



Organic cultivation of industrial crops: a review

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Abstract

During the last decade, consumers' trust in food quality has decreased drastically, mainly because of growing ecological awareness and several food scandals. It has been found that intensive conventional agriculture can introduce contaminants into the food chain. Consumers have started to look for safer and better controlled foods produced in more environmentally friendly, authentic and local systems. Organic food products are widely believed to satisfy the above demands, leading to lower environmental impacts and higher nutritive values. Organic crops contain fewer nitrates, nitrites and pesticide residues but, as a rule, more dry matter, vitamin C, phenolic compounds, essential amino acids and total sugars than conventional crops. The term "industrial crop" generally refers to an agricultural product that is grown as a commodity and/or as the raw material for industrial goods, rather than for direct human consumption. Owing to positive influence of organic components in industrial crop farming systems, it is therefore, be assumed that those farmers who adopted organic management practices, have found a way to improve the quality of their soil, or at least stemmed the deterioration ensuring productive capacity for future generations. From this review, technical aspects of industrial crops organic farming shows modern concept and environmentally friendly. By these ways, the economic aspects in the agricultural sector are being better.

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Introduction

Organic agriculture (OA) is a production system which avoids or excludes the use of synthetic preparation-artificial fertilizers, pesticides, growth accelerators and fodder additives. As an alternative to these means, OA applies a number of modern preventive methods to maintain the natural soil fertility and non-chemical control of weeds, pests and diseases such as:

- Alternating sowing of crops (with leguminous crops inclusive)
- Suited use of manure
- Stimulating the populations of useful insects (entomophages and pathogens for the pests)
- Vegetation associations (combined cultivation of two or more crops in one and the same place)
- Use of mechanical methods for weed control
- Use of sustainable plant varieties and livestock breeds that are well adapted to the relevant environmental conditions.

These environment-friendly processes, above mentioned, are based on natural cycles and ensure the sustainability of soil life, its structure and the suitable balance of useful microorganisms.

However, negative aspects: the crop yields from OA generally are lower than those of conventional (industrial) agriculture and also, the conventional agriculture the prime cost of organic products is higher than those of industrial agriculture (IFOAM, 2007).

Organic agriculture means a farming system which produces healthful and quality products improve the quality of life, preserve the organic diversity, improvement of the soil structure and balance soil inhabiting microorganisms; without any application of synthetic product. The above mentioned principles and processes are followed as the main principles of International Federation of Organic Agriculture Movements (IFOAM), which are:

1. Production of enough high quality and nutritious food.
 2. Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. Organic management must be adapted to local conditions, ecology, culture and scale.
 3. Maintenance of natural soil fertility
 4. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.
 5. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty
 6. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of health and well-being. Consequently, any harmful action should be stopped (IFOAM, 2007).
- On the physical and chemical characteristics of the effective of industrial crops, the climate and soil conditions are considered as two major factors. These plants require different climatic conditions to grow depending on their natural origin. Most industrial crops require sunny, aerated places sheltered from strong winds and late winter frosts. The soil must be fertile and contains the required amounts in optimal combination of Na, P, Cu, minerals, organic and other elements needed for the crops to grow (Karlen *et al.*, 1997). Sustainability of agricultural systems has become an important issue throughout the world. Many of the sustainability issues are related to the quality and time dependent changes of the soil (Karlen *et al.*, 1997). It is well known that intensive cultivation has led to a rapid decline in organic matter and nutrient levels besides affecting the physical properties of soil. Conversely, the management practices with organic materials influence agricultural

sustainability via improving physical, chemical and biological properties of soils (Saha *et al.*, 2008). The use of organic amendments has long been recognized as an effective means of improving the structure and fertility of the soil (Follet *et al.*, 1981), increasing the microbial diversity, activity and population, improving the moisture-holding capacity of soils and crop yield (Frederickson *et al.*, 1977).

The main objective of this review is to provide information to help in future researches and development in organic industrial crops cultivation.

Effect of compost on industrial crops

Composting is a biological process in which organic biodegradable wastes are converted into hygienic, humus rich product (compost) for using as a soil conditioner and an organic fertilizer (Popkin, 1995). These are also used to provide biological control against various plant pathogens (Hoitink and Grebus, 1994). Aqueous extracts of compost have also been suggested to replace synthetic fungicides (Zhang *et al.*, 1998). The addition of municipal solid waste compost to agricultural soils has had beneficial effects on crop development and yield via improving soil physical and biological properties (Zheljazkov and Warman, 2004).

Application of compost to improve soil structure, fertility and consequently development and productivity of industrial crops were studied in several cases. Taheri *et al.* (2007) reported that potato shoot dry matter was increased by compost application, due to improved soil structure and ventilation, and thereby tubers development was increased in the better soil bed. Soil resistance against to tubers growth was reduced by compost application (Tu *et al.*, 2006; Arancon *et al.*, 2003). Madejon (1996) reported that compost application had similar effects to that of inorganic fertilizer on nutritional status and yield of sugar beet and also, plant analysis revealed that nutritional status of plants from compost and inorganic fertilizers treatments was similar. Moreover, yield quality measured of α -amino

N, Na and K contents in root juice were similar in organic and inorganic treatments. However, Madejon (1996) reported that the total P uptake by sugar beet plants was similar in the compost and inorganic fertilizer treatments. Kazemeini *et al.* (2008) concluded that canola yield under chemical fertilizer alone treatment and application of 40 ton/ha compost was comparable to 50 percent chemical fertilizer treatment suggesting that 50 percent of the required fertilizer might be replaced by compost and also mentioned that application of organic matter can not only increase canola seed yield but simultaneously reduce canola N requirement, possibly through improvement of soil physical, chemical and biological characteristics which may be considered as a step toward sustainable agriculture.

Effect of vermicomposting on industrial crops

Vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Edwards, 1998). Vermicompost has large particulate surface area that provides many microsites for the microbial activity and strong retention of nutrients. It is rich in microbial population and diversity, particularly fungi, bacteria and actinomycetes (Edwards, 1998). It contains plant growth regulators and other growth-influencing materials produced by microorganisms (Atiyeh *et al.*, 2002). Krishnamoorthy and Vajrabhiah (1986) reported the production of cytokinins and auxins in organic wastes that were produced by earthworms. Vermicompost also contains large amounts of humic substances and some of the effects of these substances on plant growth have been shown to be very similar to those of soil-applied plant growth regulators or hormones (Muscolo *et al.*, 1999). As a result, most nutrients are easily available such as; nitrates, phosphates, and exchangeable calcium and soluble potassium (Edwards, 1998), which are responsible to increase the plant growth and crop yield. Vermicompost has been shown to increase the dry weight (Edwards, 1995), and nitrogen uptake efficiency of plants (Tomati, 1994). The beneficial effects of

vermicompost have been observed in horticultural (Atiyeh *et al.*, 2000a; Atiyeh *et al.*, 2000b; Goswami *et al.*, 2001) and agronomical crops (Pashanasi *et al.*, 1996; Roy *et al.*, 2002). Rafiq *et al.* (2009) in the investigation of the effect of vermicompost on sunflower reported that the best vegetative growth, higher yield of seeds and oil content was obtained under the application of 1 kg/pot of vermicompost and also mentioned that the increase in yield may be due to the rich nutrient pool, which contribute high seed yield. Vermicompost is rich in macro and microelements, which are responsible to increase the qualitative and quantitative yields of many crops (Atiyeh *et al.*, 2002; Roy *et al.*, 2002). Growth parameters like plant height and head diameter in sunflower were found to be higher in vermicompost treatments as compared to chemical fertilizer and no manure (Chinnamuthu and Venkatakrishnan, 2001). The application of vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa *et al.*, 1999) which all of them can affect biosynthesis of compounds. Dhane *et al.* (1996) reported that pod yield of groundnut was significantly increased by application of vermicompost and it was found to be as effective as chemical fertilizer. Kopczyński *et al.* (1999) studied the effect of vermicompost with value of 6 ton/ha on yield of sugar beet roots. Vermicompost increased the yield of roots and sugar and enhanced the content of sugar in the roots. Vermicompost application might be associated with increasing in photosynthetic activity, root nodules, good translocation efficiency and grain yield in soybean (Tandaie *et al.*, 2009). Zende *et al.* (1998) reported the increased yields of sugarcane after amending soils with vermicomposts at rates of 5ton/ha together with 100% of the recommended application rate of inorganic fertilizers. Significant increase was recorded in groundnut crop grown in 200 g vermicompost treatment and increases in protein content were reported in the grown crops under vermicompost application (Channabasanagowda *et al.*, 2008).

Effect of bio-fertilizers on industrial crops

a) Mycorrhizal fungi

Environmental impacts which are caused by over application of chemical fertilizers, energies, expenses of their production and etc. are the reasons for global tendency toward application of bio-fertilizers (Kannayan, 2002).

Mycorrhizal fungi are beneficial microorganisms and hence, have been considered as bio-fertilizer. Most terrestrial ecosystems depend on mycorrhiza, which promote the establishment, growth and health of plants. The improved productivity of AM (AM=VAM: Vesicular Arbuscular Mycorrhiza) plants was attributed to enhanced uptake of immobile nutrients such as Phosphorus, Zinc and Copper. Resistance against biotic and abiotic stresses has been argued to be due to the effects of AM fungi on inducing plant hormones production (Sharma, 2003). Phosphate solubilizing microorganisms are another sort of bio-fertilizers which have the ability to solubilize organic and inorganic phosphorus compounds by producing organic acid or phosphatase enzyme (Rashid *et al.*, 2004). Many studies showed that PGPR (Plant Growth Promoting Rhizobacteria) bacteria have a synergistic effect with mycorrhizal fungi and coinoculation of them leads to more absorption of water and soil minerals and increases growth of host plant (Ratti *et al.*, 2001). For plants such as potato, which have a low root density (Pursglove and Sanders, 1981) and high growth potential, the VAM symbiosis may be of particular significance in coping with P deficiency stress in natural ecosystems. This also appears to be true for the commercial production of potato, since significant yield increases due to VAM fungi have been recorded (Black and Tinker, 1977; McArthur and Knowles, 1991). The AMF symbiosis could stimulate leaf growth and expansion (McArthur and Knowles 1993), increase shoot fresh weight, root dry weight and the number of tubers produced per potato plant (Yao *et al.*, 2002). In field studies, inoculation with commercial inoculants containing AMF (*Glomus intraradices*) resulted in higher yields and larger tubers than treatments using conventional

chemical fertilizers (Douds *et al.*, 2007). The AMF enhance potato tuber production partly due to the increased nutrient uptake, particularly P uptake (McArthur and Knowles, 1993), and enhanced disease resistance (Niemira *et al.*, 1996). Surendran and Vani (2013) reported that AMF applied plots showed significant difference in germination percentage, tiller number, internode thickness and sugarcane yield. Besides, quality parameters such as POCS (Pure Obtainable Cane Sugar) and brix% of sugarcane also significantly improved with the application of AMF, compared to control. 25% of P fertilizer can be reduced in medium P soils, without affecting the sugarcane yield and sustainability of soil fertility. Also, Adewole *et al.* (2010) reported that better yield of sunflower (4.05 g/pot was obtained when compared with 0.17 g/pot at control treatment) was obtained under *Glomus intraradices* mycorrhiza inoculation.

b) Bacterial biofertilizers

Some bacteria provide plants with growth promoting substances and play major role in phosphate solubilizing (Belimov *Et al.*, 1995). An advantageous of phosphate solubilizing microorganisms is related to their propagation rate that can relatively remove the plant requirements to phosphorus at the root region (Sharma, 2002). Belimov *et al.* (1995) demonstrated that, inoculation of soil with bacterial mixtures caused a more balance nutrition for plants and improved the root uptake of nitrogen and phosphorus in a main mechanism of interaction between phosphate solubilizing and bacteria nitrogen fixing.

Tahmasbi *et al.* (2011) concluded that application of Nitroxin (a bio-fertilizer) caused significantly higher tuber yield and the amount of mineral nitrogen fertilizer can be reduced to half. On the other hand, the production of various antibiotics by the bacteria present in Nitroxin in rhizosphere of roots may prevent the invasion of the root and seed tuber by infectious soil-borne organisms and nematodes and increase the resistance of plants to these destructive

agents. El-Habbasha and Abd El-Salam (2010) illustrated that increasing nitrogen fertilization significantly decreased the oil content in canola seeds. Ahmadi and Bahrani (2009) showed that nitrogen fertilizer affected the oil content negatively and decreased it by 3.3% in canola. In contrast, Yasari *et al.* (2008) reported that the application of *Azotobacter* and *Azospirillum* helped increase the oil content of canola seeds. This finding was supported by Yasari and Patwardhan (2007) who reported that application of *Azotobacter* and *Azospirillum* strains increased canola yield (21.17%), pod per plant (16.05%), number of branches (11.78%) and weight of 1000 grain (2.92%). Tran *et al.* (2006) reported that the optimal fertilizer dose for soybean production can be suggested with 40 N-rhizobial inoculant + phosphate solubilizing bacteria (PSB) fertilizer - 30 K₂O, and showed that application of bradyrhizobia (*Bradyrhizobium japonicum*) and PSB (*Pseudomonas* spp.) can enhance the number of nodules (26.9 to 40.8), dry weight of nodules (0.258 to 0.307 gr), yield components, grain yield (2.067 to 2.167 ton/ha), soil nutrient availability and uptake of soybean crop. Moreover, the economic efficiency can be increased due to reducing the production cost for soybean. Rhizosphere associated N₂-fixing and P-solubilizing bacteria have increasingly been used in non-legume crop species such as sugar beet and sugar cane (Dobereiner, 1997; Hecht-Buchholz, 1998). Asymbiotic N₂-fixing bacteria were reported to replace 60 percent of N requirements of sugar cane amounting to 200 kg N/ha (Urquiaga *et al.*, 1992). Sahin *et al.* (2004) in two years experiment indicated that single inoculations with N₂-fixing bacteria increased sugar beet root yields by 9.8–11 percent over control. Inoculation with phosphate solubilizing bacteria alone increased yields only by 7.5 percent. Dual co-inoculation of N₂-fixing bacteria and P-solubilizing bacteria gave yield increases by 11.9–12.4 percent in sugar beet. Mixed inoculation of two N₂-fixing bacteria in combination with P-solubilizing bacteria gave yield increases over control by up to 12.7 percent.

In addition to nitrogen fixation, *Azospirillum* improves root growth through generation of stimulating compounds and these results in an increasing in water and nutrients uptake and the general performance of the plant (Tilak *et al.*, 2005). Subba (1979) reported that the most important growth stimulating bacteria are *Azospirillum*, *Azotobacter*, and *Pseudomonas* which in addition to biological fixation of nitrogen and solubilizing the soil phosphate, considerably affect plant growth regulators especially auxin, gibberellin and cytokinin and hence improve the plant performance. *Azotobacter* is able to produce antifungal compounds that fight plant diseases and increase viability and germination of the seeds and, as a result, improve the overall plant growth (Chen, 2006).

Intercropping of industrial crops

The term “intercropping” refers to the special cropping system obtained by the simultaneous growing of two or more species (Caporali *et al.*, 1987). Agricultural specialists suggest intercropping, as a useful means for enhancing yields for one or all the consociated species, thanks to the ability of the consociated systems to reduce weeds and pests (Baumann *et al.*, 2000; Hatcher and Melander, 2003; Kenny and Chapman, 1988; Poggio, 2005) and to improve the exploitation of the available environmental resources with respect to monocropping systems (Arnon, 1992; Caporali *et al.*, 1987; Park *et al.*, 2002). Therefore, the intercropping technique is thought to minimize the risks of production and improve strategies for food production. A given intercropping system may be advantageous when there is a mutualistic relationship between the partners or when the interspecific competition is lower than intraspecific competition. When either species, or the most productive species, is affected more by intraspecific competition than interspecific competition, the optimal plant population may be higher when intercropped than when grown separately (Willey, 1979b; Fordham, 1983). Some further interest in the potential role of industrial crops in intercropping systems has arisen

from the widespread trend toward the cultivation of such species with organic and, generally speaking, sustainable methods. Especially interesting are the experiments performed on species with a different production cycle, intercropped for one year or more; such an arrangement has been tested on some industrial crops (Callan and Kennedy, 1996), and when this multiple cropping involves an annual and a perennial, the overall results of the obtained cropping system seem to be strongly dependent upon the reactivity of the perennial, considered the “primary” crop, to the competition with the annual. In the cultivation of industrial crops the aspect of bare productivity, although important, is not the only one to be considered; in such special crops, as a matter of fact, particular attention must be paid to the quality features of the products. The potential benefits of successful intercropping of vegetable legumes with industrial crops include nitrogen fixation, soil erosion control, and improvement of soil structure and organic matter content (Biederbeck and Bouwman, 1994; Kandel *et al.*, 1997). Olowe and Adebimpe (2009) reported that the intercrop and mixture mean yields of the sunflower varieties were similar to those of the mono-crops probably, because of the enhanced productivity of individual plants under intercropping conditions. This could be due to reduced interplant competition among sunflower stands compared with those in monocrop and absence of appreciable interspecific competition by soybean (Shivaramu and Shivashankar, 1992). However, Amujoyegbe *et al.* (2013) mentioned that the grain yield of sunflower under sole cropping were significantly higher than those under intercropping, however the high Land Equivalent Ratio (LER) indicating about 200% superiority compared to sole cropping. The high value of LER was due to the high values of the relative yield of maize and sunflower. Midmore *et al.* (1988) reported that tuber yield of potato planted simultaneously with maize was not significantly less than potato yield of sole crops until maize population exceeded 0.6 plants m⁻², i.e. the population reducing transmission by more than 30% to the potato crop. In a replacement-series experiment, tuber yield was

greater in mixed than in sole plots at 1:11 and 1:9 maize:potato proportions (375 and 391 g/m² vs 273 g/m² for sole plots) and the maximum reduction in tuber yield at the densest maize population (1:6) was 34 percent (1030 and 1563 g/m² for mixed and sole plot). However, LER always exceeded unity since maize yield in mixtures was disproportionately greater than yield based on per-plant yields of sole-maize plots. Naeem *et al.* (2013) reported that wheat-canola intercropping systems under two spatial patterns reduced yield of wheat but canola crop growing in pattern of four rows of wheat alternating with four rows of canola gave almost equivalent yield over sole plantation of canola, but a higher LER (1.37) showed that intercropping generates a greater yield on a certain piece of land by making use of resources that would otherwise not be utilize by component crops grown as pure stand.

Conclusion

According to the effect of wide spread demand to use of organic products as well as industrial crops, as a suitable substitution of industrial agriculture products, it is necessary to serious attention of organic cultivation of industrial crops. Based on the above results, it is concluded that the application of organic cultivation system was found more beneficial and significantly improved growth parameters, biochemical constituents, yield and yield components in industrial crops. Totally, the obtained results revealed that using organic system significantly improved the quantity and quality characters compared to control. Organic farming enhances soil organic carbon, available phosphorus content and microbial population / enzymatic activity of soil thus making it sustainable for organic industrial crops production. According to positive influence of organic components industrial cropping system, it is therefore, be assumed that those farmers who adopted organic management practices found a way to improve the quality of their soil, or at least stemmed the deterioration. The system is became long term productive by protecting soils and

enhancing their fertility ensuring productive capacity for future generations.

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