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Nematicidal Properties of Ethanol Extracts of *Khaya senegalensis* Against Root-Knot Nematodes Affecting Cowpea (*Vigna unguiculata*) L.in Sokoto

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ABSTRACT

Root-knot nematode infection is one of the greatest menace affecting the growth and yield of many crops not only in Nigeria but globally. The present study aimed at conducting a greenhouse experiment to test the efficacy of leaf extract of *khaya senegalensis* for the control of root-knot nematodes of cowpea. A questionnaire method was used to obtain information from the local farmers in Sokoto State on the type of plants they use to treat suspected cases of root-knot infection. A total of 300 questionnaires were distributed, with 100 for each senatorial district. A total of nine plants were identified and about 3 plants were selected for the experiment one from each senatorial district based on the frequency of appearance of the plants in the responses. Thirty plastic pots mouth open of 15cm was obtained and filled with autoclaved soil. Week old cowpea seedlings raised separately was uprooted and transferred in to the pots and inoculated with 1000 juveniles of nematodes except the first group that was left as control. Extract of leaves of *Khaya senegalensis* was measured and applied in to the inoculated seedlings at different concentration (100mg/ml, 200mg/ml, 300mg/ml & 400mg/ml) except the second group which serve as another control. Four weeks after the transplant, growth was measured in term of plant height, root length, as well as extent of galling likewise nematodes population was also taken. The result indicated an improved growth in all the parameters tested over the untreated groups especially those treated at the highest level of concentration. The phytochemical screening of the plant leaves indicated the presence of some glycosides which may be responsible for the observed nematicidal activities. It is however important that further research be carried out to identify the phytoconstituents that may be of possible effects using other plant models.

Keywords: Root-knot nematodes, Cowpea, *Khaya senegalensis*, Sokoto

INTRODUCTION

Agricultural Produce means all produce and commodities, whether processed or unprocessed, of agriculture, horticulture, apiculture, sericulture, livestock and products of livestock, fleeces (raw wool) and skins of animals, forest produce and fisheries. It may also include two or more of such products (Wang *et al.*, 2019). Civilization started with agriculture which, to this day, remains very important and plays a significant role in our lives. While its significance may be even more pronounced in some countries than others, the reality is that every country depends on agriculture to sustain itself in one way

or another (Folawiyo, 2008). For decades, it's been associated with the production of food crops. However, the importance of agriculture goes above and beyond farming. It's evolved into forestry, fruit cultivation, beekeeping, arbitrary, mushroom, dairy, etc. Today, the processing, distribution, and marketing of crops and livestock products are all acknowledged as a part of agriculture.

Agriculture plays an essential role in sustaining and driving the economy. It's the backbone of everything that drives us. In addition to providing food and other raw materials, it also provides employment opportunities. Safe to say the importance of agriculture cannot be overstated (Mark, 2017)

The nematode parasites of plants (the causal organism of ear cockle of wheat) were reported as early as 1743. However, the importance of these tiny organisms in the scheme of human welfare is of much later realization. There had been stray cases when these organisms had been found to cause significant damage in the nineteenth century (such as the sugar beet cyst nematode) but it was only after the second world war (1945), when some easy to apply and relatively cheap nematicides were discovered, that their significance as widely occurring destructive plant parasites was demonstrated.

Many crops including cowpea are susceptible to nematodes attack, for instance an evaluated yield loss of bean cultivar was found out that 45-63% yield loss was due to nematodes. Several workers like Taylor 2009, Ritter 2002, and Adamova 2005, reported losses of up to 50% of the total gross production of vegetable and 2% of the fruits due to root nematodes in southern Europe and Mediterranean.

On a global basis, out of the approximately 34% crop losses annually caused by crop enemies like fungi, bacteria, nematodes, viruses, insects, and weeds, nematodes alone are responsible for losses of about 11% (Broodier et al., 2007). According to Sasser and Freckman (2010), the annual loss of crops due to nematodes is about 12.3%, more in the developing countries like Nigeria than in the developed countries of Europe and America. Losses in potato, cowpea, eggplant, okra and pepper (chilli) are 12.2, 20.6, 16.9, 20.4, and 12.2%, respectively (Olowe, 2011). Loss of yield in cowpea is estimated to be 60-70% (Odihirifi, 2008). Even in a developed country like the USA about 7.2% of the annual crop value was lost to nematode attacks during the mid-sixties of the last century, in England, the potato cyst nematode caused annual loss of about 20 million dollars (Sasser et al., 2017). The root knot nematodes annually destroy 29-90 % of vegetable crops (Alose, 2019). In Nigeria, reduction in yield of cowpea due to root-knot is reported to range from 26.5 to 43. 3% (Shaukat et al, 2017). In legume-crops, Suatmadji (2019) have estimated a loss of 13.7% in chickpea due to root- knot and 13.2% in pigeon pea due to root-knot, cyst nematode and *Rotylenchulus reniformis*. Citrus decline, pepper yellows, molya disease of wheat and barley (cereal cyst nematode), and ear cockle of wheat are some of the examples of the damage caused by plant parasitic nematodes. There is hardly any horticultural crop that is not attacked by nematodes, even some grain crops suffer heavily from their attack (Suatmadji 2019)

Damage to crops by nematodes is related to the population of the nematodes attacking the crops. Controlling such pests mean lessening the number until yield loss is economically acceptable, (Adesiyon et al., 2010). Maintenance to acceptable limit, might require outright killing of the nematodes using chemical, or may be achieved indirectly by adding soil amendments that encourage the growth of the host plant and antagonists that kill the nematodes. A number of control practices have been used over time. These control methods includes chemical control, use of resistant varieties, crop rotation, biological control, and recently the use of plant extracts and soil amendments.

There are several nematicides that can be used effectively for nematode pests of annual crops (Van Berkum and Hoekstra, 2009), but there appears to be little prospect for management of nematodes in many susceptible, perennial crops without repeated application of nematicides. Only in certain cases will such treatments be justified economically. Nematicides are highly toxic compounds that have very low LD50 values. This is particularly important for operators of application machinery and people at risk from exposure to the chemicals during their application.

The liquid formulations of some of the non-fumigant nematicides are emulsifiable concentrates. Their use should therefore be restricted to skilled operators who take adequate safety precautions. This may not always be the case where basic levels of education are poor or where operators cannot read the instructions on the labels of the products. The application of nematicides to crops too near to harvest is

another risk which pesticide residue monitoring may not be sufficiently well coordinated to prevent poisoning.

In Nigeria, root-crops, cereals, legumes and vegetables are grown in mixture on most traditional agricultural fields. The root-knot nematodes infest these groups individually, but with limited economic losses on cereals (Egunjobi, 2005). It was further reported that in intercropping system, maize confers significant protection to Cowpea against root-knot nematodes.

The only problem with crop rotation is that, one designed to reduce a given nematode species, often lead to the increase in the population of other species to damaging levels (Brodies *et al.*, 2007).

A number of plants are thought to have contained extracts with some nematocidal properties. The nematocidal activities of plant has been investigated by several workers. These substances have been found to reduce a popular level of some nematodes species. In vitro test of water extracts leaves stems and bark of *tylencus spp* and that of *Anguina spp* indicated 50-70% mortality of nematodes at 4mg/ml dilution after 48hrs of treatments. The water extracts of neem oil cake and leaves renders the root of susceptible plants highly unfavourable to *Meloidogyne* and similarly the use of such extracts have been found to render the roots unfavourable for nematodes hence causing poor penetration and later retardation in the biological activity such as feeding and reproduction of root-knot nematodes.

Gowen and Ahmed (2018) have listed a number of plant species whose extract possess the ability to control various nematodes species. These included *Ageratum conyoides* acting on *Meloidogyne incognita* and *M.javanica*; *Allantus excels* acting on *M. incognita* and *M.javanica*; *Brassica nigra* acting on *Tylenchorhynchus brassica* where the extracts are absorbed by the roots.

Statement of the Problem

Nematodes are known to cause a lot of damage to many plants including cowpea and cowpea. Rarely any crop is free from their attack, yet they escape notice because of their microscopic size and protective position (Southey, 2016). Many control measures such as chemical method, crop rotation, etc. have been put in place with little or no success. Although some are quite effective, their side effects by far outweigh the success.

The widespread use of synthetic pesticides has significant draw back including development of strain resistant to insecticides, increased cost, handling hazards, concern about threat to human health, animal and environmental components. Repeated use of synthetic chemicals for pest and vector control has disrupted natural biological control system; it has also resulted in the development of resistance, undesirable effects on non-target organisms and fostered environmental and human health concern. It is therefore pertinent to find a way of reducing the yield loss incurred by these pests using the safest way of disease management, in order to boost world food production.

Nowadays there is growing awareness on the hazards of using chemicals in plant disease control, both on the soil nutrients and the individual himself. This resulted in banning the use of some chemical such as the D.D.T. Interest is therefore shifting towards the use of plant extracts in disease management. This therefore necessitated this research to be conducted with the aim of using natural plant materials in the control of the root-knot nematodes (*Meloidogyne*) of cowpea and cowpea.

Justification

This research is important to farmers and to the society because it provide an alternative method of nematode control which has been a great menace and an obstacle in the yield and production of many important crops including Cowpea. Economically, it also provides a cheaper and safer method of plant disease management, which complements other nematode control methods. Chemical fungicides and pesticides are used for effective control of phytopathogens. However, the deleterious effects of these chemicals on human health and environment strongly demand the search for an alternative eco-friendly approach for Pathogen control. Use of plant extracts provides a safer, Biocompatible and nontoxic methods of control of plant parasites and has received great attention as a Biopesticides. It enhances promotion of plant growth and disease control and thus can improve the Bio-availability, stability, of fungicides or pesticides

It is important scientifically for other researchers in the field to be able to make further enquiry in plant disease management and specifically in the control of root-knot nematodes.

Aim and Objectives of the Work

The aim of this work is to determine the nematicidal potentials of *Khaya senegalensis* extracts used to control root-knot nematodes affecting cowpea. The specific objectives are to:-

- Collect, identify and select the *K.senegalensis* in sokoto state
- Screen the plants that appeared frequently in the administered questionnaire for a Nematicidal activity
- Determines the phytochemical composition of the tested plant
- Determines the effects of the extracts on the plant height, root length, number of galls as well as nematodes population of the cowpea inoculated with root-knot - nematodes.

MATERIALS AND METHODS

Study Area

Sokoto State generally is located in the extreme North Western part of Nigeria between latitude 13°N to 13°58'N and longitude 4°8'E and 6°54'E. It covers a total land area of about 28,232.37 square kilometers of land mass. The State shares boundaries with the Republic of Niger to the North, Kebbi State to the West and South-West and Zamfara State to the East. The State has 23 Local Government areas, in which the Metropolis comprised two major Local Government councils namely Sokoto North and Sokoto South, and captured many parts of *Wamakko*, *Kware* and *Dange-Shuni local government areas* (Ministry of Information, Sokoto, 2006). Sokoto metropolis specifically lies between 12° 55'N and 13° 10' N and longitudes 5° 09' E and 5° 17' E (Sokoto master plan). It extends to a 16 km radius from Shehu Kangiwa Square during the 2006 census. With the present expansion of the city, the metropolis is projected to be 17km in radius (Bello, et al 2017).

Map of Sokoto City

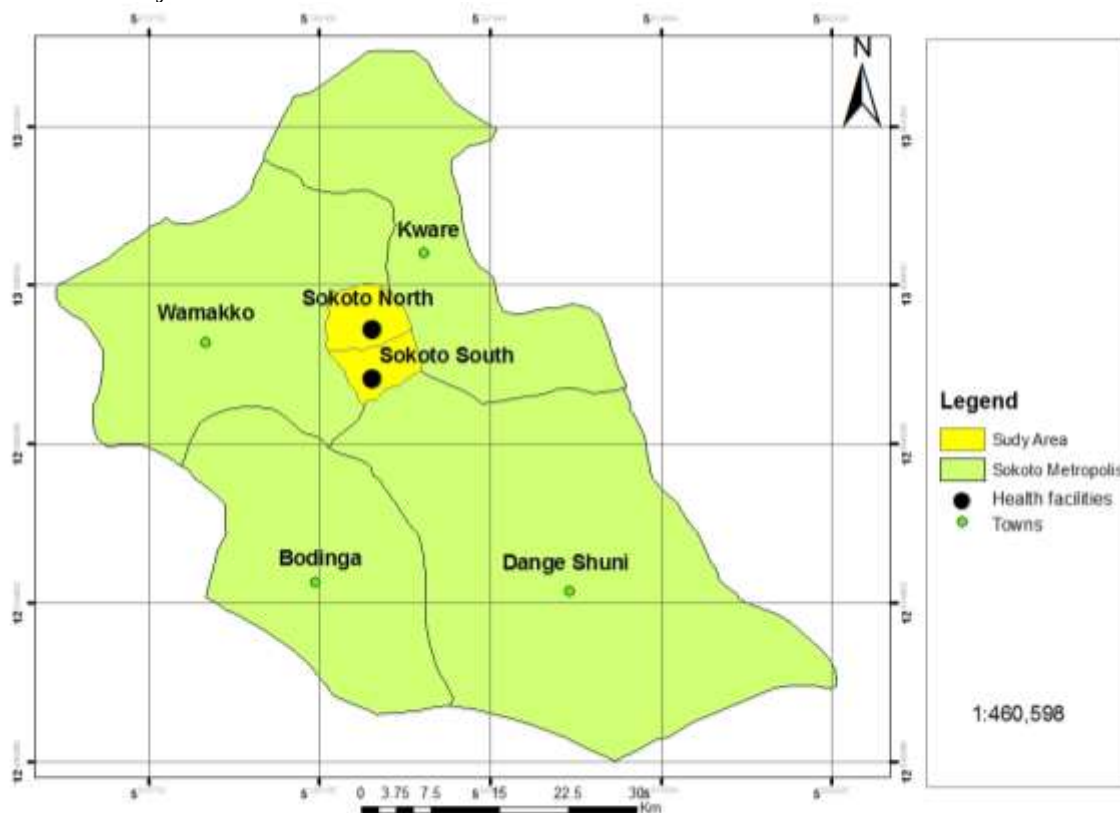


Figure 1: Study Area Source: OSGOF Drawn at GIS Lab. Department of Geography UDUS, 24

Climate of the Area

The climate of Sokoto is largely influenced by the interactions between two air masses, the tropical moisture air mass from the Atlantic Ocean and the Tropical continental air mass from Sahara Desert. The climate is characterized by rapid changes in temperature and humidity. Temperatures are generally high in the months of March–May, with highest recorded mean monthly temperature of about 40° in April, Ismail, (2013). The lowest temperatures occur in the months of December and January due to influence of Harmattan, Seasonal rainfall prediction by NIMET (2019) shows that Sokoto will have a range between rainy seasons of about 65–70%. The city is surrounded by two major rivers, River *Rima* and River *Bunsuru*. These rivers afford year round water which provides fertile soil and a lot of *Fadama* areas in the state. The warmest months are from March to May, where day temperature can exceed 45°C (113°F). The rainy season is from June to October, during which showers occur daily. The showers rarely last long and are far than the regular torrential showers known in the tropical regions. Harmattan wind blows Sahara dust over the land. The dust dims the sunlight thereby lowering temperature significantly (Shamaki, 2015).

Population and People of the study area

The population in Sokoto metropolis consists mainly of *Hausa*, *Fulani* and *Zabarmawa* ethnic groups. With the colonial conquest in 1903 and the emergence of Nigeria as a political entity in 1914, many other ethnic groups from the South and Middle Belt of the country have migrated and taken permanent residence in the area. Although the *Igbos* and *Yorubas* top the list of Southern migrants, one can find large numbers of almost all over 250 other ethnic groups of Nigeria. One can also find some other tribes of West Africa in this metropolis particularly from Niger and Benin Republic.

Administration of Questionnaire

A questionnaire was administered to the local farmers within the study area in order to ascertain the types of plants they use to treat symptoms of nematodes infection. The questionnaire comprised of six sections namely: Age of farmer, Local government area, name of senatorial zone, name of collecting centre, type of crops raised, name of plants and or parts used when symptoms of nematodes infection is suspected. The responses gotten were used as the basis for the selection of the plants used for the experiment.

Collection of Inoculums.

Soil samples were collected from an infested cowpea farm in kwalkwalawa area along the Usmanu Danfodiyo University main campus where villagers raise their crops. Infestation was confirmed by looking at the emergence of galls within the root of the plants (Abubakar, 1999). Similarly some samples were collected in an infested farm behind bursary area of the main campus, by digging around the rhizosphere of the cowpea, 3cm below the surface of the soil using a shovel. All the samples were then placed in a polythene bags and taken to the laboratory and kept under room temperature until it is due for isolation.

Isolation of Nematodes from the Soil Samples

For isolation, Cobb decantation and sieving technique was employed. In this method, the soil sample was poured into a bucket half-filled with water. The mixture of soil and water was then stirred gently to remove any lump and allowed to settle for about 30 seconds. The supernatant liquid which contain most of the nematodes was decanted and poured through series of eight inches diameter sieves of varying mesh sizes (40, 80 and 120cm) some of the nematodes were trapped in the sieves. The suspension was collected in a basin and poured again for the second time over the sieves for maximum collection of nematodes. The residue from each sieve was collected, which contain the Nematodes required for the inoculation (Abubakar, 1999).

Extraction of Plants Extracts

The leaves of the plant chosen for this experiment obtained and identified were shade-dried; the dried parts were ground using pestle and mortar and sieve to obtain a fine powder. 200g of the dried fine powder was measured and placed in 1 liter conical flask and 500ml of distilled water was added. It was manually shaken vigorously and allowed to stand for 48 hours (2 days), it was then shaken for about 20 minutes and filtered using size 1 whatman filter paper to obtain an aqueous extract of the experimental plant. The

volume was noted and placed in an electric drier and evaporated slowly at 45°C as described by Muyibi *et al.*, (2000).

Determination of Nematicidal Effect of *K.senegalensis* on Cowpea inoculated with root-knot nematodes

Extracts of leaves of the plant obtained was tested for its effects on root -knot nematodes. The extract of leaves obtained by the method earlier described was used. 30 plastic pots of 15cm diameter were obtained for the plant material to be tested. The pots were divided in to six group of five. Each pot was filled with 1kg of autoclaved soil. Each pot was inoculated with 1000 juveniles nematodes earlier isolated from the soil sample except the 1st group of six which serve as control. One week old seedlings of cowpea raised separately in the autoclaved soil were uprooted and transferred into the pots earlier inoculated a with nematodes. Ten (10mls) of extracts of *K senegalensis* was measured and applied to each of the pots earlier inoculated with nematodes using the various concentrations obtained, except the first control group and second group of six that were inoculated and left untreated to serve as another control (Southey, 2016). The cowpea was watered regularly. The cowpea used, was obtained from Sokoto central market.

Four weeks after the transplant, one cowpea plant was removed from each pot and growth was observed in terms of plant height, root length, extent of galling as well as final nematodes population. The extent of galling was established on a scale of 0- 5 (Sasser et al., 1984) as follows; where 0= no galling; 1 = 1-10 galls; 2=11-20 galls; 3=21-30 galls 4=31-100 galls; and 5= more than 100 galls per root system. The galling was identified by removing the plant and observing their emergence.

Data Analysis

The data obtained was subjected to analysis of variance (one way Anova) and Duncan multiple range tests was used to test the treatments for significance at 5% level of significance.

RESULTS

The Plant Commonly Used as Nematicides in the Study Area

As a result of the questionnaire administered to the local farmers, a total of nine (9) plants were found to be used as Nematicides in the study area. These are *Azadirachta indica*, *Balanite aegyptiaca*, *Carica papaya*, *Khaya senegalensis*, *Tamarindus indica*, *Psidium guajava*, *Ricinus cummunis*, *Tagetes specie*, and *Vernonia amygdalina* (Table 1).

Out of these, three (3) plants were identified as most frequently used as it appears in the answered questionnaire. They are *Khaya senegalensis*, *Vernonia amygdalina* and *Azadirachta indica* (Table 2). And one (1) was selected for the purpose of this research and that is *Khaya senegalensis*

TABLE 1: List of Indigenous Plants used as Nematicides as Responded by Local Farmers in the Study Area

S/No	Scientific Name	English Name	Local Name	Plant Part Used
1.	<i>Azadirachta indica</i>	Neem Tree	Dogon Yaro	Leaves
2.	<i>Balanite aegyptiaca</i>	Desert date	Aduwa	Stem bark
3.	<i>Tamarindus indica</i>	Tamarin	Tsamiya	Stem bark
4.	<i>Khaya senegalensis</i>	Mahogany	Madacci	Leaves
5.	<i>Carica papaya</i>	Pawpaw	Gwanda	Leaves
6.	<i>Psidium guajava</i>	Guava	Gwaba	Leaves
7.	<i>Ricinus cummunis</i>	Castor Bean	Mamudu	Leaves
8.	<i>Tagetes spp.</i>	Marigold	Danya	Fruits
9.	<i>Vernonia amygdalina</i>	Bitter Leaf	Shuwaka	Leaves

TABLE 2: List of Indigenous Plants most frequently used as Nematicides as Responded by Local Farmers in the Study Area

S/No	Scientific Name	English Name	Local Name	Plant Part Used	Senatorial District Collected
1.	<i>Khaya senegalensis</i>	Mahogany	Madacci	Leaves	Sokoto East (Zone A)
2.	<i>Azadirachta indica</i>	Neem Tree	Dogon Yaro	Leaves	Sokoto Central (Zone B)
3.	<i>Vernonia amygdalina</i>	Bitter Leaf	Shuwaka	Leaves	Sokoto South (Zone C)

Table 3: Phytochemical Constituents of the Ethanol Extracts of *Khaya Senegalensis*

Phytochemical Constituents	Inferences
Alkaloids	++
Flavonoids	+
Tannins	++
Phenol	-
Saponins	++
Steriods	+
Glycosides	-

Key: + = trace, ++ = moderate +++ = high - = not detected

Effects of Extracts of *Khaya senegalensis* on Plant Height, Root Length, Number of Galls and Nematodes Population

Table 4 shows that treatment of infected cowpea with the leaf extract of *khaya senegalensis* has resulted in an improved plant height over the untreated seedlings at all level of concentration. The mean plant height of the uninoculated seedlings (28.13cm) indicted an optimal growth in the absence of nematodes. The inoculated and untreated control in which the plant is exposed to nematodes infection exhibited a significantly lower mean height(18.40cm) compared to the uninoculated control demonstrating the detrimental effect of nematode infection on the cowpea plant.

The application of different concentration of khaya senegalensis leaves extract resulted in varying degrees of growth recovery resulting in an improved plant height in nematode infested plant. At 400mg/ml concentration, there is the most significant improvement in plant height (26.33 cm) almost approaching the height of uninoculated control.

At lower concentration (100-300 mg/ml) there is also a positive effect with an increasing concentration, generally leading to an increased plant height. The P-value for the treatment groups indicates a significant difference in plant height between the treatment groups

Table 4: Height of the Cowpea Plants Inoculated with Nematodes and Treated with Extract of *Khaya senegalensis* at Different Concentrations

Concentration/Treatment(mg/ml)	Mean of the Plant Height(cm)	p-value
Uninoculated	28.13± 0.176 ^a	0.001
Inoculated	18.40± 0.100 ^f	
100	21.50± 0.058 ^e	
200	23.33± 0.167 ^d	
300	25.13± 0.167 ^c	
400	26.33± 0.033 ^b	
Total	23.81 ± 0.778	

Values are expressed as Mean±SEM of three replicates. Values in row having different superscript differs significantly at p≤0.05 level of significant (One Way ANOVA followed by Duncan Multiple Range Test).

Table 5 showed that the uninoculated plants showed the highest mean root length (8.39cm) indicating a healthy root growth in the absence of nematodes. The inoculated untreated seedlings that are exposed to nematodes infestation and left untreated exhibited a significantly shorter mean root length of (6.17 cm) compared to the un inoculated control. This demonstrates the negative impact of nematodes infection on the root development.

The application of *k. senegalensis* leaves extract at different concentration resulted in varying degrees of root-length recovery in the nematode infected seedlings. At 400mg/ml concentration, there is most significant improvement in root length (7.17cm) almost approaching the length of the un inoculated control. Higher concentration of *k.senegalensis* extracts generally showed a trend towards increased root length compared to the un-inoculated control. The P-value of the treatment groups also showed a significant difference in root- length ($p < 0.05$). Similarly the same trend was exhibited in both extend of galling as well as the nematodes population. As expected, the uninoculated seedlings showed no galling (0.00) indicating absence of nematodes infection while the inoculated control exhibited high number of galls (12.00) confirming a severe impact of nematodes infection on the root health. It was observed that at the highest concentration of 400mg/ml of extract of *K. senegalensis* gall formation has significantly reduced to zero similar to the uninoculated control. At lower concentration of 100mg/ml (6.30 cm), 200mg/ml(6.37 cm) and 300mg/ml (6.77cm) some level of gall reduction was observed but the effect was less pronounced compared to that of the highest concentration of 400mg/ml. The P-value however indicated a significant difference in gall formation between the treatment groups.

Table 5: Root Length of the Cowpea Plants Inoculated with Nematodes and Treated with Extract *Khaya senegalensis* at Different Concentrations

Concentration/Treatment(mg/ml)	Mean of the Root Length (cm)	p-value
Uninoculated	8.39 $\pm$ 0.003 ^a	0.000
Inoculated	6.17 $\pm$ 0.088 ^d	
100	6.30 $\pm$ 0.058 ^d	
200	6.37 $\pm$ 0.186 ^d	
300	6.77 $\pm$ 0.033 ^c	
400	7.17 $\pm$ 0.067 ^b	
Total	6.86 $\pm$ 0.188	

Values are expressed as Mean $\pm$ SEM of three replicates. Values in row having different superscript differs significantly at $p \leq 0.05$ level of significant (One Way ANOVA followed by Duncan Multiple Range Test) Table 6 and 7 provides strong evidence that *K. senegalensis* leaves extract can effectively suppress gall formation caused by nematodes on cowpea roots as well as reducing the overall nematodes population. The 400mg/ml concentration in both treatments also demonstrated the most potent nematicidal activity significantly reducing gall formation and nematode population comparable to infected plants

Table 6: Number of Galls in the Roots of the Cowpea Plants Inoculated with Nematodes and Treated with Extract of *Khaya senegalensis* at Different Concentrations

Concentration/Treatment(mg/ml)	Mean + Standard Error	p-value
Uninoculated	0.00 $\pm$ 0.00 ^b	0.040
Inoculated	12.00 $\pm$ 0.577 ^{ab}	
100	13.33 $\pm$ 0.882 ^a	
200	11.33 $\pm$ 0.333 ^{bc}	
300	10.33 $\pm$ 0.333 ^c	
400	0.00 $\pm$ 0.000 ^d	
Total	7.83$\pm$ 1.370	

Values are expressed as Mean±SEM of three replicates. Values in row having different superscript differs significantly at $p \leq 0.05$ level of significant (One Way ANOVA followed by Duncan Multiple Range Test)

Table 7: Number of Nematodes of the Cowpea Plants Inoculated with Nematodes and Treated with *Khaya senegalensis* at Different Concentrations

Concentration/Treatment(mg/ml)	Mean Number of the Nematodes	p-value
Uninoculated	0.00± 0.00 ^e	0.010
Inoculated	531.67 ± 4.409 ^a	
100	263.33± 1.667 ^b	
200	241.00± 1.000 ^{bc}	
300	223.67 ± 0.667 ^c	
400	114.67 ± 17.676 ^d	
Total	229.06 ± 39.499	

Values are expressed as Mean±SEM of three replicates. Values in row having different superscript differs significantly at $p \leq 0.05$ level of significant (One Way ANOVA followed by Duncan Multiple Range Test)

DISCUSSION

Root-knot Nematodes is one of the major problems affecting many crops not only in Nigeria but globally (Whitehead,2009).There is rarely any crop that escape their attacks but yet escape notice because of their microscopic size and protective position within the soil (Southey,2016). Recently there is a growing interest in using plants constituent for the environmental investigations.

The reduction in the number of nematodes recorded in the various cowpea plants inoculated with the root-knot nematodes and treated with the different concentration of *K.senegalensis* may be accounted for by the presence of some substances in the test plant are deleterious to the nematodes like saponin found in it. The observed decrease in the number of nematodes may be responsible for the increase in growth of the seedlings. Such decrease means fewer disturbances to the seedlings resulting in an unhindered growth (Vander-Borgett et al., 2014). The fewer number of galls observed in the plants treated with the various concentration of the extract may equally be indication of an acquired resistance imposed by the extracts. The result therefore establishes the nematicidal potentials of the extract obtained from the plant. The efficacy of Mahogany leaves can be attributed to the presence of a compound called saponin which is known to have antiparasitic properties (Githiori, 2016)

The improvement in the root length and plant height of cowpea plant observed may be as a result of decrease in the number of nematodes which is known to cause a stunted growth on the infected plant as well as causing galling on the root which consequently affect the proper growth of the roots. This agreed with the work of Olowe T, (2011) on the use of root extracts of *K. senegalensis* in the control of root-knot nematodes. The study further shows that the potentials for treatment by the extracts of *K.senegalensis* is directly proportional to their concentrations. That at lower concentration of 100mg/ml the active ingredient with the nematicidal effect takes longer period to accumulate to the point of potency. This is in conformity with the work of Mahmoud and Siddique (2013) on the effects of Saponin on the growth of cowpea and reproduction of *Rotelenchus reinformis*.

Khaya senegalensis as shown in the phyto chemical screening of its constituents (Table 3) is rich in various bioactive compounds such as flavonoids, tannins, Glycosides, saponin, and alkaloids. This agreed with the findings of Akhtar and Malik (2001), however phenols and glycosides were not detected in this studies. This variation is not surprising because it is known that both genetic and environmental factors influence the content and composition of secondary metabolites in plants (Koupai-Abyazani et al; 1993).The geographical location of the sites of sample collection could also be responsible for variation in the chemical constituents of the plant. These compounds exhibit an array of biological activities including antifungal, anti-bacterial, and nematicidal effects. An in vivo study has confirmed the effectiveness of *K. senegalensis* extract in suppressing nematodes population in cowpea plants (Olowe et al., 2019). Ogunyemi et al., 2021, Adebayo et al., 2020, all reported an improved growth parameters such as root

length, shoot height and fruit yield as well as enhanced soil microbial activity which contributes to nematodes suppression. Flavonoids in particular have been documented to disrupt nematodes development and reproduction. Research indicates that extracts from different parts of the plant including leaves and bark can have varying levels of toxicity against meloidogyne specie. The significant differences observed in the various treatment groups in the experiment have indicated strong evidence that the extract of leaves of *K. senegalensis* hold the potentials as nematicides.

CONCLUSION

Khaya senegalensis leaf extract have shown a promising potential as an eco-friendly and sustainable alternative for controlling root-not nematodes infection in cowpea plant.

From the result obtained it can be concluded that the extracts of leaves of *Khaya senegalensis* holds the potentials for nematicidal activities. They may contain such active substances which are harmful to nematodes and as such they could be used as nematicides Farmers may be encouraged to use the leaves either by mixing them with the soil through proper tilling method or by applying them directly to the susceptible crops.

The result further establishes the effect of concentration on the treatment which indicated that at lower concentration the difference between the plant height and root lengths of all the cowpea plants treated with various extracts and those that are left untreated are insignificant. Likewise the same trend was observed with respect to nematodes population. The best solution to the nematodes problems is treatment with plant extracts which contain toxic substance to nematodes of which a good example is *K.senegalensis*. The 400mg/ml concentration in both treatments have demonstrated the most potent nematicidal activity significantly reducing gall formation and nematode population comparable to infected plants

The nematicidal activity of *Khaya senegalensis* represents a promising avenue for sustainable nematodes management in cowpea crops. While current research indicates its effectiveness, further studies are essentials to elucidate the specific mechanism involved and to determine optimal application rates and methods. By leveraging the natural properties of *K.senegalensis* farmers may not only reduce nematodes infestation but also contribute to a more sustainable agricultural system. Continued exploration in to the plant-based nematicides could lead to more environmentally friendly practice in crop production as the quest

The Phytochemical screening of the experimental plant revealed the presence of a wide range of phyto-constituents some of which have been reported to possess nematicidal activity and which enables them to effectively suppress nematodes population while promoting plant health. However as indicated, further research is needed to optimize application methods and evaluates their long term impact under field conditions

RECOMMENDATIONS

Based on the above findings the following are recommended

- i) Further studies be carried out to identify phytoconstituents that may be of possible effect using other plant models
- ii) Farmers should be encourage to use this plant as an alternative method of controlling nematodes in order to reduce their menace on our crops

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