The difference in biochar application depths affects nitrate leaching and water budget

The Haber–Bosch process enables humanity to produce nitrogen fertilizer, allowing the population to grow by increasing food production. However, the global nitrogen cycle is disturbed beyond the planetary boundary. Nitrogen applied as fertilizer often leaches from farmland in nitrate form, moving into the groundwater, rivers, and other water bodies and polluting the surrounding environment. Therefore, mitigating nitrogen leaching is urgently required. Biochar has been applied to farmlands to mitigate leaching while storing carbon. The effect of biochar application differs depending on the application depth; however, the effect of the application depth remains unclear. This study aimed to evaluate the effects of the biochar application depth on nitrogen leaching and soil water conditions.

We conducted a pipe experiment with no plant using bagasse biochar (800 °C) with four treatments: no biochar application (control), surface application (0 – 5 cm), plow layer application (0 – 30 cm), and subsurface application (25 – 30 cm). The experiment was conducted in a glass room. The amount of applied biochar was the same among the treatments (10 t ha^{-1}). Biochar content rates (expressed as weight ratios) in the biochar amendment layer were 1.57% for surface/subsurface application and 0.26% for plow layer application. Surface irrigation was conducted every two or three days, and powdered fertilizer was applied monthly. We measured the amount of drainage and nitrate leaching during the experiment. The results showed that the drainage and nitrate leaching amounts differed depending on biochar application depths. Nitrate leaching tended to be reduced by surface application, whereas drainage and leaching were reduced by plow layer application. Subsurface application did not alter drainage and leaching. We estimated the water budget for each treatment. Compared with the control, soil evaporation tended to reduce under surface application, whereas it tended to increase under plow layer application.

Our study indicated that, although the same amount of biochar was applied, the effect of biochar application differs depending on the application depth. Surface and plow layer applications reduced nitrate leaching; the change in soil moisture conditions might induce these differences. Choosing a proper biochar application depth could contribute to mitigating nitrate leaching and possibly reducing nitrogen fertilizer use.

Authors: Hamada, K., Nakamura, S., Kanda, T. [JIRCAS]

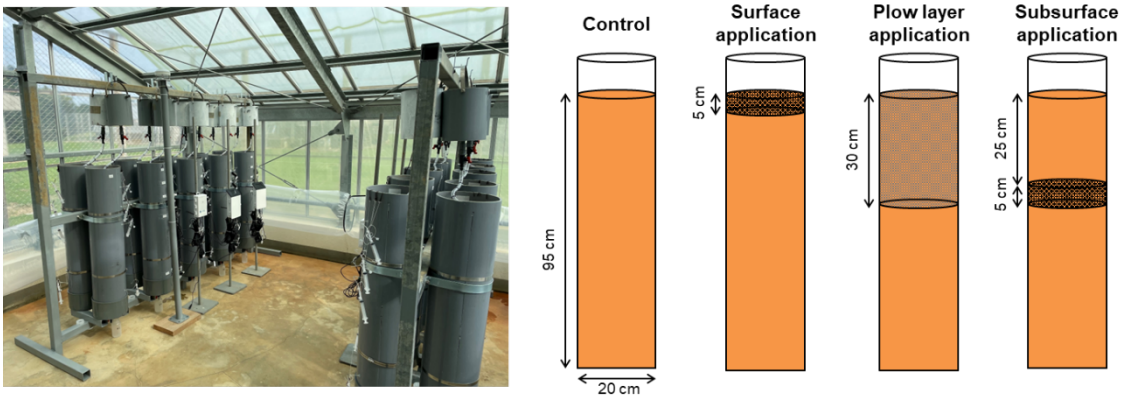

Fig. 1. Pipe experiment

The pipe experiment was conducted from August to November in a glass room. We applied four treatments with five replicates. The soil bulk density was set to 1.25 g cm^{-3}.

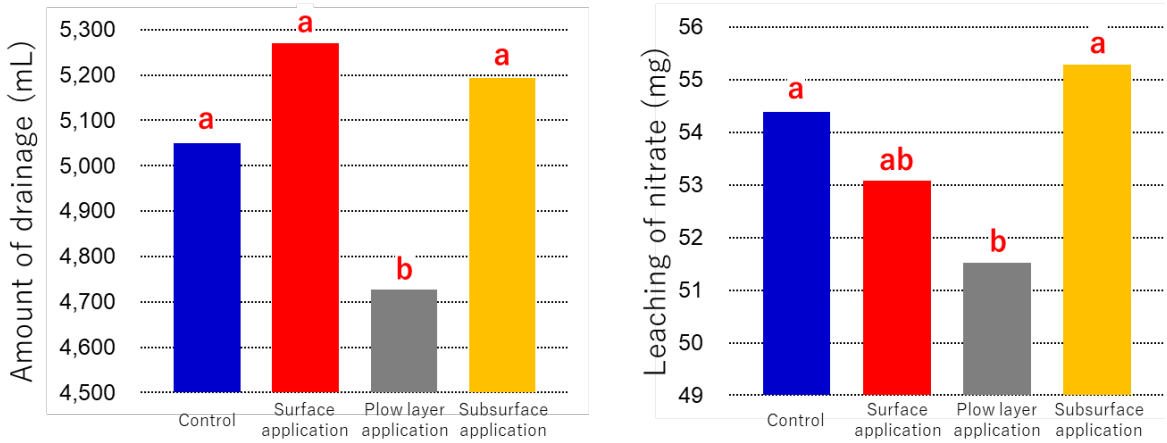

Fig. 2. Cumulative amount of drainage (left) and nitrate (right)

Letters indicate significant difference ($p<0.005$).

Table 1. Water budget within the pipes

	Control	Surface application	Plow layer application	Subsurface application
Irrigation (mL)		14,850		
Evaporation (mL)	8,960	8,754	9,389	9,149
Water in the pipe (mL)	6,977	7,175	6,860	6,964
Drainage (mL)	5,049 [a]	5,269 [a]	4,726 [b]	5,194 [a]

Water in the pipe was calculated by multiplying sensor values (n=2) at depths of 10, 20, 35, and 80 cm by soil layer volumes. Evaporation was calculated using the amount of irrigation, drainage, and water in the pipe. Letters show significant difference ($p<0.05$).

Reference: Hamada K, Nakamura S, Kanda T, Takahashi M. (2023) Effects of biochar application depth on nitrate leaching and soil water conditions. *Environmental Technology*. https://doi.org/10.1080/09593330.2023.2283403.