Ecological Indicators 37 (2014) 119–130

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Differences in soil quality indicators between organic and sustainably managed potato fields in Eastern Canada

Johanna E. Nesbitt[a], Sina M. Adl[a,b,*]

[a] Department of Biology, Dalhousie University, Halifax, NS, Canada, B3H 4J1
[b] Department of Soil Science, University of Saskatchewan, Saskatoon, SK, Canada, S7N 5A8

ARTICLE INFO

Article history:
Received 2 April 2013
Received in revised form 13 August 2013
Accepted 1 October 2013

Keywords:
Agro-ecosystem
Bio-indicators
Farming systems
Organic agriculture
Soil ecology
Soil quality

ABSTRACT

The aim of this study was to determine if organic management of fields promoted soil quality indicators compared to sustainably managed fields following best-management practice guidelines. Using a soil quality minimum data set, conventionally and organically managed commercial potato fields in eastern Canada were compared. Microbial biomass, testate amoebae, nematodes, and microarthropods served as bioindicators, while soil pH, C:N ratio, light fraction, bulk density, and soil moisture served as the chemical and physical indicators. We also investigated whether differences in site location (different soil texture and local climate) were more or less important than field management (organic or conventional). When site location and seasonal factors were considered, the soil quality indicators were better at differentiating organic and conventional potato fields. There was no single indicator that could clearly differentiate, on its own, between the two field managements due to variability with site location or month of sampling. Microbial biomass, testate amoebae, microarthropod and soil moisture varied significantly through the growing season. The mean soil pH, C:N ratio, and moisture were significantly different between sites. However, the indicators were affected to different degrees, and differed to some extent to both "site location" and "time of sampling". The results of this study also provide a baseline for similar soil quality evaluations in management of eastern Canada potato fields. We recommend that several indicators, including bioindicators should be used together, and that several sites should be sampled. In addition, one-time field sampling of an indicator, as it has been often practiced by growers, is likely to give false results as it does not account for variability through the growing season.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Intensification of agriculture was accompanied with increased use of synthetic fertilizers, pesticides and herbicides that has raised concerns regarding their side-effect on the environment. In reaction to this, a variety of sustainable agriculture practices have gained popularity, as well as organic agriculture as an alternative to the intensive inputs in conventional agriculture. These sustainable practices include adding organic matter to the soil, covering soil with cover crops or crop residues, reducing tillage intensity or practicing conservation tillage, using legumes within a crop rotation, implementing strip cropping, improving drainage, and avoiding compaction (Madgoff, 2001; Kennedy and Papendick, 1995). Best management practices were proposed to reduce the amount of synthetic chemicals used in conventional agriculture while maintaining acceptable levels of economic return (Hilliard and Reedyk, 2000; Korol, 2004). Organic agriculture claims to be environmentally sustainable, socially just, and economically sound production practices but prohibits using most synthetic fertilizers, herbicides, and pesticides, as well as other restrictions (Lotter, 2003; El-Hage Scialabba and Hattam, 2002; Biao et al., 2003). Increasing soil biological activity in order to maintain long term soil fertility through decomposition of the organic matter are the first priorities of organic agricultural management practices (IFOAM, 2011; Fliessbach and Mader, 2000; Biao et al., 2003). In this study we compared conventional fields under best management practise to fields under organic agriculture.

Soil quality is a key element in evaluating the sustainability of agriculture practices (Carter, 2002). By combining Brookes (1993) criteria, Doran and Parkin's (1994) criteria, and Doran and Safley's (1997) criteria, Stenberg (1999) produced a list of five essential criteria used in determining proper soil quality indicators. Because soil functions are difficult to measure, soil properties that are sensitive to change in a specific ecosystem are often used as indicators of soil quality (Stenberg, 1999; Acton and Padbury, 1993). A minimum data set is a group of soil quality indicators that are chosen based on a definition of soil quality and soil quality indicator

* Corresponding author at: Department of Soil Science, University of Saskatchewan, Saskatoon, SK, Canada, S7N 5A8. Tel.: +1 306 966 6866.
E-mail address: sina.adl@usask.ca (S.M. Adl).

1470-160X/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ecolind.2013.10.002

criteria (Larson and Pierce, 1991; Doran and Parkin, 1994; Harris et al., 1996). Modern studies have argued that physical, chemical, and biological indicators must be evaluated together in order to provide a correct assessment of soil quality (Stenberg, 1999; Wander and Bollero, 1999; Stenberg et al., 1998; Gomez et al., 2004; Schloter et al., 2003a). However, a comprehensive analysis of soil will not accurately describe soil quality unless the indicators are chosen with a specific soil function in mind, within a defined ecosystem (Janzen et al., 1992; Stenberg, 1999; Acton and Padbury, 1993). In this study, we focused on potato production within the eastern Canada Maritimes and indicators were selected accordingly.

Potatoes (*Solanum tuberosum* L.) are the third most important food crop in the world and play an important role in feeding the world's population (International Potato Center, 2011). Potato production in eastern Canada continues to increase and produces about 1,772,000 tonnes annually, and it is the main crop from this region (Agriculture Canada, 2011). However, potato nutrient demand on soil is high, and tuber quality requires both high organic matter and nitrogen availability. The intense use of synthetic chemicals, as fertilizer and pathogen control, in conventional potato production has also caused concern for the adjacent waterways and the surrounding environment (Patriquin et al., 1991). Sustained conventional potato monoculture as practised is leading to decreased output per hectare without substantially increasing chemical inputs, thus raising costs (Saini and Grant, 1980; Porter and McBurnie, 1996; Carter et al., 1998, 2003). To sustain soil fertility and production levels, more sustainable forms of potato production have been proposed (i.e. rotations and spring tillage) that would reduce production costs (Porter and McBurnie, 1996; Patriquin et al., 1991; Carter et al., 1998).

In this study we tested the hypothesis that fields under each management practice (conventional-best management or organic-management) would not be different based on indicators of soil quality. The two management practices were chosen because they are claimed to be sustainable. Potato fields were chosen because of the significance of this food crop in the region and globally. Although other soil quality studies have been conducted on potato fields in Prince Edward Island (Canada) and Maine (U.S.A.) (Carter, 2002; Porter and McBurnie, 1996; Carter et al., 2003), this is the first study to include bioindicators and to compare fields across the region. It is also the first study to compare two types of sustainable practices in potato production in the region.

2. Materials and methods

2.1. Soil sampling

Three conventional and three organic potato fields were chosen within a 150 km radius for a total of six field sites. All six sites were commercial farms, not experimental fields. Each organic field was located within a few kilometres of a conventional field. Fields were sampled in each of May, July, and September within one day of each other. For each field, soil samples were collected at three locations on a randomly selected diagonal transect across the field. Samples were taken in the middle of the potato hill, approximately 15–20 cm from the stem, to a depth of 10 cm. At each sampling location, separate samples were collected for nematode, testate amoebae, soil pH, C:N ratio, and soil moisture using a 2.5 cm soil corer, as described below. Similarly, separate samples for microarthropod, light fraction and bulk density were taken using a 5 cm soil corer, and microbial biomass was measured from a 1 kg composite soil sample. Soil samples were transported to the lab in a cooler where they were processed within 24 h of sampling.

2.2. Field sites

The first organic management field (O1) is an easily drained fine sandy loam Charlottetown series soil, but has a small percentage of easily drained fine sandy loam Alberry soil as well. The farm has been under cultivation since the mid 1900s, but was converted to organic agriculture over a seven year period (1993–2000) and was certified in 2000. Parasol 50% (copper hydroxide, fungicide) was applied twice, Bluestone (copper sulphate, fungicide) was applied twice, and Entrust (spinosad, insecticide) was applied once during the 2004 growing season. Potato tops were physically cut off at the end of the season.

The first conventional management field (C1) is an easily drained fine sandy loam of the Charlottetown series. The land has been under potato cultivation since 1942. The potato rows were seeded alongside a band fertilizer of NPK-Mg. Lorox (linuron, herbicide) was applied once, Manzate (mancozeb, fungicide) was applied six times, Ridol-Bravo was applied once, Bravo (chlorothalonil, fungicide) was applied three times, and mineral oil was applied five times throughout the 2004 growing season. Reglone (diquat dibromide (37.3%), desiccant/herbicide) was applied twice at the end of the season as a top kill.

The second organic management field (O2) is a poorly draining clay loam Washburn series soil. The farm has been in cultivation since 1980 and was certified organic in 1987. The rotation used in this field is manure, clover, potatoes, and then mixed vegetables. Parasol was applied three times and Entrust was applied twice during the 2004 growing season. A propane flamer was used at the end of the season to clean up late blight, as a final Colorado Potato Beetle control and as a top-kill.

The second conventional management field (C2) is on a poorly drained silty loam of the Interval series. The land has been under cultivation since the early 1800s. The rotation includes corn, brassica, and potatoes. Chemical applications to the field did occur but were not recorded.

The third organic management field (O3) is found on light brown sandy loam of the Torbrook series with good to excessive drainage. The farm has been under organic cultivation since 1988. The rotation consists of potatoes, two years of mixed vegetables, followed by a green manure of oats and peas which are left in through the winter and harrowed under in the spring. Floating row covers are used to speed the early stages of growth, and to avoid pests and disease.

The third conventional management field (C3) is found on sandy loam Truro series soil with good to fair drainage. Admire (imidacloprid, insecticide) and an N–P–K fertilizer were banded in furrow when the crop was seeded. An N fertilizer was also broadcast on the crop mid-growing season. Sencor (herbicide) was applied once, Bravo was applied three times, and Tatoo C (fungicide) and Cymbush (cypermethrin, insecticide/miticide) were applied once throughout the growing season. Reglone was applied once as a top kill.

2.3. Soil quality indicator measurements

Microbial biomass C was measured using chloroform fumigation-extraction according to standard procedures (Paul et al., 1999). On each sampling occasion, a composite sample of approximately 1 kg of soil was taken from each field. The soil was sieved using a 2.83 cm diameter sieve and organic particles larger than 3 mm were removed by hand. The fumigated and unfumigated extracted filtrates were stored in 50 mL falcon tubes at −20 °C until the chloroform labile C analysis was analysed with a LECO CNS auto-analyser.

Testate amoebae were stained and enumerated using standard procedures (Adl et al., 2006a) from three 2.5 cm × 10 cm deep soil

Download English Version:

https://daneshyari.com/en/article/4373257

Download Persian Version:

https://daneshyari.com/article/4373257

Daneshyari.com