Sheep Manure Improves the Nutrient Retention Capacity of Apple Orchard Soils

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INTRODUCTION

The tree fruit industry has been rapidly developed in the last decade in China. Most of the new orchards were established in mountainous areas, and the orchard soils are usually shallow, sandy and infertile. The soil nutrient and water supply, in most case, cannot satisfy the demand of trees, and therefore tree growth and development is hindered (Shu 1998). Coarse soil structure also results in serious leaching loss of applied chemical fertilizers and irrigation water, which not only increases the production cost, but also causes environmental problems. Improving soil fertility including soil nutrient retention capacity are challenges for the orchard management.

It has been found that application of organic amendments can improve physical and chemical properties of soil and increase soil nutrient and water-holding ability and crop production (Martens and Frankenberger 1992, Turner et al 1994, Dong et al 1997, Zebarth et al 1999, Moskal et al 2001, Whalen et al 2002, Yamada 2002). Soil organic amendments reduced soil bulk density, promoted the formation of organic-inorganic colloid, stabilized soil aggregates and increased bioactivity. There are various soil organic amendments available for the local growers such as animal manures, municipal biosolids, crop straws and industrial wastes. The objective of this study was to determine effects of sheep manure on soil fertility with an emphasis on soil nutrient retention capacity.

MATERIALS AND METHODS

Two experiments were designed in this study:

Experiment 1: A coarse-sandy soil orchard was selected in Taian, Shandong, China with three-year-old ‘Starkrimson’ Red Delicious/*Malus hupehensis* Reld apple trees. Forty-eight uniform trees were selected in a north-south orientation block and divided into 18 plots with 3 trees per plot. Sheep manure at rate of 0, 15 and 30 MT/ha was, respectively, applied to soil surface under the canopy with 6 plots (replicates) for each rate (treatment) in the early spring of two consecutive years. The manure was manually mixed into the top soil with a rake. Leaves and root-zone soil (0-30cm) were, respectively, sampled in May, June, July, August and October for analyses of leaf N status, and soil organic matter (OM) and cation exchange capacity (CEC). Leaf N was determined by Kjedahl method (Schuman et al, 1973). Soil organic matter and CEC were determined as described in the handbook *Physical and Chemical Analysis of Soils* (1978).

Experiment 2: Soil from the same orchard as in Experiment 1 was taken and mixed sheep manure at rate of 0, 15 and 30 MT/ha, and the mixture was incubated in 4-liter pots under room temperature (22±2.5^{o}C) with 6 replicates for each rate (treatment). One-gram urea dissolved in water was applied to each pot and all pots were watered to nearly field capacity (but not leaching) at the start of the incubation. Sixty days after incubation, pots were leached with different amounts of water equal to 0, 2, 4, 6, 8 and 10mm rainfall. Then soil available N was extracted with 0.5M NaHCO3 and analyzed by Kjedahl method (Schuman et al, 1973).

RESULTS AND DISCUSSIONS

Soil Organic Matter and CEC

The orchard soil in the experiment had very low soil organic matter (around 0.6% based on soil dry weight). Sheep manure significantly increased soil organic matter (OM), and there was a positive relationship between amounts of manure applied and soil OM contents (Fig. 1). Application of 15 and 30 MT/ha sheep manure, respectively, raised soil OM levels from 0.6 to 2.3% and 3.6%. In response, soil CEC was also increased by sheep manure application (Fig. 2). Application of 15 and 30 MT/ha sheep manure, respectively, raised soil CEC from 5.7 to 13.5 and 19.5 meq/100g soil. There was a significant positive relationship between soil OM content and CEC (Fig. 3). Soil available N increased from 57.6±6.5 to 157±12.3 and 205±15.6 μg/kg, respectively, by the application of 15 and 30 t/ha sheep manure.

Soil Nutrient Retention Capacity

As soil OM and CEC increased by the application of sheep manure, soil nutrient retention capacity increased. The incubation-leaching experiment (Experiment 2) showed that soil available N negatively related to amount of leaching water (Fig. 4). The application of sheep manure increased soil anti-leaching ability and soil available N was significantly raised by the manure application after leaching process at each ‘rainfall’ level. Available N was leached out rapidly in control soil with water equal to 2-4mm ‘rainfall’ but manure-mixed soil did not show much leaching until amount of water equal to 8-10mm ‘rainfall’ (Fig. 4).

Plant Nutrient Status

Application of sheep manure improved plant nutrient status. Leaf N concentration was significantly increased by the manure application, but there was no significant difference in leaf N between the two application rates (15 and 30 MT/ha) in this experiment (Fig. 5). This suggested that the rate of 15 t/ha supply enough available N for the plant during the course of the experiment. Other nutrients such as P and K were also improved by the sheep manure (data not showed).

CONCLUSIONS

1. Sheep manure application increased soil organic matter and soil cation exchange capacity, and therefore the soil nutrient retention capacity was increased.
2. Sheep manure application increased soil available N and improved plant N status.

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Figures

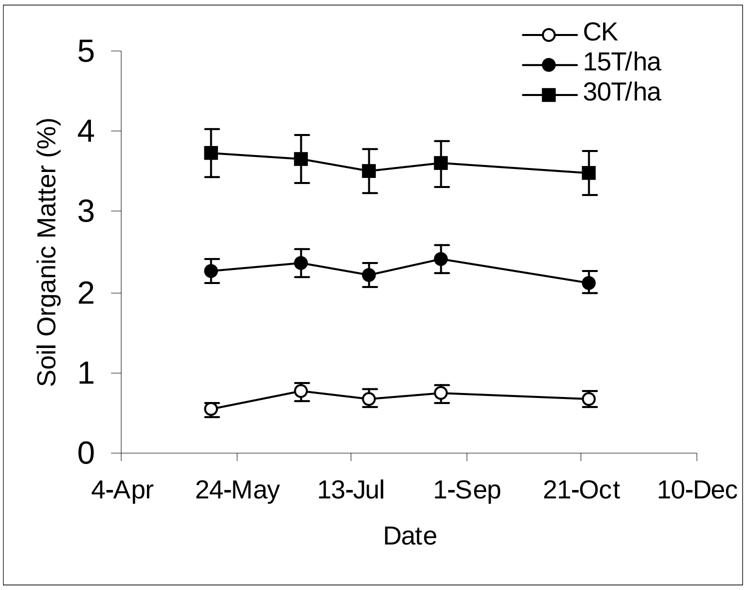

Fig. 1. Annual change of soil organic matter following sheep manure application in a coarse sandy orchard soil in Taian, Shandong, China.

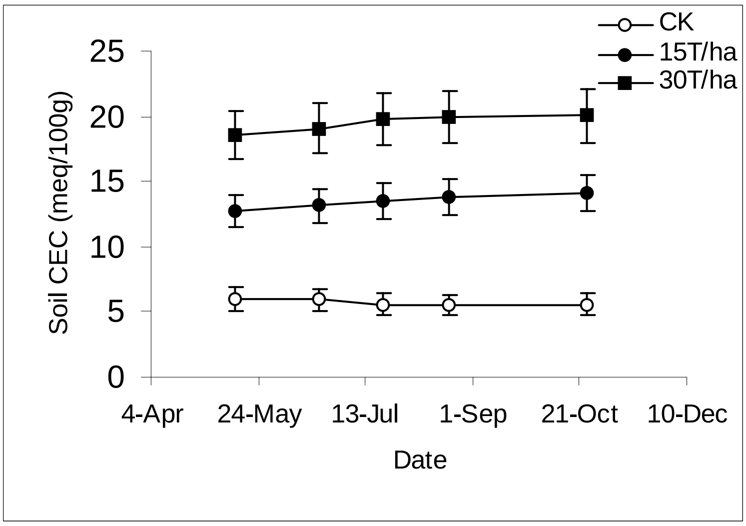

Fig. 2. Annual change of soil cation exchange capacity following sheep manure application in a coarse sandy orchard soil in Taian, Shandong, China.

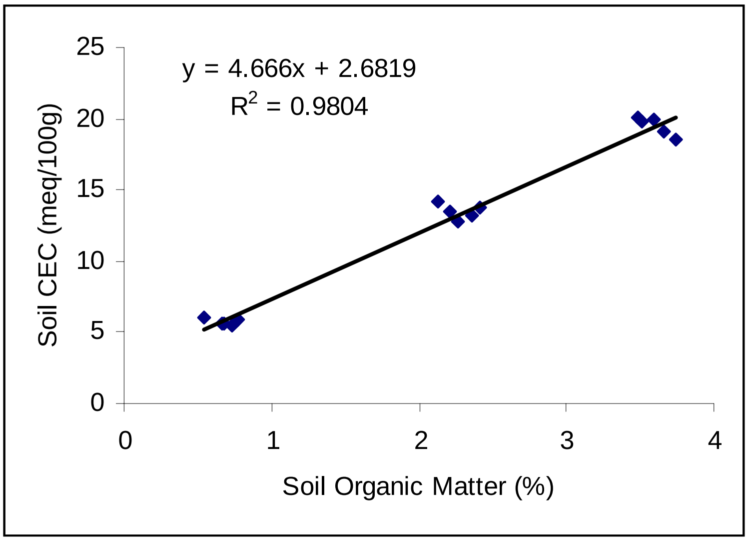

Fig. 3. Relationship between soil organic matter and cation exchange capacity following sheep manure application in a coarse sandy orchard soil in Talan, Shandong, China.

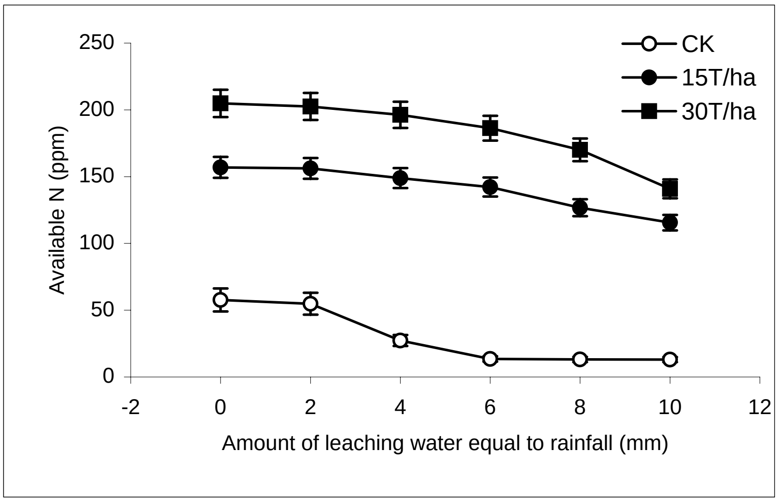

Fig. 4. Relationship between soil available N after leaching and amount of leaching water following sheep manure application in a coarse sandy soil in Taian, Shandong, China.

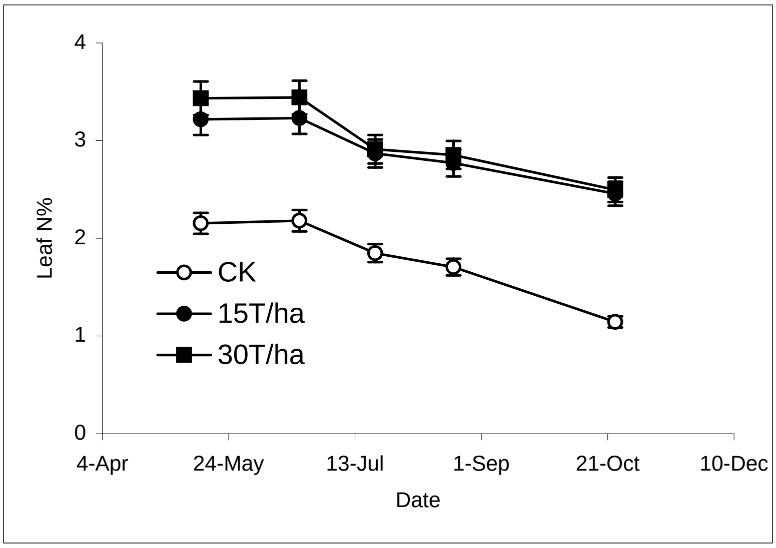

Fig. 5. Annual change of leaf N of three-year-old ‘Starkrimson’ Red Delicious/*Malus hupehensis* apple tree following sheep manure application in a coarse sandy orchard in Taian, Shandong, China.