Nutrition management in conversion-to-organic citrus orchard in the Indonesian citrus and subtropical fruits research institute

Sutopo¹ and T G Aji¹

¹Indonesian Citrus and Subtropical Fruits Research Institute
Jalan Raya Tlekung No. 1, Junrejo, Batu City, East Java, Indonesia

Email: opotus10@gmail.com

Abstract. One of the main challenges in organic citrus cultivation is how to manage land and nutrients so that plant needs can be met all the time while maintaining soil quality. This paper provides information on applied nutrition management, evaluation of changes in soil characters, and production in the conversion-to-organic citrus orchard in the Indonesian Citrus and Subtropical Fruits Research Institute. The citrus used are 5-year-old Siam citrus (Citrus nobilis Lour.) grafted on Japansche Citroen rootstock. The initial stage in the conversion to organic farming is the creation of ecosystems that support organic agriculture and improvement of soil fertility through the cultivation of gliricidia (Gliricidia sepium) and marigold (Tagetes erecta L.) as living hedges around the garden, planting citronella grass (Cymbopogon nardus) and marigold (Tagetes erecta L.) in the embankment, and planting land cover crop. Nutrition management in the orchard includes the application of green manure sourced from biomass of the living hedges, soybeans (Glycine max (L.) Merill) and wild plants obtained from the orchard; application of compost from dolomite enriched goat manure; and application of liquid organic fertilizer from fermented goat manure with local microorganisms. Nutrition management applied in the organic conversion orchard in the first year was followed by improvement in some soil characters, namely pH, organic matter content, cation exchange capacity, total N and exchangeable Ca but vice versa for available P, exchangeable K, and Mg. Citrus production in the first year fell by about 11% from the previous year and was followed by a decrease in the other quality parameters of fruits, except for the levels of vitamin C and total acid.

1. Introduction
Healthy lifestyle trends that develop in the global community require that agricultural products have guaranteed safety attributes (food safety attributes), high nutritional content (nutritional attributes), and environmentally friendly (eco-labeling attributes). This phenomenon has driven the demand for organic agricultural products to increase rapidly. According to the World Trade Organization (WTO), consumer choice of world organic products grows at an average of 20% per year, while the market share that can be fulfilled is only 0.5-2% of the overall agricultural product.

Organic farming is an agricultural cultivation system that relies on natural ingredients without using synthetic chemicals, whereas according to IFOAM [1], organic agriculture is a holistic farming system that supports and accelerates biodiversity, biological cycles, and soil biological activities. Organic farming has many advantages, such as reducing environmental pollution, higher price of the product meaning higher profit to farmers, producing sufficient, safe, and nutritious food so as to improve public
health. Organic farm products also have higher levels of vitamin C, phenolic compounds, essential amino acids, and contain fewer pesticide residues. They usually have better sensory and show better quality during storage. Despite having many advantages, organic farming also has some negative aspects. Crops in the organic farming systems generally have 20% lower yields than those produced in conventional farms [2]. The disadvantages of organic farming include the need for more labor, especially for pest and disease control which is still done manually. When using natural pesticides, pesticides need to be made on their own because natural pesticides are not yet available in the market. Besides, the physical appearance of organic plants is less good, for example, smaller in size and leaves with holes.

In Indonesia, the development of organic citrus farming has also begun through the conversion of conventional citrus orchards such as those conducted in Malang Regency and Batu City (mandarin) and in Lamongan Regency (lime). During the conversion period, the principles of organic agricultural production (Health, Ecology, Fairness, Care) must have been applied to the land in accordance with SNI 6729: 2016. Optimum management of soil and plant nutrition during the conversion period is one of the critical point because it affects the production and quality of citrus fruits.

Citrus Agricultural Science Park of Indonesian Citrus and Subtropical Fruits Research Institute located in Batu City, East Java converted the Siam citrus gardens, which are around 5 years old, in the Tlekung Experimental Garden as a show window for organic gardens and educational tourism. This paper provides information on applied nutrition management, evaluation of changes in soil characteristics, and production in the garden.

2. Materials and Methods
The Siam citrus orchard in the Tlekung Experimental Garden, Indonesian Citrus and Subtropical Fruits Research Institute was converted to an organic garden after harvesting in July 2018. There were 568 Siam citrus (Citrus nobilis Lour.) trees in the orchard aged 5 years with Japansche Citroen rootstock. The garden is located at an altitude of about 950 m above sea level, latosol soil (inceptisol) with a thick layer of solum, brown in color, with a clay texture and very low organic matter content. Before starting the conversion, the soil reaction was acidic with low total N content, low available P, very high exchangeable K, Ca and Mg and high cation exchange capacities.

During the conversion period, the orchard nutrition management is aligned with the principles of organic farming (SNI 6729: 2016). Nutrition management in organic conversion garden blocks includes planting of live hedges and cover crops, as well as application of various sources of natural nutrients, namely green manure, compost, goat manure, dolomite, and liquid organic fertilizer. Nutrition management applied in conventional garden blocks includes: application of 20 kg/tree goat manure circular under the canopy (ring placement) and application of 1 kg/tree NPK fertilizer (16-16-16) three times, namely in December 2018, March and May 2019 by placing fertilizer into a few holes under the canopy (spot placement). Soil characteristics and citrus fruit production were observed before and after conversion as a basis for improvement of nutrient management the following year. The measured soil characters include soil pH (pH H2O: 1:2), C-organic (Walkley & Black), N-total (Kjedahl), available P (Olsen), CEC (NH4OAc), exchangeable K (NH4OAc), exchangeable Ca (NH4OAc), and exchangeable K (NH4OAc). Harvesting was done in July-August 2019 and then observation was conducted on fruit production per tree, fruit size, fruit weight, juice content, total soluble solids (TSS), total acid (TA), vitamin C content, and the ratio of TSS: TA.

3. Results and Discussion
Activities in the first year of conversion of organic gardens are prioritized to create biodiversity and ecosystem stability that can support organic nutrition management and pest and disease management in line with the principles of organic farming. The practice of nutrition management begins with the supply of fertilizer sources from the garden environment through the planting of live hedges, terrace reinforcement plants, and intercropping/cover crops followed by the application of various kinds of natural fertilizers in solid and liquid forms.
3.1. Living fence plants and terrace reinforcement

Live hedge plants are selected species of gliricidia (*Gliricidia sepium*) which are planted single-spaced tightly around the edge of the garden or gliricidia planted together with double rowed marigolds (*Tagetes erecta* L.) (gliricidia in the inner row, marigold in the outer row). Gliricidia plants are easily propagated through cuttings, adapt well to dryland, and grow quickly so they are suitable for land conservation. This plant biomass, especially leaves, can be used as a source of green manure and botanical pesticides. The application of gliricidia leaf fertilizer in dryland increases the content of organic matter in the soil, improves the physical properties of the soil such as allowing water to infiltrate into the soil more quickly, increasing water holding capacity, restoring and improving soil quality, and increase yields [3]. Gliricidia leaves contain various phytochemicals such as flavonoids, triterpenoids, coumarin, coumaric acid, melilotic acid, and stigmastanol glucoside. The leaves of these plants can be used as mosquito repellent, and they have antifungal and antibacterial activity [4], controlling larvae of *Aedes aegypti* mosquitoes [5], controlling papaya mealybugs [6], pest control of *Helicoverpa armigera* (Lepidoptera; Noctuidae) [7], and controlling insects, nematodes, and bacteria [8].

In addition to living fences, each garden terrace is planted with fragrant lemongrass or marigold that are used to prevent erosion of the terrace, make the terrace more stable, improve the condition of the fields, as a sediment filter, as refugia (marigold), and support the supply of botanical pesticides and sources of organic material soil. The main chemical component of essential oils is lemongrass grass is geraniol (28.62%), citronellal (23.62%) and citronellol (17.10%) [9]. Lemongrass essential oil is promoting options for developing pesticides to manage *Myzus persicae* pests. Results in a study by Nakahara [10] suggested linalool and citronellal from lemongrass oil contribute significantly to total antifungal. In the future, citronella oil is the best way to control the insect population of gram pod borers [11].

The U.S. Environmental Protection Agency [12] reported that marigold oil is a new biochemical pesticide active ingredient intended for use as an insecticide/acaricide for the control of mites, whiteflies, aphids, thrips, mealybugs, scales, and psylla on a variety of food crops. The crude extract of *Tagetes patula* L., obtained using water as a solvent, was effective as a bio-control preparation for various tomato plant diseases [13]. *Tagetes erecta* also has good insecticidal activity and can be used in the control of *Tribolium castaneum* populations with integrated pest management systems which seems to be economically feasible and ecologically sound [14]. *Tagetes erecta* extract as a bioinsecticide is able to control *Spodoptera frugiperda* environmentally friendly [15].

3.2. Application of organic fertilizer

Compared to chemical fertilizers, organic fertilizer content is lower and available for plants slower but contains a more complete type of nutrient. Therefore, organic fertilizers from various sources are applied at higher doses with faster application intervals in both solid and liquid forms to meet plant needs and improve soil health. Some fertilizer sources applied include goat manure, biomass of gliricidia, tithonia, and soybeans, extraction of goat manure and citrus fruits attacked by fruit fly pests (liquid organic fertilizer), and dolomite (Table 1).

i. **Goat manure fertilizer.** Sources of goat manure fertilizer are collected from traditional goat breeders (grass-fed) around the orchard. As much as 30 kg of goat manure fertilizer is applied per tree. It is mixed with the topsoil circumferential under the canopy carefully so as not to cut the main root. This fertilizer is applied once a year before the rainy season (October/November) so that fertilizer nutrients can be available to support the growth of new shoots and flowers that appear at the beginning of the rainy season. Before application, goat manure fertilizer is crushed using a grinding machine, then added 2% dolomite with the aim of neutralizing the pH of the fertilizer and adding elements of calcium and magnesium, then composted.

ii. **Green manure.** Biomass of gliricidia, tithonia and soybeans are the main sources of green manure applied during orchard conversion. Gliricidia biomass is obtained from pruning live hedges,
Tithonia is collected from the land around the orchard, and soybeans are collected from intercropping/cover crop wastes in the orchard. Green manure is applied twice a year, namely August/September (a mixture of gliricidia and tithonia biomass 50:50 w/w) and February/March (mixture of gliricidia biomass and soybeans waste 50:50 w/w). The dosage of each tree is 1 kg of chopped biomass. It is put into a row of tilled strips ± 10-20 cm below the edge of the canopy in the direction of the tree row and then covered with soil. This green manure plays an important role in adding and completing the supply of nutrients for plants that are not sufficient only from the application of goat manure, as it does not significantly influence soil microbial biomass, C, N, P and soil fertility [16]. Application of 1 ton/ha of gliricidia leaf fertilizer provides 21 kg N; 2.5 kg P; 18 kg K; 85 g Zn; 164 g Mn; 365 g Cu; 728 g Fe and a number of S, Ca, Mg, B, Mo elements and others [3], while tithonia green leaf biomass contains an average of about 3.5% N, 0.37% P and 4.1% K based on plant dry weight [17].

iii. **Liquid organic fertilizer.** Fruit fly attack is one of the serious problems in the Tlekung Experimental Garden because it causes a decrease in the production of an average of 10-20% per year. Control is done by installing the methyl eugenol trap before fertilization and picking the attacked fruits before falling from the tree to inhibit the development of the pest population. Furthermore, the fruits are squeezed, then the juice is mixed with goat manure fertilizer and chopped gliricidia leaves, then added a little dolomite to neutralize the pH of the solution. The mixture of these ingredients is added with water then fermented anaerobically using local microorganisms isolated from banana roots. After the fermentation process is complete, liquid organic fertilizer plus water is then poured into the plant's root area as much as 20 liters per tree once a month. This fertilizer is more often applied than solid fertilizer to avoid nutrient deficiency because liquid organic fertilizer can be directly absorbed by plants, while solid organic fertilizer is slow to be available. The presence of local microorganisms in liquid fertilizers is expected to increase the beneficial microbial population in the soil and help overhaul organic material so that solid organic fertilizer is more quickly available to plants. The application of liquid organic fertilizer also results in an increase in soil organic matter content [18]. The beneficial effects of organic fertilizers and biofertilizers were also reported by several researchers [19–22].

| Table 1. Fertilizer application schedule |
|----------------------------------------|
| Fertilizer                        | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Dolomite enriched goat manure      | x   |     | x   |     |     |     |     |     |     |     |     |     |
| Green manure                      |     | x   | x   |     |     |     |     |     |     |     |     |     |
| Liquid organic fertilizer         | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   | x   |

3.3. **Changes in soil character**

After a nearly one year conversion process, some soil chemical characters undergo better status changes and others vice versa. Initially, soil reaction was acidic and increased towards slightly acidic, soil organic matter content changed from very low to low, exchangeable Ca and cation exchange capacity increased, but available P levels and exchangeable K were relatively decreased (Table 2). The improvement in pH is related to the application of various organic fertilizers with dolomite [23]. Although still in low status, the total content of N in soil increased from 0.11% to 1.13%. This is a
contribution from the mineralization of organic material applied to the soil. Mineralization of soil organic matter involves the work of enzymes to hydrolyze complex proteins. Soil microorganisms utilize carbon compounds in organic matter to obtain energy with the by-product of CO$_2$ so that the C content of organic matter during decomposition decreases or the C/N ratio decreases. The rate of mineralization of organic N to inorganic N is an important factor in determining the availability of N in the soil [24]. Increased soil cations exchange capacity is the main contribution of various sources of organic fertilizer which was applied for almost a year. This change is in line with the results of the previous studies [25–28].

After harvest, levels of available P and exchangeable K in the soil decreased compared to before organic conversion. This shows that the organic fertilizer applied, even though it contains elements P and K, but the amount does not meet the needs of plants for vegetative growth and to produce fruit. The effect of organic fertilizer on soil and plant fertility was reported by several researchers [16,21,29,30].

| Soil character | Before conversion | 12 months after conversion |
|----------------|-------------------|---------------------------|
| pH H$_2$O      | 5.45 (acidic)     | 5.70 (slightly acidic)    |
| C-organic      | 0.88% (very low)  | 1.6% (low)                |
| N-total        | 0.11% (low)       | 1.1% (low)                |
| P$_2$O$_5$ available | 214.74 ppm (very high) | 156 ppm (very high) |
| Exchangeable cations |                  |                           |
| - Exchangeable K | 1.18 me.100 g$^{-1}$ (very high) | 0.62 me.100 g$^{-1}$ (very high) |
| - Exchangeable Ca | 24.26 me.100 g$^{-1}$ (very high) | 27 me.100 g$^{-1}$ (very high) |
| - Exchangeable Mg | 10.05 me.100 g$^{-1}$ (very high) | 7.4 me.100 g$^{-1}$ (moderate) |
| Cations exchange capacity | 33.37 me.100 g$^{-1}$ (high) | 37.8 me.100 g$^{-1}$ (high) |

3.4. Yield and Fruit Quality

Fruit production in the first year of the conversion process decreased by about 11% of the harvest before conversion and some parameters of fruit quality also fell (weight and size of fruit, fruit juice, TSS, and the ratio of TSS/TA), in contrast to relatively increased content of vitamin C and titrated acid levels (Table 3). This decline in production is in line with Lotter's report [31] but contrary to the case reported by Pretty and Hine [32] that the transition from 'traditional' agriculture in rainfed areas to organic farming also often leads to increased yields. Furthermore, IFAD [33] reports an interesting note on rice farming in the State of Karnataka (India) that rice production using superior varieties (high production) and chemical fertilizers was reduced by more than 50% during the 2001-2002 drought, whereas organic rice in the region loses less than 20%. Likewise, sugar cane losses were 58% and 1% in conventional and organic farming, respectively. One factor that influences the difference in these results is the environment. Because organic fertilizers in the soil are broke down into inorganic fertilizers by microorganisms whose activities are strongly influenced by soil temperature, water content, and pH as well as the characteristics of microorganism ecosystems.
Table 3. Production and quality of Siam citrus before and during the organic conversion period

| Parameters                  | Before conversion to organic (Harvest on July 2018) | After conversion to organic (Harvest on August 2019) |
|-----------------------------|-----------------------------------------------------|------------------------------------------------------|
| Average yield/tree (kg)     | 37                                                  | 33                                                   |
| Fruit weight (g)            | 77.33                                               | 69.33                                                |
| Fruit diameter (cm)         | 5.45                                                | 5.17                                                 |
| Juice volume (ml)           | 35.00                                               | 26.00                                                |
| Juice content (%)           | 13.50                                               | 12.47                                                |
| TSS (Brix)                  | 45.13                                               | 37.38                                                |
| TA (%)                      | 4.66                                                | 5.92                                                 |
| TSS:TA ratio                | 9.68                                                | 6.31                                                 |
| Vitamin C                   | 59.44                                               | 60.57                                                |

The effect of organic nutrition on the increase in vitamin C in citrus juice is in line with the reports of several researchers [34,35]. In addition to vitamin C, organic plants also contain more iron, magnesium, and phosphorus and are significantly less nitrate than conventional plants [2]. Tomatoes from organic farming undergo stress conditions that cause oxidative stress and accumulation of higher concentrations of dissolved solids such as sugar and other compounds that contribute to the nutritional quality of fruits such as vitamin C and phenolic compounds [36].

4. Conclusion
Nutrition management applied in the conversion-to-organic citrus orchard in the first year was followed by improvement in some soil characters, namely pH, organic matter content, cation exchange capacity, total N and exchangeable Ca but vice versa for available P, exchangeable K, and Mg. Citrus production in the first year fell by about 11% from the previous year and was followed by a decrease in the other quality parameters of fruits, except for the levels of vitamin C and total acid.

References
[1] IFOAM 2012 The IFOAM Norms for Organic (International Federation of Organic Agriculture Movements)
[2] Rembialkowska E 2017 Quality of plant products from organic J. Sci. Food Agric. 87 2757–62
[3] Rao C S, Venkateswarlu B, Babu M D, Wani S P, Dixit S, Sahrawat K L and Kundu S 2011 Soil Health Improvement with Gliricidia Green Leaf Manuring in Rainfed Agriculture. On Farm Experiences (Hyderabad)
[4] Reddy L J and Jose B 2010 Evaluation of antibacterial activity of the bark, flower and leaf extracts of Gliricidia sepium from South India Int. J. Curr. Pharm. Res. 2 18–20
[5] Krishnaveni K V, Nayaki R T and Balasubramanian M 2015 Effect of Gliricidia sepium leaves extracts on Aedes aegypti: Larvicidal activity J. Phytophylac. 7 26–31
[6] Nukmal N, Pratami G D, Rosa E, Sari A and Kanedi M 2019 Insecticidal effect of leaf extract of gamal (Gliricidia sepium) from different cultivars on papaya mealybugs (Paracoccus marginatus, Hemiptera: Pseudococcidae) IOSR J. Agric. Vet. Sci. 12 4–8
[7] Jose S and Sujatha K 2017 Antifeedant activity of different solvent extracts of Gliricidia sepium against third instar larvae of Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) Int. J. Adv. Res. Biol. Sci. 4 201–2 – 4
[8] Nazli R, Akhter M, Ambreen S, Solangi A H and Sultana N 2008 Insecticidal, nematicidal and antibacterial activities of Gliricidia sepium Pakistan J. Bot. 40 2625–9
[9] Pinheiro P F, Queiroz V T de, Rondelli V M, Costa A V, Marcelino T de P and Pratissoli D 2013 Insecticidal activity of citronella grass essential oil on Frankliniella schultzei and Myzus persicae Ciência e Agrotecnologia 37 138–44
[10] Nakahara K, Alzoreky N S, Yoshihashi T, Nguyen H T T and Trakootivakorn G 2003 Chemical
composition and antifungal activity of essential oil from Cymbopogon nardus (citronella grass) Japan Agric. Res. Q. 37 249–52
[11] Papulwar P P, Rathod B U and Dattagonde N R 2018 Studies on insecticidal properties of citronella grass (lemon grass) essential oils against gram pod borer (Helicoverpa armigera) Int. J. Chem. Stud. 2 44–6
[12] USEPA 2012 Biopesticides Registration Action Document - Tagetes Oil - PC Code : 176602 22
[13] Nahak G and Kanta Sahu R 2017 Bio-controlling effect of leaf extract of Tagetes patula L. (marigold) on growth parameters and diseases of tomato Pakistan J. Biol. Sci. 20 12–9
[14] Nikkon F, Habib M R, Karim M R, Ferdousi Z, Rahman M M and Haque M E 2009 Insecticidal activity of flower of Tagetes erecta L. against Tribolium castaneum (Herbst) Res. J. Agric. Biol. Sci. 5 748–53
[15] Salinas-Sánchez D O, Aldana-Llanos L, Valdés-Estrada M E, Gutiérrez-Ochoa M, Valladares-Cisneros G and Rodríguez-Flores E 2012 Insecticidal activity of Tagetes erecta extracts on Spodoptera frugiperda (Lepidoptera: Noctuidae) Florida Entomol. 95 428–32
[16] Gyapong K A B and Ayisi C L 2015 The effect of organic manures on soil fertility and microbial biomass carbon, nitrogen, and phosphorus under maize-cowpea intercropping system Discourse J. Agric. Food Sci. 3 65–77
[17] Jama B, Palm C A, Buresh R J, Niang A, Gachengo C, Nziguheba G and Amadalo B 2000 Tithonia diversifolia as a green manure for soil fertility improvement in western Kenya: a review Agrofor. Syst. 49 201–21
[18] Martinez-Alcántara B, Martinez-Cuenca M R, Bermejo A, Legaz F and Quiñones A 2016 Liquid organic fertilizers for sustainable agriculture: Nutrient uptake of organic versus mineral fertilizers in citrus trees PLoS One 11 e0161619
[19] Sulfab H A 2013 Effect of bio-organic fertilizers on soil fertility and yield of groundnut (Arachis hypogaea L.) in Malakal area, Republic of South Sudan J. Nat. Resour. Environ. Stud. 14–9
[20] Hadole S S, Waghmare S and Jadhao S D 2015 Integrated use of organic and inorganic fertilizers with bioinoculants on yield, soil fertility and quality of Napur mandarin (Citrus reticulata Blanco) Int. J. Agric. Sci. 11 242–7
[21] Yadav S K, Khokhar U U, Sharma S D and Kumar P 2016 Response of strawberry to organic versus inorganic fertilizers J. Plant Nutr. 39 194–203
[22] Ennab H A 2016 Effect of organic manures, biofertilizers and NPK on vegetative growth, yield, fruit quality and soil fertility of Eureka lemon trees (Citrus limon (L.) Burm). J. Soil Sci. Agric. Eng. Mansoura Univ. 7 767–74
[23] Syahputra D, Alibasyah M R and Arabia T 2015 Pengaruh kompos dan dolomit terhadap beberapa sifat kimia ultisol dan hasil kedelai (Glycine max L. Merril) pada lahan berteras J. Manaj. Sumberd. Lahan 4 535–42
[24] Benbi D and Richter J 2002 A critical review of some approaches to modelling nitrogen mineralization Biol. Fertil. Soils 35 168–83
[25] Bakayoko S, Soro D, Nindjin C, Dao D, Tschannen A, Girardin O and Assa A 2009 Effects of cattle and poultry manures on organic matter content and adsorption complex of a sandy soil under cassava cultivation (Manihot esculenta Crantz.) African J. Environ. Sci. Technol. 3 190–7
[26] Angelova V R, Akova V I, Artinova N S and Ivanov K I 2013 The effect of organic amendments on soil chemical characteristics Bulg. J. Agric. Sci. 19 958–71
[27] Almaz M G, Halim R A, Martini M Y and Samsuri A W 2017 Integrated application of poultry manure and chemical fertiliser on soil chemical properties and nutrient uptake of maize and soybean Malaysian J. Soil Sci. 21 13–28
[28] Soremi A, Adetunji M, Adejuwgbie C, Bodunde J and Azeez J 2017 Effects of poultry manure on some soil chemical properties and nutrient bioavailability to soybean J. Agric. Ecol. Res. Int. 11 1–10
[29] Dong W, Zhang X, Wang H, Dai X, Sun X, Qiu W and Yang F 2012 Effect of different fertilizer
application on the soil fertility of paddy soils in red soil region of Southern China PLoS One 7 e44504

[30] Song K, Xue Y, Zheng X, Lv W, Qiao H, Qin Q and Yang J 2017 Effects of the continuous use of organic manure and chemical fertilizer on soil inorganic phosphorus fractions in calcareous soil Sci. Rep. 7 1164–72

[31] Lotter D W 2003 Organic agriculture J. Sustain. Agric. 21 59–128

[32] Pretty J N and Hine R 2001 Reducing Food Poverty with Sustainable Agriculture : A Summary of New Evidence

[33] IFAD 2005 Evaluation of Organic Agriculture and Poverty Reduction in Asia: China and India Focus

[34] Hassan S A, Mijin S, Yusoff U K, Ding P and Wahab P E M 2012 Nitrate, ascorbic acid, mineral and antioxidant activities of Cosmos caudatus in response to organic and mineral-based fertilizer rates Molecules 17 7843–53

[35] Citak S and Sonmez S 2010 Effects of conventional and organic fertilization on spinach (Spinacea oleracea L.) growth, yield, vitamin C and nitrate concentration during two successive seasons Sci. Hortic. (Amsterdam). 126 415–20

[36] Oliveira A B, Moura C F H, Gomes-Filho E, Marco C A, Urban L and Miranda M R A 2013 The impact of organic farming on quality of tomatoes is associated to increased oxidative stress during fruit development PLoS One 8 e56354