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Impact of reduced tillage on soil organic carbon and nutrient budgets under organic farming

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Abstract

No-tillage (NT) and reduced tillage (RT) systems are well-known management tools for reducing soil erosion and improving soil fertility. NT and RT may improve the environmental and economic performance of organic farming, but they are still not common practice among organic farmers. This paper presents the effects of tillage [RT versus conventional tillage (CT)], fertilization (slurry versus manure compost) and biodynamic preparations (with versus without) on soil fertility indicators such as soil organic carbon (C_{org}), microbial biomass and microbial activity, soil nutrients and nutrient budgets in an organic farming system during the first six-year crop rotation period of a long-term experiment on a clayey soil in a temperate climate. RT caused stratification of soil organic carbon (C_{org}), microbial properties and soil nutrients in the soil profile. Under RT, C_{org} in the 0–10 cm soil layer increased from 2.19 to 2.61% (w/w) from 2002 to 2008, whereas it remained constant under CT. In both tillage treatments, C_{org} remained constant in the 10–20 cm soil depth. Microbial biomass C increased by 37% under RT in the 0–10 cm soil depth and microbial activity [dehydrogenase activity (DHA)] was enhanced by 57%. Soil microbial biomass C and DHA in the 10–20 cm soil depth were also higher under RT (+10 and +17%, respectively). Soluble soil P and K were 72 and 40%, respectively, higher in 0–10 cm soil depth under RT when compared with CT. Fertilization showed no effects on the measured soil properties. Biodynamic preparations increased solely the C_{mic}-to-N_{mic} (soil microbial biomass C to soil microbial biomass N) ratio by 7% in the 0–10 cm soil depth. Nutrient budgets for P were balanced in all treatments, but N and K exports were higher under RT compared to CT. We conclude that RT is a suitable method for increasing indicators of soil fertility in organic farming systems. The combined effects of RT and an organic farming system with a diverse, ley-based crop rotation and organic fertilization merit further promotion and it may be considered for supporting actions by the agricultural policy schemes.

Key words: conservation tillage, soil fertility, organic fertilization, biodynamic preparations, nutrient budget, soluble soil nutrients

Introduction

Soil erosion and other forms of soil degradation are major problems facing agriculture today. Soils are not renewable over a human timescale. Most arable soils are prone to degradation, mainly caused by soil mismanagement. The degradation processes are more dependent on 'how' rather than on 'what' crops are grown[1], highlighting the importance of sustainable soil and crop management.

No-tillage (NT) and reduced tillage (RT) systems are well-known management tools for preventing soil erosion and conserving soil fertility[2]. A positive effect on soil organic carbon (C_{org}) contents in the superficial soil layer has frequently been reported[2–7], whereas the effects on C_{org} in the whole profile are still a matter of controversy[8]. NT and RT cause a stratification of C_{org} and microbial properties in the soil profile[3,6,9,10]. The intensity of tillage operations in RT and the amount and management of above-ground crop residues affect the degree of stratification. Total N, organic N, mineralizable N, P and K usually follow the same pattern with a concentration in the surface layer and no change or decrease below[10].