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Variation in urease and β-glucosidase activities with soil depth and root density in a 'Cripp's Pink'/M7 apple orchard under conventional and organic management

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The effects of conventional (CON; utilising synthetic fertiliser and herbicide) and organic (ORG; nutrients supplied in compost, weeds controlled with straw mulch) orchard floor management practices on depth-wise variation in urease and β-glucosidase activities in tree-row soils were compared in a Western Cape 'Cripp's Pink'/M7 apple orchard. Urease and β-glucosidase activities were determined spectrophotometrically in soils from five depth intervals from the walls of trenches excavated across the tree rows after seven years of treatment application. Soil pH, organic carbon, nitrate (NO_3^-) and ammonium (NH_4^+) nitrogen were also determined, as was root density. Enzyme activities were higher in the ORG than the CON topsoils but did not differ significantly ($p = 0.05$) at depths >30 cm. The positive effects of the ORG treatments were attributed to the liming effect and carbon and nitrogen contributions of the compost. Urease and β-glucosidase activities correlated strongly. Activities of both enzymes correlated significantly and positively with carbon, NO_3^- and pH: urease more strongly than β-glucosidase. Only urease correlated with root density. Organic orchard floor management practices may be more effective than CON practices in promoting microbial enzyme activities in the 0–30 cm soil depth intervals of Western Cape apple orchard soils.

Keywords: compost, fertiliser, herbicide, root density, straw mulch

Introduction

Nutrient supply and weed control are critical aspects of orchard floor management in Western Cape apple orchards. Whereas synthetic fertilisers and herbicides are used for these respective purposes in conventional (CON) orchards, nutrients are supplied in compost and mulch is used to control weeds in organic (ORG) orchards (Wooldridge et al. 2013a). Compared with topsoils, which have greater microbial loads and are the sites of higher rates of organic decomposition and mineralisation than subsoils (Bardgett et al. 2005), microbial communities in the deeper soil material are poorly researched (Rumpel and Kögel-Knabner 2011; Kramer et al. 2013). Because the root systems of deciduous fruit trees commonly extend to depths >60 cm in well-prepared soils (Wooldridge et al. 2013b), information concerning microbial activity in the lower rootzone is also required. Both the quantity and quality of metabolisable organic carbon (C) substrate decrease with increasing depth (Blume et al. 2002; Bausenwein et al. 2008; Gelsomino and Azzellino 2011). Irrespective of depth, populations of soil microorganisms are greatest in zones where access to nutrients is easiest (Schütz et al. 2009). Densities of microorganisms in soil profiles therefore reflect gradients in mineralisable substrates (Bossio and Scow 1998; Griffiths et al. 1999; Schütz et al. 2009). Soil factors that affect microbial populations also affect the availability and activity of enzymes produced by those microorganisms (Sinsabaugh et al. 1993; Paul and Clark 1996; Kramer et al. 2013). β-glucosidase and urease facilitate cycling of C and nitrogen (N), respectively. Activities of these enzymes are sensitive to management-induced changes in the soil (Masciandaro and Ceccanti 1999; Caravaca et al. 2002). Notable variables are soil pH (Perucci et al. 2000; Makoi and Ndakidemi 2008; Das and Varma 2011), temperature (Zogg et al. 1997), moisture (Kieft et al. 1993; Lundquist et al. 1999; Schimel et al. 1999), and rhizo-deposition of root exudates reflecting vertical gradients in root distribution (Smalla et al. 2001; Yao et al. 2005).

Topsoils experience greater and more rapid variation in temperature and moisture content than subsoils (Brady and Weil 2002). Microbial communities in topsoils under orchard tree rows that are kept weed-free with herbicides and exposed to sunlight should therefore differ from those in mulch-covered topsoils (Tisdall et al. 1984; Hogue and Neilsen 1987). Variability in soil moisture and temperature, and rate of degradation of organic material decreases with increasing depth. The effects of contrasting soil management practices on microorganisms and enzyme activities are therefore also likely to decrease with increasing depth. Potentially, soil management-induced changes in the dynamics of soil organic matter, and in root distribution and exudate production, may be reflected by the activity levels of soil enzymes (Badiane et al. 2001; Moore-Kucera and Dick 2008). Management systems that facilitate decomposition, nutrient cycling and nutrient retention should