

<https://doi.org/10.17221/148/2025-SWR>

Use of agricultural wastes to reduce toxicity effect of tetracycline on soil nematode community

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Electronic Supplementary Material (ESM)

The authors are fully responsible for both the content and the formal aspects of the electronic supplementary material. No editorial adjustments were made.

Table S1. The abbreviation of each treatment

Abbreviation	Treatment	Abbreviation	Treatment
CK	no addition	LC	compost 40 t/ha + T
T	tetracycline	MC	compost 60 t/ha + T
LB	biochar 40 t/ha + T	HC	compost 80 t/ha + T
MB	biochar 60 t/ha + T	LI	compost 20 t/ha + biochar 20 t/ha + T
HB	biochar 80 t/ha + T	MI	compost 30 t/ha + biochar 30 t/ha + T
		HI	compost 40 t/ha + biochar 40 t/ha + T

Table S2. Physicochemical properties of each amendment and field management in this study

Materials	Using time	Moisture (%)	T _{BET} (m ² /g)	pH	TOC			
					TN	TP	TK	(g/kg)
Compost	before planting, 0–30 cm depth	44.7	–	6.89	177.1	2.67	1.92	2.09
Biochar	before planting, 0–30 cm depth	3.07	232.9	8.66	623.3	2.36	1.86	4.02
Tetracycline	before planting, 0–30 cm depth				100 mg/L, 600 L/ha			

T_{BET} – total Brunauer-Emmett-Teller surface area; TOC – total organic carbon; TN – total nitrogen; TP – total phosphorus; TK – total potassium

Table S3. Soil tetracycline, property and nematode analyses

Index	Full name	Analysis method
T	tetracycline	soil sample was sieved (0.25 mm), freeze-dried, and sealed in brown glass bottles for tetracycline extraction using a liquid chromatography-tandem mass spectrometry system equipped with a C18 column (3 μm \times 150 mm \times 4.6 mm) at 40 $^{\circ}\text{C}$ described by Hong et al. (2020)
SM	soil moisture	soil sample was oven-dried at 105 $^{\circ}\text{C}$ for 48 h
PO	soil porosity	soil sample was measured by a cutting ring
ST	soil texture	soil was measured by a pycnometer
MA	soil macro-aggregate	soil sample was measured by wet-sieving
pH	soil pH	soil sample was measured in a soil-water suspension (1:2.5 w/v) with a glass electrode
TOC	soil total organic carbon	soil sample was measured by dry combustion, using an SSM-5000A solid sample module
TN	soil total nitrogen	soil sample was determined by Kjeldahl digestion
AN	soil available N	soil sample was analysed by Continuous Flow Analytical System (AutoAnalyzer 3, Germany)
AP	soil available P	soil sample was analysed by Spectrophotometer (Unico 7200, China)
AK	soil available K	soil sample was analysed by Flame photometer (FP 640, China)
TNEM	total nematode	A sample of 100 g fresh soil was used for nematode extraction; samples were first elutriated and sieved (mesh size 250 μm and 38 μm) with water; nematodes from the suspensions were then extracted using a modified cotton-wool filter method (Townshend 1963) for 48 h; the collected nematodes were heat-killed (60 $^{\circ}\text{C}$) and fixed with 4% triethanolamine formaldehyde (TAF); each nematode suspension was counted using a dissecting microscope; an average of 150 nematodes (100 nematodes at minimum) per sample were identified using a compound microscope at 400 \times to 1000 \times to genus or family level; the abundance of nematodes was expressed per 100 g dry weight soil; nematodes were assigned to feeding groups (Yeates et al. 1993) and to c (colonizer)-p(persister) classes (Bongers & Bongers 1998)

All the soil properties analyses were described by Lu (2000)

Table S4 Meaning and calculation of each index

Index	Full name	Meaning	Calculation
H'	Shannon-Weaver diversity	are linked to soil nematode diversity which are calculated according to Yeates and Bongers (1999)	$H' = -\sum P_i (\ln P_i)$, where P_i is the proportion of each of the i genera present
SR	species richness		$SR = (S - 1)/\ln(C)$, where C is abundance of total nematodes and S is number of species
MI	maturity index	reflect changes in soil circumstance due to human disturbance, which are calculated according to Bongers and Bongers (1998)	$MI = \sum P(i) \cdot C(i)$, where $C(i)$ is the coloniser-persister (c-p) rating of taxon i according to the 1-5 c-p scale
PPI	plant parasite index		PPI was determined in a similar manner for plant parasitic genera.
SI	structure index	provide information about nematode community in stressed, enriched, stable structured, and decomposition environments, respectively	$SI = 100 \times (s/(s + b))$
EI	enrichment index		$EI = 100 \times (e/(e + b))$
BI	basal index		$BI = 100 \times (b/(e + s + b))$
CI	Channel index	(Ferris 2010)	$CI = 100 \times 0.8Fu2/(3.2Ba1 + 0.8Fu2)$

$e = \sum(3.2Ba1 + 0.8Fu2)$; $b = \sum 0.8(Ba2 + Fu2)$; $s = \sum[1.8(Ba3 + Ca3) + 3.2(Ba4 + Fu4 + Ca4 + Om4) + 5.0(Ca5 + Om5)]$; the numeric after Ba, Fu, Om and Ca is the respective c-p value and is used to represent the functional guilds of bacterivores, fungivores and omnivores-carnivores, respectively

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Table S5. Inferred condition of the soil food web and its environment based on weighted nematode faunal analysis

Abbreviation	Degree of disturbance	Food web condition
$0 < SI < 50, 50 < EI < 100$	high disturbed	disturbed
$50 < SI < 100, 50 < EI < 100$	low to moderate disturbed	maturing
$50 < SI < 100, 0 < EI < 50$	undisturbed	structured
$0 < SI < 50, 0 < EI < 50$	stressed	degrade

REFERENCES

- Bongers T., Bongers M. (1998): Functional diversity of nematodes. *Applied Soil Ecology*, 10: 239–251.
- Ferris H. (2010): Form and function: Metabolic footprints of nematodes in the soil food web. *European Journal of Soil Biology*, 46: 97–104.
- Hong X.X., Zhao Y.C., Zhuang R.D., Liu J.Y., Guo G.T., Chen J.M., Yao Y.M. (2020): Bioremediation of tetracycline antibiotics contaminated soil by bioaugmentation. *The Royal Society of Chemistry*, 10: 33086–33102.
- Lu R.K. (2000): *Soil Agricultural Chemistry Analysis Method*. Beijing, Chinese Agriculture Science Press. (in Chinese)
- Townshend J.L. (1963): A modification and evaluation of the apparatus for the Oostenbrink direct filter extraction method. *Nematologica*, 9: 106–110.
- Yeates G.W., Bongers T. (1999): Nematode diversity in agroecosystems. *Agriculture, Ecosystems and Environment*, 74: 113–135.
- Yeates G.W., Bongers T., De Goede R.G.M., Freckman D.W., Georgieva S.S. (1993): Feeding habits in soil nematode families and genera—an outline for soil ecologists. *Journal of Nematology*, 25: 315–331.