Comparisons between 'conventional' and low-input 'biological' systems.

Biological farming (or low-input, ecological or alternative) systems use significantly less agro-chemicals, are more energy efficient, reduce greenhouse gas emissions, improve soil qualities without reducing output and financial benefits, resulting in a more ecologically, economically and socially more robust model compared to the conventional farming approach.

Document summary

The addition of biological foods with reduced chemical inputs have been clearly shown to improve or maintain soil structure, reduce erosion (Eltun et al, 2002) increase soil organic matter, improve soil fertility, cation exchange capacity (CEC), lower bulk density (Bulluck et al, 2002, Clark et al, 1998; Deurer et al, 2009; Fortuna et al, 2003; Pimentel, 2012) and reduce weed pressures (Liebman et al, 2008; Liebman, 2000) while encouraging beneficial soil fauna and contribute to the control of pathogens (Arden-Clarke & Hodges, 1988; Baldi et al, 2010; Bhardwaj et al, 2011).

Low input biological systems improve economic return per unit of fossil energy invested and improve energy efficiencies (Alluvione et al, 2011; Bailey et al, 2003; Cruse et al, 2010). Importantly, compared to the conventional approach, many researchers found that the low-input systems maintained or improved crop yields (Bhardwaj et al, 2011; Bulluck et al, 2002; Clarke et al, 1998, Coulter et al, 2011; Liebman et al, 2008; Makinde & Ayoola, 2010; Pimentel, 2012; Poudel et al, 2002) and the economic returns are comparable (Rasul & Gopal, 2004). Efthimiadou et al (2010) also found a positive correlation with yield and rate of photosynthesis.

Improved soil management can also lead to decreases in greenhouse gas emissions from soil and an increase in carbon sequestration (Deurer et al, 2009; Fortuna et al, 2003; Kong & Six, 2010). Alluvione et al (20110) also found that improved energy efficiency suggests the reduction of greenhouse gas emissions from agricultural practices.

Using biological practices including crop rotations, which build soil carbon levels and enhancing the natural N-cycle nitrogen availability and use efficiency (Bhardwaj et al, 2011; Constantin et al, 2010; Efthimiadou et al, 2010; Kong et al, 2007; Kramer et al, 2002) soil organic matter and total N were positively correlated to soil microbial biomass (Baldi et al, 2010). Reduced input systems were found to effectively match nitrogen availability with crop uptake (Kramer et al, 2002).

Low input systems have been shown to have less potential environmental impacts (Clarke 1998a; Bailey at al, 2003; Eltun, 2002; Poudel et al, 2002; Rasul & Gopal, 2004; Deurer et al, 2009) with significant reductions in nutrient runoff and/or leaching, soil erosion (Kramer et al,

2002; Wells et al, 2000) and pesticide contamination (Eltun et al, 2002). Improved environmental outcomes are also shown by biologically managed soils increased adsorption of ag-chemicals (Deurer et al, 2009; Mallawatantri & Mulla, 1992).

Oquist et al (2007) found that alternative farming practices reduced subsurface drainage discharge by 41%, and nitrate N losses by between 59 and 62% compared with conventional practices, this finding is being supported by New Zealand research undertaken by the New Zealand Biological farming research centre (Magesan and McFadden, 2012).

Clarke et al (1998b) conclude that "the low-input system appeared to be most efficient, and the conventional systems were least efficient." Cruse et al (2010) also reflected that if fossil energy prices continue to rise significantly without increases in crop value, diversified low-input systems may become preferable to conventional cropping systems and used more widely.

Note: this summary is only for the papers included in this document, many of these benefits are expanded upon in more depth in other ABF papers www.biologicalfarmers.co.nz

References

Alluvione, F., Moretti, B., Sacco, D. and Grignani, C. (2011). **EUE (energy use efficiency) of cropping systems for a sustainable agriculture.** *Energy* Volume 36, Issue 7, Pages 4468–4481

Abstract

Energy efficiency of agriculture needs improvement to reduce the dependency on non-renewable energy sources. We estimated the energy flows of a wheat–maize–soybean–maize rotation of three different cropping systems: (i) low-input integrated farming (LI), (ii) integrated farming following European Regulations (IFS), and (iii) conventional farming (CONV). Balancing N fertilization with actual crop requirements and adopting minimum tillage proved the most efficient techniques to reduce energy inputs, contributing 64.7% and 11.2% respectively to the total reduction. Large differences among crops in energy efficiency (maize: 2.2 MJ kg^{-1} grain; wheat: 2.6 MJ kg^{-1} grain; soybean: 4.1 MJ kg^{-1} grain) suggest that crop rotation and crop management can be equally important in determining cropping system energy efficiency. Integrated farming techniques improved energy efficiency by reducing energy inputs without affecting energy outputs. Compared with CONV, energy use efficiency increased 31.4% and 32.7% in IFS and LI, respectively, while obtaining similar net energy values. Including SOM evolution in the energy analysis greatly enhanced the energy performance of IFS and, even

more dramatically, LI compared to CONV. Improved energy efficiency suggests the adoption of alternative farming systems to reduce greenhouse gas emissions from agriculture. However, a thorough evaluation should include net global warming potential assessment.

Arden-Clarke, C. and Hodges, R.D. (1988) **The environmental effects of conventional and organic/biological farming systems. II. Soil ecology, soil fertility and nutrient cycles**. *Biological Agriculture and Horticulture,* Vol. 5, no. 3, pp. 223-287.

Abstract:

The inputs characteristic of conventional and organic/biological farming systems are examined, and their physical, chemical and biological impacts on the ecology and fertility of agricultural soils, and on nutrient cycles within these systems, are evaluated. Inorganic fertilisers applied in conventional systems may not preserve soil structure, can cause wide fluctuations in the pH and ion concentrations of the soil solution, and can substantially reduce some soil faunal populations, especially earthworms. Organic manuring practices characteristic of organic systems tend to maintain soil structure, are less disruptive of the soil chemical environment, encourage populations of beneficial soil fauna and contribute to the control of microbial pathogens.

Bailey, A.P., Basford, W.D., Penlington, N., Park, J.R., Keatinge, J.D.H., Rehman, T., Tranter, R.B., and Yates, C.M. (2003) **A comparison of energy use in conventional and integrated arable farming systems in the UK**. *Agriculture, Ecosystems & Environment* Volume 97, Issues 1–3, pp. 241–253

Abstract

The LINK Integrated Farming Systems (LINK-IFS) Project (1992–1997) was set up to compare conventional and integrated arable farming systems (IAFS), concentrating on practical feasibility and economic viability, but also taking into account the level of inputs used and environmental impact. As part of this, an examination into energy use within the two systems was also undertaken. This paper presents the results from that analysis. The data used is from the six sites within the LINK-IFS Project, spread through the arable production areas of England and from the one site in Scotland, covering the 5 years of the project. The comparison of the energy used is based on the equipment and inputs used to produce 1 kg of each crop within the

conventional and integrated rotations, and thereby the overall energy used for each system. The results suggest that, in terms of total energy used, the integrated system appears to be the most efficient. However, in terms of energy efficiency, energy use per kilogram of output, the results are less conclusive.

Baldi, E., Toselli, M., Marcolini, G., Quartieri, M., Cirillo, E., Innocenti, A. and Marangoni, B. (2010) **Compost can successfully replace mineral fertilizers in the nutrient management of commercial peach orchard**. *Soil Use and Management,* 26: 346–353.

Abstract

The objective of this experiment was to evaluate in the long-term (9 years), the suitability of compost as a fertilizer in commercial peach orchard. The experiment was carried out on nectarine trees (Prunus persica var.nectarina), Stark Red Gold grafted on GF677 peach × almond (P. amygdalus L.) hybrid. The treatments were: (1) unfertilized control; (2) mineral fertilization including phosphorus (P at 100 kg/ha) and potassium (K at 200 kg/ha) applied at planting and nitrogen (N at 70–130 kg/ha/yr) split in two applications at 40 days after full bloom (60%) and in September (40%); (3) cow manure supplied at planting [10 t dry weight (dw)/ha] and then, from the forth year at the rate of 5 t dw/ha/yr in spring; (4) compost supplied at planting (10 t dw/ha) and then, from the forth year at the rate of 5 t dw/ha/yr in spring; (5) compost supply at a rate of 5 t dw/ha/yr, and (6) 10 t dw/ha/yr, both treatment 5 and 6 split as described for treatment 2. Nitrate-N soil concentration was usually not affected by treatments. Soil microbial carbon, organic matter, total N, P, K were increased by application of organic fertilizers. SOM and total N were positively correlated to soil microbial biomass. Aggregate stability, humic and fulvic acid concentration were not affected by fertilization treatment. Only the application of compost at 10 t dw/ha/yr (6) increased fruit production.

Bhardwaj, A.K., Jasrotia,P., Hamilton, S.K., and Robertson, G.P. (2011) **Ecological management of intensively cropped agro-ecosystems improves soil quality with sustained productivity**. *Agriculture, Ecosystems & Environment*. Volume 140, Issues 3-4, March, Pages 419-429

Abstract:

Intensively cropped agricultural production systems should be managed to improve soil quality and ecological processes and ultimately strengthen system capacity for sustained biological productivity. We examined the long-term changes (>20 years) in soil quality and productivity

with incorporation of ecological management principles in a set of intensively managed row crop systems of the upper Midwest, USA. Replicated experimental treatments include corn (maize)–soybean–wheat cropping systems under four different management regimes: (a) conventional tillage and fertilizer/chemical inputs (Conventional), (b) no tillage with conventional fertilizer/chemical inputs (No-till), (c) conventional tillage with 30% of conventional fertilizer/chemical inputs and a leguminous cover crop (Reduced Input), and (d) conventional tillage with no fertilizer/chemical input and a leguminous cover crop (Organic). Effects of these treatments on soils were compared by developing a soil quality index (SQI) from 19 selected soil health indicators. An old field community maintained in early succession provided a benchmark for comparison. Reduction in tillage or fertilizer (No-till, Reduced Input and Organic) resulted in increased SQI and improved crop production. The No-till (SQI = 1.02) and Reduced Input (SQI = 1.01) systems outperformed Conventional management (SQI = 0.92) in nitrogen availability and use efficiency, soil stability and structure improvement, and microbial nitrogen processing. Improvements in soil quality corresponded with increased primary production and crop yield in these systems, illustrating the value of an ecologically defined SQI for assessing the long-term effects of fertility and tillage management regimes in agricultural production systems.

Research highlights

Long term changes in soil quality and crop productivity with fertilizer and tillage. Soil Quality Index (SQI) developed using Principal Components Approach. Improved soil quality in No-till, Reduced Input compared to conventional management. Conservation management improves nutrient availability, soil stability and structure. Soil quality concord with microbial nitrogen processing, nitrogen use and leaching.

Bulluck, L.R., Brosiusb, M., Evanylob, G.K. and Ristainoa, J.B. (2002) **Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms**. *Applied Soil Ecology*. Volume 19, Issue 2, pp. 147–160

Abstract

Field experiments were conducted to examine the effects of organic and synthetic soil fertility amendments on soil microbial communities and soil physical and chemical properties at three organic and three conventional vegetable farms in Virginia and Maryland in 1996 and 1997. Two treatments, including either an alternative organic soil amendment (composted cotton-gin trash, composted yard waste, or cattle manure) or synthetic soil amendment (fertilizer) were applied to three replicated plots at each grower field location. Production history and time affected propagule densities of Trichoderma species which remained higher in soils from

organic farms. Propagule densities of Trichoderma species, thermophilic microorganisms, and enteric bacteria were also detected in greater numbers in soils amended with alternative than synthetic amendments, whereas propagule densities of Phytophthora and Pythium species were lower in soils amended with alternative than synthetic fertility amendments. Concentrations of Ca, K, Mg, and Mn were higher in soils amended with alternative than synthetic fertility amendments. Canonical correlations and principle component analyses indicated significant correlation between these soil chemical factors and the biological communities. First-order canonical correlations were more negative in fields with a conventional history, and use of synthetic fertilizers, whereas canonical correlations were more positive in fields with a history of organic production and alternative soil amendments. In the first year, yields of corn or melon were not different in soil amended with either synthetic or organic amendments at four of six farms. In the second year, when all growers planted tomatoes, yields were higher on farms with a history of organic production, regardless of soil amendment type. Alternative fertility amendments, enhanced beneficial soil microorganisms reduced pathogen populations, increased soil organic matter, total carbon, and cation exchange capacity (CEC), and lowered bulk density thus improving soil quality.

Clark, M.S. Ferris, H., Klonsky, K. Laanini, W.T., van Bruggen, A.H.C. and Zalom, G. (1998 a) **Agronomic, economic, and environmental comparison of pest management in conventional and alternative tomato and corn systems in northern California**. *Agriculture, Ecosystems & Environment.* Volume 68, Issues 1–2, pp 51–71

Abstract

The effectiveness, economic efficiency, and environmental impact of pest management practices was compared in conventional, low-input, and organic processing tomato and field corn systems in northern California. Pests, including arthropods, weeds, pathogens, and nematodes, were monitored over an 8-year period. Although both crops responded agronomically to the production-system treatments, arthropods, pathogens, and nematodes were found to play a relatively small role in influencing yields. In contrast, weed abundance was negatively correlated with tomato and corn yields and appeared to partially account for lower yields in the alternative systems compared to the conventional systems. Lower pesticide use in the organic and low-input systems resulted in considerably less potential environmental impact but the economic feasibility of reducing pesticide use differed dramatically between the two crops. The performances of the organic and low-input systems indicate that pesticide use could be reduced by 50% or more in corn with little or no yield reduction. Furthermore, the

substitution of mechanical cultivation for herbicide applications in corn could reduce pest management costs.

Clark, M.S. Horwath W.R., Shennan, C. and Scow, K.M. (1998b) **Changes in soil chemical properties resulting from organic and low-input farming practices.** *Agron. J.*, 90 , pp. 662–671

Abstract

Soil chemical properties during the transition from conventional to organic and low-input farming practices were studied over 8 yr in California's Sacramento Valley to document changes in soil fertility status and nutrient storage. Four fanning systems differing in crop rotation and external inputs were established on land previously managed conventionally. Fertility in the organic system depended on animal manure applications and winter cover crops; the two conventional systems received synthetic fertilizer inputs; the low-input system used cover crops and animal manure during the first 3 yr and cover crops and synthetic fertilizer for the remaining 5 yr. At 4 and 8 yr after establishment, most changes in soil chemical properties were consistent with predictions based on nutrient budgets. Inputs of C, P, K, Ca, and Mg were higher in the organic and low-input systems as a result of manure applications and cover crop incorporations. After 4 yr, soils in the organic and low-input systems had higher soil organic C, soluble P, exchangeable K, and pH. Ceasing manure applications in the low-input system in Year 4 resulted in declining levels of organic C, soluble P, and exchangeable K. Crop rotation (the presence or absence of corn) also had a significant effect on organic C levels. Differences in total N appeared to be related in part to inputs, but perhaps also to differing efficiency of the farming systems at storing excess N inputs: the low-input system appeared to be most efficient, and the conventional systems were least efficient. Electrical conductivity (EC), soluble Ca, and soluble Mg levels were tightly linked but not consistently different among treatments. Relatively stable EC levels in the organic system indicate that animal manures did not increase salinity. Overall, our findings indicate that organic and lowinput farming in the Sacramento Valley result in small but important increases in soil organic C and larger pools of stored nutrients, which are critical for long-term fertility maintenance.

Constantin, J., Mary, B., Laurent, F., Aubrion, G., Fontaine, A., Kerveillant, P. and Beaudoin, N. (2010) Effects of catch crops, no till and reduced nitrogen fertilization on nitrogen leaching and balance in three long-term experiments. Agric Ecosyst Environ 135:268–278

Abstract

Improved agricultural practices are encouraged to reduce nitrate leaching and greenhouse gas emissions. However, the effects of these practices are often studied at annual or rotation scale without considering their long-term impacts. We have evaluated the effects of catch crops (CC), no-till (NT) and reduced nitrogen fertilization (N−) on nitrogen fate in soil–plant system during 13–17 years in three experiments in Northern France. CC were present in all sites whereas tillage treatment and N fertilization rate were tested separately at one site. Crop biomass, N uptake and N leaching were monitored during the whole period. The N balance, i.e. the difference between N inputs and crop exportations, was only affected by fertilization rate whereas leached N varied with all techniques. CC was the most efficient technique to decrease N leaching (from 36 to 62%) and remained efficient on the long term. NT and N− had a positive but smaller impact. N storage in soil organic matter was markedly increased by CC (by 10–24 kg ha^{-1} yr^{-1}), decreased by N− (−7.3 kg ha^{-1} yr^{-1}) and not significantly affected by NT. The differences in gaseous N losses (denitrification + volatilization) between treatments were assessed by nitrogen mass balance. CC establishment had no significant effect on N gaseous emissions while NT increased them by 3.6 ± 0.9 kg N ha^{-1} yr^{-1} and N− reduced them by 13.6 ± 4.6 kg N ha^{-1} yr^{-1}. Catch crops appear as a win/win technique with respect to nitrate leaching and C and N sequestration in soil.

Coulter, J.A, Sheaffer C.C., Wyse, D.J., Haar, M.J., Porter, P.M, Quiring, S.R. and Klossner, L.D. (2011) **Agronomic Performance of Cropping Systems with Contrasting Crop Rotations and External Inputs.** *Agronomy Journal* Volume 103, pp 182–192

Abstract

Cropping systems with less reliance on external inputs could improve agricultural sustainability if they can produce high and stable crop yields over time. A 16-yr experiment was conducted in southwestern Minnesota to evaluate the effects of zero external input (ZEI), low external input (LEI), high external input (HEI), and organic input (OI) systems on crop yield and yield stability in a 2-yr soybean [Glycine max (L.) Merr.]–corn (Zea mays L.) rotation and a 4-yr oat (Avena sativa L.)/alfalfa (Medicago sativa L.)–alfalfa–corn–soybean rotation. Oat yield was stable and highest with the LEI, HEI, and OI systems. Alfalfa yield was highest with the LEI, HEI, and OI systems in the first 8 yr and the OI system in the last 8 yr. Corn grain yield was 0, 13, 26, and 40% greater with the 4-yr rotation than the 2-yr rotation in the HEI, LEI, OI, and ZEI systems, respectively, and was greatest with the HEI system in the 2-yr rotation and the LEI, HEI, and OI systems in the 4-yr rotation. Soybean yield was 7% greater with the 4-yr rotation than the 2-yr rotation and was among the highest with the LEI and HEI systems. Stable corn and soybean yields occurred with the LEI and OI systems, while above-average yield increases under favorable growing conditions occurred with the LEI and HEI systems in alfalfa and the HEI system in corn. These

results demonstrate the value of extended crop rotations for corn and soybean, and that high crop yields can be obtained with reduced-input systems.

Cruse, M.J., Liebman, M., Raman, D.H. and Wiedenhoeft, M.H. (2010). **Fossil energy use in conventional and low-external-input cropping system**. *Agron*. J. 102:934–941

Abstract

Conventional agriculture production systems in developed countries rely heavily on fossil energy, but emerging uncertainties in energy supply indicate a need to better understand energy efficiency in conventional and alternative systems. We used 6 yr of data from a cropping systems experiment conducted in Iowa to compare energy use of a conventionally managed corn (Zea mays L.)–soybean [Glycine max (L.) Merr.] system (a 2-yr rotation) with two low-external input (LEI) cropping systems that used more diverse rotations and manure, but substantially lower quantities of synthetic N fertilizer and herbicides. Depending on how fossil energy costs were assigned to manure, the two LEI systems (a 3-yr rotation of corn-soybean-small grain/red clover [Trifolium pratense L.], and a 4-yr rotation of corn-soybean-small grain/alfalfa-alfalfa, Medicago sativa L.) used between 23 and 56% less fossil energy than did the conventional system. In general, the primary category for fossil energy use in all systems was grain drying. The conventional 2-yr system used substantially more fossil energy embodied in synthetic fertilizers and pesticides than did the LEI systems. Economic return, harvested crop weight, and potential energy production of the conventional 2-yr and LEI 4-yr systems were similar. Efficiency ratios, including crop energy output and economic return per unit of fossil energy invested, were significantly higher in the LEI 4-yr rotation than in the conventional system. In coming years, if fossil energy prices rise significantly without concomitant increases in crop value, diversified LEI systems may become preferable to conventional cropping systems and used more widely.

Deurer, M., Grinev, D., Young, I., Clothier, B.E. and Müller, K. (2009). **The impact of soil carbon management on soil macropore structure: a comparison of two apple orchard systems in New Zealand.** *European Journal of Soil Science* Volume 60, Issue 6, pages 945–955

Summary

We analysed the long-term effect of the addition of organic carbon (C) on the macropore structure of topsoils. For this purpose we compared the top 50 mm in the tree rows of an organic apple orchard with those in an adjacent conventional orchard with the same soil type, texture and previous land-use history in New Zealand. After 12 years the topsoils of the organic orchard had 32% more soil organic carbon (SOC) sequestered than those of the conventional, integrated orchard because of regular compost applications and grass coverage. We quantified the macropore structure (macropores = pores > 0.3 mm) of nine undisturbed soil columns (43 mm long, 20 × 17 mm in the plane) within each orchard using 3D X-ray computed tomography. The macroporosity (7.5 ± 2.1%) of the organic orchard soil was significantly greater than that of the integrated orchard (2.4 ± 0.5%). The mean macropore radius was similar in the organic and integrated systems, with 0.41 ± 0.02 mm and 0.39 ± 0.01 mm, respectively. The connectivity of macropores tended to be greater in the organic than in the integrated system, but this was not statistically significant. The pronounced soil C management in the organic orchard increased both the formation of macropores by roots and a larger fresh weight of anecic earthworms, and the stabilization of the macropore structure was increased by a larger aggregate stability and microbial biomass compared with those of the integrated orchard. We simulated the diffusion through the measured pore structures of segments of the soil columns. The segments had the length of the mean aggregate size of the soils. The relative diffusion coefficients at this aggregate scale were significantly greater in the organic (0.024 ± 0.0009) than in the integrated (0.0056 ± 0.008) orchard. In a regression analysis with both the porosity and connectivity of macropores as significant variables, 76% of the variability of the relative diffusion coefficients was explained in the integrated, and, with the porosity as the only significant factor, 71% of the variability in the organic orchard. We hypothesize that a greater relative diffusion coefficient at the aggregate scale would reduce nitrous oxide (N_2O) production and emission in a wet soil and suggest that soil C management combats climate change directly by sequestering C and indirectly in the form of a reduction of N_2O emissions, by creating more macropores.

Efthimiadou, A., Bilalis ,D., Karkanis, A. and Froud-Williams, B. (2010) **Combined organic/inorganic fertilization enhance soil quality and increased yield, photosynthesis and sustainability of sweet maize crop.** *AJCS* 4(9):722-729

Abstract

A field experiment was conducted to determine the effects of inorganic and combined organic/inorganic fertilization on growth, photosynthesis and yield of a sweet maize crop (Zea mays L. F1 hybrid Midas), under Mediterranean climatic conditions. A randomized complete block design was employed with four replicates per treatment (inorganic fertilizer (21-0-0),

control and 12 combined organic (poultry, cow manure and barley) and inorganic fertilization (synthetic fertilizer: 21-0-0) treatments. The amount of N contributed to the soil via the different fertilization treatments was the same (240 kg N ha-1). Organic soil amendments increased the level of soil organic matter and total nitrogen. The highest height, dry weight, leaf area index and yield were recorded with the cow manure treatments (with or without chemical fertilizer). Moreover, combined organic and inorganic fertilizers resulted in higher increase in photosynthetic rate and stomatal conductance compared with those found under inorganic fertilization. A high correlation coefficient ($r=0.926$, $p<0.001$) between yield and photosynthetic rate was found. Sustainability yield indices (sustainable yield index and agronomic efficiency) showed that the maize crop is more stable under combined organic and inorganic fertilization compared with mineral fertilization. Our results indicate that combined organic and inorganic fertilization enhances organic matter in soils and increases yield of sweet maize.

Eltun, R., Korsaeth, A. and Nordheim, O. (2002) **A comparison of environmental, soil fertility, yield, and economical effects in six cropping systems based on an 8-year experiment in Norway** *Agriculture, Ecosystems &* Environment Volume 90, Issue 2, Pages 155–168

Abstract

Development of environmentally and economically sound agricultural production systems is an important aim in agricultural policy and has a high priority in agricultural research worldwide. The present work uses results from the first complete crop rotation period (1990–1997) of the Apelsvoll cropping system experiment in south-eastern Norway to discuss the effect of cropping systems and their management practices on environment, soil fertility, crop yields and the farm economy, and how this knowledge may be used to develop a more sustainable agriculture. The experiment includes conventional arable (CON-A), integrated arable (INT-A), ecological arable (ECO-A), conventional forage (CON-F), integrated forage (INT-F) and ecological forage (ECO-F) cropping systems which were established on model farms of 0.2 ha. On the basis of nutrient runoff, soil erosion and pesticide contamination, the following ranking from the most to the least favourable was made for environmental effects: INT-F>ECO-F>ECO-A>INT-A>CON-F>CON-A. Environmental effects such as N and P runoff losses were very much linked to the proportion of ley in the system. Thus, major improvements to reduce the effects of agriculture on nutrient runoff, cannot be achieved without changing the cropping systems in the direction of more mixed farming with reduced cropping intensity. The nutrient balance calculations showed that there were considerable deficits in the ecological systems, a fact which must be taken into consideration in the development of sustainable ecological cropping systems. The yield reduction experienced with integrated and ecological cropping, relative to conventional cropping, was smaller for forage crops and potatoes than for cereals. This suggests that it is easier to maintain the yield level by reduced cropping intensity in mixed farming systems with

livestock than in arable farming systems without livestock. Because of the premium prices and government subsidies to ecological farming, the economic results were equally good in the ecological systems as in the conventional ones. Economically, integrated farming was less favourable than the other systems. It is concluded that, overall, integrated and ecological forage systems results in the least environmental harm, and based upon the present government subsidies, the forage systems also seem the most profitable, along with the ecological arable system.

Fortuna, A., Harwood, R. Kizilkaya ,K. and Paul, E.A. (2003) **Optimizing nutrient availability and potential carbon sequestration in an agroecosystem.** *Soil Biology and Biochemistry* Volume 35, Issue 8 Pages 1005–1013

Abstract

The uniformity, low cost and ease of application associated with inorganic fertilizers have diminished the use of organic nutrient sources. Concern for food safety, the environment and the need to dispose of animal and municipal wastes have focused attention on organic sources of N such as animal-derived amendments, green manures, and crop rotations. Managing organic N sources to provide sufficient N for crop growth requires knowledge of C and N decomposition over several years, particularly where manure and compost are applied. We report a comparison of compost and chemical fertilizer, use of a corn–corn–soybean–wheat rotation compared to continuous corn and the use of cover crops. Nitrogen (150 d) and C incubations (317 d) were conducted to determine the effect of cropping system and nutrient management on: N mineralization potential (NMP), the mineralizable organic N pool (N_o), the mean residence time (MRT) of No, C mineralization (C_{min}), and soil organic carbon (SOC) pool sizes and fluxes. Compost applications over 6 y increased the resistant pool of C by 30% and the slow pool of C by 10%. The compost treatment contained 14% greater soil organic C than the fertilizer management. Nitrogen was limiting on all compost treatments with the exception of first year corn following wheat fallow and clover cover crop. The clover cover crop and wheat-fallow increased inorganic N in both nutrient managements. We recommend that growers adjust their N fertilizer recommendation to reflect the quantity and timing of N mineralized from organic N sources and the N immobilization that can be associated with compost or other residue applications. Proper management of nutrients from compost, cover crops and rotations can maintain soil fertility and increase C sequestration.

Kong, A.Y.Y. and Six, J. (2010) **Tracing Root vs. Residue Carbon into Soils from Conventional and Alternative Cropping Systems.** *Soil Science Society of America Journal*. Vol. 74 No. 4, p. 1201-1210

Abstract

We investigated the fate and rate of stabilization of root vs. residue C and the role of soil aggregates in root- vs. residue-derived C accumulation within long-term conventional (mineral fertilizer), low-input (mineral fertilizer and cover crop), and organic (manure and cover crop) cropping systems. Both hairy vetch (Vicia dasycarpa Ten.) roots and residue were ^{13}C labeled in situ and then traced into whole-soil samples and three soil organic matter (SOM) fractions (coarse particulate organic matter [CPOM, >250 µm], microaggregates [53–250 µm], and silt and clay [<53 µm]). At the end of the maize (Zea mays L.) growing season, 52% of the root-derived C was still present in the soil, while only 4% of residue-derived C remained. These results suggest that root C contributes more to overall C stabilization than residue C, which supports a nascent body of research demonstrating greater retention of root-derived than residue-derived C in SOM. The ratio of root- to residue-derived C (an indicator of relative root contribution) was higher in the microaggregates and silt-and-clay fractions than the CPOM of low-input and conventional systems. In contrast, relative root contribution was greater in the whole soil of the organic (6.76) than the conventional (1.43) and low-input cropping systems (3.24), and particularly greater in the CPOM of the organic system (7.53). This trend mirrored long-term soil C stocks across the cropping systems, i.e., organic > low input = conventional, and suggests that the CPOM fraction is pivotal to short-term accumulation of root-derived C and, ultimately, to long-term C sequestration under organic crop management.

Kong A.Y.Y., Fonte, S.J., van Kessel, C. and Six, J. (2007) **Soil aggregates control N cycling efficiency in long-term conventional and alternative cropping systems.** *Nutrient Cycling in Agroecosystems* Volume 79, Number 1, pp 45-58

Abstract

This paper presents novel data illustrating how soil aggregates control nitrogen (N) dynamics within conventional and alternative Mediterranean cropping systems. An experiment with 15N-labeled cover crop residue and synthetic fertilizer was conducted in long-term (11 years) maize–tomato rotations: conventional (synthetic N only), low-input (reduced synthetic and cover crop-N), and organic (composted manure- and cover crop-N). Soil and nitrous oxide (N2O) samples were collected throughout the maize growing season. Soil samples were separated into three aggregate size classes. We observed a trend of shorter mean residence times in the silt-and-clay fraction than macro- (>250 µm) and microaggregate fractions (53–250 µm). The majority of synthetic fertilizer-derived 15N in the conventional system was associated with the silt-and-clay fraction (<53 µm), which showed shorter mean residence times (2.6 months) than cover crop-derived 15N in the silt-and-clay fractions in the low-input (14.5 months) and organic

systems (18.3 months). This, combined with greater N2O fluxes and low fertilizer-N recoveries in both the soil and the crop, suggest that rapid aggregate-N turnover induced greater N losses and reduced the retention of synthetic fertilizer-N in the conventional system. The organic system, which received 11 years of organic amendments, sequestered soil organic carbon (SOC) and soil N, whereas the conventional and low-input systems merely maintained SOC and soil N levels. Nevertheless, the low-input system showed the highest yield per unit of N applied. Our data suggests that the alternating application of cover crop-N and synthetic fertilizer-N in the low-input system accelerates aggregate-N turnover in comparison to the organic system, thereby, leading to tradeoffs among N loss, benefits of organic amendments to SOC and soil N sequestration, and N availability for plant uptake.

Kramer, A.W., Doane, T.A., Horwath, W.R. and van Kessel, C. (2002) **Combining fertilizer and organic inputs to synchronize N supply in alternative cropping systems in California.** *Agriculture, Ecosystems & Environment,* Volume 91, Issues 1–3, pp 233–243

Abstract

One of the principal aims of alternative cropping systems is to minimize excessive loss of N while maximizing N use efficiency and meeting crop N requirements. Many such cropping systems substitute intensive application of synthetic fertilizer with organic inputs, such as N2-fixing legumes. The effectiveness of legume residues as a N source for subsequent crops depends heavily on temporal N release from the residue during the growing season. A field experiment with -labeled fertilizer and -labeled vetch residue was conducted to determine the temporal pattern of N release from both sources in conventional and alternative cropping systems in California. The experiment was conducted within conventional (fertilizer), low-input (fertilizer and organic N), and organic (organic N only) cropping systems established 9 year previously. Availability of N from the labeled inputs was determined based on uptake by maize (Zeamays L.). Uptake of total N and by maize in each cropping system was monitored at 10 day intervals from 50 to 90 days after seeding for determination of uptake rates. Uptake of N from fertilizer in the conventional system was greater than uptake of N from vetch in the low-input and organic systems. Uptake of N from vetch was delayed, but with a sustained availability later in the season. Uptake rates of N from fertilizer peaked at 4.3 kg N ha−1 per day between 70 and 80 days while those from vetch residue reached a maximum of 0.6 kg N ha−1 per day during the same time period. Grain and N yield at harvest did not differ between cropping systems despite different temporal and quantitative availability of N from organic and inorganic N inputs. This demonstrates that optimum yields can be achieved under management which uses alternative sources of N and can successfully match N availability with crop uptake.

Kramera, A.W., Doaneb, T.A., Horwathb, W.R. and van Kessela, C. (2002) **Combining fertilizer and organic inputs to synchronize N supply in alternative cropping systems in California.** Agriculture, Ecosystems & Environment Volume 91, Issues 1–3, pp 233–243

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Law, A. (2009) **Evaluating The Effects Of Organic And Conventional Inputs On Soil Chemical And Biological Properties In A Four-Year Vegetable Rotation And The Investigation Of Soil Microbial Properties On Plant Gene Expression**. University of Kentucky Doctoral Dissertations Graduate School. Available online.

Abstract:

The objective of this research was to determine the effects of conventional inputs on soil chemical and biological properties compared to organic systems in a four year vegetable rotation. Tillage and cover crops were the same in all treatments to avoid confounding factors often present in similar research. Additional experiments investigated plant gene expression in organic and conventional management systems and in soils with decreased microbial diversity.

Experimental plots were prepared in the spring of 2004; four replications of three management treatments, organic, low-input and conventional, were arranged in a randomized complete block design. The rotation consisted of edamame soybean, sweet corn, fallow (pastured poultry in organic plots), and potatoes.

Soil samples were taken in the spring and fall of each year, along with data for pest damage, weed control, yield and quality. Soil samples were analyzed for enzyme activity (maximum activity under substrate saturation) and basic soil chemical properties. Treatments were compared over time using 2-Way ANOVA. Multiplex terminal-restriction fragment length polymorphism (M-TRFLP) profiles of the soil microbial community were compared using Multiple Response Permutation Procedures (MRPP). Multi-way ANOVA detected significant treatment effects over time in total carbon, nitrogen, Mehlich III K, Exchangeable K and exchangeable Na ($p=0.05$). Many significant changes in soil properties over time could not be attributed to treatment effects. All treatments produced similar yields, indicating that successful organic production of these vegetables is possible in Kentucky. Input costs for organic were 37% higher than conventional, due to the cost of organic fertilizer. The organic system required nearly 50% more labor hours than conventional or low-input. The low-input system was the most cost effective, with 58% less input expenses than the conventional system. Microarray analysis of approximately 37,500 Glycine max transcripts did not show significant differences in the gene.

Liebman, D. (2000) **Integration of soil, crop and weed management in low-external-input farming systems.** *Weed Research*, volume 40, pp 27–47.

Abstract

Greater adoption and refinement of low-external-input (LEI) farming systems have been proposed as ways to ameliorate economic, environmental and health problems associated with conventional farming systems. Organic soil amendments and crop diversification are basic components of LEI systems. Weed scientists can improve the use of these practices for weed management by improving knowledge of four relevant ecological mechanisms. First, multispecies crop rotations, intercrops and cover crops may reduce opportunities for weed

growth and regeneration through resource competition and niche disruption. Secondly, weed species appear to be more susceptible to phytotoxic effects of crop residues and other organic soil amendments than crop species, possibly because of differences in seed mass. Thirdly, delayed patterns of N availability in LEI systems may favour large-seeded crops over small-seeded weeds. Finally, additions of organic materials can change the incidence and severity of soil-borne diseases affecting weeds and crops. Our research on LEI sweetcorn and potato production systems in central and northern Maine (USA) suggests that these mechanisms can reduce weed density and growth while maintaining crop yields. Low-external-input farming systems will advance most quickly through the application of interdisciplinary research focused on these and other ecological mechanisms.

Liebman, M., Gibson, L.R., Sundberg, D.N., Heggenstaller, A.H., Westerman, P.R., Chase, C.A., Hartzler, R.G., Menalled, F.D., Davis, A.S. and Dixon P.M. (2008) **Agronomic and economic performance characteristics of conventional and low-external-input cropping systems in the central corn belt.** *Agron.* J. 100:600–610.

Abstract

We conducted a 9-ha field experiment near Boone, IA, to test the hypothesis that yield, weed suppression, and profit characteristics of low-external-input (LEI) cropping systems can match or exceed those of conventional systems. Over a 4-yr period, we compared a conventionally managed 2-yr rotation system {corn (Zea mays L.)/soybean [Glycine max (L.) Merr.]} with two LEI systems: a 3-yr corn/soybean/small grain + red clover (Trifolium pratense L.) rotation, and a 4-yr corn/soybean/small grain + alfalfa (Medicago sativa L.)/alfalfa rotation. Synthetic N fertilizer use was 59 and 74% lower in the 3- and 4-yr systems, respectively, than in the 2-yr system; similarly, herbicide use was reduced 76 and 82% in the 3- and 4-yr systems. Corn and soybean yields were as high or higher in the LEI systems as in the conventional system, and weed biomass in corn and soybean was low (≤4.2 g m^{-2}) in all systems. Experimentally supplemented giant foxtail (Setaria faberi Herrm.) seed densities in the surface 20 cm of soil declined in all systems; supplemented velvetleaf (Abutilon theophrasti Medik.) seed densities declined in the 2- and 4-yr systems and remained unchanged in the 3-yr system. Without subsidy payments, net returns were highest for the 4-yr system ($540 ha^{-1} yr^{-1}), lowest for the 3-yr system ($475 ha^{-1} yr^{-1}), and intermediate for the 2-yr system ($504 ha^{-1} yr^{-1}). With subsidies, differences among systems in net returns were smaller, as subsidies favored the 2-yr system, but rank order of the systems was maintained.

Magesan, G. and McFadden, G. (2012) **NUTRIENT LEACHING UNDER CONVENTIONAL AND BIOLOGICAL DAIRY FARMING SYSTEMS.** Available online:

http://flrc.massey.ac.nz.ezproxy.massey.ac.nz/workshops/12/Manuscripts/Magesan_2012.pdf

Abstract

Interest in, and support for, biological farming systems is growing in New Zealand. This is because some farmers are anxious about the increased use of synthetic fertilisers that has caused both economic (e.g. increase in fertiliser costs) and environmental concerns (e.g. water quality). In the Central North Island, New Zealand, nutrient leaching has become a risk to the viability of many farming ventures as farmers are compelled to reduce nutrient losses.

The Rotorua Lakes and Land Trust (RLLT) – a joint venture between Te Arawa Federation of Maori Authorities and Rotorua/Taupo Province of Federated Farmers – is interested in exploring if biological farming systems can be used to achieve the same financial results as current farming practices while lowering nutrient leaching. Recently, the RLLT organised a national conference on biological farming systems, and announced the formation of NZ Biological Farming Systems Research Centre.

Farmers using biological farming systems have observed positive changes to soil, and improvements in plant and animal health. Scientific investigation is warranted to establish the mechanisms and processes responsible for these observed improvements in economic and environmental performance and to ensure that potential benefits can be more widely adopted.

The RLLT set up two experimental sites, one at Reporoa and one at Edgecumbe. At each site sets of 12 drainage flux-meters were installed on a biological and a neighbouring conventional dairy farm. The drainage flux-meters were used to measure amounts of drainage and nitrate concentrations in the soil water. In addition to nitrate, concentrations of ammonium, dissolved organic nitrogen and dissolved organic carbon were also measured in the soil water.

Here, we report preliminary leaching results of nitrate and dissolved organic carbon from two experimental sites. The results showed that, in general, the biological farms had significantly lower nitrate concentrations than the conventional farms in both farms. In Edgecumbe site, which had biological farming for a longer period, the leaching of dissolved organic carbon was greater in the biological farm than in the conventional farm. More research is needed in this area of biological farming systems.

Mallawatantri, A.P. and Mulla, D.J. (1992) **Herbicide Adsorption and Organic Carbon Contents on Adjacent Low-Input Versus Conventional Farms**. *Journal of Environmental Quality* Vol. 21 No. 4, p. 546-551

Abstract

Little quantitative information is available concerning the long-term impact of alternative framing practices on herbicide adsorption and soil factors that control adsorption. The objective of this study was to evaluate the effects of long-term conventional vs. long-term, low-input farming management practices on herbicide adsorption and soil properties that control adsorption at different landscape positions. Soil samples were collected at depths of 0 to 15 cm along a 350-m boundary between adjacent long-term conventional and low-input farms near Spokane, WA. These samples were characterized for soil organic C (OC) and clay contents, soil pH, and linear adsorption partition coefficients (Kd) using the 14C radiolabeled herbicides metribuzin [4, amino-6-11,1-dimethylethyl)-3-(methylthio)-1,24-triazine-5(4,1,1)-one], diuron, [3-(3,4-dichlorophenyl)-1,1-dimethylurea], 2,4-D [(2,4-dichlorophenoxy)acetic acid], and triallate [S-(2,3,3-trichloroally) diisopropylthiocarbamate]. Carbon contents were significantly higher on the low-input farm than the conventional farm at all slope positions, with values at the bottom slope position of 19.4 g kg−1 on the low-input farm and 12.2 g kg−1 on the conventional farm. Carbon contents also decreased significantly at upper slope positions, with values at the top slope of 9.0 g kg−1 on the low-input farm and 6.0 g kg−1 on the conventional farm. The Kd values for the four herbicides studied were significantly larger on the low-input farm than the conventional farm at all slope positions. Significant decreases in adsorption occurred on both farms at top-slope positions relative to bottom-slope positions. From 80 to 95% of the increase in Kd values could be explained by increases in OC contents, but the best-fitting regression line had a large negative intercept for metribuzin, 2,4-D, and diuron. We conclude from this that although the regression model may be used to estimate Kd values from measured OC contents at moderate to high values of OC, the model has no physicochemical significance and the slope of the model does not equate to a value for Koc.

Makinde, E.A. and Ayoola, O.T. (2010) **Growth, yield and NPK uptake by maize with complementary organic and inorganic fertilizers**. *African Journal of Food, Agriculture, Nutrition and Development* Volume 10, No 3

Abstract

High and sustainable crop yields in the tropics have been reported to be only possible with judicious combination of mineral fertilizers and organic amendments. Fertilizing croppings to achieve this has usually been a difficult task to achieve. The growth and yield of maize cultivated with a complementary application of organic and inorganic fertilizers was assessed

compared with sole organic and sole inorganic fertilizers between April and July 2003 and 2004 at Ibadan, Nigeria, in the degraded tropical rain forest zone. There was a no-fertilizer treatment as the control. The organic fertilizer was an equal mixture of composted domestic waste and stale cow dung, applied at 10 tonnes ha-1. Urea and Single super phosphate were applied as the inorganic fertilizer to supply 70 kg N and 13 kg P2O5 ha-1 respectively. The mixture of organic and inorganic fertilizer treatment consisted of half the rates used for sole organic and sole inorganic fertilizer treatments: 5 tonnes organic mixture was applied, with 35 kg N and 6.5 kg P2O5. Maize plant height at 8 weeks after planting was highest with inorganic fertilizer application while the leaf area was highest with organic fertilizer application. Stover yield and cob yields were also highest with inorganic fertilizer. Complementary application of organic and inorganic fertilizers however had similar plant heights; stover yield as well as cob yields with inorganic fertilizer. Nitrogen appeared chelated with organic fertilizer application. Plant ear – leaf Nitrogen was highest (1.68%) with inorganic fertilizer while the control plots had a Nitrogen content of 1.12% which was higher than 0.84% and 0.98% N from sole organic and a complementary application of organic and inorganic fertilizers, respectively. Plant P content was increased by 136% and 15% with organic and inorganic fertilizers, respectively, but was reduced by 15% with complementary application of organic and inorganic fertilizers. The K content was highest with inorganic fertilizer (1.91%). Complementary application of organic and inorganic fertilizers had a K content of 1.70% while the organic – fertilized leaves had 1.53%. Stover nutrient uptake was highest for N and K with inorganic fertilizer while the P was highest with organic fertilizer application. Cultivating maize with complementary organic and inorganic fertilizers gives a comparable cob yield as inorganic fertilizer and has nutrients higher than from sole organic fertilizer application.

Oquist K.A., Strock, J.S. and Mulla, D.J. (2007) **Influence of Alternative and Conventional Farming Practices on Subsurface Drainage and Water Quality**. *Journal of Environmental Quality* Vol. 36 No. 4, pp 1194-1204

Abstract

Agricultural runoff contributes nutrients to nonpoint-source pollution of surface waters. This study was conducted to investigate the potential use of alternative farming practices to improve water quality. The study examined the effects of both alternative and conventional farming practices on subsurface drainage and nitrogen and phosphorus loss through subsurface drainage from glacial till soils (i.e., Calciaquolls, Endoaquolls, Eutrudepts, Hapludolls) in southwest Minnesota. Alternative farming practices included organic management practices, species biodiversity, and/or practices that include reduced inputs of synthetic fertilizer and pesticides. Conventional farming practices include corn–soybean (Zea mays L.–Glycine max L., respectively) rotations and their associated recommended fertilizer rates as well as pesticide

usage. Precipitation was highly variable during the 3-yr study period including a below-average year (2003), an average year (2002), and an above-average year (2004). Results indicate that alternative farming practices reduced subsurface drainage discharge by 41% compared with conventional practices. Flow-weighted mean nitrate-nitrogen (nitrate N) concentrations during tile flow were 8.2 and 17.2 mg L^{-1} under alternative and conventional farming practices, respectively. Alternative farming practices reduced nitrate N losses by between 59 and 62% in 2002 and 2004 compared with conventional practices. Ammonium-nitrogen (ammonium N), orthophosphorus, and total phosphorus losses in subsurface drainage were very low and did not pose a substantial risk of pollution. Results suggest that alternative farming practices have the potential to reduce agricultural impacts on water quality.

Pimentel, D., Hepperly, P., Hanson, J., Douds, D. and Seidel, R. (2005) **Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems** *BioScience* 55(7):573-582.

Abstract

Various organic technologies have been utilized for about 6000 years to make agriculture sustainable while conserving soil, water, energy, and biological resources. Among the benefits of organic technologies are higher soil organic matter and nitrogen, lower fossil energy inputs, yields similar to those of conventional systems, and conservation of soil moisture and water resources (especially advantageous under drought conditions). Conventional agriculture can be made more sustainable and ecologically sound by adopting some traditional organic farming technologies.

Poudel, D.D., Horwath, W.R., Lanini,W.T., Temple, S.R. and van Bruggene, A.H.C. (2002) **Comparison of soil N availability and leaching potential, crop yields and weeds in organic, low-input and conventional farming systems in northern California**. *Agriculture, Ecosystems & Environment,* Volume 90, Issue 2, July 2002, Pages 125–137

Abstract

Increasing dependence on off-farm inputs including, fertilizers, pesticides and energy for food and fiber production in the United States and elsewhere is of questionable sustainability resulting in environmental degradation and human health risks. The organic (no synthetic fertilizer or pesticide use), and low-input (reduced amount of synthetic fertilizer and pesticide

use), farming systems are considered to be an alternative to conventional farming systems, to enhance agricultural sustainability and environmental quality. Soil N availability and leaching potential, crop yields and weeds are important factors related to agricultural sustainability and environmental quality, yet information on long-term farming system effects on these factors, especially in the organic and low-input farming systems is limited. Four farming systems: organic, low-input, conventional (synthetic fertilizer and pesticides applied at recommended rates) 4-year rotation (conv-4) and a conventional 2-year rotation (conv-2) were evaluated for soil mineral N, potentially mineralizable N (PMN), crop yields and weed biomass in irrigated processing tomatoes (Lycopersicon esculentum L.) and corn (Zea mays L.) from 1994 to 1998 in California's Sacramento Valley. Soil mineral N levels during the cropping season varied by crop, farming system, and the amount and source of N fertilization. The organic and low-input systems showed 112 and 36% greater PMN pools than the conventional systems, respectively. However, N mineralization rates of the conventional systems were 100% greater than in the organic and 28% greater than in the low-input system. Average tomato fruit yield for the 5-year period (1994–1998) was 71.0 Mg ha−1 and average corn grain yield was 11.6 Mg ha−1 and both were not significantly different among farming systems. The organic system had a greater aboveground weed biomass at harvest compared to other systems. The lower potential risk of N leaching from lower N mineralization rates in the organic and low-input farming systems appear to improve agricultural sustainability and environmental quality while maintaining similar crop yields.

Rasul, G and Gopal, B.T. (2004) **Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives.** *Agricultural Systems*. Volume 79, Issue 3, Pages 327–351

Abstract

The sustainability of conventional agriculture in Bangladesh is under threat from the continuous degradation of land and water resources, and from declining yields due to indiscriminate use of agro-chemicals. An NGO is pursuing efforts to promote ecological agriculture with emphasis on better use of on-farm resources and the reduction of external inputs. This paper examines the sustainability of two production systems in terms of their environmental soundness, economic viability and social acceptability based on empirical data collected through a household survey, soil sample analysis, observations and discussions with key informants. Twelve indicators were selected to evaluate sustainability. Significant differences were found between the two systems in crop diversification, soil fertility management, pests and diseases management, and use of

agro-chemicals. However, no significant variations were found in other indicators such as land-use pattern, crop yield and stability, risk and uncertainties, and food security. Although crop yield and financial return were found to be slightly higher in the conventional system, the economic return and value addition per unit of land did not show any difference. The findings suggest that ecological agriculture has a tendency towards becoming ecologically, economically and socially more sound than conventional agriculture, as it requires considerably less agro-chemicals, adds more organic matter to the soil, provides balanced food, and requires higher local inputs without markedly compromising output and financial benefits. Broad-policy measures, including the creation of mass awareness of adverse health effects of agrochemical-based products, are outlined for the promotion of ecological agriculture.

Wells, A.T., Chan, K.C. and Cornish, P.S. (2000) **Comparison of conventional and alternative vegetable farming systems on the properties of a yellow earth in New South Wales**, *Agriculture, Ecosystems & Environment* Volume 80, Issues 1–2, Pages 47–60

Abstract

Intensive vegetable farming has the potential to damage soil health, leading to poor productivity and large environmental impacts. This paper reports on changes in soil properties after three and a half years of vegetable cropping and discusses the implications for sustainability. A vegetable farming-systems experiment began in 1992 at Somersby, in NSW, Australia. The aim of the experiment was to compare five different approaches to vegetable cropping in terms of their productivity, profitability, soil effects and environmental impact. The experimental treatments represent whole production systems, intended to simulate real farms, but under more controlled conditions than is possible on farms. The systems are defined by the goals and values of the farmer rather than by the management practices employed. The actual management practices — nutrition, tillage, rotations, pest and weed management, etc. — were selected to satisfy these goals and values. For instance, to satisfy the goal of 'maximise profit', fertilisers and pesticides were applied in excess to ensure high yields of large, undamaged produce which receive the best prices. Conversely, one of the management practices used to satisfy the goal 'optimise profit while minimising environmental impact' was to grow cover crops regularly in rotation with vegetable crops. A range of chemical, physical and biological properties of surface soil (0–10 cm) from the farming-systems were measured and compared to baseline measurements. The two alternative systems, which received large inputs of compost, had higher soil organic carbon, microbial biomass, total nitrogen, total phosphorus, exchangeable nutrient cations, water-holding capacity and aggregate stability than the conventional systems. The system that received the largest mineral fertiliser inputs, and the most tillage, had the highest available phosphorus levels, the lowest phosphorus sorption

capacity and lower aggregate stability than the alternative systems. Consequently this high input system had the greatest potential to lose sediments and phosphorus to the environment. The two other conventional systems had smaller fertiliser inputs and maintained a phosphorus sorption capacity that was no different from the alternative systems. These more carefully managed conventional systems offer hope that relatively small changes in management can have significant environmental benefits. Yet the broad improvement in soil health achieved by the biological approaches should provide better long-term fertility and lower off-site impacts. It may be wise to make use of both these approaches to management in attempting to balance the short and long-term viability of intensive vegetable farming.