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Tillage-induced Soil Properties and Chamber Mixing Effects on Gas Exchange

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Abstract: Agricultural ecosystems can play a significant role in the production and consumption of greenhouse gases, specifically carbon dioxide (CO_2) from tillage. This work evaluated effects of tillage-induced changes in soil properties on CO_2 and H_2O loss as measured by a portable dynamic chamber. Information was collected three times per second to characterise dynamic pressure at the soil surface and wind speed (measured 2 cm above the soil surface) with one or four chamber fans operating during the 30 s measurement period. A chamber was used to characterise CO_2 and H_2O losses from a 5.5 m-wide ploughed strip perpendicular to the prevailing wind. Fluxes of CO_2 were high immediately after mouldboard plough (MP) tillage and decreased with time. Short-term tillage-induced CO_2 losses measured with a large chamber using different air mixing rates independently verified turbulent mixing and pressure effects on CO_2 and H_2O losses. Fan number had greater effect on the CO_2 and H_2O fluxes from freshly tilled surfaces compared to surfaces not tilled (NT). Fluxes were lower with only one fan operating (press. = -0.39 Pa), compared to four fans (press. = –1.62 Pa) operating suggesting that increased negative dynamic pressure enhanced the flux. The magnitude of the increase was related to tillage-induced changes in soil properties. The results suggest caution when interpreting and extrapolating chamber-measured fluxes. While the absolute magnitude of the fluxes may be in question, the relative flux difference for different tillage treatments likely reflects the relative carbon (C) loss. Higher gas exchange occurred from MP versus NT when soil air permeability was more sensitive to convective pressure fluctuations. The tillage-induced change in soil properties led to short-term CO_2 losses that were higher than those from undisturbed soil. Changes in surface soil properties caused by tillage combined with the aerodynamic pressure forces associated with natural wind movement over the soil can result in substantial CO_2 loss. The large differences in CO_2 and H_2O loss between MP and NT treatments were likely caused by tillage in combination with wind speed effects in the chamber. The results demonstrated a need for better understanding of chamber effects, improved soil management and policies that favour less intensive conservation tillage to minimise C loss and increased C sequestration in agricultural production systems.