Compost effects on soil properties and plant growth

A thesis submitted to the University of Adelaide in fulfilment of the requirements for the degree of Doctor of Philosophy

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March 2013

Dedicated to my father, Duong Ba Dong and my mother Nguyen Thi Kim Sanh

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Statements of Authorship

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ACKNOWLEDGEMENTS

I would never reach this successful accomplishment of the project without help and encouragements of my parents, the engineers of my wisdom; who have sacrificed their today for my better future and I really wish to live up their expectations with my best. My husband Lam and my children, TiTi and Tony are my pillars of support, strength and inspiration.

I wish to express my pronounce gratitude to A/Prof. Petra Marschner, my principal supervisor, for her enormous encouragement and professional help throughout the project which helped me somehow develop a scientific vision and thrive for becoming an emerging scientist. Petra, I could feel your persistent struggle when you have tried to broaden my mind scientifically and correct my broken English as well. I have highly appreciated what you have done for me.

I am also extensively thankful to my other supervisors Dr. Chris Penfold and David Chittleborough for their extended help, valuable suggestions and discussions along the completion of the project.

My gratitude is also to Rubber Research Institute of Vietnam, particularly Director Lai Van Lam, for your unwavering and endless support.

I lovingly acknowledge my siblings, Le, Anh, Ai, Thi, their husbands and wife and their kids for their unconditional support to keep me go through any difficulties, ups and downs during my candidature.

My acknowledgement is also to Colin Rivers, Hasnuri Mat Hassan, Suman Lata Verma and my group members for your patient listening, sharings and help with my lab work. Last but not least, thanks are due to my Vietnamese friends at Waite Campus, my RRIV colleagues; and to one and all those who happily helped me directly and indirectly throughout my project.

ABSTRACT

Compost production is considered an economic and environmentally friendly means to reduce the waste going into landfill. Compost application can improve soil quality and productivity as well as sustainability of agricultural production by replenishing soil organic matter and supplying nutrients. Organic matter is a vital component of a healthy soil as it plays an important role in soil physical, chemical and biological fertility. In this project, four experiments were conducted to assess the effect of compost mulch on soil properties and plant growth and nutrient uptake as influenced by compost composition and particle size, soil type and time after application.

The first experiment was carried out using four composts from various feedstocks applied as mulch to a sandy loam. Their effect on soil properties, plant growth and nutrient uptake was assessed after 2, 4, 6, 9, 13 and 18 months. The composts were C1 and C2 (from organic fraction of municipal solid waste); C3 (from manure); C4 (from straw and manure). A soil without compost amendment was used as control. At each sampling date, the soil was sampled after removing the compost mulch and the remaining soil was planted with wheat; plant growth and nutrient uptake were determined after 4 weeks. The coarse-textured compost (C2) had the least effect on nutrient availability and plant growth despite moderate concentrations of available N and P in the compost. However, its total N and P concentrations were low which, together with the coarse texture resulted in low mobilisation rates. The other three composts increased soil aggregate stability and water holding capacity although there was no measurable increase in soil organic C, suggesting that the improved soil structure was due to microbial activity (bacterial slimes, fungal hyphae). These three composts also increased soil N and

P availability, plant growth and nutrient uptake with N and P availability increasing over time whereas plant growth was maximal after 4 months. The increased soil nutrient availability was due to two mechanisms: either release of P and N already present in available form in the composts or mobilisation of the nutrients during the experiment which varied with compost type.

Despite the fact that the beneficial effects of compost on soil properties are generally well-known, there are few systematic studies comparing the effects of composts on soils of different texture. The second experiment was conducted to assess the effects of two types of composts derived from different feedstocks: C1 (from garden waste) and C2 (from agricultural residues and manures) applied as mulch on three soils with different clay content (46%, 22% and 13%, hereafter referred to as S46, S22 and S13) on soil properties as well as on plant growth and nutrient uptake. Wheat plants were grown for 35 days and to grain filling (70 days). The soil was sampled after removal of the mulch layer. The composts reduced the soil pH by 0.3-0.7 units and slightly increased total organic C compared to unamended soil. Soil respiration was highest in S13, and at grain filling it was greater in soil amended with C2 than that amended with C1 and the non-amended soil. The addition of compost significantly increased soil cation exchange capacity (CEC) in S22 and S46, but not in S13 which had the lowest CEC among the soils. C2 increased the available P concentration and macro-aggregate stability in all soils compared to C1 and the unamended soil. Compost addition increased available N in S46 and S22 compared to the unamended soil with a stronger effect by C1. Both composts increased wheat growth and shoot P concentrations with the effect of C2 being greater than that of C1. Generally, the effect of soil type was greater than that of compost type. It is concluded that the

effect of composts on soil properties and plant growth is strongly affected by soil properties.

There are few studies in which the effect of several composts applied as on soil properties and plant growth has been studied under controlled conditions. To address this knowledge gap, a third experiment was carried out with six types of composts applied as mulch on two soils (13% and 46% clay, referred to as S13 and S46). Wheat was grown and harvested at 42 days and at 77 days (grain filling). Composts differed in total and available N and P and particle size with C1, C3, C4 and C5 being fine-textured, whereas C2 and C6 were coarse-textured. Compost addition increased soil TOC and EC, but had no effect on pH. In all treatments, cumulative soil respiration was higher in S13 than in S46 and was increased by compost addition with the greatest increase with C2 and C6. Compared to the unamended soil, most composts (except C2) increased macroaggregate stability. Compost mulches significantly increased available P and N in both soils, except for C2. Compost mulches increased available N concentrations up to 6-fold in both soils with the strongest increase by C5. Most composts also increased wheat growth and shoot P and N concentrations, except C2 which decreased shoot N and P concentrations compared to the unamended soil. Most composts (except C2) increased mycorrhizal colonization by up to 50% compared to the unamended soil. It can be concluded that fine-textured compost mulches generally had a greater effect on soil properties and plant growth than coarse-textured composts. In this experiment, a given compost had similar effects in both soil types.

In most studies to date, compost effects on soils have been studied in the bulk soil without considering the distance from the compost. This distance could be

important because the effects are likely to be greater in the immediate vicinity compared to further away. Thus by taking a bulk soil measurement, one may underestimate the effect in immediate vicinity of the compost whereas the effect in greater distance is overestimated. A fourth experiment was carried out to assess the effect of compost on soil properties in their immediate vicinity. This experiment was also used to assess the changes in nutrient concentrations withing the composts. Three composts from different feedstocks: C1 (from animal manures) and C2 and C3 (from the organic fraction and municipal solid waste) were applied as a layer which was separated from the soil by a mesh. Microcosms without compost served as controls. Microbial and chemical properties of the soil were determined at 0-5 and 5-10 mm distance from the mesh after 30 and 63 days. During the 63 day incubation, the total C, N and P and available N concentrations in the composts decreased whereas the available P concentration increased. The composts induced higher microbial biomass and activity, total organic C and available N and P concentrations up to 10 mm into the surrounding soil with greater effects after 30 than after 63 days. The nutrient concentrations were generally greater in soil adjacent to the two finer-textured composts with the higher nutrient concentration (C1 and C3) than in the coarser-textured compost (C2) which had lower nutrient concentrations. The 0-5 and 5-10 mm layers did not differ in most of the measured properties except for greater soil respiration and N and P availability in the 0-5 mm layer. It can be concluded that composts affect soil properties up to 10 mm distance but that the greatest effect on microbial activity is limited to the first 5 mm.

The experiments showed that compost properties, particularly particle size and nutrient concentration determine the effect of compost on soils. Finer composts

have greater effects than coarse-textured composts. Nutrients released from composts may derive from the nutrients already available in the composts or may become mobilised after compost application. Compost effects were modulated by soil type and changed over time.

DECLARATION

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Tra Thi Thanh Duong Date: 05/09/2013

LIST OF PUBLICATIONS

Tra T. T. Duong, Chris Penfold., Petra Marschner, 2012. Time-dependent effects of different composts on soil properties, plant growth and nutrient uptake. Paper submitted to Journal of Plant Nutrition and Soil Science.

Tra T. T. Duong, Chris Penfold, Petra Marschner, 2012. Differential effects of composts on properties of soils with different textures. Biology and Fertility of Soils (48): 699-707

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