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Effect of time of application of sunn hemp aqueous seed extract on root knot nematodes and yield of groundnut

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Abstract

A field experiment was conducted to determine the effects of time of application of sunn hemp (*Crotalaria juncea* L.) seed extract on root knot nematodes of groundnut. An aqueous sunn hemp seed extract was applied at planting and repeated biweekly till six weeks after planting (6 WAP). Synthetic nematicide (Carbosulphan) application and untreated controls served as positive and negative checks, respectively. The experiment consist of six treatments which were laid in a Randomized Complete Block Design (RCBD). Treatments were replicated three times. Each plot received 500g/500ml of the seed extract at different times of application. The results of the current study revealed that sunn hemp seed extract was most effective against root knot nematodes when applied at planting. The results further revealed that nematode population and root gall index were significantly reduced when the extract was applied at the time of planting (T1). The findings of this study have shown that early application of sunn hemp aqueous seed extract application schedule reduces root-knot nematode severity and improves yield of groundnut under field conditions. Application of sunn hemp aqueous seed extract within the first two weeks after planting would achieve a maximum reduction of root knot nematodes severity and hence improve yields in groundnut under field conditions. This finding will serve as information for future root knot nematodes management interventions.

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Introduction

Groundnut (*Arachis hypogea* L.) is widely known as an oil and food crop. Its nutritional facts include a 43 – 55% oil, and 25 – 28% protein (Janila *et al.*, 2013; Mohammed *et al.*, 2018).

Although groundnut is primarily cultivated for human consumption, it also serves as a major source of income for producers and marketers. As a leguminous crop, it plays a significant role in soil fertility management as well as conservation of soil moisture. According to Vanlauwe *et al.* (2015), it contributes to the reduction of farmer's vulnerability to weather-induced shocks.

Furthermore, groundnut biomass is also used as fodder in livestock farms across many sub-Saharan regions. FAOSTAT (2017) estimated a 37.64 million tons of groundnut pods produced in 2017. Of the global production volume, Klei *et al.* (2020) reported that Ghana produces about 420,000 tons on 338,000 hectares of land area annually. The northern regions have been documented to be responsible for about 85 % of the total production in Ghana (Owusu-Adjei, 2017).

Notwithstanding its high contribution to global food security, groundnut is highly susceptible to biotic agents such as root knot nematodes (*Meloidogyne* spp.). Root knot nematodes infection on the crop leads to poor field establishment, growth, development, and quantity and quality of yield. Furthermore, it also increases the cost of production. Impacts of nematode infestation in groundnuts are usually seen in a reduction of the number of effective nodules, leading to a reduction in the activity of nitrogen fixing bacteria. Pods infested with nematode pest show symptoms of brownish spots that grows darker with time.

Traditionally, nematodes management has depended on the use of crop rotation and conventional nematicides. The wide host range of root knot nematodes makes it difficult if not impossible to identify non-host crops to reduce their population and damage caused. As much as chemical control has been reported to be one of the most effective approaches to managing root knot nematode menaces, it tends to be costly for the resource poor farmers with weaker purchasing powers. Also, it poses danger to the health of users and their environment. This has led to withdrawal or loss of registration of several nematicides previously used in most advanced countries (Danchin, 2013). An alternative to the conventional pesticides is the use of botanical nematicides. This option is not only human friendly, but also environmentally sustainable and, in some cases, easy to be prepared by farmers at the farm level. Several authors have reported a successful use of bioproducts and extracts from plants such as *Azadirachta indica*, *Lantana camara*, mungbean and African marigold to manage a wide range of nematode species infesting crops of economic importance (Leonard *et al.*, 2021; D'Addabbo *et al.*, 2020). The use of sunn hemp (*Crotalaria juncea* Linn) as a crop and also for nematodes management has been well documented in several studies (Silpi and Narpinderjeet, 2017; Kankam *et al.*, 2015; Wang and McSorley, 2009). Sunn hemp's root, stem, and seeds contains pyrrolizidine alkaloids and other secondary metabolites, such as non-protein amino acids (Colegate *et al.*, 2012; Pandharmise *et al.*, 2022). These compounds can suppress weeds, bacteria, fungi, and nematodes in the soil. In an account of Amulu *et al.* (2021), sunn hemp leaf extract was able to significantly reduce root knot nematodes population. Nevertheless, it is also important to note that the efficacy of pesticides is greatly affected by the time of application. It is therefore important for one to factor this into considerations when designing nematodes management schemes involving botanical nematicides. Giannakou *et al.* (2005) reported that applying pesticides at the right time increases their efficacy against diseases, reduces the cost control and improves the quantity and quality of yield in most crops. The current study therefore seeks to determine the optimum application time of sunn hemp aqueous seed extract for effective management of root knot nematodes infestation in groundnut.

Materials and methods

Study site

The study was carried out at the University for Development Studies, Nyankpala experimental fields during the major groundnut seasons of 2021 and 2022. The mean annual rainfall for the area ranges between 1000 - 1200 mm. Relative humidity ranges between 46 - 76.8% with a mean minimum and maximum temperatures of 21.9°C and 34.1°C, respectively (Adu *et al.*, 2018). The selected experimental site was previously planted with tomatoes and had a history of high incidence of root knot nematodes.

Source and preparation of sunn hemp aqueous seed extract

Sunn hemp pods were harvested from their natural habitation at the University for Development Studies Experimental fields, Nyankpala. Sunn hemp seeds were obtained by gently pressing pod in between the thumb and forefinger to obtain seed for use. Five hundred grams (500 g) of the seeds were weighed and washed under tap water. The washed seeds were grounded in 500 ml of distilled water in an electric blender for 3 mins. The blended mixture was filtered through a two-layer muslin cloth to obtain a clear filtrate. The filtrate obtained was stored in a refrigerator at 4 °C and used as stock solution.

Field establishment and application of treatments

Groundnut seeds (*Chinese*) were purchased from CSIR-SARI, Nyankpala in the Northern region of Ghana. The plot size used for the field experiment was 100 m^2 (10 m × 10 m). The field was demarcated into three plots as replications, each replication was (3 m × 10 m) with 1 metre between each replicate and beds were prepared manually with hand hoes. The seeds were sown at 45 cm × 15 cm spacing and at a depth of about 5 - 7 cm. The experiment consisted of six treatments, including application of aqueous sunn hemp at planting (T1), application of sunn hemp at two weeks after planting (T2), application at four weeks after planting (T3), application of sunn hemp six weeks after planting (T4), a synthetic nematicide (Carbosulphan) (T5) at four weeks after planting and an untreated control (T6). Each plot received 500g/500ml of the seed extract at different times of application while the Carbosulphan was applied at the rate of 5 kg ai/ha. Treatments were arranged in a Randomized Complete Block Design (RCBD) and were replicated three times.

Data collection

Plant height, pod number and grain yield measurement

Ten middle row plants were selected and tagged after inoculation. The selected plants were used to determine the effect of treatments on plant height, pod number and grain yield for the period of the study. While plant height was taken at 4, 6, and 8 weeks after inoculation, the number of pods (filled and unfilled) per plant and grain yield were determined at 8 weeks after planting. Grain yields were expressed in kg/ha.

Nematode extraction from soil samples

Samples of soil were collected randomly from each experimental unit at a depth of 15 cm using the soil auger. Samples were bulked to form a composite sample per plot from which root knot nematodes were extracted from 220 cubic centimeters using the modified Baermann's tray method (McSorley, 1987; Whitehead and Hemming, 1965). Extracted nematodes were identified and counted using an inverted microscope (Olympus, China) at 40x magnification with the aid of a Doncaster counting dish and tally counter. Initial and final soil samplings for root knot nematodes extraction were done at planting and harvesting, respectively.

Assessment for root galling severity

Eight weeks after treatment application, 10 plants from each plot were randomly selected and uprooted for assessment. Roots of uprooted plants were visually assessed for the presence of root galls using Bridge and Page (1980) rating chart (0 =no galls, 10 = severely knotted).

Statistical analysis

The two-year data was pooled together and subjected to analysis of variance (ANOVA) using the GenStat (edition 12). Treatment means were separated using LSD at 5%. Nematode control effect was calculated using the formula: [(Root galling index in control-Root galling index in treated)/ Root galling index in control] (Chen *et al.*, 2015). Significance was defined at $p < 0.05$ and where necessary data was transformed (log x + 1) for normality.

Results

Plant height

There were significant differences ($p < 0.05$) among treatments in terms of plant height. Plant height at 4 WAP was between 5.73 cm – 7.53 cm. The highest plant height was observed for application of sunn hemp at planting (T1) while the lowest was observed when no control measure was applied (T6). However, there were no significant variations among treatments when assessed at both 6 WAP and 8 WAP (Table 1).

Table 1. Effect of time of application of sunn hemp seed extract on plant height

Treatments	Plant height		
	4 WAP	6 WAP	8 WAP
T1	7.53 ± 0.23^{a}	16.60 ± 0.72	34.27 ± 3.14
T2	5.73 ± 0.42^{b}	14.73 ± 2.12	30.27 ± 3.31
T3	5.80 ± 0.35^{b}	15.27 ± 1.03	32.13 ± 0.95
T4	6.73 ± 0.76^{a}	15.93 ± 1.33	35.13 ± 4.74
T5	7.60 ± 0.92^{a}	16.53 ± 1.30	35.73 ± 2.61
T6	6.73 ± 0.83^{ab}	14.93 ± 2.23	33.47 ± 3.56
Rep	3	3	3
SED	0.639	1.555	3.256
F.pro	<0.001	0.565	0.381
Df	12	12	12

Values represent mean ± standard deviation. Values within a column with different superscript letter are significantly different at $p < 0.05$). T1; Sunn hemp extract applied at planting, T2; Sunn hemp extract applied at 2 weeks after planting (WAP), T3; Sunn hemp extract applied at 4 weeks after planting, T4; Sunn hemp extract applied at 6 weeks after planting, T5; Synthetic nematicide (Carbosulphan) (T5) at four weeks after planting and T6, untreated control.

Yield assessment

Treatments in this study did not exhibit significant variations ($p > 0.05$) in the number of pods per plant. However, there was a significant difference ($p < 0.05$) among treatments when yield was assessed as grain yield (Table 2). Sunn hemp seed extract application at planting (T1) produced the highest grain yield (1124 kg/ha) while the lowest (826 kg/ha) was obtained where no treatment was applied (T6) (Table 2).

Table 2. Effect of time of application of sunn hemp seed extract on yield on groundnut

Treatments	Number of pods per plant	Pod weight
T1	14.80 ± 0.80	1124.00 ± 136.74
T2	14.53 ± 0.95	1032.00 ± 43.00
T3	14.37 ± 1.82	967.00 ± 113.25
T4	14.20 ± 1.57	986.00 ± 176.77
T5	14.43 ± 1.25	1025.00 ± 251.01
T6	13.00 ± 0.500	826.00 ± 85.11
Rep	3	3
SED	1.235	149.9
F.pro	0.581	0.331
Df	12	12

Values represent mean ± standard deviation. Values within a column with different superscript letter are significantly different at $p < 0.05$). T1; Sunn hemp extract applied at planting, T2; Sunn hemp extract applied at 2 weeks after planting (WAP), T3; Sunn hemp extract applied at 4 weeks after planting, T4; Sunn hemp extract applied at 6 weeks after planting, T5; Synthetic nematicide (Carbosulphan) (CT) at four weeks after planting and T6; Untreated control.

Incidence of root knot nematodes population in the soil

There was a significant difference ($p < 0.05$) among treatments in terms root knot nematodes juvenile population. Plants treated with sunn hemp at planting (T1) had the least incidence (1.75) and the highest (2.23) incidence was observed for the untreated plants (T6) (Table 3).

Table 3. Effects of time of application of sunn hemp seed extract on root knot nematodes population

Treatments	Untransformed mean	Transformed mean
T1	55.00 ± 17.57^{b}	1.75 ± 0.13^{b}
T2	69.00 ± 12.16^{b}	1.85 ± 0.07^{b}
T3	61.00 ± 10.14^{b}	1.79 ± 0.07^{b}
T4	62.33 ± 20.26^{b}	1.80 ± 0.13^{b}
T5	55.67 ± 16.74^{b}	1.75 ± 0.12^{b}
T6	167.00 ± 13.23^{a}	2.23 ± 0.03^{a}
Rep	3	3
SED	15.41	0.10
F.pro	<0.001	<0.001
Df	12	12

Log10 (X+1) transformed, where X = mean count. Values represent mean ± standard deviation. Values within a column with different superscript letter are significantly different at $p < 0.05$). T1; Sunn hemp extract applied at planting, T2; Sunn hemp extract applied at 2 weeks after planting (WAP), T3; Sunn hemp extract applied at 4 weeks after planting, T4; Sunn hemp extract applied at 6 weeks after planting, T5; Synthetic nematicide (Carbosulphan) (CT) at four weeks after planting and T6; Untreated control.

Root galling severity

Treatments varied significantly ($p < 0.05$) in terms of root galling index at harvest. The highest root galling index (4.66) was observed for untreated plants (T6) while the least (2.66) was recorded on those treated with synthetic nematicide, Carbosulphan (T5) (Table 4).

Table 4. Effect of time of application of sunn hemp seed extract on root gall index of groundnut

Treatments	Root gall index
T1	4.34 ± 0.58^{ab}
T2	3.56 ± 0.51^{ab}
T3	3.33 ± 0.00^{cd}
T4	3.33 ± 0.34^{cd}
T5	2.67 ± 0.58^{d}
T6	4.66 ± 0.58^{a}
Rep	3
SED	0.478
F.pro	0.003
Df	12

Values represent mean ± standard deviation. Values within a column with different superscript letter are significantly different at $p < 0.05$). T1; Sunn hemp extract applied at planting, T2; Sunn hemp extract applied at 2 weeks after planting (WAP), T3; Sunn hemp extract applied at 4 weeks after planting, T4; Sunn hemp extract applied at 6 weeks after planting, T5; Synthetic nematicide (Carbosulphan) (CT) at four weeks after planting and T6; Untreated control.

Discussion

Results of this study revealed a varying level of efficacy of the sunn hemp aqueous extract on root knot nematodes. Just like many other management approaches, the time of implementation of the strategy is one of the most critical contributing factors to the efficacy of the control agent.

The results revealed that application of sunn hemp aqueous extract at planting had the lowest nematode incidence and root galling index (Table 3 and 4). This could be due to the fact that nematode populations were lower when sunn hemp was applied at planting (Sharma and Sharma, 2015). Perhaps, the early application did not only control existing nematode eggs but also acted as a protectant that prevents or inhibits the incident of and development of nematode eggs. This finding corroborates with Silpi and Narpinderjeet (2017), Kankam (2015), and Wang and McSorley (2009) who also reported some success stories from the use of sunn hemp as a biological control agent for nematode management. Furthermore, reports from Leonard *et al.* (2021), D'Addabbo *et al.* (2020) also revealed some higher potentials of extracts from plants such as *Azadrichta indica*, *Lantana camara*, mungbean and African marigold as nematicides.

This approach, coupled with timely application could therefore be a sure replacement or at least an alternative to the orthodox application of various synthetic nematicides, considering its high efficacy, environmental, and economic friendliness. The effectiveness of early application of the sunn hemp extract was further revealed in agronomic and yield parameters such as plant height, number of pods per plant, and grain yield. Plant height, number of pods per plant, and grain yield observed when sunn hemp was applied at planting were comparatively higher. According to Giannakou *et al.* (2005), adequate and timely management of nematicides enhances both the agronomic and yield potentials in crops. The density of root knot nematode increased with the corresponding increase in time of applications (weeks) of sunn hemp seed extract. High population might have led to higher competition for food and nutrients among the developing nematodes within the root rhizosphere, probably using a reduction in nutrient and water available for plant uptake (Karssen and Moens, 2006). In essence, the result of this could be related to a drastic reduction in the physiological activities of the plant (Bird, 2004; Robert, 2013).

Furthermore, this could be due to the fact that plants, when free from pests and diseases, direct most, if not all of their resources into growth and development, and reproduction rather than fighting stress (Ploeg, 2001; Mahmood *et al*., 2010).

Conclusion

In this study, application of sunn hemp aqueous seed extract at planting was the most effective for the control of root knot nematodes of groundnut. It was also observed that late application of the extract resulted in a corresponding decrease in plants height, number of pods per plant, and grain yield. Also, it resulted in arise in nematodes population and root gall index. In effect, it is recommended that sunn hemp aqueous seed extract should be applied as early as possible, possibly at planting for maximum efficiency. The current finding will also serve as a useful information for future interventions.

References

Adu GB, Alidu H, Amegbor IK, Abdulai MS, Nutsugah SK, Obeng-Antwi K, Kanton RA, Buah SS, Kombiok MJ, Abudulai M. 2018. Performance of maize populations under different nitrogen rates in northern Ghana. Annals of Agricultural Sciences **63**(2), 145–152.

Amulu LU, Oyedele DJ, Adekunle OK. 2021. Effects of sunn hemp (*Crotalaria juncea*) and Mexican sunflower (*Tithonia diversifolia*) leaf extracts on the development of *Meloidogyne incognita* on African indigenous vegetables. Archives of Phytopathology and Plant Protection **54**, 1247–1260.

Bird D. 2004. Signaling between nematodes and plants. Plant Biology **7**(4), 372–376.

Bridge J, Page SLJ. 1980. Tropical pest management, root gall scoring scale **26**(3).

Cheng X, Liu X, Wang H, Ji X, Wang K, Wei M. 2015. Effect of Emamectin benzoate on root-knot nematodes and tomato yield. PLoS One **10**(10), e0141235.
https://doi.org/10.1371/journal.pone.0141235

Colegate SM, Gardner DR, Joy RJ, Betz JM, Panter KE. 2012. Dehydropyrrolizidine alkaloids, including monoesters with an unusual esterifying acid, from cultivated *Crotalaria juncea* (Sunn hemp cv. 'Tropic Sun'). Journal of Agricultural and Food Chemistry **60**, 3541–3550.

D'Addabbo T, Argentieri MP, Zuchowski J, Biazzi E, Tava A, Oleszek W, Avato P. 2020. Activity of saponins from *Medicago* species against phytoparasitic nematodes. Plants **9**, 443.

Danchin EG. 2013. Identification of novel target genes for safer and more specific control of root-knot nematodes from a pangenome mining. PLoS Pathogens **9**, e1003745.
https://doi.org/10.1371/journal.ppat.1003745

FAO. 2017. FAO production yearbook, Vol. 60. Rome, Italy.

Giannakou IO, Karpouzas DG, Anastasiaes I, Tsiropoulos NG, Georgiadou A. 2005. Factors affecting the efficacy of non-fumigant nematicides for controlling root-knot nematodes. Pest Management Science **61**(10), 961–972.

Janila P, Nigam SN, Pandey MK, Nagesh P, Varshney RK. 2013. Groundnut improvement: Use of genetic and genomic tools. Frontiers in Plant Science **4**, 13.

Kankam K, Suen FA, Adomako J. 2015. Nematicidal effect of sunn hemp (*Crotalaria juncea*) leaf residues on *Meloidogyne incognita* attacking tomato (*Solanum lycopersicum* L.) roots. Journal of Crop Protection **4**(2), 241–246.

Karssen G, Moens M. 2006. Root knot nematodes. In: Perry RN, Moens M (eds). Plant Nematology. CABI Publishing, 59–90.

Kleih U, Bosco S, Kumar R, Apeeliga J, Lalani B, Yawlui S. 2020. Groundnuts value chain analysis in Ghana. Report for the European Union, DG-DEVCO. Value Chain Analysis for Development Project (VCA4D CTR 2016/375-804), 150.

Leonard UA, Durodoluwa JO, Ojo KA. 2021. Effects of sunn hemp (*Crotalaria juncea*) and Mexican sunflower (*Tithonia diversifolia*) leaf extracts on the development of *Meloidogyne incognita* on African indigenous vegetables. Archives of Phytopathology and Plant Protection **54**(15–16), 1247–1260. https://doi.org/10.1080/03235408.2021.1899371

Mahmood KT, Mugal T, Ulhaq I. 2010. *Moringa oleifera*: A natural gift – A review. Journal of Pharmaceutical Sciences and Research **11**, 775–781.

McSorley R. 1987. Extraction of nematodes and sampling methods. In: Brown RH, Kerry BR (eds). Principles and Practice of Nematode Control in Crops, 13–47.

Mohammed KE, Afutu E, Odong TL, Okello DK, Nuwamanya E, Grigon O, Rubaihayo PR, Okori P. 2018. Assessment of groundnut (*Arachis hypogaea* L.) genotypes for yield and resistance to late leaf spot and rosette diseases. Journal of Experimental Agriculture International **21**(5), 1–13. https://doi.org/10.9734/JEAI/2018/39912

Owusu-Adjei E, Baah-Mintah R, Salifu B. 2017. Analysis of the groundnut value chain in Ghana. World Journal of Agricultural Research **5**(3), 177–188. https://doi.org/10.12691/wjar-5-3-8

Pandharmise P, Tambe AN, Kamble S, Tuwar DA. 2022. Preliminary phytochemical screening and HPTLC analysis of leaf extract of *Crotalaria juncea* from Vidarbha region, MS, India. Journal of Maharaja Sayajirao University of Baroda **56**, 269–274.

Ploeg A. 2001. When nematicides attack is important. California Grower, October, 12–13.

Robert OG. 2013. Effects of sunn hemp (*Crotalaria juncea*) on root knot nematodes (*Meloidogyne* spp.) of lettuce. Dissertation submitted to Department of Agronomy, Faculty of Agriculture, University for Development Studies, Tamale, Ghana.

Sharma IP, Sharma AK. 2015. Effect of initial inoculum levels of *Meloidogyne incognita* J2 on development and growth of tomato cv. PT-3 under control conditions. African Journal of Microbiology Research **9**(20), 1376–1380.

Silpi P, Narpinderjeet KD. 2017. Evaluation of sunnhemp (*Crotalaria juncea*) as green manure/amendment and its biomass content on root knot nematode (*Meloidogyne incognita*) in successive crop brinjal. Journal of Entomology and Zoology Studies **5**(6), 714–715.

Vanlauwe B, Descheemaeker K, Giller KE, Huising J, Merckx R, Nziguheba G. 2015. Integrated soil fertility management in sub-Saharan Africa: Unravelling local adaptation. Soil **1**, 491–508.

Wang KH, McSorley R. 2009. Management of nematodes and soil fertility with sunn hemp cover crop. Publication #ENY-717. University of Florida, IFAS Extension.

Whitehead AG, Hemming JR. 1965. A comparison of some quantitative methods of extracting small vermiform nematodes from soil. Annals of Applied Biology **55**, 25–38.