ECSOC-29 2025 Conference
The 29th Intl Electronic Conference on Synthetic Organic Chemistry
14–28 November 2025 | Online
MDPI

Bionematicidal potential of undecanoic acid against plant root parasitic nematodes

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INTRODUCTION & AIM

Plant-parasitic nematodes (PPNs) are a major biotic threat, causing billions of dollars in annual crop losses worldwide. Among them, root-knot nematodes (RKNs, *Meloidogyne* spp.) are the most damaging, infecting key crops such as rice, soybean, and tomato. These induce root galls that disrupt water and nutrient uptake, leading to stunted growth, wilting, and yield reduction. Traditional control relies on synthetic nematicides, which, despite their efficacy, pose serious environmental and health risks, and contribute to resistance development. Consequently, there is growing interest in natural, eco-friendly alternatives such as plant-derived biopesticides. Medium-chain saturated fatty acids offer promising prospects due to their natural occurrence, low toxicity, and biodegradability. This study investigates the *in vitro* nematicidal activity of undecanoic acid against *M. ethiopica* and *M. graminicola*, using the free-living *Cephalobus* sp. as an ecological indicator. The results aim to support the development of sustainable, fatty acid–based alternatives for RKN management.

METHODOLOGY

- **Nematode Growth and Maintenance**
  - *Meloidogyne ethiopica* → maintained on *Solanum lycopersicum*
  - *M. graminicola* → maintained on *Oryza sativa*
  - *Cephalobus* sp. → isolated from rice rhizosphere
  - **Growth Conditions:**
    - *M. ethiopica*: 1 L pots (1:1:1, soil:sand:substrate), 25 ± 1 °C, 60 d post-inoculation
    - *M. graminicola*: 0.5 L pots (2:1, sand:substrate), 26 ± 1 °C, 45 d post-inoculation
- **Egg & J2 Recovery:**
  - Eggs extracted using 0.52 % NaOCl; J2 hatched at 25 °C in moist chambers
  - Counting under stereomicroscope (Olympus SZX12)
- **Free-living Nematodes**
  - Identification via morphology and molecular analysis (18S rDNA, primers 988F/1912R).
  - DNA extracted using Qiagen DNeasy Kit; PCR with NZYTaq II Master Mix.
  - Sequences analyzed via BLAST (GenBank).
  - Cultured *in vitro* on Schenk & Hildebrandt medium (8 g/L agar, 30 g/L sucrose, pH 5.6).
  - Populations increased monoxenically; nematodes recovered after 4 weeks via Baermann method.
- **Direct-Contact Bioassays**
  96-well microplates:
  - 95 µL suspension (±60 J2s) + 5 µL undecanoic acid (20 mg/mL in methanol).
  - Controls: water (natural mortality) and methanol (solvent control).
  - Plates sealed, shaken (800 rpm, 1 min), incubated 24 h at 25 ± 1 °C, 60 rpm, in darkness.
  - Each treatment in triplicate (9 total bioassays)
- **Data Analysis**
  - Mortality (%) = (dead/total J2s) × 100
  - Corrected mortality (%) = [(treatment − control)/(100 − control)] × 100
  - Environmental fate (PED %) predicted with **EPA EPISuite** for undecanoic acid vs. oxamyl & fluopyram

RESULTS & DISCUSSION

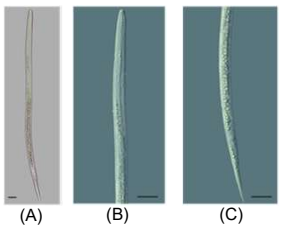
Natural mortality for RKNs after 24h in water:
-M. ethiopica = 2.1%±0.1%
-M. graminicola = 0.0%±0.0%

Control RKN mortality by exposing J2 to 5% methanol:
-M. ethiopica = 2.3%±0.1%
-M. graminícola = 0.0%±0.0%

RKNs mostly unaffected by methanol as a carrier agent for undecanoic acid.

Complete mortality of *M. ethiopica* and *M. graminicola* after 24 h

Nematode	PWN mortality	Nematicidal strength
M. ethiopica	100.0±0.0	Strong
M. graminicola	100.0±0.0	Strong
Cephalobus sp.	17.1±0.5	Low/inactive


(A) (B) (C)

RKN control

(A) intact internal organization

(B) Anterior region with distinct stylet and esophageal structures

(C) Posterior region with granular intestinal content

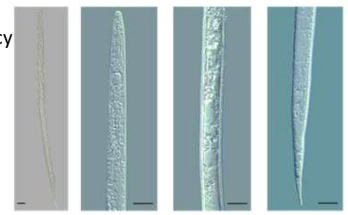
RKN with1 mg/ml of undecanoic acid

(D) Internal body disruption and loss of transparency

(E) Median bulb and esophageal structures barely distinguishable

(F) Extensive vacuolization and disintegration of internal organs

(G) Disrupted tissues and a shrunken tail


(D) (E) (F) (G)

Predicted environmental distribution (PED) (%)

Compound	Air	Water	Soil	Sediment
Undecanoic acid	2.7	28.2	68.9	0.2
Oxamyl	0.0	35.0	64.9	0.1
Fluopyram	0.0	2.7	80.3	17.0

Undecanoic acid may behave similarly to oxamyl and fluopyran, although differences in partitioning suggest that undecanoic acid may behave distinctly in certain environments.

CONCLUSION

Undecanoic acid achieved complete mortality of *M. ethiopica* and *M. graminicola* J2 within 24 h at 1 mg/ml and only caused minor mortality in the non-target, free-living nematode *Cephalobus* sp., indicating a degree of specificity towards root-knot nematodes.
The environmental modeling suggested similar behavior to conventional nematicides oxamyl and fluopyram.
Undecanoic acid shows promising potential as a selective biopesticide.

FUTURE WORK / REFERENCES

Further research needed on environmental persistence, ecological risks and field-level efficacy.

ACKNOWLEDGMENTS: Partly funded by Fundação para a Ciência e a Tecnologia (FCT), through project NemACT, grant DOI: 10.54499/2022.00359.CEECIND/CP1737/CT0002