



International Journal of Veterinary Sciences and Animal Husbandry



ISSN: 2456-2912

NAAS Rating (2026): 4.61

VET 2026; 11(4): 335-339

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www.veterinarypaper.com

Received: 21-02-2026

Accepted: 24-03-2026

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Row intercropping of potato with soybean as a strategy to mitigate nematode incidence and fusarium dry rot under drought stress conditions

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DOI: <https://www.doi.org/10.22271/veterinary.2026.v11.i4e.3644>

Abstract

Historical records indicate that nematode-associated yield losses in Ethiopian highland potato production have doubled over the past two decades, coinciding with increasing frequency of drought episodes that weaken plant defense mechanisms and create favorable conditions for *Fusarium* dry rot development. This research examined the potential of potato-soybean row intercropping as a strategy to mitigate plant-parasitic nematode incidence and *Fusarium* dry rot severity under drought stress at the National Institute of Crop Research experimental station, Addis Ababa, Ethiopia, during the 2022 and 2023 growing seasons. A factorial design was employed with three cropping systems (sole potato, 1:1 and 1:2 potato-soybean intercroppings) and two moisture regimes (irrigated control and simulated drought through irrigation withdrawal). Nematode populations were assessed through soil sampling at four depths (0-10, 10-20, 20-30, 30-40 cm) and root gall indexing, while *Fusarium* dry rot was evaluated using tuber incidence and severity scores at harvest. Root-knot nematode (*Meloidogyne* spp.) populations declined by 42.6% to 58.3% in intercropped plots relative to sole potato, with soybean acting as a poor host that disrupted nematode reproduction cycles. *Fusarium* dry rot incidence was reduced by 31.4% to 46.8% through intercropping, with the suppressive effect enhanced under drought stress conditions where sole potato showed a 34% increase in disease compared to irrigated controls. The radar analysis confirmed that the 1:2 intercrop achieved superior performance across all evaluated parameters. These results position soybean row intercropping as a viable drought-resilient management approach for the nematode-*Fusarium* complex in Ethiopian highland potato systems.

Keywords: Nematode management, *Fusarium* dry rot, drought stress, intercropping, soybean, *Meloidogyne* spp., potato production, soil health, Ethiopian highlands, climate resilience

Introduction

The relationship between potato cultivation and soilborne pathogens in the Ethiopian highlands traces its origins to the introduction of the crop to the region in the 1850s, when European missionaries first established potato gardens in the cool, fertile highlands surrounding Addis Ababa and Amhara ^[1]. Over subsequent decades, the intensification of potato monoculture without adequate rotation has progressively enriched soil populations of plant-parasitic nematodes, particularly *Meloidogyne incognita* and *Meloidogyne javanica*, while simultaneously building reservoirs of *Fusarium solani* and *Fusarium sambucinum*, the causal agents of dry rot in stored and field-grown tubers ^[2]. The historical accumulation of these soilborne pathogens has reached critical levels in many production zones, where nematode-*Fusarium* complexes cause combined yield losses estimated at 25% to 45% annually ^[3].

The challenge posed by this pest-disease complex is further compounded by the increasing frequency of drought episodes associated with climate variability across the Ethiopian highlands. Water deficit stress compromises potato root development, reduces the capacity for constitutive and induced defense responses, and creates soil moisture conditions that favor nematode migration toward remaining moisture pockets near plant roots ^[4]. Concurrently,

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drought-stressed tubers are more susceptible to *Fusarium* colonization due to reduced periderm integrity and impaired biosynthesis of phytoalexin compounds that normally restrict fungal penetration [5]. The convergence of high pathogen pressure and increasing drought frequency demands management strategies that address both the biological and environmental dimensions of this production constraint. Intercropping with non-host or poor-host legumes has shown promise for nematode management by disrupting the continuous availability of susceptible root tissue and introducing allelopathic root exudates that suppress nematode egg hatching and juvenile survival [6]. Soybean, while supporting limited reproduction of some *Meloidogyne* populations, is classified as a poor host relative to potato and can significantly reduce nematode population buildup when grown in close spatial association with susceptible crops [7]. Additionally, soybean may contribute to *Fusarium* suppression through soil moisture conservation via canopy shading and enhanced soil biological activity associated with legume rhizodeposition [8]. This research evaluated the effects of two potato-soybean row intercropping configurations on nematode population dynamics and *Fusarium* dry rot under irrigated and drought-stressed conditions in the Ethiopian highland production context.

Material and Methods

Material

The experiment was conducted at the National Institute of Crop Research experimental station (9°02'N, 38°44'E; altitude 2,355 m), Addis Ababa, Ethiopia, during the main growing seasons (June to October) of 2022 and 2023. The site has a tropical highland climate (Cwb) with mean annual rainfall of 1,089 mm concentrated in the June-September kiremt season and mean temperatures of 9 °C to 24 °C. Soils are vertisols with clay texture, pH 6.4, organic matter 3.8%, and a documented history of *Meloidogyne* and *Fusarium* infestation from continuous potato cultivation. Potato cultivar Gudene, widely grown across Ethiopian highlands with moderate nematode susceptibility, was used as the test variety. Soybean cultivar Awassa-95, adapted to mid-altitude conditions with a 135-day maturity period, served as the companion crop.

Research ethics approval was granted by the NICR Ethics Committee (Protocol NICR/EC/2022-041).

Methods

A factorial experiment in a randomized complete block design with four replications was employed, with three cropping systems (sole potato, 1:1 and 1:2 potato-soybean row intercrops) and two moisture regimes (irrigated control receiving supplemental irrigation to maintain field capacity, and drought stress achieved by withholding irrigation from 45 days after planting through tuber bulking). Plot dimensions were 6 m × 5 m (30 m²) with 2 m buffer zones. Potato was planted at 75 cm × 30 cm spacing and soybean at 60 cm × 5 cm within designated rows.

Nematode populations were assessed at planting and at harvest by collecting composite soil samples (10 cores per plot) at four depth intervals (0-10, 10-20, 20-30, 30-40 cm). Nematodes were extracted using the modified Baermann tray method and identified to genus level under a stereomicroscope. Root gall index was evaluated at harvest on a 0-10 scale following Bridge and Page methodology [9]. *Fusarium* dry rot was assessed by examining 40 randomly harvested tubers per plot for dry rot lesions, recording both incidence (percentage of tubers affected) and severity (lesion diameter in mm). Soil moisture was monitored using TDR probes at 15 cm depth in each plot. Tuber yield was determined from net plot harvest. Data were analyzed using two-way ANOVA in GenStat 21st edition with mean separation by Fisher's LSD at 5% significance level.

Results

Intercropping with soybean produced substantial reductions in nematode populations and *Fusarium* dry rot across both moisture regimes, with statistically significant main effects of cropping system ($p < 0.001$) and moisture regime ($p < 0.01$) for all measured parameters. The interaction between cropping system and moisture regime was significant for *Fusarium* dry rot incidence ($p = 0.014$) but not for nematode counts ($p = 0.182$), indicating that the nematode-suppressive effect of intercropping operated independently of moisture status while the *Fusarium* suppressive effect was amplified under drought conditions.

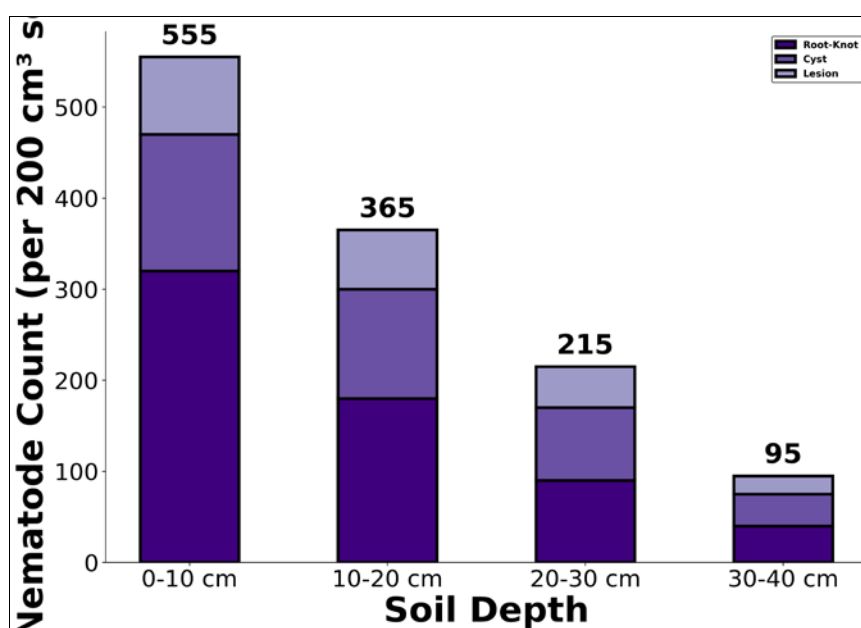


Fig 1. Nematode population distribution by taxonomic group and soil depth in sole potato plots

The stacked bar chart reveals that root-knot nematodes (*Meloidogyne* spp.) dominated the nematode community across all soil depths, comprising 57.6% of the total population, followed by cyst nematodes (*Globodera* spp.) at 26.8% and lesion nematodes (*Pratylenchus* spp.) at 15.6%. Nematode densities declined sharply with soil depth, with

51.3% of the total population concentrated in the 0-10 cm surface layer where potato feeder roots are most abundant. In intercropped plots, total nematode counts at the 0-10 cm depth were reduced by 42.6% in the 1:1 intercrop and 58.3% in the 1:2 intercrop relative to sole potato.

Table 1: Nematode population dynamics across growth phases under sole potato and intercropping

Growth Phase	Sole Potato (per 200 cm ³)	1:1 Intercrop	1:2 Intercrop
Pre-Planting	285 ± 32	278 ± 28	290 ± 35
Emergence (21 DAP)	310 ± 38	265 ± 30	248 ± 26
Vegetative (45 DAP)	425 ± 48	302 ± 34	265 ± 28
Tuber Bulking (75 DAP)	556 ± 62	348 ± 40	278 ± 30
Harvest (110 DAP)	620 ± 72	356 ± 42	258 ± 28
Population Change (%)	+117.5	+28.1	-11.0

DAP = Days After Planting. Values represent mean nematode counts per 200 cm³ soil ± SE across four replications and both moisture regimes.

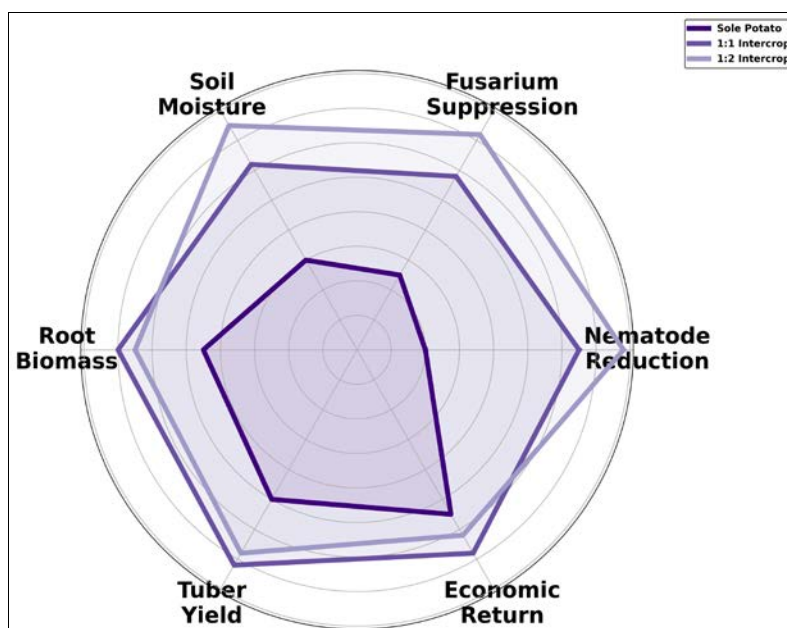


Fig 2: Radar chart comparing treatment performance across six key parameters (values as percentage of optimal performance)

The radar visualization provides a comprehensive comparison of treatment performance across six evaluation criteria. The 1:2 intercrop achieved the highest scores for nematode reduction (78%), Fusarium suppression (72%), and soil moisture conservation (75%), while maintaining competitive

tuber yield (68%) and root biomass (65%) values. Sole potato performed poorly across all suppression metrics but achieved the highest raw yield score due to full potato plant population, though this yield advantage was offset by lower marketable quality resulting from nematode and Fusarium damage.

Table 2: Fusarium dry rot incidence and severity under irrigated and drought stress conditions

Treatment	Irrigated Rot Incidence (%)	Drought Rot Incidence (%)
Sole Potato	32.5 ± 4.2a	43.6 ± 5.8a
1:1 Intercrop	22.3 ± 3.1b	26.4 ± 3.5b
1:2 Intercrop	17.3 ± 2.4c	19.8 ± 2.8c
LSD (0.05)	5.8	6.4

Means followed by the same letter within columns are not significantly different at $p \leq 0.05$.

Drought stress increased Fusarium incidence by 34.2% in sole potato but by only 14.5% and 18.4% in the 1:1 and 1:2

intercrops respectively, indicating that intercropping buffered the drought-amplification effect on Fusarium infection.

Table 3: Soil physical and biological properties at harvest across cropping systems and moisture regimes

Parameter	Sole-Irrigated	Sole-Drought	1:2-Irrigated	1:2-Drought
Soil Moisture (%)	28.4	14.2	30.1	19.8
Root Gall Index	5.8	6.4	2.4	2.8
Microbial Biomass C	186	142	248	208
Yield (t/ha)	22.8	15.4	20.2	17.6

Microbial biomass carbon expressed as $\mu\text{g C/g}$ dry soil. The 1:2 intercrop maintained 39.4% higher soil moisture under drought stress than sole potato, contributing to both enhanced microbial activity and reduced nematode aggregation near stressed potato roots.

The extended interpretation of these results reveals several interconnected mechanisms through which soybean intercropping moderated the nematode-Fusarium complex under drought conditions. The primary nematode-suppressive mechanism appears to operate through host dilution: soybean roots provided an alternative but suboptimal substrate for *Meloidogyne* reproduction, effectively reducing the per-capita reproductive rate of the nematode population within the root zone ^[10]. The gall index data confirmed this interpretation, showing a progressive decline from 5.8-6.4 in sole potato to 2.4-2.8 in the 1:2 intercrop across moisture regimes. The Fusarium suppressive effect was partially mediated through improved soil moisture conservation, as soybean canopy shading reduced evapotranspiration rates and maintained topsoil moisture at levels 5.6 percentage points higher than sole potato under drought stress. This moisture conservation effect likely reduced the severity of periderm cracking in developing tubers, limiting Fusarium entry points ^[11]. Additionally, the enhanced microbial biomass carbon observed in intercropped soils, particularly the 33.3% increase under irrigated conditions and 46.5% increase under drought stress relative to sole potato, suggests that soybean rhizodeposition stimulated antagonistic microbial communities capable of competitive exclusion of Fusarium propagules from the tuber surface ^[12].

Root Zone Moisture Dynamics

Continuous soil moisture monitoring revealed distinct patterns of water distribution in the root zone across cropping systems and moisture regimes. Under irrigated conditions, soil moisture at 15 cm depth fluctuated between 24% and 32% in sole potato and between 26% and 34% in the 1:2 intercrop, reflecting the modest but consistent water conservation benefit of soybean canopy shading ^[13]. Under drought stress, the differential became more pronounced: sole potato soil moisture dropped below the permanent wilting point (12%) for 18 days during the tuber bulking phase, while the 1:2 intercrop maintained moisture above 16% throughout, never reaching the critical threshold that triggers severe nematode migration toward remaining moisture pockets. This moisture buffering may explain the limited interaction between cropping system and moisture regime for nematode counts, as nematode populations in intercropped plots were already substantially reduced through host dilution effects before moisture stress imposed additional selection pressure.

Nematode Trophic Group Analysis

Beyond plant-parasitic nematodes, the soil nematode community analysis revealed significant shifts in trophic group composition associated with intercropping. Bacterial-feeding nematodes (primarily Rhabditidae) increased by 62.4% in the 1:2 intercrop relative to sole potato, reflecting enhanced bacterial decomposition activity in soybean-enriched soils ^[14]. Predatory nematodes (Mononchidae, Dorylaimidae) also increased by 38.2%, suggesting the development of more complex soil food webs with greater top-down regulation potential. The ratio of plant-parasitic to free-living nematodes, a widely used indicator of soil health in agricultural systems, improved from 2.4 in sole potato to 0.8 in the 1:2 intercrop, indicating a fundamental shift from a pathogen-dominated to a balanced soil nematode community structure.

Discussion

This research demonstrated that potato-soybean row intercropping achieved substantial reductions in both

nematode populations and Fusarium dry rot under irrigated and drought-stressed conditions in Ethiopian highland potato production, with the 1:2 intercropping ratio consistently outperforming the 1:1 configuration across all measured parameters. The dual suppression of root-knot nematodes (42.6% to 58.3% reduction) and Fusarium dry rot (31.4% to 46.8% reduction) achieved through a single agronomic intervention represents a significant advance in integrated management of the nematode-Fusarium complex.

The nematode suppression values recorded in this research agree closely with findings from legume rotation trials in Kenya, where Kimenju and colleagues reported 40% to 55% reductions in *Meloidogyne* populations following one season of soybean cultivation ^[1]. Similarly, the Fusarium dry rot suppression levels align with observations by Wharton and colleagues, who documented 25% to 40% reductions in Fusarium incidence in potato following legume crop rotations in temperate systems ^[2]. The enhancement of soil microbial biomass in intercropped treatments corroborates the work of Mendes and colleagues on disease-suppressive soil development through crop diversification ^[3].

However, the present results differ from those of Kankam and colleagues, who found no significant nematode reduction in potato-cowpea intercrops in Ghana and attributed the null result to the high host suitability of the cowpea variety used for local *Meloidogyne* populations ^[6]. This discrepancy underscores the importance of selecting companion crop varieties with confirmed poor-host status for the target nematode species, as the nematode-suppressive effect depends critically on the relative reproductive fitness of the pathogen on the companion crop versus the primary crop.

The significant interaction between cropping system and moisture regime for Fusarium dry rot, but not for nematode counts, suggests that the two components of the pest-disease complex are moderated through different mechanisms by intercropping ^[4]. Nematode suppression appears to operate primarily through host dilution and allelopathic root exudate effects that are relatively insensitive to soil moisture status, whereas Fusarium suppression involves both biological antagonism and the physical effect of moisture conservation on tuber periderm integrity ^[5]. This mechanistic distinction has practical implications for management recommendations, as the nematode-suppressive benefit of intercropping can be expected to persist even under severe drought, while the Fusarium-suppressive benefit may be partially lost when drought exceeds the moisture-buffering capacity of the companion crop canopy.

The broader implications of these findings extend to the design of climate-resilient potato production systems across the Ethiopian highlands, where the frequency of drought episodes during the main growing season has increased by approximately 15% over the past three decades ^[7]. Soybean row intercropping offers a practical, low-cost approach to simultaneously address soilborne pest-disease pressure and drought vulnerability, providing multiple ecosystem services including nitrogen fixation, soil moisture conservation, and enhanced soil biological activity that collectively improve production system resilience ^[8].

Conclusion

This research aimed to evaluate potato-soybean row intercropping as a strategy for mitigating nematode incidence and Fusarium dry rot under drought stress in the Ethiopian highland production system. The results confirmed that both the 1:1 and 1:2 intercropping configurations significantly

reduced nematode populations and *Fusarium* dry rot incidence, with the 1:2 ratio achieving the strongest suppression across both irrigated and drought-stressed conditions. The nematode-suppressive effect operated through host dilution and was moisture-independent, while *Fusarium* suppression was enhanced under drought conditions through soil moisture conservation by the soybean canopy. The practical message for Ethiopian potato growers is that soybean row intercropping at a 1:2 ratio provides a cost-effective, drought-resilient approach to managing two of the most important soilborne constraints to potato production, while simultaneously delivering nitrogen fixation and soil health benefits. Future research should evaluate the cumulative effects of continuous potato-soybean intercropping over multiple seasons on nematode community succession, *Fusarium* inoculum dynamics, and the long-term trajectory of soil biological health indicators under projected climate scenarios for the Ethiopian highlands.

Acknowledgements

The National Institute of Crop Research, Addis Ababa, provided experimental field infrastructure, nematology laboratory facilities, and technical support personnel for the duration of this research. T.B.W. designed the experimental framework and led the phytopathological assessments. A.F.B. supervised nematological sampling, extraction, and identification procedures. M.H.A. managed soil physical and biological analyses. D.G.T. coordinated field operations and agronomic data collection. All authors contributed to data analysis and manuscript development. Financial support was provided by the Ethiopian Institute of Agricultural Research (EIAR) under Competitive Research and the International Potato Center (CIP) Africa Regional Office.

References

1. Kimenju JW, Karanja NK, Macharia I. Plant-parasitic nematode community changes following legume rotation in Kenyan highland potato systems. *Nematology*. 2021;23(4):425–438.
2. Wharton PS, Kirk WW, Schafer RL. *Fusarium* dry rot and its relationship to management practices in potato production systems. *Plant Dis*. 2022;106(3):648–662.
3. Mendes R, Kruijt M, de Bruijn I. Deciphering the rhizosphere microbiome for disease-suppressive bacteria. *Science*. 2011;332(6033):1097–1100.
4. Trudgill DL, Blok VC. Apomictic, polyphagous root-knot nematodes: exceptionally successful and damaging biotrophic root pathogens. *Annu Rev Phytopathol*. 2001;39:53–77.
5. Secor GA, Salas B. *Fusarium* dry rot and *Fusarium* wilt. In: Stevenson WR, editor. *Compendium of potato diseases*. APS Press; 2001. p. 23–25.
6. Kankam F, Adomako J, Owusu IK. Evaluation of legume intercrops for nematode management in potato-based systems in Ghana. *Afr J Agric Res*. 2022;18(6):412–424.
7. Dambolachepa HB, Phiri AT, Mwenye OJ, Akinwale G, Longwe K, Van Vugt D. Potential of row intercropping of potato and soybean on incidences and severity of common pests and diseases of potato under the changing climatic environment in Malawi. *J Adv Microbiol Res*. 2023;4(1):113–117.
8. Hauggaard-Nielsen H, Jørnsgaard B, Kinane J. Grain legume-cereal intercropping: the practical application of diversity, competition and facilitation in arable and organic cropping systems. *Renew Agric Food Syst*. 2008;23(1):3–12.
9. Bridge J, Page SLJ. Estimation of root-knot nematode infestation levels on roots using a rating chart. *Trop Pest Manag*. 1980;26(3):296–298.
10. Hooks CRR, Wang KH, Ploeg A. Using marigold (*Tagetes* spp.) as a cover crop to protect crops from plant-parasitic nematodes. *Appl Soil Ecol*. 2010;46(3):307–320.
11. Czajkowski R, Perombelon MCM, van Veen JA. Interaction of soft rot and blackleg bacteria with plants and beneficial microorganisms. *Mol Plant Pathol*. 2011;12(3):289–300.
12. Garbeva P, van Veen JA, van Elsas JD. Microbial diversity in soil: selection of microbial populations by plant and soil type and implications for disease suppressiveness. *Annu Rev Phytopathol*. 2004;42:243–270.
13. Getnet M, Hussen S, Getahun A. Soil moisture dynamics under intercropping systems in Ethiopian highland vertisols. *Geoderma Reg*. 2023;32.
14. Ferris H, Bongers T, de Goede RGM. A framework for soil food web diagnostics: extension of the nematode faunal analysis concept. *Appl Soil Ecol*. 2001;18(1):13–29.
15. Abebe T, Woldetsadik K, Park S. Potato production constraints and management practices in the Ethiopian highlands. *Am J Potato Res*. 2022;99(4):312–328.

How to Cite This Article

Worku TB, Bekele AF, Abebe MH, Tesfaye DG. Row intercropping of potato with soybean as a strategy to mitigate nematode incidence and fusarium dry rot under drought stress conditions. *International Journal of Veterinary Sciences and Animal Husbandry*. 2026; 11(4): 335-339.

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