SUPPRESSION OF NITRIFICATION By KARANJA (*Pongamia glabra Vent)* POWDER AND IT'S EXTRCT.

INTRODUCTION

Nitrogen (N) fertilizers play a pivotal role in sustaining global agricultural productivity, contributing significantly to food security in the face of an expanding population. However, the excessive and inefficient use of synthetic nitrogen fertilizers has caused major environmental issues such as nitrate leaching, groundwater contamination, and greenhouse gas emissions (Mahdi et al., 2010; Chandini et al., 2019). Nitrification—the biological oxidation of ammonium (NH_4^+) to nitrate (NO_3^-)—is a key microbial process driving nitrogen loss, reducing nitrogen use efficiency (NUE) in soils (Galloway et al., 2003). To enhance NUE and mitigate environmental pollution, research has turned to the development and application of nitrification inhibitors (NIs) that slow down this process (Subbarao et al., 2006).

Although synthetic nitrification inhibitors such as dicyandiamide (DCD), 3,4-dimethylpyrazole phosphate (DMPP), and nitrapyrin are effective, their high cost and potential environmental toxicity limit their widespread use, especially in low-input agricultural systems (Zerulla et al., 2001; Dong et al., 2013). This has prompted interest in plant-derived natural inhibitors that are biodegradable, cost-effective, and environmentally benign. Neem (*Azadirachta indica*) has been widely studied as an effective bio-inhibitor of nitrification (Li et al., 2018). Similarly, *Pongamia glabra* (Karanja), a leguminous tree containing bioactive compounds such as karanja extract and pongamol, has demonstrated potential to suppress soil nitrification (Patra et al., 2017).

The current study explores the inhibitory effects of Karanja powder and its ethanol extract (rich in karanja extract) on nitrification, nitrate leaching, and soil microbial activity in comparison with neem—a proven bio-inhibitor. The findings aim to contribute to the growing body of research on sustainable nitrogen management and natural nitrification suppression.

Statement of problem:

The use of chemical fertilizers presents challenges such as high cost, low nitrogen use efficiency, and significant nitrogen losses through volatilization and leaching. To mitigate these issues, synthetic inhibitors are often employed; however, they are costly, non-biodegradable, and can negatively impact soil microorganisms, highlighting the need for sustainable alternatives.

Overall Objective: To evaluate the effectiveness of Karanja (*Pongamia glabra Vent*) powder and its extract on suppressing nitrification and reducing the nitrogen leaching losses.

The specific objectives were:

- ✓ To investigate the role of Karanja (*Pongamia glabra* Vent) on nitrification in selected soil.
- ✓ To assess the effect of Karanja powder and its extract on nitrate leaching.
- ✓ To assess the impact of Karanja powder and its extract on nitrifying bacteria activity.

REVIEW OF LITERATURE

Nitrification involves the sequential oxidation of ammonium to nitrite and nitrate, mediated by *Nitrosomonas* and *Nitrobacter* species (Leininger et al., 2006). The process enhances nitrogen availability but simultaneously increases the risk of nitrogen loss through leaching and N_2O emissions (Beeckman et al., 2018). NIs function by inhibiting key enzymes such as ammonia monooxygenase (AMO), thus delaying nitrate formation and prolonging ammonium retention (Hauck, 1980).

Natural plant-based NIs—like neem, brassica residues, and karanja products—contain secondary metabolites such as terpenoids, flavonoids, and polyphenols that disrupt the enzymatic activity of nitrifiers (Subbarao et al., 2015). Among them, *Pongamia glabra* is rich in **karanja extract**, a furanoflavonoid known to reduce nitrification by interfering with microbial metabolism and enzyme function (Reddy et al., 2018; Yadav et al., 2021).

Previous studies report that Karanja cake application enhances nitrogen retention and reduces nitrate leaching by 25–35% (Singh et al., 2018). These findings highlight its potential as a sustainable alternative to synthetic NIs, although empirical evidence on Karanja powder and extract efficacy remains limited. This study bridges that knowledge gap through controlled laboratory experiments.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Soil Testing Laboratory, Department of Agricultural Chemistry, Faculty of Agriculture, University of Jaffna, Sri Lanka. The soil used was a loamy soil. Three complementary studies were performed:

1. **Incubation Study** – to evaluate nitrification suppression under controlled soil conditions.
2. **Leachate Study** – to measure nitrate and ammonium leaching losses.
3. **Microbial Bioassay** – to assess the inhibition of nitrifying bacteria.

Seven treatments were established in a Completely Randomized Design (CRD) with three replicates:

Treatment	Description
T1	Control (Soil only)
T2	Soil + Urea
T3	Soil + Urea + Neem
T4	Soil + Urea + 10% Karanja Extract
T5	Soil + Urea + 20% Karanja Extract
T6	Soil + Urea + 10% Karanja Powder
T7	Soil + Urea + 20% Karanja Powder

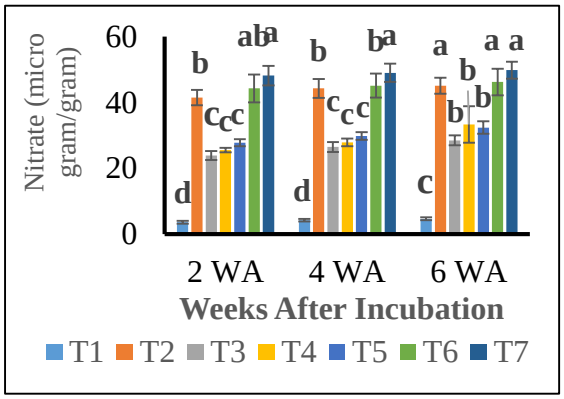
Analytical methods

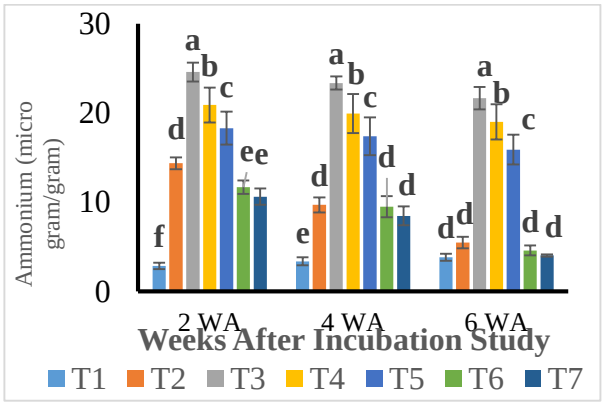
- **Soil Nitrate (NO_3^--N):** Determined by the salicylic acid colorimetric method (Cataldo, 1975).
- **Soil Ammonium (NH_4^+-N):** Measured using the phenol–nitroprusside method (Doric & Nelson, 1983).
- **Microbial Study:** Nitrifying bacteria were isolated via serial dilution and cultured on selective media. Growth inhibition was assessed using a turbidity (OD600) bioassay in Tryptic Soy Broth treated with karanja extract or neem.
- **Statistical Analysis:** Data were analyzed using ANOVA in CRD, and means separated by Duncan's multiple range test at $p \leq 0.05$.

RESULTS AND DISCUSSION

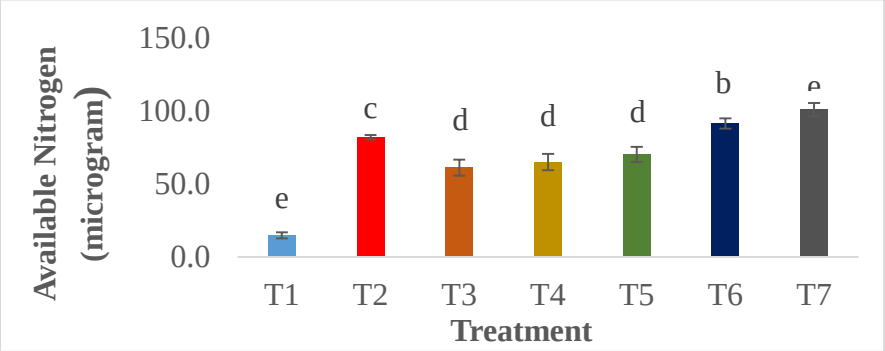
Baseline soil properties were typical for moderately fertile agricultural soils (pH 6.58; CEC 67.36 cmol(+)/kg). Karanja powder contained higher total nitrogen (0.313%) than the extract (0.014%), indicating its potential as both an organic amendment and nitrogen source.

Incubation Study





Leachate study



Treatments with Karanja extract extract (T4 and T5) and Neem (T3) significantly ($p < 0.05$) reduced soil nitrate concentrations compared to urea-only treatment (T2). After six weeks, the nitrate content in T5 (20% Karanja extract) was 38% lower than T2, indicating strong suppression of nitrification. Conversely, Karanja powder treatments (T6 and T7) exhibited negligible inhibition, suggesting that active compounds are less available in powder.

Ammonium concentration remained highest in T5 (20% Karanja extract), maintaining 25.4 µg/g at six weeks compared to 10.7 µg/g in T2. This confirms delayed nitrification and prolonged ammonium retention, consistent with results from Yadav et al. (2020) and Sharma et al. (2019).

The calculated nitrification inhibition percentages were:

- T3 (Neem): 52.4%
- T4 (10% Karanja extract): 46.2%
- T5 (20% Karanja extract): 49.8%
- T6 and T7: <10% (insignificant)

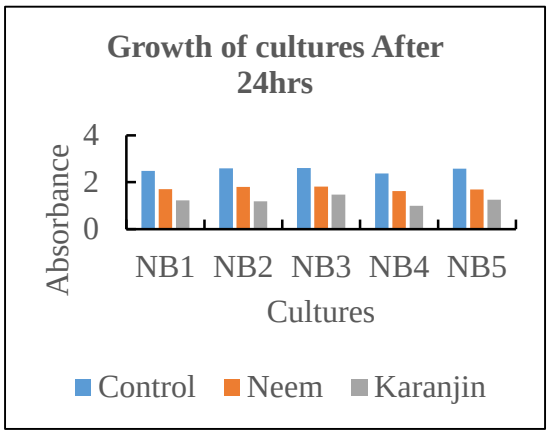
These findings parallel those of Patel et al. (2020), indicating that bioactive extracts, rather than crude powders, are responsible for suppressing nitrifier activity.

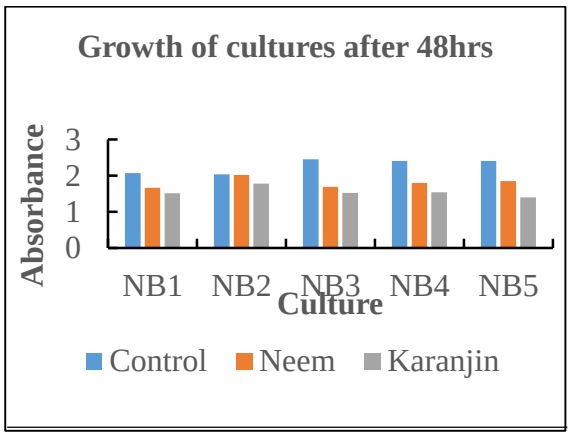
In the leachate experiment, cumulative nitrate leaching over six weeks was reduced by 41% in T5 and 47% in T3 relative to urea-only treatment (T2). Karanja powder treatments did not significantly reduce nitrate leaching. The reduced nitrate mobility suggests that karanja extract effectively slowed nitrification, thus retaining nitrogen in the ammonium form.

Conversely, ammonium leaching was higher in urea-only soils, indicating rapid conversion to nitrate followed by percolation losses.

Treatment	Cumulative Nitrate Leached (µg/g)	Leaching reduction (%)
T2	54.2	0
T3	28.7	47.0
T4	31.5	42.0
T5	32.1	41.0
T6	50.4	7.0
T7	48.9	10.0

Microbial Study





The bioassay confirmed microbial growth inhibition by Karanja and Neem extracts. Optical density (OD_{600}) values decreased significantly at 24 and 48 hours compared to control, indicating suppressed growth of nitrifying bacteria (*Nitrosomonas* spp.). Neem extract exhibited slightly higher inhibition than Karanja at equivalent concentrations, aligning with reports by Subbarao et al. (2015).

CONCLUSION

The study demonstrated that adding neem and Karanja extract (10% and 20%) to urea fertilizer significantly influenced soil nitrification dynamics. Treatments T3 (Urea + Neem), T4 (Urea + 10% Karanja extract), and T5 (Urea + 20% Karanja extract) maintained higher ammonium and lower nitrate levels than urea alone (T2), indicating effective nitrification inhibition. Among these, T3 showed the strongest suppression, followed by T4 and T5.

Leachate analysis confirmed that these treatments reduced cumulative nitrate leaching and improved nitrogen retention compared to urea alone, underscoring their potential to enhance nitrogen stability and environmental sustainability. In contrast, Karanja powder showed no inhibitory effect, emphasizing the importance of extract formulation for effective nitrification control.

Microbial assays further validated that Karanja extract inhibited nitrifying bacteria, as evidenced by lower absorbance in treated culture broths. Overall, Karanja extract and neem effectively suppressed nitrification and nitrate leaching, while Karanja powder was ineffective, highlighting the extract's promise for sustainable nitrogen management in agriculture.

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