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EFFECTS OF SOIL SOLARIZATION AND POWDERED BOTANICALS ON NEMATODE POPULATION, SOIL PHYSICAL PROPERTIES AND WEED DIVERSITY

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ABSTRACT

Plant parasitic nematodes have significant effects on plant health, crop productivity, and food security. A study was designed to evaluate the effect of soil solarization and botanical powder, solely and synergistically, on the population of nematodes, soil physical properties and weed diversity during the rainy season (between June and August 2023). Seven treatments, including standard check and control, were evaluated. The seven treatments were transparent polythene, transparent polythene and powdered botanicals (Carica papaya and Vernonia amygdalina), black polythene, black polythene and powdered botanicals (C. papaya and Vernonia amygdalina), powdered botanicals (C. papaya and V. amygdalina) only, standard check (Carbofuran) and control. Treatments were applied on plots measuring 1.4 m x 1.6 m (2.24 m^2) in a completely randomized design with three replications. Data were collected on nematode population, soil moisture content, soil temperature and weed diversity. Data collected were subjected to analysis of variance (ANOVA) using Minitab Software, Version 17. The results obtained showed that black polythene, used singly, had the highest reduction (44.84%) of the overall nematode population and 50.00% reduction of the Meloidogyne spp. population. It also had the highest reduction, 60.00%, in the population of Meloidogyne spp. when used with powdered botanicals. Furthermore, the two treatments had 100.00% inhibition on weed growth. Transparent polythene had the highest increase in soil temperature (31.48%) and moisture, 1.80%. Black polythene may be recommended for use in the management of soil-borne plant parasitic nematodes during the rainy season. It has the added benefit of weed control.

Key words: plant health, plant parasitic nematodes, polythene, soil moisture, soil temperature.

INTRODUCTION

Plant-parasitic nematodes (PPNs) pose a serious threat to plant health, crop productivity and yield quality, causing significant economic losses to farmers and food insecurity globally (Cotton *et al.,* 2014; Hailu and Hailu, 2020). In Nigeria, root knot nematodes *Meloidogyne* spp.) are the most problematic. Imegwu *et al.* (2014) reported that three species (*M. incognita*, *M. arenaria* and *M. javanica*) have been reported to be the most dominant. The host range of PPNs is wide and diverse. They include commercially important families like Solanaceae (tomato, potato, and pepper), Fabaceae (cowpea and soybean), Malvaceae (cocoa and cotton), Amaranthaceae (sugar beet), and Poaceae, (sugarcane rice, wheat, and maize). (Warmerdam *et al.,* 2018; Ajayi, 2019). Most PPNs infest plant roots, where they obtain nourishment and accommodation. Root infestation by PPNs interferes with the root cell physiology and brings about a reduction in the overall root mass. Consequently, water and nutrient absorption is disrupted, leading to poor plant health and abnormal growth. Symptoms become more obvious with increasing density of the nematode population (Kayani *et al.,* 2017). Additionally, nematode infestation weakens plants, making them more susceptible to withering (Irshad *et al.,* 2012), as well as to infection by other pathogens and reducing their ability to compete with weeds.

The use of synthetic nematicides, though highly effective in most cases, is currently being discouraged, owing to safety and environmental concerns. This has necessitated the exploration of alternative methods. Solarization, an age-old practice that employs polythene sheets to raise soil temperature and reduce nematode population is environmentally friendly and a promising alternative (Candido *et al.,* 2011; Blanco-Canqui and Ruis, 2018). The success of this approach is however, dependent on factors like soil types, temperature, and moisture content (Ferreira *et al.,* 2020; Kranz *et al.,* 2020). Furthermore, soil physical properties play a vital role in crop health. It is for this reason that the application of biochar and the practice of conservation agriculture, to enhance soil structure and fertility, has become a growing trend in crop production (Mondal *et al.,* 2020; Singh *et al.,* 2022).

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Additionally, powdered botanicals, some of which are known to have bioactive constituents with nematicidal properties, offer natural and environment-friendly alternatives to synthetic chemicals for nematode management, while also promoting soil health and fertility (Blanco-Canqui, 2017).

According to literature (Santosh *et al.*, 2023), the best period for solarization is usually during the warm summer months, when optimum solar radiation and heat can be harnessed from the sun. Unfortunately, most farmers in Africa do not have irrigation facilities required for crop production during this period. Consequently, they rely on rain-fed farming and crop production activities are usually put on hold during the summer months. This has prevented most farmers from benefitting from the numerous benefits associated with solarization. This study was designed to evaluate the effectiveness of solarization at controlling soil nematodes during the rainy season and to determine its effect on weed infestation and soil physical properties. The aim was to encourage the use of soil solarization for managing plant parasitic nematodes. The objective was to evaluate the effect of solarization, aided with powdered botanicals, on nematode population in the soil during the rainy season, soil physical properties and weed diversity.

MATERIALS AND METHODS

Study Location

The study was conducted at the Federal University of Technology, Akure during the rainy season of 2023. Akure is on longitude 5°06′E to 5°38′E and between latitude 7°07′N to 7°37′N. It is in the rainforest agro-ecological zone of Nigeria. The nematode isolation and identification process were carried out in the Pathology Laboratory, Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, Federal University of Technology, Akure.

Experimental Design, Land Preparation and Treatment Application

The site of the study was a two-year fallow land, previously under vegetable cultivation. Clearing of weeds was followed by ploughing and levelling of soil to give an even surface, after which a land area measuring 13 m × 1.4 m (18.2 m^2) was marked out for the study. It was divided into seven plots, with each plot measuring 1.6 m × 1.4 m (2.24 m^2) and a 0.3 m space between plots. This was followed by treatment applications. The polythenes, transparent and black (100 microns in thickness), were laid with their edges tucked into the earth to prevent heat escape (Figures 1a and 1b). The powdered botanicals consisted of 140 g (70 g *C. papaya* + 70 g *V. amygdalina*) applied evenly on the soil surface. The standard check consisted of an even application of carbofuran, a synthetic nematicide, at the manufacturer's recommended rate. The control had no treatment applied. Treatments were allocated to plots randomly in a completely randomized design (CRD). The treatments evaluated were; Treatment A (Transparent polythene film only), Treatment B (Powdered botanicals only), Treatment C (Black polythene film only), Treatment D (Carbofuran, standard check), Treatment E (Transparent polythene + powdered botanicals), Treatment F (Control) and Treatment G (Black polythene + powdered botanicals). All plots were watered sufficiently after treatment application and the evaluation period was six weeks.

Collection of Soil Samples from the Plots

Soil samples were collected, from each plot, for nematode extraction before treatment applications and at the end of the study. Sample collection was done following the procedure described by Coyne *et al.* (2007). Soil samples were collected on each plot using a soil core sampler at a depth of 15 cm. Seven samples in all were taken from each and the soil was sealed in polythene bags and protected from sun to avoid soil moisture loss. The samples were poured and mixed thoroughly by hand on a smooth surfaced board to homogenize them. The homogenized sample was then divided into three, replicates, for nematode extraction.

Figure 1: Solarization with (a) Transparent polythene and (b) Black polythene

Extraction of Nematodes from Soil Samples
The Baermann-funnel technique for nematode extraction, as described by Cesarz *et al.* (2019), was adopted with some modifications. The funnel was substituted with perforated plastic, measuring 8 cm in diameter and 6 cm in depth. The filter paper was also replaced with a two-layered serviette paper. Exactly 100 g of soil each, from the composite sample, was weighed and placed onto the serviette papers within the perforated plastic. The perforated plastic, and the soil within it, were suspended in a shallow container having 100 ml of water. The extraction process was allowed to run for 48 h after which filtrates from each replicate were obtained. Centrifugation was performed, and the supernatant was decanted, leaving 10 ml of nematode suspension in appropriately labelled sample bottles.

Killing, Fixing and Staining of Extracted Nematodes
The hot fixative method, described by Ryss (2017), was employed for this process. Extracted nematodes in sample bottles were fixed using a formalin solution containing 40% formaldehyde. Exactly 2 ml of the solution was added to 10 ml of nematode suspension and heated to 70°C in a water bath, following the procedure described by Van Bezooijen (2006).

Microscopy, Counting and Identification of Isolated Nematodes
The extracted nematodes were observed under a light microscope at ×250 magnification, utilizing an AmScope® microscope equipped with a 2.0-megapixel camera connected to a laptop computer. 1 ml of the heat-fixed nematode suspension from each treatment was extracted using a pipette and transferred onto a calibrated hollow slide. Identification of individual nematodes was carried out with a guide from standard texts (Coyne *et al*., 2007) and pictorial keys (Eisenback, 2002; Mekete *et al*., 2012). Counting and identification procedures were conducted in triplicate for each plot.

Data Collection and Statistical Analysis
Data were collected on the following parameters.
Nematode population and diversity: The total number of nematodes in 1 ml aliquot from the fixed solution in each treatment were counted and identified up to the genera level. The values obtained were extrapolated to estimate the number of nematodes present in 100 g of soil sample.
Soil moisture: This was done by determining the initial weight of soil, immediately after collection with core samplers, and the final weight after oven drying to constant weight at a temperature of 105ºC. Moisture content was calculated using the formula of ASTM (2000). The soil moisture content determination was done before treatment application and at the end of the study after six weeks.

$$Moisture\ content\ (\%) = \frac{W_2 - W_3}{W_3 - W_1};$$

where W_1 is weight of the container, W_2 is weight of the container + moist soil, and W_3 is weight of the container + oven-dried soil.

i. ***Soil temperature:*** The temperature of the soil in each plot was measured at mid-day twice. Before treatment application and at the end of the study period, before the removal of polythene sheaths. Measurement was done with the aid of a soil thermometer by dipping it through the polythene sheath into the soil to a depth of 4 cm. The values displayed were read off and recorded.
ii. ***Weed infestation:*** Weed population/diversity in each treatment was determined, at the end of the study period, through the use of a 38 cm × 38 cm quadrat. The area covered by the quadrat was used as representative of the entire plot for each treatment. The quadrat was placed randomly at locations within each plot, after which all the weeds within the quadrats were removed, identified and counted.

For statistical analysis, all numerical data were subjected to analysis of variance using MINITAB (17) software, and mean separation done using Tukey's test at a 5% level of probability.

RESULTS

Effects of Treatments on Nematode Population and Diversity
Thirteen nematode genera, *Meloidogyne* spp., *Hoplolaimus* spp. and *Bursaphelenchus* spp. amongst others, were identified from all the plots evaluated (Table 1). *Meloidogyne* spp. was the most commonly isolated and the most populous (Table 2; Figure 2a). It was found in all the plots. *Hoplolaimus* spp and *Helicotylenchus* spp were the second and third most populous, respectively. *Longidurous* spp. (Figure 2b) was the least populous, it was found only in treatment F (Control). Only three treatments, C (black polythene only) and G (black polythene + powdered botanicals) brought about a significant reduction in the overall nematode population at the end of the evaluation period.

Table 1: A list of genera of nematodes isolated from the plots

Genera	Family Name	Common Name
Meloidogyne spp.	Meloidogynidae	Root-knot Nematode
Pratylenchus spp.	Paratylenchidae	Pin Nematode
Hoplolaimus spp.	Hoplolaimidae	Lance Nematode
Helicotylenchus spp.	Hoploliamidae	Spiral Nematode
Rotylenchulus spp.	Tylenchulidae	Reniform Nematode
Heterodera spp.	Heteroderidae	Cyst Nematode
Tylenchorhyncus spp.	Tylenchidae	Stunt Nematode
Hemicyclophora spp.	Hemicycliophoridae	Sheath Nematode
Ditylenchus spp.	Anguinidae	Stem & Bulb Nematode
Belolaimus spp.	Belonolaimidae	Sting Nematode
Longidorus spp.	Longidoridae	Needle Nematode
Psilenchus spp.	Tylenchidae	Needle Nematode
Bursaphelenchus spp.	Aphelenchidae	Pinewood Nematode

Table 2: Relative abundance of nematode genera isolated from the plots before (FNP) and after (SNP) treatment application

Treatments/ Nematode Genera	A		B		C		D		E		F		G		TOT.
	FNP	SNP	FNP	SPN	SNP	SPN	FNP	SNP	FNP	SNP	FNP	SNP	FNP	SNP	
Meloidogyne spp.	8.00a	11.00a	4.00a	5.00a	10.00a	5.00a	6.00a	12.00a	11.00a	10.00a	7.00a	1.00b	13.00a	5.00a	108.00
Pratylenchus spp.	1.00b	1.00c	1.00c	1.00c	4.00c	2.00b	1.00d	2.00b	3.00d	4.00b	2.00b	1.00b	4.00c	3.00c	30.00
Hoplolaimus spp.	1.00b	3.00b	2.00b	3.00b	6.00b	1.00c	2.00c	2.00b	5.00b	4.00b	2.00b	2.00a	1.00e	1.00e	35.00
Helicotylenchus spp.	1.00b	1.00	1.00c	1.00c	6.00b	2.00c	2.00c	2.00b	4.00c	4.00b	1.00c	1.00b	7.00b	1.00e	34.00
Rotylenchus spp.	0.00c	1.00c	0.00d	1.00c	0.00f	0.00d	1.00d	0.00d	0.00f	3.00c	0.00d	1.00b	3.00d	4.00b	14.00
Heterodera spp.	1.00b	0.00d	1.00c	1.00c	2.00d	2.00b	3.00b	1.00c	1.00e	4.00b	1.00c	0.00c	4.00c	2.00d	23.00
Hemicyclophora spp.	0.00c	0.00d	1.00c	1.00c	1.00e	1.00c	0.00e	1.00c	0.00f	1.00e	0.00d	1.00b	0.00f	1.00e	8.00
Ditylenchus spp.	0.00c	1.00c	0.00d	0.00d	0.00f	1.00c	1.00d	0.00d	0.00f	0.00f	0.00d	0.00c	3.00d	2.00d	8.00
Tylenchorhyncus spp.	0.00c	1.00c	0.00d	0.00d	0.00f	0.00d	0.00e	0.00d	0.00f	1.00e	0.00d	1.00b	0.00f	0.00f	3.00
Belolaimus spp.	0.00c	0.00d	0.00d	0.00d	0.00f	0.00d	0.00e	1.00c	0.00f	0.00f	0.00d	2.00a	0.00f	2.00d	5.00
Longidorous spp.	0.00c	0.00d	0.00d	0.00d	0.00f	0.00d	0.00e	0.00d	0.00f	0.00f	0.00d	1.00b	0.00f	0.00f	1.00
Psilenchus spp.	0.00c	0.00d	0.00d	1.00c	0.00f	1.00c	0.00e	1.00c	0.00f	1.00e	0.00d	0.00c	0.00f	1.00e	5.00
Bursaphelenchus spp.	0.00c	0.00d	0.00d	0.00d	0.00f	1.00c	0.00e	1.00c	0.00f	2.00d	0.00d	1.00b	0.00f	1.00e	6.00
TOTAL	12.00	19.00	10.00	14.00	29.00	16.00	16.00	23.00	24.00	34.00	13.00	12.00	35.00	23.00	279.00

A - transparent polythene film only, B - powdered botanicals only, C - black polythene film only, D - carbofuran, E - transparent polythene film + powdered botanicals, F - control, G - black polythene film + powdered botanic, FNP - initial nematode population, SNP - final nematode population, FNP - first nematode population, SNP - second nematode population

Figure 2: Isolated nematodes from treatments (a). *Meloidogyne* spp. (b). *Longidorus* spp.

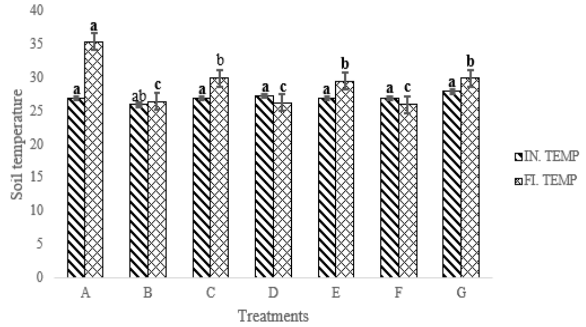

Figure 3: Effect of treatments on soil temperature.
A - Transparent polythene film only, B - Powdered botanicals only, C - Black polythene film only, D - Carbofuran, E - Transparent polythene film + powdered botanicals, F - Control, G - Black polythene film + powdered botanicals; IN. TEMP - initial temperature, FI. TEMP - final temperature
Bars with the same pattern and letter are not significantly different by Tukey's test at $p < 0.05$.

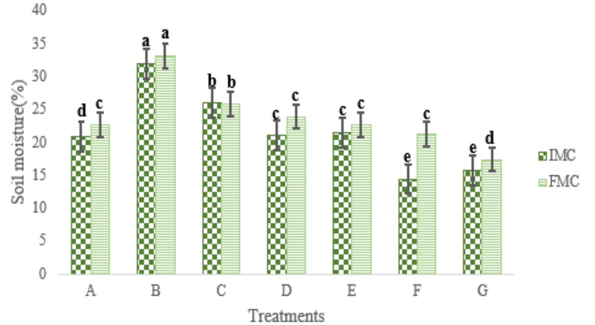

Figure 4: Effect of treatments on soil moisture content
Explanations are as for Figure 3, except for IMC - initial moisture content and FMC - final moisture content

Treatment C (black polythene only) reduced the overall nematode population, 29.00, at the beginning of the study to 16.00 at the end of the study, with 44.84% population reduction. More interestingly, the population of *Meloidogyne* spp. reduced by 50.00%, from 10.00 to 5.00 at the end of the study (Table 2). A similar trend was observed in treatment G (Black polythene + powdered botanicals). The overall nematode population reduced by 34.28% (35.00, initial, to 23.00 final), while *Meloidogyne* spp. reduced by 61.53% (13.00, initial, to 5.00 final) (Table 2). An increase in the final nematode population, above the initial value, was observed in all other treatments, except F (Control), where a marginal decrease of 7.69% was recorded.

Effects of Treatments on Soil Physical Properties

Soil temperature

The initial soil temperature was not significantly ($p \leq 0.05$) different across all treatments, but the highest value, 28ºC, was obtained from treatment G, while the least, 26ºC, was obtained from treatment B (Powdered botanicals only) (Figure 3). The final temperature at the end of the study showed variations among the treatments. Treatment A (transparent polythene only) had the highest, 35.5ºC, and significantly ($p \leq 0.05$) different values. This value represented a 31.48% increase over the initial temperature. Treatments C (Black polythene only), E (transparent polythene + powdered botanicals and G (black polythene + powdered botanicals) all recorded marginal increases of 3.00ºC, 2.50ºC and 2.00ºC over the initial temperatures respectively and were all not different statistically. Treatment D (Carbofuran) had its final temperatures lower than the initial one and was the poorest (Figure 3).

Moisture content

Figure 4 presents treatment effects on soil moisture content. The difference between initial and final values was highest in treatment D, 2.89%, surpassed only by the control, 6.84% (Figure 4). Treatment A had 22.77% final moisture content, a 1.80% increase over the initial value, making it the second best, while treatment G had a 1.72% increase over the initial value. Treatment B was the least effective. The final moisture content was 25.91%, which was 0.09% lower than the initial one (Figure 4).

Effect of Treatments on Weed Population and Diversity

The list of weed species identified from all the plots evaluated is shown in Table 3. All the species identified were grouped into 14 genera. These include Asteraceae, Poaceae and Fabaceae amongst others (Table 3). The distribution pattern showed that treatments C and G were the most effective at controlling the weed population. There was no weed growth on both plots at the end of the 6 weeks evaluation period (Table 4). Treatment A was the next most effective, only two genera, Cynodon and Portulaca were seen to have grown at the end of the study period. The weed population was also sparse. Treatment F, control, had the highest weed population and diversity at the end of the study period. A total of 6 genera grew back and were identified at the end of the study period. The weed population was also dense. Treatment E had a very poor effect on weed inhibition. It was the least effective among the treatments. It had the highest diversity of genera, 5, one less than the control (Table 4), but the weeds had a light-yellow colour, poor growth and were sparsely distributed. *Euphorbia* spp. was the most resistant to the treatments evaluated, it grew on 4 plots, B, D, E and F. The remaining genera were more susceptible and were limited to 1 or 2 plots (Table 4).

Table 3: A list of genera of weeds identified from the plots

Genera	Family
Ageratum spp.	Asteraceae
Arabidopsis spp.	Brassicaceae
Calopogonum spp.	Fabaceae
Commelina spp.	Commelinaceae
Cynodon spp.	Poaceae
Cyperus spp.	Cyperaceae
Digitaria spp.	Poaceae
Eleusine spp.	Poaceae
Euphorbia spp.	Euphorbiaceae
Imperata spp.	Poaceae
Olidenlandia spp.	Rubiaceae
Pandanus spp.	Pandanaceae
Portulaca spp.	Portulacaceae
Tridax spp.	Asteraceae

Table 4: Distribution of weed species across the treatments evaluated

Weed Diversity	Treatments						
	A	B	C	D	E	F	G
Ageratum spp	×	×	×	×	×	✓	×
Arabidopsis spp.	×	×	×	×	✓	×	×
Calopogonum spp.	×	×	×	×	✓	×	×
Commelina spp.	×	×	×	×	✓	×	×
Cynodon spp.	✓	×	×	×	×	✓	×
Cyperus spp.	×	✓	×	×	×	×	×
Digitaria spp.	×	×	×	×	✓	✓	×
Eleusine spp.	×	×	×	×	×	✓	×
Euphorbia spp.	×	✓	×	✓	✓	✓	×
Imperata spp.	×	×	×	✓	×	×	×
Olidenlandia spp.	×	✓	×	×	×	×	×
Pandanus spp.	×	✓	×	×	×	×	×
Portulaca spp.	✓	×	×	×	×	×	×
Tridax spp.	×	×	×	✓	×	✓	×

✓- weed present, × - weed is absent, A - Transparent polythene film only, B - Powdered botanicals only, C - Black polythene film only, D - Carbofuran, E - Transparent polythene film + powdered botanicals, F - Control, G - Black polythene film + powdered botanicals

DISCUSSION

Results from this study showed that *Meloidogyne* spp. was the most commonly occurring nematode, out of the 13 genera identified in the study location. This is not unexpected. Report from previous studies shows that root-knot nematodes, (*Meloidogyne* spp.) are among the four most common species in Africa and the world at large, with a wide range of hosts (Ajayi, 2019). The knots and swellings that root-knot nematodes generate on plant roots are what give them their name (Coyne *et al.,* 2007). The effects of treatments on the overall nematode population showed that black polythene, used singly and synergistically with powdered botanical was the most effective, better than transparent polythene that has been widely reported in the literature (Candido *et al.,* 2011). The reason for this observation may be due to the period of the year, the rainy season, when this study was conducted, instead of the conventional dry and warm period. The absence of weeds in plots solarized with black polythene may also have resulted in the absence of a host for the nematodes, bringing about a reduction in their population over the study period. The reduced efficacy of transparent polythene at controlling the nematode population may be due to the weed growth under it. Previous findings have reported that weed growth under transparent polythene can result in an increased nematode population (Thomas *et al.,* 2005; Frankenberg *et al.,* 2007). In a similar vein, the application of synthetic nematicide, Carbofuran, was expected to bring about a major reduction in the nematode population at the end of the study period. This was, however, not the case. The treatment did not result in any significant reduction in the nematode population. This may also be connected with the heavy rains associated with the period the study was carried out. This may have diluted the concentration beyond the lethal dose. The same can be said for the powdered botanicals, especially when applied singly. It was not effective and so did not result in any significant reductions in the nematode population, contrary to several reports (Fadina, 2010; Duong *et al*., 2014). Johnson (2019) reported that botanical powders may have their nematicidal properties influenced by factors like soil conditions and the specific botanical source.

The effect of treatments on soil temperature showed that solarization with transparent and black polythene, either singly or synergistically with botanicals, all brought about an increase in soil temperature. The highest increase was, however, recorded in treatment A, transparent polythene only. This result is in agreement with previous studies on the potential of transparent polythene to increase soil temperature and to help in managing soil-borne plant parasitic nematodes (Candido *et al.,* 2011; Shutt *et al*., 2021). The mechanism of action is through the trapping of solar radiation, which is prevented from escaping and used to heat the soil, bringing about an increase in soil temperature, especially in the topmost layer (Candido *et al.,* 2011; Blanco-Canqui and Ruis, 2018; Osakwe *et al*., 2023). The temperature increase in the present study was, however, lower than was reported in previous works (Shutt *et al*., 2021). This may be due to the period the study was carried out, the rainy season, when solar radiation is less, coupled with the cooling effects produced by water every time it rains. This may also have accounted for the poor ability of treatment A and E to bring about a significant difference between the initial and final nematode population. The final moisture contents of solarized plots were higher than the initial ones. This is a confirmation of the ability of solarization to retain soil moisture (Sakthivel, 2019). The values obtained in these plots were, however, significantly lower than the control plot. This can once again be attributed to the effect of the rains during the period of the study. Water may have moved into the control plots easily, but a similar situation in the solarized plots may have been prevented by the polythene cover. An interesting finding was that treatment D, carbofuran, had the highest increase in the final soil moisture among the treatments, excluding the control. It is not clear why this was so. It can only be speculated that a certain relationship may have existed between carbofuran and the moisture present in the soil, helping to lock the moisture within the pores of the soil. This view is supported by the findings of Mohamed *et al.* (2022), that soil moisture is required by carbofuran for mineralization and dissipation in the soil.

Treatments involving solarization with black polythene, C and G, were the most effective in suppressing weed growth. The reason for this observation is clear. Black polythene prevented light from getting to the soil surface, thus depriving germinated weed seeds from receiving much-needed light for photosynthesis (Amuji *et al.*, 2024). Consequently, the seedlings died after a short while. This explains why treatments C and G had zero weed growth at the end of the 6-week study period. The effectiveness of black polythene in controlling weed growth, when used as mulching material, has been reported (Sakthivel, 2019; Kavitha *et al.,* 2021). The high population of *Euphorbia* spp. in most of the treated plots may be due to their hardiness and wide distribution, being the third largest genus of Angiosperm (Joharis and Kumar, 2020), as well as their adaptation to warm tropical habitats.

CONCLUSION

The results of this study showed that black polythene, used singly and in synergy with powdered botanicals, was the most effective at reducing the nematode population and suppressing weed growth. It also brought about a moderate increase in soil moisture. It is recommended that black polythene be adopted for soil solarization, by farmers, during the rainy season, for the control of plant parasitic nematodes. It has the added benefit of weed control.

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