differences in polyphenols content
Granato et al. 2015	Purple grape juices (n = 31) produced in Europe	Total phenolics	826.60 ± 382.99	714.42±244.63	mg of chlorogenic acid equivalents per liter of juice	No differences in polyphenols content

Conclusion

Sustainable development in agriculture and yield improvement of crops can be achieved through restoration and scientific management of land productivity. For yield maximization in intensive cropping, supply of appropriate source and amount of nutrients is indispensable. In conventional practice, improved cropping system involving high value crops rely on the use of chemical fertilizer due to its immediate availability of nutrients. Indiscriminate and continuous use of such chemical fertilizers leads to instability in yield and also poses a threat to soil health particularly due to micronutrients deficiency and fertilizer related environment pollution. Moreover, the produce so developed may raise a question about its quality and acceptability in market. For restoration of soil fertility and stability in crop yield and quality, organic farming practice can be an option.

Organic enrichment of soil is most common through the application of composted materials, microbial biofertilizer or recycling of crop wastes. Vermicompost, a stable organic manure produced as vermicast by earthworm feeding on biological wastes materials is an important source of biofertilizer material. The major constituents of vermicompost are essential macro and micro nutrients, immobilized enzymes, vitamins, antibiotics, humic acid and growth hormones. Other natural source of biofertilizer is free living N-fixer like Azotobacter which has tremendous potential in increasing soil fertility. Besides these biofertilizer sources, recycling of crop wastes in a cropping system is a simplest approach to add organic matter in soil. These organic materials, with varying C:N ratios and biochemical composition release nutrients at different pace. There are ample evidences that under integrated nutrient management, nitrogenous chemical fertilizer accelerate the pace of mineralization by lowering the wide C:N ratio of organic matter rich in carbon and low in nitrogen. Therefore, chemical fertilizer and organic matter have a complementary role in nutrient release in the soil and the release pattern is expected to vary with varying agro-climate. Under such intensive cropping, the organic and conventional fertilizer input management and their reflection on the crop quality has attracted the attention of researcher in recent years.

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