Organic and conventional farming. Case study: Sweet corn

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Environmental factors such as light radiation (Del Pozo *et al.,* 1991; Fasheun and Dennett, 1982, for beans), temperature and water, and agronomic practices such as tillage (Bilalis *et al.*, 2000), plant density (Del Pozo and Dennett, 1999, for *Vicia faba*) and timing of nitrogen fertilization (Paolini *et al.,* 1999, for sugar beet) can produce significant differences in plant and weed growth, which are greater than that expressed due to genetic differences. Soil organic matter content is also a very important factor for plant growth, since it improves soil physical properties and is essential for sustainable productivity particularly in semi-arid regions where its input in soil is very low. A number of studies have indicated that organic matter, due to its low bulk density, has the ability to increase soil aggregate stability and consequently to result in lower soil bulk density, higher soil porosity and infiltration rate, and increase of soil water content at field capacity. However, its influence on the previously mentioned soil physicochemical properties depends upon the amount, type and origin of the added organic materials.

During the 90s, the rising environmental and health concerns have promoted an interest in organic production systems (Ernst *et al.*, 1998; Mawapanga and Debertin, 1996). The key issues for future development of the organic sector are centered on farm diversification, agro ecological self-sufficiency, and agronomic practices that permit organic farm management (Lyngbaek *et al.*, 2001; Massoni, 2002). There is a contradiction between the last century's gains in the human condition and life expectancy and the widespread belief that the modern technology and science, especially in agriculture, are uniquely life threatening (Gregory, 2001).

The European Commission recently announced that it plans to target future farming subsidies at smaller, less intensive farms. The aim is to get farmers to return to more traditional, less environmentally damaging practices (Afusoiae *et al.*, 1996, for vegetables; Almeida *et al.*, 1984; Berentsen *et al.*, 1998, for biological dairy farming). Many agricultural systems characterized as traditional ways of life can be considered as a hidden source of organic food production (Rist *et al.*, 2000). Although much research has been undertaken on the subject of best practice on organic farms, it is clear that this research must be ongoing I.V.J., 2001; Cordon *et al.*, 2000; Wuest *et al.*, 1999,).

Many scientists study the future of conventional and organic agriculture and much research has been carried out with regard to production capacity, environment and profitability (Hanackova *et al.*, 1995; Meynard *et al.*, 2002; Mosier *et al.*, 2002; Taverdet, 1998; Harborn, 1988). Conventional farming achieves the production and profitability goals as well as the goal of less nitrogen pollution, but not the goals for landscape management, biodiversity and reduced pesticide use. Organic farming achieves these latter three goals, but not the goals for reduced nitrogen pollution and increased production capacity (Kumm, 2001; Sanna, 1997; Stobbelaar, 2000; Follett *et al.*, 2001). An experiment conducted in Denmark indicated that the average nitrate N content in soil samples from organic farms was similar to that in samples from conventional farms using manure, but greater than that in conventional farms where inorganic nitrogen fertilizers were used (Kristensen *et al.*, 1994; Nazaryuk *et al.*, 2002). It has also been claimed that organic farming systems are less efficient for nitrogen use (Eneji *et al.*, 2002). This is because nitrogen mineralization from manure treated soils is very low, and this means that in the short term their N effect on crop production is low and consequently poses greater health risks but only produces half the yields of conventional farming systems (Eneji *et a.l*, 2002; Shukla *et al.*, 1998). Nevertheless, organic farming became one of the fastest growing segments of US and European agriculture during the 1990s because it had higher soil quality and potentially lower negative environmental impact than the conventional system (Reganold *et al.*, 2001; Dalgaard *et al.*, 2001; Mengel and Pilbeam, 1992; Norris and Shabman, 1992).

Other researchers found that organic farming practices have a significantly reduced nitrogen load and improve the overall condition of the soil (Miettinen *et al.,* 1997; Muchova and Jaska, 1996, for wheat; Hamouz *et al.*, 1999, for potato). An increase in the area of organic farming would improve the total environmental and resource use performance of agriculture; hence the support of organic farming can be a useful part of the agri-environmental policy tool-box (Stolze *et al.,* 2000; Rembialkowska, 1998; Njoka and Mochoge, 1997, for coffee; Reptsstad and Eltun, 1997; Rejesus and Hornbaker, 1999).

As regards gas emissions (CO_2, CH_4), Flessa *et al.*, 2002, reported that the conversion from conventional to organic farming will lead to reduced emissions per hectare, but yield-related emissions will not be reduced (Kimpe, 1999). However the contribution of synthetic fertilizers to the greenhouse effect and to the depletion of the ozone layer is relatively small (Heijndermans, 1991; Dalberg *et al.*, 2000).

Research carried out in Germany and the Netherlands indicated that organic farming could be used as an alternative to reduce water pollution and to enforce restrictive regulations on conventional farming systems (Heissenhuber, 1992; Werff and Meulenbroek, 1992; Berg *et al.*, 1997; Berg *et al.*, 2000; Yagi and Hosen, 2002). However, a rough estimate of the environmental impact of ecological farming compared with that of conventional farming showed that organic farming emits slightly less ammonia to the atmosphere, but more nitrogen to the water (Szoege *et al*, 2001).

Regarding the yields, the opinions between scientists differ. Some of them claim that yield reductions of organic agriculture systems relative to conventional agriculture average 10-15%, however these are generally compensated for by lower input costs and higher gross margins (Lotter, 2003). Others claim that the yield reduction in organic farming compared to that in conventional farming ranges from 10 to 80% (Oerke *et al.*, 1994; NCFAP, 2003; Curuk *et al.*, 2004; Hanegraaf *et al.*, 1998).

- **Organic farming in Greece**

Organic farming is a form of agriculture which excludes the use of synthetic fertilizers and pesticides, plant growth regulators, livestock feed additives, and genetically modified organisms. As far as possible, organic farmers rely on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests. Organic farming is often contrasted with conventional chemical farming. Organic agriculture can be considered a subset of sustainable agriculture, the difference being that organic implies certification in accordance with legal standards. Organic methods are studied in the field of agroecology.

Since 1990 the market for organic products has grown at a rapid pace, averaging 20-25 percent per year, and this has driven a similar increase in organically managed farmland. Approximately 306,000 square kilometres (30.6 million hectares) worldwide are now farmed organically. In addition, as of 2005 organic wild products are farmed on approximately 62 million hectares (IFOAM 2007:10).

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements, an international umbrella organization for organic organizations established in 1972. The overarching goal of organic farming is defined as follows:

"The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings."

For the last decade organic farming is also expanding in Greece. Greece has been an agricultural country with great history in farming. Nowadays, the cultivated land under the organic farming practice is expanding. The rising environmental and health concerns have promoted an interest in organic production systems and a new market in Greece has opened. This market under the title: "Healthy eating and living" is attracting more and more customers, increasing the demand on organically grown products.

• **Overview of an organic production system**

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 adding organic matter to the soil. At the time, most organic production systems include use of modern equipment, improved cultivars, and new technologies such as drip-irrigation and plastic mulch.

In contrast to "conventional agriculture", organic farming relies on preventive rather than corrective practices. Instead of depending on synthetic insecticides, fungicides, and herbicides for pest control, organic growers employ an Integrated Pest Management (IPM) approach and use beneficial insects and biological products such as Bacillus thuringiensis (Bt). Rather than amending the soil with synthetically derived fertilizers, organic growers build soil fertility by using natural products such as cover crops, manure, and compost. A successful organic system provides a grower with an income adequate to maintain a good standard of living by producing an abundance of high-quality food, while at the same time nurturing the soil, protecting the environment and ensuring that the land will be healthy and productive for generations to come.

• **Organic Certification**

The organic industry uses standards to verify that foods labeled "certified organic" are produced without the use of synthetic fertilizers or pesticides. To be certified organic, land must not be treated with any prohibited substances for 3 years. During that 3-year period, a farm is considered transitional. In addition, a grower must have and follow an ecological soil management program.

• Soil Management and Fertility

Soil management is a key factor for organic agriculture. For example the cultivation of sweet corn: Sweet corn grows best in a well-drained soil. In choosing a site for corn production, heavy clay soils with poor drainage and areas subject to flooding should be avoided. Dry, sandy sites should only be used if irrigation is available.

Sweet corn is a fairly heavy feeder, and proper soil fertility is critical for high yields and good growth (Fernandez Santos *et al.*, 1992). Once stunted by lack of nutrients, sweet corn may never fully recover.

Nitrogen deficiency is fairly common in sweet corn, particularly in cold, wet soils; flooded soils; or dry, sandy soils. Nitrogen deficiency in young plants causes the whole plant to be pale with spindly stalks and yellow leaf tips. In older plants, nitrogen stress is often expressed by shriveling of tip kernels.

Phosphorus-deficient plants are usually dark green with reddish-purple leaf tips and margins. At low pH or in sandy soils, magnesium deficiency may occur. Magnesium deficiency in corn appears as yellow to white striping between veins of leaves. Older leaves become reddish-purple and leaf tips may die.

Many local growers use poultry litter or commercially available poultry-litter based products. Natural sources for micronutrients include rock phosphate, greensand marl, and limestone rock. Adding organic matter such as feedlot manure and compost to the soil increases the level of nutrients, improves soil microbial activity, and increases water-holding and nutrient-holding capacity (Hazard, 1994, for sweet corn). Organic matter also improves the physical condition of the soil for cultivation and improves soil structure so the surface of the soil does not crust. Any soil can be improved through the addition or organic matter. A vast array of organic materials are available in south eastern Greece including manures from poultry and livestock operations, wood by-products from mills, and crop residues from a wide variety of farming operations. All of these materials may be used fresh or composted. Cover crops are also an important, inexpensive way to add organic matter to the soil, and much of sweet corn's N needs can be met via cover cropping.

• Cover Cropping Systems

Most organic sweet corn growers use cover crops to increase organic matter, improve soil tilth, and reduce erosion. Legumes, such as hairy vetch, clover and alfalfa, fix nitrogen from the atmosphere and can supply N. To ensure the nitrogen-fixing capabilities of the legume, a grower should inoculate the legumes with the proper bacteria before seeding. Grasses, such as wheat and rye, produce large amounts of biomass and develop long roots which can bring nitrogen up from deep within the soil.

In most low-till or no till systems, the cover crop is sown in the autumn, killed in the spring, and left on the surface of the soil as a mulch. For an organic grower, the options for killing the cover crop include mowing or undercutting. In a no-till system, the crop is planted through the cover crop. In a low-till system, a narrow strip is cultivated for planting the crop seed or transplant.

Growing a cover crop as a living mulch between rows of corn is an alternative to conventional cultivation and fertilization. A perennial living mulch provides a year-round groundcover which protects against erosion and soil compaction. Growing the corn in narrow rows with wide mulch strips improves access to the corn and facilitates mechanical control for the mulch crop. Even under very wet conditions, with a living mulch in place a grower can still move equipment through the field. A living mulch increases soil nitrogen availability and reduces annual weed populations. Legumes, such as alfalfa, clover and hairy vetch, add fixed nitrogen and organic matter to the soil. To avoid competition with the corn, a living mulch may need to be suppressed or controlled by mowing or light tilling during the growing season.

Grubinger and Minotti (1990) in New York tested white clover as a living mulch for sweet corn. The clover was broadcast seeded in late April. In early June, a wheel-hoe (a hoe blade on the wheeled frame) was used to open 15-inch strips for sowing the corn. They found the most effective means of clover suppression was partial rototilling with a multivator (multiple-row unit rototiller) when the clover was well established, about 2 weeks after corn emergence. As long as a strip of clover roots passed intact between the tiller tines, regrowth of the clover was extensive providing an effective, yet non-competitive, living mulch. Corn yields were reduced when the clover was mowed rather than tilled. Conversely, in an Oregon study by Fischer and Burrill (1993), mowing the clover did not seriously reduce sweet corn yields. A grower might want to experiment with both methods in this region. An interesting side note from the Oregon study was that when corn smut was present, corn grown with suppressed clover suffered less damage than clean, cultivated corn. Growers should note that a living mulch system for vegetables can be risky if irrigation is not available, because the mulch may out-compete the cash crop for limited soil moisture.

A living mulch system can be difficult to manage. Some problems that may be encountered include increased numbers of rodents and slugs, as well as cooler soils, which may slow germination. According to Burril *et al.* (1987, for sweet corn), the most predictable and least complex system to start with involves annual seeding of clover after the corn is well established. The clover then has no chance to compete with the corn and makes most of its growth after the corn is harvested. The clover then protects the soil during the winter and grows in the following spring. The clover can then be disked under and another crop planted.

• Crop Rotations and Intercropping

Crop rotation is the single most important practice in an organic vegetable production system. Crop rotation is the practice of following one annual crop with another crop that is as different from the first crop as possible in terms of nutrient needs, rooting patterns, disease and insect pests, and growth habit. Many growers have detailed, complicated crop-rotation plans that range from 3 to 7 years before the same crop is replanted on a plot of land. For example, sweet corn may be planted in a 3-year rotation with pumpkins and beans.

Soils deteriorate because of erosion, continuous cropping, deep ploughing, and compaction, Rotating fields with soil-improving crops maintains long-term soil fertility. According to Coleman (1995) a well-thought-out crop rotation is worth 75% of everything else that might be done, including fertilization, tillage, and pest control. Diversity is the key to stability in a biological system.

Intercropping is the practice of planting several crops together in one area. Increasing diversity of crops and reducing the amount of land in a monoculture discourages many pests. To conserve space sweet corn is often planted at the same time in a field with vine crops, such as cucumbers, pumpkins, and muskmelons. The vines can be trained to grow between the corn plants. An alternative to intercropping within the same filed is strip-cropping. In this system, two or three different crops are grown in strips, commonly 2 to 6 rows wide (Coleman, 1995).