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Short-term effects of cover cropping on the quality of a *Typic Argiaquolls* in Central Ohio

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ABSTRACT

Quality of agricultural soils is influenced by different management practices. The purpose of conducting on-farm field research is to come up with fact-based answers to farming's challenging questions and this type of research targets "real world" data that are typically more variable than smaller fields used for small-plot/small-scale research. Therefore, the objective of this study was to assess the immediate (one year) impacts of pea (*Pisum sativum*) and turnip (*Brassica rapa rapa*) as cover crops on properties of a Kokomo silty clay loam soil (*Fine, mixed, superactive, mesic Typic Argiaquolls*) in Central Ohio under on-farm conditions. A range of soil parameters were tested for soil sampled from four depths (0–10, 10–20, 20–40 and 40–60 cm) after the first season of cover cropping and before seeding of soybean (*Glycine max*) in 2013. Data indicate that only few soil parameters were significantly affected by the cover crop treatment. For 0–10 cm depth, cover crops significantly decreased pH from 6.7 to 5.7 and increased soil organic C (SOC) concentrations from 2.3 to 2.5% (g 100 g^{-1}). Although cover crops did not have any significant effects on other soil properties, however, there were trends of lower field dry bulk density (BD) and water stable aggregates (WSA) in 0–10 cm depth under the cover cropping system (BD: 1.3 Mg m^{-3}, WSA: 72%) than those of control (BD: 1.5 Mg m^{-3}, WSA: 80% in 0–10 cm), and similar observations were found for deeper soil layers. The lack of significant effects on other soil properties may be due to high field variability and short duration under cover cropping. Similarly, soybean grain yield was not significantly impacted by the treatment but yield was slightly higher under cover crop (4.6 Mg ha^{-1}) than under control (4.3 Mg ha^{-1}). These data suggest that some improvements in soil characteristics are likely even over a short period under an appropriate cover crop, however, longer-term data are needed to see whether or not these trends are transient.

1. Introduction

Establishing a cover crop between two growing seasons is a management strategy to cover the soil surface, protect it against water and wind erosion, and prevent nutrient loss by leaching (Reeves, 1994). Other beneficial impacts of establishing cover crop include weed suppression, carbon (C) sequestration and pest management (Dabney et al., 2001; Reicosky and Forcella, 1998). Winter cover crops, grown during the fallow period, may improve soil properties and crop-yield (Hermawan and Bomke, 1997; Kuo et al., 1997; Ritter et al., 1998; Roberson et al., 1991). For example, a 10-year field experiment with annual winter cover crops of wheat (*Triticum aestivum* L.), and hairy vetch (*Vicia villosa Roth*) significantly increased cotton (*Gossypium hirsutum* L.) yield compared to the field under native vegetation (Boquet et al., 2004). Similarly, rye (*Secale cereale* L.), hairy vetch and crimson clover (*Trifolium incarnatum* L.) significantly increased soil organic C (SOC) and N concentrations compared to those under control without a cover crop (Sainju et al., 2002). However, while hairy vetch and clover significantly increased the yield of tomato (*Lycopersicon esculentum* Mill.) and eggplant (*Solanum melongena* L.) throughout the years, rye either significantly decreased the crop yield compared to control or the differences were not statistically significant, demonstrating the dependence of crop-yield on the choice of cover crop (Sainju et al., 2002).

There are few data documenting impacts of short-term (1–3 years) cover cropping on soil quality. For example, growing barley (*Hordeum vulgare* L.) in Spain (Pérez-Álvarez et al., 2013) and rye in Netherlands (Schröder et al., 2013) reduced nitrate leaching, establishing oat and vetch in California, USA, increased SOC concentration (Hu et al., 1997), and cover cropping with rye and barley increased the mean weight diameter (MWD) of aggregates albeit with notable seasonal variations depending on soil water content at the time of sampling in British Columbia, Canada (Hermawan and Bomke, 1997). While changes in soil structural properties have been observed under short-term cover cropping, there are a few data on the effects on crop yield. For example, corn dry biomass and grain yield were significantly increased by 2-years of rye, crimson clover, and hairy vetch compared to those under fallow, but yield-enhancement was the strongest with leguminous (crimson clover, and hairy vetch) than non-legume (rye) cover crop indicating the importance of N-fixation in North Carolina (Wagger, 1989). Similarly,

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1-year of winter wheat and dandelion (*Taraxacum officinale*) significantly increased shoot dry weight and grain yield of corn compared to fallow without a cover crop in Pennsylvania (Kabir and Koide, 2000). Another short-term study indicated that corn (*Zea mays*) yield was significantly increased under vetch, but was the lowest under rye in Maryland (Clark et al., 1994). On the contrary, no significant difference in corn yield was observed between rye cover crop and non-cover crop treatments in a 3-year study suggesting variability in yield based on soil types and micro-climate in Delaware (Ritter et al., 1998).

Although positive impacts have been observed even with short-term cover cropping, several studies have indicated several risks to soil quality and subsequent crop yield. Four main risks involved with cover cropping are: (i) loss of land for cash crops, (ii) immobilization of soil N, if C/N ratio of the cover crop biomass is ~25 (Wyland et al., 1996), (iii) increase in incidence of weeds and other pests, if not adequately managed, and (iv) cost of growing versus buying N. Thus, it is important to understand the effects of cover crop on soil quality and associated crop yield during the initial years, i.e., short-term effects of cover crop under specific soil type and management. Additionally, the purpose of conducting on-farm field research is to come up with research which targets “real world” data that are typically more variable than smaller fields used for small-plot/small-scale research. Therefore, the present study was conducted to test the hypothesis that some soil properties [e.g., pH, bulk density (BD) and SOC concentrations] will be changed following short-term cover cropping compared to those under control on-farm conditions. Specific objectives of this study were to assess crop performance after one year of cover cropping and effects on soil quality parameters in Central Ohio.

2. Materials and methods

The experiment was conducted under on-farm conditions, i.e., from farmers' owned fields in Franklin county, Ohio (40°00′41.2″N, 83°12′23.1″W). The annual average temperature in the studied zone is 52.6 °F and 40.0 in., respectively (US climate data: http://www.usclimatedata.com/climate/franklin/ohio/united-states/usoh0323, accessed on November 10, 2014). Soil of the experimental site is classified as Kokomo silty clay loam (Ko: *Fine*, *mixed*, *superactive*, *mesic Typic Argiaquolls*) and samples were collected from two adjacent lands under the same soil type (Fig. 1) but different management practice: cover crop and no cover crop (discussed in the following). The site had been cultivated by no-till (NT) practice under corn and soybean (*Glycine max* L.) annual rotation. However, a mixture of pea (*Pisum sativum* L.) and turnip (*Brassica rapa* L.) with the seeding rate of 140 kg ha^{-1} was seeded by the broadcasting method prior to growing soybean in 2013 after previous year corn. Thus, treatments tested in the on-farm experiment included soil with no-cover-crop (NCC) and soil with 1-year of cover-crop (CC) and triplicate soil samples were collected for each management practice. In other words, one set of samples was taken at each of the three locations indicated on the map (Fig. 1). The NT plots received previous year's crop-residues of 9.8 ± 1.8 Mg ha^{-1} and were grown to a winter cover crop. Roundup-ready variety of soybean (Monsanto Inc.) was seeded on April 20th, 2013 and was harvested on September 30th, 2013, which took couple of days. Row spacing of 15 in. was used during planting and dry granular N as fertilizer (although this is not much common practice for soybean in the region) and glyphosate (roundup) herbicide were added at the rate of 150 lb acre^{-1} and 28 oz acre^{-1}, respectively. The overall growth of cover crops was sufficient for the purpose under this management and cover crops were terminated by herbicide before winter. The harvest index (HI) of soybean was calculated as ratio of dry grain yield and dry biomass (Hay, 1995). Soil core (diameter: 4.7 cm, height: 4.9 cm) and bulk samples were collected before planting soybean from four depths (0–10 cm, 10–20 cm, 20–40 cm, and 40–60 cm). Soil BD was determined by the core method (Grossman and Reinsch, 2002). A minimum of three penetration resistance (PR) measurements were made for all depths using a CP40II cone penetrometer (Herrick and Jones, 2002) and values were reported after moisture correction (Blanco-Canqui et al., 2011). Bulk samples were air dried at room temperature. A part of the bulk sample was sieved through 8 and 5 mm sieves to obtain aggregates of 5–8 mm size. The remaining sample was gently ground and sieved through a 2 mm sieve for other laboratory measurements. Proportion of water stable aggregates (WSA) was determined on the 5–8 mm fraction by the wet sieving method (Yoder,

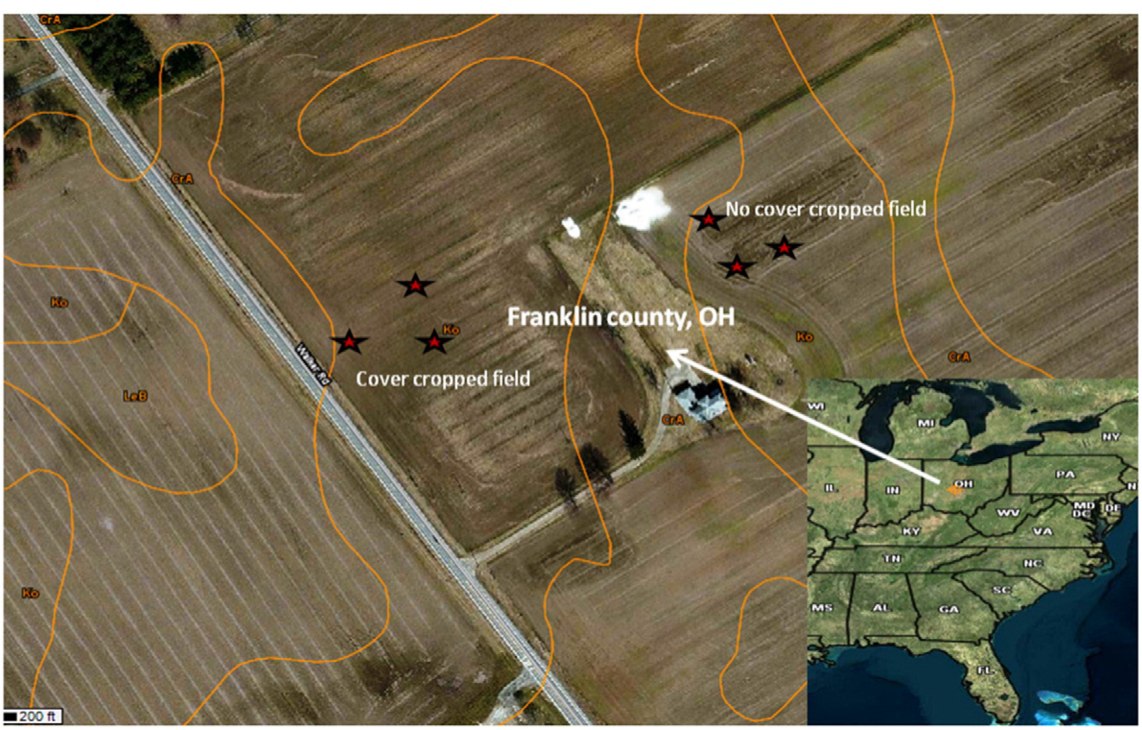

Fig. 1. Sampling locations of Franklin county, Ohio (inset: Boundary locations of adjacent states with indication of the actual location of sampling in Ohio), Ko: Kokomo silty clay loam soil.