PLANT PARASITIC NEMATODES ASSOCIATED WITH *JATROPHA CURCAS* ACCESSIONS IN SOME LOCAL GOVERNMENT AREAS OF KADUNA STATE, NIGERIA

BY

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DECLARATION

I hereby declare that the work in this dissertation titled ‘‘Plant Parasitic Nematodes Associated with *Jatropha curcas* Accessions in Some Local Government Areas of Kaduna State, Nigeria’’ has been performed by me in the Department of Crop Protection under the supervision of Drs. Chindo, P. S., Alao, S. E. L. and. Agbenin, N. O. The information derived from the literature has been duly acknowledged in the text and in the references. No part of this dissertation was previously presented for another degree at any University.

Jeremiah Olamide OLATUNJI	_______________	________
Name of Student	Signature	Date

CERTIFICATION

This dissertation entitled PLANT PARASITIC NEMATODES ASSOCIATED WITH *JATROPHA CURCAS* ACCESSIONS IN SOME LOCAL GOVERNMENT AREAS OF KADUNA STATE, NIGERIA by Jeremiah Olamide OLATUNJI meets the regulations governing the award of the degree of Master of Science in Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

Dr. P. S. Chindo (Chairman, Supervisory Committee)	______________ Signature	______________ Date
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Prof. K. Bala (Dean, School of Postgraduate Studies.)	______________ Signature	______________ Date

DEDICATION

This work is dedicated to the glory of God Almighty, the author and finisher of my faith and to the memory of my late father, Elder Abel Olabisi Olatunji.

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ABSTRACT

A study was conducted to determine the genera, frequency and prominence value of plant parasitic nematodes associated with *Jatropha curcas* accessions in Sabon Gari, Kudan, Giwa and Zaria Local Government Areas of Kaduna State, Nigeria in 2013. Using systematic random method of sampling, 72 soil and root samples were collected from the Jatropha plant stands, and nematodes extracted from the samples using the sieving and decanting and modified Baermann pan methods. Twenty-four genera of plant-parasitic nematodes were recorded in all the locations. Plant-parasitic nematodes recovered includes *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera Xiphinema, Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus, Tylenchulus, Telotylenchus, Pratylenchoides, Telotylenchoides, and Rotylenchoides.* The most prominent nematode from the soil were *Scutellonema* with prominence value of 81.09, followed by *Meloidogyne* and *Rotylenchus* with prominence values of 46.50 and 39.60 respectively, and from the roots, *Scutellonema*, *Meloidogyne* and *Rotylenchus* with prominence values of 77.15, 50.93 and 26.94, respectively. *Scutellonema, Tylenchus* and *Meloidogyne* were the most abundant nematodes from the soil with frequency values of 97.22%, 95.83% and 86.11% respectively, while *Meloidogyne, Scutellonema,* and *Pratylenchus* were the most abundant nematodes from the root with frequency values of 55.56%, 34.72% and 25.00% respectively,

Reaction of *Jatropha curcas* accessions; IARJAT2009020, IARJAT2009011, IARJAT2009041 and IARJAT2009016 to infection with 2000 eggs of *Meloidogyne incognita* was evaluated under controlled environmental conditions in Samaru. There was no significant differences at P=0.05 between the four accessions with respect to

number of galls/ root at 8 weeks after inoculation and final nematode population count. IARJAT2009016 had the highest galls/ root 10.0 followed by IARJAT2009041with 6.67 galls/ root. However, final population count had IARJAT2009011with 37.27 followed by IARJAT2009016, 28.11 and lowest population 13.50 obtained on IARJAT2009041. Although plant parasitic nematodes were found to be associated with *Jatropha curcas* on the surveyed areas the pathogenicity test has shown that *Meloidogyne incognita* is not pathogenic on the *Jatropha curcas* accessions used. These accessions (IARJAT2009020, IARJAT2009011, IARJAT2009041 and IARJAT2009016) therefore may be used to manage *Meloidogyne incognita* infected soils in a mixed crop combination.

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CHAPTER ONE

1.0 INTRODUCTION

The term "Jatropha" is usually used to refer to the species *Jatropha curcas,* although there are approximately 170 known species of the plant (Dehgan, 1984), they include *Jatropha integerrima*, *Jatropha cardiophylla*, *Jatropha cathartica*, *Jatropha cinerea, Jatropha cuneata*, *Jatropha podagrica* and *Jatropha curcas.* It originated from Central America (Jongschaap *et al.,* 2007). It was introduced to Africa and Asia and cultivated world-wide in many parts of the tropics and subtropics where it is grown as a hedge crop and for traditional use (Heller, 1996; Kumar and Sharma, 2008). *Jatropha curcas* is the most common species recorded in Nigeria. Names used to describe the plant vary per region or country. It is most commonly known as "Physic nut". In Nigeria it is known as "cinidazugu" "wuluidi" and "lapalapa" in Hausa Igbo and Yoruba languages respectively (Blench, 2007).

Jatropha curcas is a member of the family Euphorbiaceae, a large drought-resistant multipurpose shrub with several attributes and considerable potential and has evoked interest all over the tropics as a potential biofuel crop (Jones and Miller, 1991; Openshaw, 2000). *J. curcas* has a straight trunk with thick branchlets. It has green leaves with a length and width of 6 cm to 15 cm. Five roots are formed from seeds: one tap root and 4 lateral roots and cuttings do not develop a taproot (Heller, 1996). The branches contain whitish latex, which causes brown stains that are difficult to remove. The fruits is about 40 mm length and contains 3 seeds (on average), which look like black beans with similar dimensions, of about 18 mm long and 10 mm wide. The seed coats constitute about 35~40% of the total seeds (www.jartropha.org). The plant and its seeds are toxic to animals and humans and are therefore used worldwide as hedges to protect agricultural fields. It grows on well drained soils with good aeration and is well adapted to marginal soils with low nutrient content. The best time for planting is in the warm season before or at the onset of the rains. In the former case, watering of the plants is required. The recommended spacing for plantation is 2 m to 3 m by 1.5 m to 3 m for plantations (Jones and Miller, 1992). The number of trees per hectare at planting may range from 1100 to 3300. Plant growth is dependent on soil fertility and rainfall. A poor nutrient level will lead to increased failure of seed development (Gubitz *et al.*, 1997). Thus, it is important to maintain soil fertility; this is contrary to statements made in some publications (Mauwa, 1995). Like all perennial plants, it displays vigorous growth at early stage of planting but this will tail off gradually towards maturity. The lifespan is more than 50 years (Openshaw, 2000). Management of Jatropha requires the addition of manure and NPK to the planting hole at 2 kg compost, 20 g urea, 120 g SSP (single super phosphate) and 16 g MOP (muriate of potash) and urea should be applied in two splits (1 and 2 months after transplanting) at 10 g per plant (Singh *et al.*, 1996). Yearly top dressings of fertilizers including the seed cake should be done. The crop has been reported to have nematicidal, insecticidal, molluscidal and fungicidal properties and is expected to be less prone to damage by these pests (Anitha and Varaprasad, 2012). However, reports of pests and diseases outbreak on Jatropha started appearing with large scale cultivation in both marginal and arable lands by agro-industries (Anitha and Varaprasad, 2012).

Just like other agricultural crops, biotic factors also limit optimum production of Jatropha. Marieke *et. al.*, (2012), reported that over 60% of Jatropha plants fell victim to attacks by soil-borne vascular diseases. Biotic factor production constraints of Jatropha include viral, fungi and nematode infections. Nematodes are abundant in the soil, many of which are parasites of plants including food crops and causing losses in both quantity and quality (Olabiyi *et al.,* 2009). Plant parasitic nematodes obtain nutrients for development and reproduction from cytoplasm of the living plant cells rendering them weak and causing enormous economic losses (Stirling *et al.,* 2002). They remain a major challenge in crop production in many developing countries including Nigeria (Nicol *et al.*, 2011). Some of the important plant parasitic nematodes are the: Root Lesion Nematodes (*Pratylenchus* spp.), the Burrowing nematodes (*Radopholus* spp.) and Cyst nematodes (*Heterodera* and *Globodera* spp.). However, the most economically important nematodes, the root-knot (*Meloidogyne* spp.) are biotrophic which are obligate parasite that induced galls (root-knots) on the roots of their host (Van Megen *et al*., 2009).

1.1 Justification

Nigeria is among the countries with the largest deposits in hydrocarbons (crude oil and natural gas) and receives considerable revenue from its large multinational oil industry sectors (FGNPB, 2008). The benefits of these resources hardly trickle down to the common man, which is generally poor. Secondly, Nigeria is constantly faced with the global energy crisis characterized by oil glut with its attendant fluctuation in crude oil prices. In addition, the effect of global warming arising from emission of greenhouse gases from fossil foils poses a serious challenge both to Nigeria and the entire world. Given these constraints, the Federal Government of Nigeria has intensified efforts aimed at diversifying the economy by looking for sources of renewable energy and alternative source of revenue (FGNPB, 2008). *Jatropha curcas* provides this alternative as it has been shown by other countries (Abila, 2011).

Similarly, Nigeria Government has stepped up efforts to sensitize farmers and other Nigerians towards massive cultivation and growing of *Jatropha curcas* for bio-fuel production for the country to attain energy security which will at the same time, solve unemployment and poverty challenges in the country. In a bid to make Jatropha cultivation a success in Nigeria, the Renewable Energy and Energy Efficiency Partnership (REEEP) donated a grant of € 70,000 to the Nigerian National Petroleum Corporation (NNPC) to support a detailed feasibility study into high biofuel feedstock for production of automotive fuel (NNPC, 2005).

The adoption of Jatropha as a biofuel source holds a diversity of opportunities and potential for Nigeria economy (Abila, 2011), but the extent to which these benefits from Jatropha production will be realized depends on many conditions which include pests and diseases. Pest and diseases have the potential to cause significant constraints on biomass production, putting the crops at risk for reductions in biomass yield and quality. Of many pests and diseases, plant-parasitic nematodes are of great economic importance because they can directly influence plant biomass and predispose plants to attack by other soil-borne pathogens. However, few available reports on pathogenic effects of nematode on Jatropha are confusing. It was reported that pests and diseases do not pose a significant threat to Jatropha, due to the insecticidal and toxic characteristics of all parts of the plant (Heller, 1996) but despite the characteristics of the plant, incidence of pests and diseases has been widely reported under plantation monoculture, and may be of economic significance (Brittaine and Lutaladio, 2010). Since cultivation of Jatropha in Nigeria is gaining prominence, it becomes imperative to characterize the nematodes that are associated with the crop and determine the species that may be pathogenic and therefore economically important to it. This information will be vital in designing management strategies that will ensure profitable and sustainable production of Jatropha. It is against this background that this research was conceived.

1.2 Objectives

Study was undertaken with the following objectives:

- to determine the genera of plant parasitic nematodes associated with *Jatropha curcas* in the selected Local Government Areas of Kaduna State.
- to determine the absolute frequency and prominence value of identified nematode genera;
- to determine the pathogenicity of one of the most prominent plant parasitic nematode genera identified on *Jatropha curcas*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Cultivation Requirements

Jatropha is a drought-resistant, non-edible perennial. It can be grown on a marginal land, it generally grows to a height of three to five meters (Carels, 2009). Given the wide range of natural conditions it tolerates, Jatropha naturally occurs throughout the tropics and sub-tropics (Carels, 2009). The plant is well adapted to unfavorable growth conditions. In arid and semi-arid climates, it survives by shedding its leaves at the beginning of the dry season (Orwa *et al.,* 2009).

However, with adequate water, pollinators and overall favorable growth conditions, it can thrive and produce fruits throughout the entire year (Kumar and Sharma, 2008). Jatropha grows well in regions with an annual mean temperature between 20 to 28^{o}C (Orwa *et al.,* 2009). Significantly higher water availability (minimum of 500 mm per year) is required for optimal seed production conditions because water availability is positively correlated with fruit production (Jongschaap *et al.*, 2007).

Drained sandy or grave soils with good aeration are optimal for Jatropha as the shrub does not tolerate water logging conditions (Heller, 1996). It is well adapted to marginal soils; optimum yields are possible where sufficient amounts of nutrients are available to the plant. Jatropha is propagated by direct seeding, planting of seedling from nursery or by cuttings.

2.2 Botanical Description of Jatropha

Jatropha produces a trilocular ellipsoidal fruit. The fruits are green when unripe (Heller, 1996) and turn yellow when matured. Numerous research works on Jatropha seed and seed chemical characterization have been carried out in most Jatropha cultivation zones

(Martinez-Herrera *et al.*, 2006; Halilu *et al.*, 2011). Halilu *et al.* (2011) reported *J. curcas* seed weight to range from 0.28 g - 0.80 g from Nigeria and 0.45-0.72 g for seeds from Mexico (Martinez-Herrera *et al.*, 2006). Jatropha fruit contain about 1 - 4 seeds and are black in color and about 2 cm long and 1 cm thick (Heller, 1996).

2.3 World Jatropha Production Pattern

Some Jatropha producers have reported as high as 10-15 kg seed per plant (that is 13-20 tonnes/hectare at 3.0 m x 2.5 m spacing) (Ojiako *et. al.*, 2014). Most researchers, however, put the optimum yield at between 5-6 tonnes/ha/year under good cultivation practices (Ojiako *et. al.*, 2014). Achten *et al*. (2007) put yield estimates to vary considerably, depending on the growth conditions. Achten *et al*. (2007) estimated output of dry seed at 1-2.5 tonnes/ha/year for land with low soil fertility and 2-5 tonnes/ha/year for land with high fertility. Oil yield in Nigeria is about 40% (Yammama, 2011).

2.4 Uses of Jatropha

Jatropha curcas is a promising species because of its useful and profitable by-products. The cultivation of Jatropha offers the advantage of restoring soil and controlling erosion, moreover, it is suitable for intercropping, especially during the first two to five years before it starts to yield fruit (Jongschaap, 2008). Jatropha plants can serve as live fence for the protection of agricultural fields against damage by live stocks. The plant acts as cost effective bio fence compared to wire fence. It is chosen for this purpose mainly because it can easily be propagated by cuttings, densely planted for this purpose, and because the said species is not browsed by cattle. Jatropha is used as purgative/laxative, and is widely known as medicinal for treatment of a variety of ailments.

Table 1 Top Jatropha Producers in the World

S/N	Country	Area Planted /ha
1	China	274 559
2	India	265 422
3	Malaysia	259 906
4	Indonesia	256 545
5	Ethiopia	20 000
6	Thailand	15 680
7	Ghana	13 000
8	Burkina Faso	10 000
9	Madagascar	8 300
10	Mexico	8 040
11	Mali	8 000
12	Nigeria	7 500
13	Tanzania	6 926
14	Togo	6 000
15	Mozambique	3 585
16	Brazil	3 135
17	Uganda	3 125
18	Sri Lanka	3 000
19	Zambia	2 789
20	Senegal	2 000
21	Honduras	1 678
22	Ivory Coast	1 500
23	Kenya	1 463
24	Vietnam	1 400
25	Argentina	1 300
26	Laos	1 204
27	Dominican Rep.	1 021
28	Benin	550
29	Taiwan	536
30	Colombia	500
31	Haiti	450
32	Peru	411
33	Cambodia	395
34	El Salvador	357
35	Malawi	350
36	Paraguay	205
37	Cameroon	205
38	Guatemala	150
39	Ecuador	150
40	Caribbean	100
41	Peru	100
42	Nicaragua	63
43	Costa Rica	24

Source: Global Market Study on Jatropha (2008)

The sap flowing from the stem is used to control the bleeding of wounds. The latex of Jatropha contains alkaloids including Jatrophine, Jatropham and curcain with anti-cancerous properties (Van den Berg *et al.*, 1995; Thomas *et al.*, 2008). The roots are reported as an antidote for snake-bites. The oil has a strong purgative action and is widely used to treat skin diseases and to soothe pain from rheumatism (Heller, 1996; Marroquin *et al.*, 1997). The oil and aqueous extract from oil has potential as an insecticide (Jain and Trivedi, 1997; Meshram *et al.*, 1994). It has been used in the control of insect pests of cotton including cotton bollworm, and on pests of pulses, potato and corn (Kaushik and Kumar, 2004). The bark of *J. curcas* yields a dark blue dye which is reported to be used for coloring cloth, fishing nets and lines. The dye may be extracted from leaves and tender stems and concentrated to yellowish syrup or dried to blackish brown lumpy mass. The dye imparts to cotton different shades of tan and brown which are fairly fast. The local production of soap is one of the most economically attractive uses of Jatropha oil. The glycerin by-product of the trans-esterification process can be used to make high quality soap or it can be refined and sold at a range of prices, depending on its purity, to be used in an immense range of products, including cosmetics, toothpaste, embalming fluids, pipe joint cement, cough medicine, and tobacco (as a moistening agent). The residue after extraction (seed cake) is an excellent source of organic manure (Sharma *et al.*, 1997). Jatropha seed cake contains curcin, a highly toxic protein similar to ricin in Castor, making it unsuitable for animal feed. Jatropha oil can be used as fuel in diesel engines directly and by blending it with methanol (Gubitz *et al.*, 1999). Biodesel made from Jatropha oil can be used for any diesel engine without modification.

2.5 Plant Parasitic Nematodes

Over 4100 species of plant parasitic nematodes have been identified (Decraemer and

Hunt, 2006), and nematodes that are considered non- important are becoming important as cropping pattern changes (Nicol, 2002).

The plant parasitic nematodes of economic importance are grouped into relatively restricted specialized groups that either cause direct damage to their host or act as a virus vector. Most plant parasitic nematodes affect crops through feeding on or in plant roots (below ground), while minorities are aerial feeders (above ground) (John *et al*, 2013).

Among the important ones are the: Root-knot nematodes (*Meloidogyne* spp.) which are obligate plant parasites that have been distributed worldwide. The genus consists of 98 species (as of February 2013) and they parasitize almost every species of vascular plant (John *et al*, 2013). Their common name comes from the galls (root-knots) induced by *Meloidogyne* on the roots of their host plants (Moens *et al.*, 2009).

The cyst nematodes are obligate biotrophs and are of great economic importance throughout the world. The most damaging species include soybean cyst nematodes (*Heterodera glycines*), potato cyst nematodes (*Globodera pallida* and *G. rostochiensis*) and cereal cyst nematodes (*Heterodera avenae* and *H. filipjevi*). Losses caused by cereal cyst nematodes can be in excess of 90% (Nicol *et al.*, 2011). Potato cyst nematodes have been estimated to cause losses of 9% of total potato production worldwide (Turner and Rowe, 2006). The ability of cyst nematodes to survive prolonged periods in the soil in the absence of host makes control and eradication by rotations difficult and almost impossible once established.

The root lesion nematodes (*Pratylenchus* spp.) There are over 60 named species which are distributed worldwide. *Pratylenchus* spp. rank third only to root-knot and cyst nematodes as having the greatest impacts on crop worldwide (Castillo and Volvas, 2007). The most important of these species such as *P. penetrans*, *P. thornei*, *P. neglectus*, *P. zeae*, *P. vulnus* and *P. coffeae*. *Pratylenchus* are migratory, intercellular root endoparasites with a life cycle that lasts 3–8 weeks depending on the species and conditions. A reduction in root growth occurs on infection, accompanied by the formation of lesions, necrotic areas, browning and dead cell. This often followed by root rotting from secondary attack by soil fungi or bacteria. Root damage slows plant growth, increases susceptibility to water stress and causes stunting and yellowing. Infected roots are usually discolored and stubby. Infection can occur along the entire length of the root, with damage to the epidermis, cortex and root endodermis. Their host range includes sugarcane, coffee, banana, maize, legumes, potato, many vegetables and fruit trees (Castillo and Volvas, 2007).

Dry rot nematodes (*Scutellonema* spp). A major economic pest of yam (*Scutellonema bradys),* known as the yam nematode and causal agent of yam dry rot. This nematode occurs mostly in West Africa, where yam is its principal host, but is also recorded on yam from parts of South and Central America and Asia (Bridge *et al.*, 2005). The nematode affects all the main cultivated yam species and cultivars in West Africa (Kwoseh, 2000; Coyne *et al.*, 2006), Nematodes feed intracellularly in tuber tissue, rupturing cell walls and resulting in necrotic lesions.

The burrowing Nematode (*Radopholus similis),* of the more than 30 species in the genus *Radopholus*, the burrowing nematode, *Radopholus similis*, is the only pathogen of widespread economic importance (Duncan and Moens, 2006). *Radopholus similis* is a migratory endoparasitic nematode that is known to be a destructive pest of citrus crops, pepper and, most importantly, banana, on which it causes toppling disease. Infection by *R. similis* results in extensive damage to root systems, which show dark lesions caused as the nematodes destructively migrate through host tissues. Tissue rot occurs as a result of secondary bacterial and/or fungal infections, weakening the root system and leaving the plant susceptible to toppling, especially in windy conditions (Duncan and Moens, 2006). All life stages of *R. similis* occur inside the roots. Nematodes infect at or near the root tip and burrow through the root system, showing a preference for younger roots rather than those that are hardened and periodically feed on cell contents.

2.6 Jatropha Pests and Diseases Status

It was reported that pests and diseases do not pose a significant threat to Jatropha, due to the insecticidal and toxic characteristics of all parts of the plant (Heller, 1996). Despite the characteristics of the plant, incidence of pests and diseases has been widely reported under plantation monoculture, and may be of economic significance (Brittaine and Lutaladio, 2010). There is increasing evidence that Jatropha is highly susceptible to pests and diseases which seriously hampers plant growth and seed production (Anitha and Varaprasad, 2012; Rouamba, 2011). Mekete (2010) reported that nematode species such as *Xiphinema, Trichodorus, Longidorus, Helicotylenchus, Hoplolaimus, Tylencharynchus* and *Pratylenchus* were associated with biofuel crops including Jatropha while Begum (1996) showed that *Meloidogyne incognita* is a parasite of *Jatropha podagrica.* Emeh (2012) reported plant parasitic nematodes (17 genera) to be associated with *Jatropha curcas* on two fields located on the Institute for Agricultural Research, Ahmadu Bello University, Zaria, and concluded that *Jatropha curcas* is a host of many plant parasitic nematodes. There have been reports on collar rot disease (caused by *Macropphomina phaseolina or Rhizoctonia bataticola*) at juvenile stages or by water-logging at adult stages, leaf spots disease, root rot disease (caused by *Fusarium moniliforme)* and damping off (caused by *Phytophtora* spp.) (Sharma and

Sarraf, 2007). Dieback/stem-rot was reported on Jatropha seedling by Zarafi and Abdulkadir (2013).

2.7 Disease Complexes Involving Root-Knot Nematodes and Jatropha

A number of disease complexes involving many crops in which root-knot nematodes are recorded interacting with fungal pathogens have been reported (McGaweley, 2001). Cultivars of Jatropha with known resistance to fungal pathogens becomes susceptible, either completely or partially, when such cultivars are simultaneously parasitized by plant parasitic nematodes (McGaweley, 2001). In certain situations, the nematode has been found to be responsible for breaking disease resistance to *Fusarium* wilt (McGaweley, 2001). Studies on Jatropha have shown that new diseases such as viral diseases causing floral deformity are being discovered to have serious damage on the plant (Gour, 2004). Plant parasitic nematodes do not only attack the plant directly but also predispose them to attack by other soil-borne pathogens (Mekete, 2010).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Determination of Nematodes Associated with Jatropha Accessions

3.1.1 Survey of Jatropha farms

Six locations distributed over four Local Government Areas of Kaduna State were surveyed to determine the different plant parasitic nematodes associated with Jatropha (Table 2 and Fig. 1). Coordinate of surveyed areas were collected using phone software called ‘Open Data Kit’. Plant samples were taken from two fields in each location. In the Zaria and Basawa orchards, soil samples were collected from Jatropha orchards using the system random sampling method. Soil samples were collected from 6 plant stands spaced 8 m apart to make a sub-sample. Samples were taken from each plant base at a distance of 25 cm from the plant. Soil samples at a depth of 25 cm were removed from the root zone using soil auger and hoe. Ten (10) sub-samples were bulk together to make a bulk sample and a total number of 6 bulk samples were taken from each field. In the farmers’ fields, soil samples were collected from 4 plants stands to make a sub-sample, 6 sub-samples were bulk together to make a bulk sample. Root samples were also collected with scissors from each Jatropha stand where soil was collected at a depth of 25 cm. The root tips were slightly exposed, cut with scissors and covered back with soil. Samples were bagged in a polythene bag, labeled for identification, sealed and taken to the Nematology Laboratory, Department of Crop Protection, Ahmadu Bello University, Zaria and stored in the Cold Room before extraction. Samples were collected at the peak of rainy season (July) and towards the end of the rainy season (September) to check the differences in nematode population.

Table 2 Sampled Locations, soil types and their Geographical Coordinates

S/NO	Location	Local Government Area	Soil Type	Coordinates	
				Latitude	Longitude
1	Jatropha Plantation of the Institute for Agricultural Research, (IAR), Samaru, Ahmadu Bello University, Zaria, Zaria.	Sabon Gari	Sandy loam	11° 9' 59.8"	7° 37' 59.5"
2	Jatropha Plantation of National Research Institute for Chemical Technology (NARICT), Basawa.	Sabon Gari	Sandy loam	11^{o} 9' 8.2"	7^{o} 41' 08.1"
3	Farmer’s field in Kurmi Bomo	Sabon Gari	Sandy loam	11^{o} 0' 4.7"	7^{o} 37' 49.6"
4	Farmer’s field in Hunkuyi	Kudan	Sandy loam	11^{o} 15' 0"	7^{o} 38' 51.9"
5	Farmer’s field in Giwa	Giwa	Loamy	11^{o} 16' 1"	7^{o} 25' 01.9"
6	Farmer’s field in Unguwar Dankali	Zaria	Sandy loam	11^{o} 4' 45 "	7^{o} 40' 57"

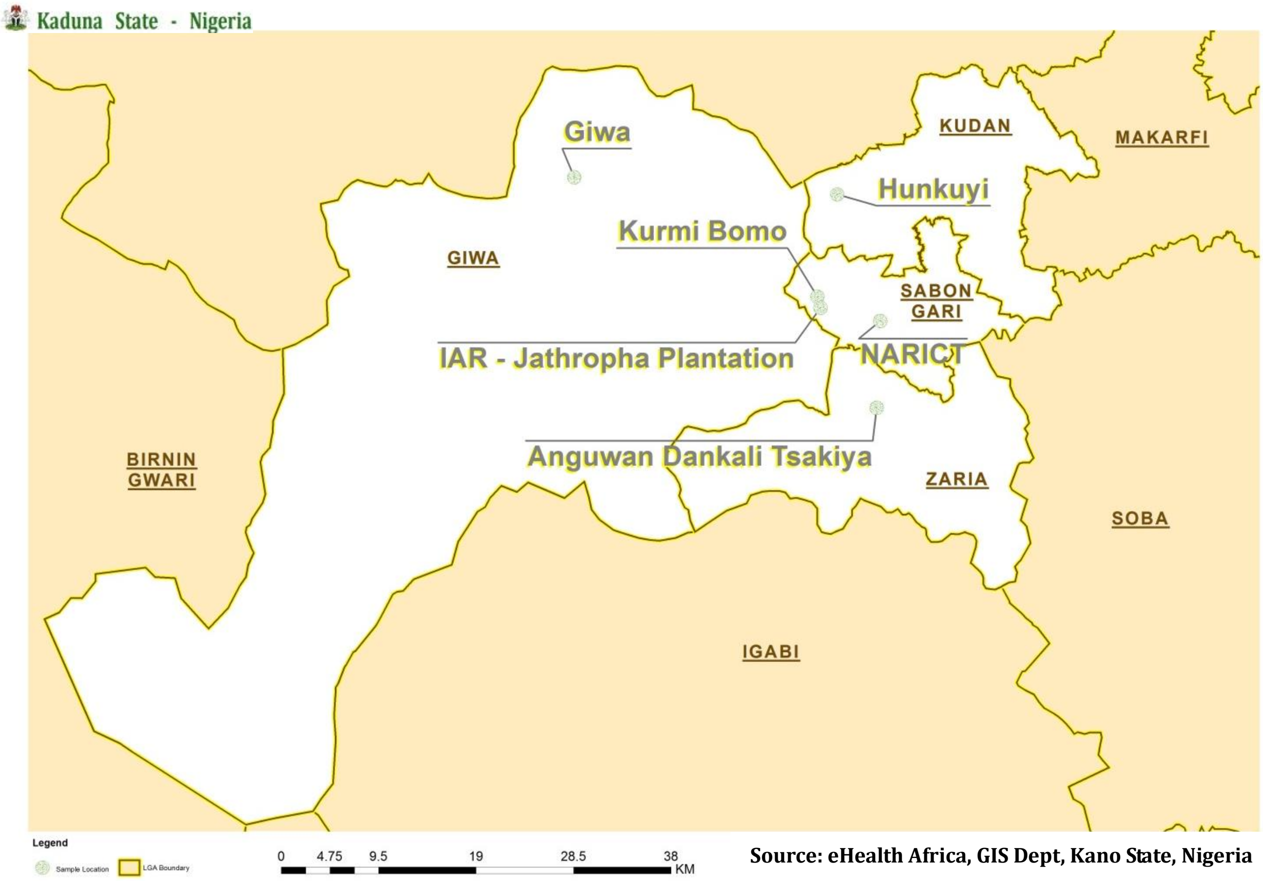

Figure 1 Surveyed Locations in four Local Government Areas of Kaduna State

3.1.2 Extraction and identification of nematode genera associated with Jatropha

Nematodes were extracted from 72 soil samples within two weeks of collection using Cobb's (1918) modified Sieving and Decanting technique. Nematodes from the roots were extracted using Baermann pan method. The final suspensions containing the nematodes in both samples were viewed under the light microscope and nematodes identification chart described by Mai and Mullin, (1996) was used to identify the nematodes.

3.2 Determination of Absolute Frequency, Prominence Value and Index of Similarity

Data on nematode numbers was analyzed using absolute frequency (AF), prominence value (PV) (Norton, 1989) and Index of Similarity (IS) (Bray and Curtis, 1957)

Absolute frequency is an independent calculation that denotes how often a genus occurs among the samples examined.

Thus Absolute Frequency (AF) = 100 $\frac{g}{n}$

where g = number of samples containing a genus

n = total number of samples collected.

Prominence Value is the density of a population multiplied by the square root of the absolute frequency.

Prominence Value (PV) = d $\sqrt{AF}$

where d = nematode density,

AF = absolute frequency

Index of Similarity is the measure of how close two sampled locations are to one another in terms of nematode genera recorded.

Index of Similarity (IS) = 2c ⁄ (a + b)

where c = number of genera two locations have in common,

a and b = the number of genera in zones a and b respectively

3.3 Determination of Pathogenicity of the Root-Knot Nematode, *Meloidogyne incognita*

Soil Sterilization

Thoroughly mixed loam, sand and manure in the ratio 2:1:1 was heat-sterilized by loading moistened soil in a longitudinally cut drum on burning fire for 90 mins with regularly turning at every 30 mins to ensure even distribution of heat. Sterilized soil was dried and utilized one week later.

Tomato plants infected with root-knot nematodes were collected from farmer's plots. These were examined for females and single egg masses under the dissecting microscope after thorough washing under a stream of tap water. Females of *Meloidogyne* spp. were distinguished using perineal patterns (Eisenback *et al*., 1981). Egg masses of identified *M. incognita* females were used to inoculate by placing the egg masses close to growing tip of roots of susceptible tomato variety Roma-VF. After eight weeks of inoculation, females were isolated from these plants and perineal patterns were made to ascertain purity of the culture (*M. incognita*). Subsequently, pure cultures were multiplied in pots (15 cm diameter × 22 cm height) with three plants grown in each. These were used for subsequent experiment.

Four *Jatropha curcas* accessions seeds namely: IARJAT2009020, IARJAT2009016, IARJAT2009041 and IARJAT2009012 obtained from the Legumes and Oilseeds Research Programe of the Institute for Agricultural Research (Samaru), Zaria and Roma-VF obtained from Premier Seeds Ltd. Zaria, were raised in separate nursery trays 100 cm x 50 cm quarter filled with heat sterilized soil. Jatropha and tomato seeds at distance of 3cm were finely spread along furrows before it was lightly covered and mulched with dry grass. The tomato and Jatropha seeds were watered at 24 hours interval.

Four (4) kilograms of sterilized soil was weighed into each plastic pot 15 cm diameter × 22 cm height, perforated at base for drainage. Two weeks old Jatropha and one week old Roma-VF tomato seedlings were transplanted at a rate of 2 seedlings per pot. Two seedlings were thinned to only one per pot five days after transplanting.

Un-inoculated *Jatropha curcas* accessions were the control treatments while Roma VF served as the standard check. The experiment was replicated six times. Sixty (60) pots were arranged in a Completely Randomized Design (CRD) in the screen-house. *Meloidogyne incognita* eggs obtained from the pure culture were used to inoculate each Jatropha and tomato seedlingsss. *Meloidogyne incognita* eggs were extracted from pure culture using Sodium Hypochlorite (NaOCl) as described by Hussey and Baker (1973). Galled roots from 42 tomato plants were washed of adhering soils, mopped dry with clean soft tissue paper and cut into 1-2 cm pieces. Root pieces were placed in 1000 ml conical flask, 0.52 %NaOCl as diluent was added at a ratio 1:3 of water. The flask was tightly corked, shaken vigorously for 2 mins to dissolve gelatinous matrix enclosing the eggs. Suspension containing the eggs and juveniles was poured over 0.075 mm size mesh nested upon 0.045 mm sieve. The sieve (0.045 mm) containing eggs/ juveniles

(J2) was placed under a gentle stream of water to rinse off residual NaOCl. Rinsed egg and J2 larvae in the mesh were washed with water into a wash bottle and adjusted to a known volume (360 ml). Using dissecting microscope, counts of eggs and J2 larvae per 10 ml aliquot was done using Doncaster counting dish. Inoculation of seedlings was done 2 weeks after transplanting (WAT) by making Shallow trench around base of each transplant using clean spatula. Approximately 2000 egg suspension was poured into the trench, cover with soil and water lightly (Iheukwumere *et al.*, 1995).

Data on plant height, stem girth, number of leaves at 14 days interval for eight weeks after inoculation (WAI) were collected. Tomato variety, Roma VF was used as standard check. Eight weeks after inoculation, soil in the pots were loosened manually, roots and soil were taken to the laboratory for assessment.

3.4 Data Collection

Roots of Jatropha and tomato plants were washed under a gentle stream of tap water, wrapped with soft tissue paper, labeled and arranged on a table, scored for galling using the 0-5 rating scale described by Taylor and Sasser (1978) presented below:

Score	Gall Rating
0	No gall on root
1	1 – 2 galls on root
2	3 – 10 galls on root
3	11 – 30 galls on root
4	31 – 100 galls on root
5	> 100 galls on root

Direct counting technique was employed to get number of galls and matured egg masses per gram of root (Daykin and Hussey, 1985). Root of each plant was cut into pieces of about 1-2 cm long and thoroughly mixed. Using a Mettler weighing balance, 2 g of root was weighed from thoroughly mixed cut roots. Root pieces were spread evenly in a grid Petri-dish. Direct counting of number of galls on these roots was done and recorded. Number of matured egg masses was also counted and recorded. Results obtained were then converted to per gram of root weight.

Nematode extraction from the soil was carried out using Sieving and Decanting method described by Cobb (1918), to determine the reproduction factor (RF) which is the ratio of final population to initial population (Oostenbrink, 1966).

$$RF = \frac{\text{Final Population}}{\text{Initial Population}}$$

3.5 Data Analysis

Data collected were subjected to Statistical Analysis of Variance (ANOVA) using the SAS Software Version 9.4 (2013). Means were separated using the Duncan Multiple Range Test (DMRT) at 5% level of probability (P=0.05).

CHAPTER FOUR

4.0 RESULTS

The absolute frequency of nematodes genera in soils grown with *Jatropha curcas* accessions is presented in Table 3. In July 2013, twenty-four (24) genera of plant parasitic nematodes were recorded from the six locations. Nematodes recorded were *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus, Heterodera , Xiphinema, Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus, Tylenchulus, Telotylenchus, Pratylenchoides, Telotylenchoides and Rotylenchoides.* At all the locations, *Scutellonema* had the highest frequency value (97.22), followed by *Tylenchus* and *Meloidogyne* with frequency values of 95.83 and 86.11 respectively. *Dorylaimus* and *Rotylenchoides* were the least nematode genera recorded with frequency value of 1.39 each. This is because *Dorylaimus* and *Rotylenchoides* were only recorded in one location, (Basawa) out of the six locations surveyed. The locations surveyed i.e. Basawa, IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi recorded 22, 19, 18, 19, 19 and 17 genera of nematodes respectively. *Telotylenchus, Pratylenchoides, Telotylenchoides* and *Tylenchulus* were not recorded in five (5) locations namely IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi while the populations encountered at Basawa were low. *Dorylaimus, Telotylenchus, Pratylenchoides, Telotylenchoides* and *Rotylenchoides* were not common to all the locations but encountered at Kurmi Bomo, Basawa and IAR Samaru.

Absolute frequency of nematodes genera in the root of *Jatropha curcas* accessions in July 2013 is shown in Table 4. Eleven (11) genera of plant parasitic nematodes were recorded in the root of Jatropha obtained from the six locations. *Scutellonema,*

Table 3 Absolute frequency of plant parasitic nematode genera in the soil grown with Jatropha in four Local Government Areas of Kaduna State, July 2013

Nematode Genera	Absolute Frequency (%)						
	Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	100.00	100.00	100.00	100.00	91.67	91.67	97.22
Hoplolaimus	75.00	50.00	83.33	83.33	91.67	83.33	77.78
Pratylenchus	66.67	91.67	58.33	83.33	66.67	58.33	70.83
Aphelenchus	91.67	91.67	83.33	58.33	91.67	83.33	83.33
Meloidogyne	100.00	75.00	83.33	83.33	91.67	83.33	86.11
Tylenchoryhnchus	16.67	25.00	16.67	41.67	25.00	8.33	22.22
Rotylenchus	91.67	66.67	83.33	83.33	91.67	83.33	83.33
Longidorus	75.00	75.00	91.67	75.00	91.67	91.67	83.33
Helicotylenchus	83.33	75.00	25.00	66.67	66.67	41.67	59.72
Paratylenchus	58.33	91.67	50.00	33.33	33.33	58.33	54.17
Heterodera	25.00	0.00	8.33	16.67	16.67	8.33	12.50
Xiphinema	83.33	100.00	83.33	83.33	91.67	58.33	83.33
Tylenchus	91.67	100.00	91.67	91.67	100.00	100.00	95.83
Criconemoides	8.33	50.00	41.67	58.33	50.00	33.33	40.28
Hemicycliophora	50.00	41.67	58.33	41.67	33.33	50.00	45.83
Aphelenchoides	83.33	50.00	75.00	75.00	75.00	50.00	68.06
Tetylenchus	25.00	16.67	8.33	16.67	16.67	16.67	16.67
Trichodorus	0.00	33.33	0.00	16.67	25.00	0.00	12.50
Dorylaimus	0.00	0.00	0.00	0.00	8.33	0.00	1.39
Tylenchulus	58.33	25.00	66.67	33.33	0.00	0.00	30.56
Telotylenchus	25.00	0.00	0.00	0.00	0.00	0.00	4.17
Pratylenchoides	33.33	0.00	0.00	0.00	0.00	0.00	5.56
Telotylenchoides	16.67	16.67	0.00	0.00	0.00	0.00	5.56
Rotylenchoides	8.33	0.00	0.00	0.00	0.00	0.00	1.39

Table 4 Absolute frequency of plant parasitic nematode genera in the root of Jatropha in four Local Government Areas of Kaduna State, July 2013

Nematode Genera	Absolute Frequency (%)						
	Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	25.00	50.00	66.67	58.33	8.33	0.00	34.72
Hoplolaimus	8.33	16.67	33.33	33.33	8.33	0.00	16.67
Pratylenchus	66.67	16.67	16.67	41.67	8.33	0.00	25.00
Meloidogyne	66.67	75.00	58.33	75.00	50.00	8.33	55.56
Rotylenchus	16.67	33.33	0.00	16.67	0.00	0.00	11.11
Longidorus	16.67	25.00	25.00	25.00	0.00	0.00	15.28
Xiphinema	0.00	33.33	25.00	33.33	0.00	0.00	15.28
Aphelenchoides	0.00	0.00	0.00	8.33	0.00	0.00	1.39
Heterodera	8.33	0.00	0.00	0.00	0.00	0.00	1.39
Helicotylenchus	8.33	0.00	0.00	0.00	0.00	0.00	1.39
Paratylenchus	8.33	0.00	0.00	0.00	0.00	0.00	1.39

Hoplolaimus, Pratylenchus, Meloidogyne, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera, Xiphinema and *Aphelenchoides* were the genera recorded. *Meloidogyne* had the highest frequency value, 55.56 in all the locations, followed by *Scutellonema,* and *Pratylenchus* with frequency values of 34.72 and 25.00 respectively. *Aphelenchoides, Heterodera, Helicotylenchus* and *Paratylenchus* were the least nematode genera encountered with frequency value of 1.39 each. The locations Basawa, IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi recorded 9, 7, 6, 8, 4 and 1 genera of nematodes respectively. *Meloidogyne* was the only nematode genus obtained at Hunkuyi while *Heterodera, Helicotylenchus* and *Paratylenchus* were recorded in Basawa. Unguwar Dankali was the only location where *Aphelenchoides* was recorded. *Scutellonema, Hoplolaimus, Pratylenchus* and *Meloidogyne* were common to Basawa, IAR Samaru, Giwa, Unguwar Dankali and Kurmi Bomo.

Prominence value of nematodes genera encountered in soil grown with *Jatropha curcas* accession in July, 2013 are presented in Table 5. Twenty-four (24) genera of plant parasitic nematodes were recorded. *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera Xiphinema, Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus, Tylenchulus, Telotylenchus, Pratylenchoides, Telotylenchoides,* and *Rotylenchoides* were the nematode recorded. Out of the 24 genera, *Scutellonema, Meloidogyne* and *Rotylenchus* were more prominent with prominence values of 81.09, 46.50 and 39.60 respectively. *Dorylaimus* was the least prominent genera (0.63) and was recorded only in Kurmi Bomo. Locations such as Basawa, IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi recorded 22, 19, 18, 19, 19 and 17 genera of nematodes respectively. *Telotylenchus, Pratylenchoides, Telotylenchoides* and *Rotylenchoides* were not recorded

Table 5 Prominence value (PV) of plant parasitic nematode genera in the soil grown with Jatropha in four Local Government Areas of Kaduna State, July 2013

Nematode Genera	Prominence value						
	Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	105.82	73.04	52.82	86.88	90.43	77.89	81.09
Hoplolaimus	41.67	20.07	24.34	51.06	37.75	33.47	35.11
Pratylenchus	25.31	30.75	21.75	38.89	28.71	36.73	30.44
Aphelenchus	36.90	23.67	27.63	29.46	32.32	23.31	28.84
Meloidogyne	49.46	54.23	39.38	52.28	43.79	40.41	46.50
Tylenchoryhnchus	6.12	12.22	3.95	9.81	5.56	3.85	7.23
Rotylenchus	44.59	29.48	32.44	56.42	54.80	18.14	39.60
Longidorus	27.65	18.99	21.18	18.41	15.43	12.30	18.84
Helicotylenchus	27.08	22.58	7.56	45.52	21.02	22.38	25.20
Paratylenchus	20.66	14.22	16.34	9.33	9.91	15.57	14.48
Heterodera	3.11	0.00	3.85	2.45	2.31	1.73	2.41
Xiphinema	30.49	22.94	16.01	16.61	14.16	12.29	18.90
Tylenchus	28.66	35.00	31.80	23.38	27.83	24.78	28.58
Criconemoides	1.54	8.49	6.37	7.71	5.11	5.39	6.08
Hemicycliophora	11.71	11.88	19.79	9.73	9.33	7.86	11.89
Aphelenchoides	20.94	8.01	12.38	13.34	13.73	12.18	13.65
Tetylenchus	5.00	3.67	1.54	2.59	6.26	3.95	3.95
Trichodorus	0.00	4.62	0.00	3.40	3.33	0.00	2.70
Dorylaimus	0.00	0.00	0.00	0.00	1.54	0.00	0.63
Tylenchulus	12.07	4.44	8.57	4.81	0.00	0.00	6.40
Telotylenchus	5.22	0.00	0.00	0.00	0.00	0.00	2.13
Pratylenchoides	7.31	0.00	0.00	0.00	0.00	0.00	2.99
Telotylenchoides	6.12	3.54	0.00	0.00	0.00	0.00	2.79
Rotylenchoides	3.66	0.00	0.00	0.00	0.00	0.00	1.49

in Giwa, Unguwar Dankali, Kurmi Bomo, Hunkuyi and IAR Samaru but *Telotylenchoides* was recorded in IAR Samaru. Nematodes, *Trichodorus, Dorylaimus, Telotylenchus, Pratylenchoides, Telotylenchoides* and *Rotylenchoides*, that were absent in most of the locations have low prominent values that ranges between 0.63 and 2.99. Seventeen (17) nematode genera were common to all the locations.

Prominence value of nematodes genera in the root of *Jatropha curcas* accession in July 2013 is shown in Table 6. Eleven (11) genera of plant parasitic nematodes recorded are *Scutellonema, Hoplolaimus, Pratylenchus, Meloidogyne, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera, Xiphinema* and *Aphelenchoides. Scutellonema, Meloidogyne, Rotylenchus* and *Pratylenchus* were more prominent with prominence values of 77.15, 50.93, 26.94 and 26.57 respectively. *Aphelenchoides* and *Paratylenchus* were the least prominent nematodes genera with a prominence value of 3.14 each and were recorded in Unguwar Dankali and Basawa respectively. Basawa, IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi had 9, 7, 6, 8, 4 and 1 genera of nematodes respectively. Genus *Meloidogyne* was the only nematode recorded at Hunkuyi. *Heterodera, Helicotylenchus* and *Paratylenchus* were absent in 5 locations but found in Basawa. *Aphelenchoides* was recorded only in Unguwar Dankali while *Scutellonema, Hoplolaimus, Pratylenchus* and *Meloidogyne* were common to all the locations except Hunkuyi that has only one (1) nematode genera.

Absolute frequency of nematodes genera associated with *Jatropha curcas* accession grown in the soil in September, 2013 is shown in Table 7. Twenty (20) genera of plant parasitic nematodes were recorded. The nematodes recorded were *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera Xiphinema,*

Table 6 Prominence value (PV) of plant parasitic nematode genera in the roots of Jatropha in four Local Government Areas of Kaduna State, July 2013

Nematode Genera	Prominence value						
	Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	65.00	118.64	65.66	123.66	28.87	0.00	77.15
Hoplolaimus	9.62	13.61	22.61	26.46	8.66	0.00	15.99
Pratylenchus	42.87	25.86	12.25	41.31	8.66	0.00	26.57
Meloidogyne	68.04	61.90	44.37	58.38	44.39	9.62	50.93
Rotylenchus	20.41	48.11	0.00	43.55	0.00	0.00	26.94
Longidorus	12.93	15.00	15.56	16.11	0.00	0.00	12.20
Xiphinema	0.00	17.80	22.22	22.61	0.00	0.00	14.69
Aphelenchoides	0.00	0.00	0.00	7.70	0.00	0.00	3.14
Heterodera	9.62	0.00	0.00	0.00	0.00	0.00	3.93
Helicotylenchus	9.62	0.00	0.00	0.00	0.00	0.00	3.93
Paratylenchus	7.70	0.00	0.00	0.00	0.00	0.00	3.14

Table 7 Absolute frequency of plant parasitic nematode genera in the soil grown with Jatropha in four Local Government Areas of Kaduna State, September 2013

Nematode Genera	Absolute Frequency (%) Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	91.67	100.00	66.67	100.00	100.00	83.33	90.28
Hoplolaimus	100.00	91.67	83.33	91.67	100.00	66.67	88.89
Pratylenchus	83.33	66.67	75.00	91.67	33.33	41.67	65.28
Aphelenchus	58.33	91.67	66.67	83.33	91.67	50.00	73.61
Meloidogyne	91.67	83.33	83.33	83.33	91.67	83.33	86.11
Tylenchoryhnchus	16.67	33.33	8.33	16.67	16.67	8.33	16.67
Rotylenchus	75.00	91.67	41.67	58.33	100.00	58.33	70.83
Longidorus	83.33	75.00	66.67	91.67	83.33	66.67	77.78
Helicotylenchus	83.33	66.67	50.00	58.33	50.00	41.67	58.33
Paratylenchus	16.67	58.33	41.67	75.00	16.67	66.67	45.83
Heterodera	8.33	16.67	8.33	8.33	33.33	8.33	13.89
Xiphinema	91.67	75.00	83.33	66.67	91.67	58.33	77.78
Tylenchus	100.00	100.00	83.33	100.00	100.00	100.00	97.22
Criconemoides	58.33	25.00	16.67	33.33	41.67	16.67	31.94
Hemicycliophora	33.33	75.00	58.33	66.67	41.67	25.00	50.00
Aphelenchoides	91.67	58.33	50.00	33.33	66.67	41.67	56.94
Tetylenchus	0.00	41.67	25.00	25.00	25.00	25.00	23.61
Trichodorus	8.33	0.00	0.00	0.00	8.33	0.00	2.78
Dorylaimus	8.33	0.00	0.00	0.00	0.00	0.00	1.39
Tylenchulus	0.00	8.33	75.00	0.00	33.33	25.00	23.61
Telotylenchus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pratylenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Telotylenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotylenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus and *Tylenchulus.* In all the locations, *Tylenchus, Scutellonema, Hoplolaimus* and *Meloidogyne* were the most frequently occurring nematode genera with frequency values of 97.22, 90.28, 88.89 and 86.11 respectively. Genus *Dorylaimus* has the least frequency value (1.39), and it was recorded in one location (Basawa) out of the six locations surveyed. The locations Basawa, IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi had 18, 18, 18, 17, 19 and 18 genera of nematodes respectively recorded. *Trichodorus* was recorded at Basawa and Kurmi Bomo while Dorylaimus was recorded only at Basawa. Out of the 20 genera of nematodes recorded, only *Dorylaimus* and *Trichodorus* were not common to all the locations.

The result of the absolute frequency of nematodes genera in the root of *Jatropha curcas* accession in September 2013 is presented in Table 8. Six (6) genera of plant parasitic nematodes were recorded in the root of *Jatropha curcas*. *Scutellonema, Hoplolaimus, Pratylenchus, Rotylenchus, Longidorus,* and *Paratylenchus* were the genera recorded. *Scutellonema* had the highest frequency value of 13.89, followed by *Hoplolaimus, Pratylenchus, Rotylenchus* and *Paratylenchus* with frequency values of 4.17 each. *Longidorus* was the least nematode genera recorded, with a frequency value of 1.39. The locations, Basawa, IAR Samaru, Unguwar Dankali and Kurmi Bomo recorded 3, 5, 3 and 2 genera of nematodes respectively. No nematode was recorded in Giwa and Hunkuyi. *Longidorus* was the only nematode genus recorded in Hunkuyi. *Scutellonema* was the only nematode common to the four locations where nematodes were recorded.
The prominence value of nematodes genera in the root of *Jatropha curcas* accession in September, 2013 is shown in Table 9. Twenty (20) genera of plant parasitic nematodes were recorded. *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus*

Table 8 Absolute frequency of plant parasitic nematode genera in the root of Jatropha in four Local Government Areas of Kaduna State, September 2013

Nematode Genera	Absolute Frequency (%)						
	Locations						
	Basawa	IAR Samaru	Giwa	Unguwar Dankali	Kurmi Bomo	Hunkuyi	All Locations
	(n=12)	(n=12)	(n=12)	(n=12)	(n=12)	(n=12)	(n=72)
Scutellonema	16.67	25.00	0.00	25.00	16.67	0.00	13.89
Hoplolaimus	0.00	8.33	0.00	16.67	0.00	0.00	4.17
Pratylenchus	8.33	16.67	0.00	0.00	0.00	0.00	4.17
Meloidogyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotylenchus	0.00	16.67	0.00	8.33	0.00	0.00	4.17
Longidorus	8.33	0.00	0.00	0.00	0.00	0.00	1.39
Xiphinema	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aphelenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heterodera	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helicotylenchus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paratylenchus	0.00	16.67	0.00	0.00	8.33	0.00	4.17

Table 9 Prominence value of plant parasitic nematode genera in the soil grown with Jatropha in four Local Government Areas of Kaduna State, September 2013

Nematode Genera	Prominence value						
	Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	155.65	276.04	29.88	73.21	137.66	40.50	122.31
Hoplolaimus	149.60	28.46	12.54	23.29	59.71	25.73	51.50
Pratylenchus	75.71	22.05	15.85	16.77	31.18	6.31	28.67
Aphelenchus	40.59	28.66	10.63	10.22	45.32	15.32	25.39
Meloidogyne	51.45	38.89	39.40	51.90	41.76	40.94	44.08
Tylenchoryhnchus	5.44	9.24	3.85	3.95	9.53	3.46	6.19
Rotylenchus	90.55	82.30	14.11	13.95	90.88	18.90	55.90
Longidorus	14.55	10.01	13.74	10.91	25.62	10.21	14.24
Helicotylenchus	142.89	22.39	5.75	10.33	28.91	45.01	45.86
Paratylenchus	6.12	7.27	6.45	10.71	14.56	11.50	9.07
Heterodera	1.54	2.45	1.73	1.73	5.48	1.73	2.73
Xiphinema	20.89	9.49	12.98	7.21	14.39	7.69	12.40
Tylenchus	35.33	23.00	12.64	30.67	32.39	15.11	25.02
Criconemoides	9.67	2.89	2.45	3.75	5.68	2.31	4.90
Hemicycliophora	16.07	9.37	8.20	7.08	6.11	4.11	8.35
Aphelenchoides	24.31	6.47	6.91	5.29	19.60	4.43	12.15
Tetylenchus	0.00	3.96	3.11	5.11	3.11	3.79	3.47
Trichodorus	3.85	0.00	0.00	0.00	1.92	0.00	1.67
Dorylaimus	1.54	0.00	0.00	0.00	0.00	0.00	0.63
Tylenchulus	0.00	1.92	9.00	0.00	5.10	5.11	4.75
Telotylenchus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pratylenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Telotylenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotylenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Heterodera, Xiphinema, Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus, and *Tylenchulus,* were the nematode recorded. Out of the 20 genera, *Scutellonema* was the most prominent (122.31) nematode genera recorded in all the locations. It was followed by *Rotylenchus, Hoplolaimus, Helicotylenchus* and *Meloidogyne* with prominence values of 55.90, 51.50, 45.86 and 44.08 respectively. *Dorylaimus* was the least prominent nematode genera (0.63) and it was recorded only in Basawa. Eighteen (18), 18, 18, 17,19 and 18 nematode genera were recorded in Basawa, IAR Samaru, Giwa, Unguwar Dankali, Kurmi Bomo and Hunkuyi respectively. *Telotylenchus, Pratylenchoides, Telotylenchoides* and *Rotylenchoides* were not recorded in all the locations. *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera Xiphinema, Tylenchus, Criconemoides, Hemicycliophora* and *Aphelenchoides* were common to all the locations.

The prominence values of nematodes genera in the root of *Jatropha curcas* accession in September 2013 is shown in Table 10. Six (6) genera of plant parasitic nematodes were recorded in the root of Jatropha. *Scutellonema, Hoplolaimus, Pratylenchus, Rotylenchus, Longidorus,* and *Paratylenchus* were the genera recorded. *Scutellonema* was more prominent (21.49) out of the 6 genera recorded. *Paratylenchus, Hoplolaimus, Pratylenchus* and *Rotylenchus* were also prominent with prominence values of 6.35, 6.12, 5.90 and 5.67 respectively. *Longidorus* was the least prominent nematode genera recorded with a prominence value of 3.54. Basawa, IAR Samaru, Unguwar Dankali and Kurmi Bomo had 3, 5, 3, and 2 genera of nematodes respectively recorded while no nematode was encountered at Giwa and Hunkuyi. *Xiphinema, Aphelenchoides, Heterodera and Helicotylenchus* were not recorded in any of the locations while *Longidorous* was recorded only in Basawa. *Hoplolaimus* and *Rotylenchus* were

Table 10 Prominence value of plant parasitic nematode genera in the root of Jatropha in four Local Government Areas of Kaduna State, September 2013

Nematode Genera	Prominence value						
	Locations						
	Basawa (n=12)	IAR Samaru (n=12)	Giwa (n=12)	Unguwar Dankali (n=12)	Kurmi Bomo (n=12)	Hunkuyi (n=12)	All Locations (n=72)
Scutellonema	12.25	27.22	0.00	42.22	20.41	0.00	21.49
Hoplolaimus	0.00	7.70	0.00	12.93	0.00	0.00	6.12
Pratylenchus	8.66	11.57	0.00	0.00	0.00	0.00	5.90
Meloidogyne	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotylenchus	0.00	11.57	0.00	7.70	0.00	0.00	5.67
Longidorus	8.66	0.00	0.00	0.00	0.00	0.00	3.54
Xiphinema	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aphelenchoides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heterodera	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helicotylenchus	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paratylenchus	0.00	13.61	0.00	0.00	7.70	0.00	6.35

recorded in IAR Samaru and Unguwar Dankali. *Scutellonema* was the only nematode genus common to all locations (Basawa, IAR Samaru, Unguwar Dankali and Kurmi Bomo).

For July 2013, the index of similarity between the locations (Basawa, IAR Samaru, Giwa, UngwaDankali, Kurmi Bomo and Hunkuyi) and number of nematodes they have in common in soil is presented in Table 11. All locations were similar in terms of nematode recorded due to the indices of similarity values that are greater or equals to 0.5. Giwa had more nematodes that were common with Unguwar Dankali and Hunkuyi while Kurmi Bomo and Basawa were two locations that have least number of nematodes in common.

For July 2013, the index of similarity between the locations (Basawa, IAR Samaru, Giwa, Ungwa Dankali, Kurmi Bomo and Hunkuyi) and number of nematodes they have in common in root is presented in Table 12. Nematodes recorded in the root of Jatropha accessions at Basawa, IAR Samaru, Giwa, Unguwar Dankali and Kurmi-Bomo was similar. There was total dissimilarity between nematodes encounted in Hunkuyi and other locations. Fewer nematodes were recovered from Jatropha roots in Hunkuyi. IAR Samaru and Unguwar Dankali have more nematodes in common compared with Hunkuyi and Basawa which had the least number of nematodes in common (dissimilarity).

For September 2013, the index of similarity between the locations (Basawa, IAR Samaru, Giwa, Ungwar Dankali, Kurmi Bomo and Hunkuyi) and number of nematodes they have in common in soil is presented in Table 13. All locations were similar in terms of nematode recorded due to the indices of similarity values that are greater or equals to 0.5. There was a perfect similarity between Hunkuyi and IAR Samaru and Hunkuyi and Giwa.

Table 11 Indices of similarity for plant parasitic nematode genera in soil of Jatropha stands in six location of Kaduna State, July 2013

Locations	Basawa	IAR Samaru	Giwa	Unguwar Dankali	Kurmi Bomo	Hunkuyi
Basawa	1.00	0.88	0.90	0.90	0.83	0.87
IAR Samaru		1.00	0.92	0.95	0.89	0.89
Giwa			1.00	0.97	0.92	0.97
Unguwar Dankali				1.00	0.95	0.94
Kurmi Bomo					1.00	0.94
Hunkuyi						1.00

IS value of 1.0 indicates total similarity between two zones, while descending values show increasing dissimilarity.

Table 12 Indices of similarity for plant-parasitic nematode genera in root of Jatropha stands in six location of Kaduna State, July 2013

Locations	Basawa	IAR Samaru	Giwa	Unguwar Dankali	Kurmi Bomo	Hunkuyi
Basawa	1.00	0.76	0.85	0.73	0.63	0.15
IAR Samaru		1.00	0.94	0.95	0.75	0.20
Giwa			1.00	0.89	0.80	0.22
Unguwar Dankali				1.00	0.71	0.18
Kurmi Bomo					1.00	0.25
Hunkuyi						1.00

IS value of 1.0 indicates total similarity between two zones, while descending values show increasing dissimilarity.

Table 13 Indices of similarity for plant-parasitic nematode genera in soil of Jatropha stands in six locations of Kaduna State, September 2013

Locations	Basawa	IAR Samaru	Giwa	Unguwar Dankali	Kurmi Bomo	Hunkuyi
Basawa	1.00	0.89	0.89	0.91	0.92	0.89
IAR Samaru		1.00	1.00	0.97	0.97	1.00
Giwa			1.00	0.97	0.97	1.00
Unguwar Dankali				1.00	0.94	0.97
Kurmi Bomo					1.00	0.97
Hunkuyi						1.00

IS value of 1.0 indicates total similarity between two zones, while descending values show increasing dissimilarity.

For September 2013, the index of similarity between the locations (Basawa, IAR Samaru, Giwa, Ungwar Dankali, Kurmi Bomo and Hunkuyi) and number of nematodes they have in common in root is presented in Table 14. The locations, IAR Samaru and Basawa, IAR Samaru and Giwa were similar in terms of number of Nematode recorded. There were no similarities between nematodes recorded at Kurmi Bomo and other locations. Nematodes were not encountered at Giwa and Hunkuyi and consequently the perfect dissimilarity between the two locations.

At 2 WAI, un-inoculated IARJAT2009020 gave the highest plant height (32.25) but it was not significantly higher than un-inoculated IARJAT2009041 (Table 15). Inoculated IARJAT2009016 gave the lowest plant height (24.08) but was not significantly lower than inoculated IARJAT2009012 and IARJAT2009041. At 4 WAI, un-inoculated IARJAT2009020 had the highest plant height (35.17) but was not significantly different from un-inoculated IARJAT2009012, IARJAT2009041 and IARJAT2009016. Inoculated IARJAT2009041 had the lowest plant height (26.67) but was not statistically different from inoculated IARJAT2009012 and IARJAT2009016. At 6 WAI, un-inoculated IARJAT2009020 had the highest plant height (36.53) but was not statistically different from un-inoculated IARJAT2009012, IARJAT2009041 and IARJAT2009016 and inoculated IARJAT2009020. Inoculated IARJAT2009041 gave the least mean value (29.47) and was not statistically different from inoculated IARJAT2009012and IARJAT2009016. At 8 WAI, inoculated IARJAT2009012 had the highest mean value (42.23) but was not significantly different from un-inoculated IARJAT2009020, IARJAT2009012, IARJAT2009041, IARJAT2009016 and inoculated IARJAT2009020. Inoculated IARJAT2009041 and IARJAT2009016 had the least mean value (35.62).

At 2 WAI, un-inoculated IARJAT2009020 gave the highest stem girth (0.89) but it was

Table 14 Indices of similarity for plant-parasitic nematode genera in root of Jatropha stands in six locations of Kaduna State, September 2013.

Locations	Basawa	IAR Samaru	Giwa	Unguwar Dankali	Kurmi Bomo	Hunkuyi
Basawa	1.00	0.55	0.00	0.29	0.33	0.00
IAR Samaru		1.00	0.00	0.60	0.44	0.00
Giwa			0.00	0.00	0.00	0.00
Unguwar Dankali				1.00	0.40	0.00
Kurmi Bomo					1.00	0.00
Hunkuyi						0.00

IS value of 1.0 indicates total similarity between two zones, while descending values show increasing dissimilarity.

Table 15 Effect of *Meloidogyne incognita* infection on plant height of four accessions of Jatropha at Zaria, 2013

Treatment	Plant Height (cm) at:			
	2WAI	4WAI	6WAI	8WAI
IARJAT2009020	32.25a	35.17a	36.53a	39.75ab
IARJAT2009020 + *Meloidogyne incognita*	27.75bcd	30.33bc	33.70abc	36.95ab
IARJAT2009012	28.90bc	32.47abc	34.85ab	39.87ab
IARJAT2009012 + *Meloidogyne incognita*	25.50cde	28.83cd	32.30bcd	42.23a
IARJAT2009041	30.42ab	32.67ab	34.50abc	38.75ab
IARJAT2009041 + *Meloidogyne incognita*	24.83de	26.67d	29.47d	35.62b
IARJAT2009016	28.58bc	32.35abc	33.95abc	38.75ab
IARJAT2009016 + *Meloidogyne incognita*	24.08e	29.92cd	30.98cd	35.62b
SE±	0.966	1.007	1.038	1.642

Mean in a column followed by different letters are significantly different using DMRT at 5% level of significance.

WAI = Weeks After Inoculation

not significantly higher than un-inoculated IARJAT2009012, IARJAT2009041 and IARJAT2009016 (Table 16). Inoculated IARJAT2009016 gave the lowest stem girth (0.70) but was not significantly different from un-inoculated IARJAT2009012, inoculated IARJAT2009020, IARJAT2009012 and IARJAT2009041. At 4 WAI, un-inoculated IARJAT2009020 had the highest stem girth (1.15) but was not significantly different from un-inoculated IARJAT2009041 and IARJAT2009016. Inoculated IARJAT2009041 had the lowest stem girth (0.94) but was not significantly different from un-inoculated IARJAT2009012, IARJAT2009041, inoculated IARJAT2009020, IARJAT2009012 and IARJAT2009016. At 6 WAI, un-inoculated IARJAT2009020 had the highest stem girth (1.39) but was not statistically different from un-inoculated IARJAT2009012, IARJAT2009041 and IARJAT2009016. Inoculated IARJAT2009041 gave the least mean value (1.10) and was not significantly different from un-inoculated IARJAT2009012, IARJAT2009041, inoculated IARJAT2009020, IARJAT2009012 and IARJAT2009016. At 8 WAI, inoculated IARJAT2009020 had the highest mean value (1.82) but was not significantly different from un-inoculated IARJAT2009012, IARJAT2009041, IARJAT2009016 and inoculated IARJAT2009012. Inoculated IARJAT2009020and IARJAT2009041 had the least stem girth (1.30) but was not significantly different from un-inoculated IARJAT2009012, IARJAT2009041, IARJAT2009016, IARJAT2009012 and IARJAT2009016

At 2 WAI, un-inoculated IARJAT2009020and IARJAT2009012gave the highest numbers of leaf (6.67) but it was not significantly higher than un-inoculated IARJAT2009041,inoculated IARJAT2009020 and IARJAT2009012 (Table 17). Un-inoculated IARJAT2009016 gave the lowest number of leaf (5.50) but was not significantly different from un-inoculated IARJAT2009041, inoculated IARJAT2009020, IARJAT2009012, IARJAT2009041 and IARJAT2009016. At 4 WAI,

Table 16 Effect of *Meloidogyne incognita* infection on stem girth of four accessions of Jatropha

Treatment	Stem Girth (cm) at:			
	2WAI	4WAI	6WAI	8WAI
IARJAT2009020	0.89a	1.15a	1.39a	1.82a
IARJAT2009020 + *Meloidogyne incognita*	0.75bcd	0.96b	1.13c	1.30b
IARJAT2009012	0.78abdc	1.00b	1.25abc	1.58ab
IARJAT2009012 + *Meloidogyne incognita*	0.71dc	0.97b	1.18bc	1.57ab
IARJAT2009041	0.83abc	1.05ab	1.24abc	1.56ab
IARJAT2009041 + *Meloidogyne incognita*	0.72dc	0.94b	1.10c	1.30b
IARJAT2009016	0.85ab	1.14a	1.32ab	1.58ab
IARJAT2009016 + *Meloidogyne incognita*	0.70d	0.95b	1.18bc	1.37b
SE±	0.036	0.037	0.049	0.079

Mean in a column followed by different letters are significantly different using DMRT at 5% level of significance.

WAI = Weeks After Inoculation

Table 17 Effect of *Meloidogyne incognita* infection on numbers of leaf counted on Jatropha plants

Treatment	Leaf Number at:			
	2WAI	4WAI	6WAI	8WAI
IARJAT2009020	6.67a	8.33a	11.33a	14.17ab
IARJAT2009020 + *Meloidogyne incognita*	6.17ab	7.50b	9.17ab	10.17b
IARJAT2009012	6.67a	8.50ab	11.50a	13.50ab
IARJAT2009012 + *Meloidogyne incognita*	6.00ab	7.33b	11.17a	14.50a
IARJAT2009041	6.17ab	8.00ab	9.67ab	12.33ab
IARJAT2009041 + *Meloidogyne incognita*	5.67b	5.83c	8.33b	10.83ab
IARJAT2009016	5.50b	7.67ab	11.00a	14.00ab
IARJAT2009016 + *Meloidogyne incognita*	5.67b	8.17ab	11.00a	13.33ab
SE±	0.227	0.354	0.696	1.076

Mean in a column followed by different letters are significantly different using DMRT at 5% level of significance.

WAI = Weeks After Inoculation

un-inoculated IARJAT2009020 had the highest number of leaf (8.33) but was not significantly different from un-inoculated IARJAT2009012, IARJAT2009041 and IARJAT2009016. Inoculated IARJAT2009041 had the lowest number of leaf (5.83) but was significantly different from other treatments. At 6 WAI, un-inoculated IARJAT2009020 had the highest number of leaf (11.33) and was statistically different from inoculated IARJAT2009041 that had the least (8.33) numbers of leaf. At 8 WAI, inoculated IARJAT2009012 had the highest mean value (14.50) and was significantly different from inoculated IARJAT2009020 that had the least number of leaves (10.17).

Table 18 shows the gall index and the nematode population on *Jatropha curcas* accessions and tomato plants inoculated with *Meloidogyne incognita.* The population of *M. incognita* differed between the tomato variety (Roma VF) which was used as standard check and the *Jatropha curcas* accessions but there was no significant difference between the *Jatropha curcas* accessions. The greatest reduction in number of galls (3.17) was observed in IARJAT2009012 accession of Jatropha followed by IARJAT2009020 (3.50) and IARJAT2009041 (6.67). The reduction in number of eggs and final nematode population obtained shows that IARJAT2009041 has the highest reduction, followed by IARJAT2009020 and IARJAT2009016. There were significant difference between the controls and standard check on the number of *M. incognita* eggs and nematode population extracted after 8 weeks of inoculation from the root of inoculated plants and the soil. There was no significant different in the mean obtained for all the Jatropha accessions. Roma VF used as standard check has the highest number of nematode population (954.53).

Table 18 Number of galls, population of *Meloidogyne incognita* and reproduction factor of inoculated Jatropha and tomato

Treatments	Number of Galls	Nematode Population	Reproduction Factor
IARJAT2009020 + *Meloidogyne incognita*	3.50b	18.77b	0.01
IARJAT2009012 + *Meloidogyne incognita*	3.17b	37.27b	0.02
IARJAT2009041 + *Meloidogyne incognita*	6.67b	13.50b	0.01
IARJAT2009016 + *Meloidogyne incognita*	10.00b	28.71b	0.01
Roma VF + *Meloidogyne incognita*	387.17a	954.53a	0.48
LSD	26.269	28.357	0.014

Means in a column followed by different letters are significantly different using LSD at 5% level of significance

WAI = Weeks After Inoculation

CHAPTER FIVE

5.0 DISCUSSION

The conducted survey indicated that twenty-four (24) genera of plant parasitic nematodes were associated with Jatropha plants in four Local Government Areas (Sabon Gari, Giwa, Kudan and Zaria) of Kaduna State. These are *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus, Heterodera , Xiphinema, Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus, Tylenchulus, Telotylenchus, Pratylenchoides, Telotylenchoides and Rotylenchoides.* All the twenty-four genera of plant parasitic nematodes were recorded in soil of Jatropha in July 2013; however, only eleven genera of the nematodes were recorded from the root of Jatropha in the same survey. These are *Scutellonema, Hoplolaimus, Pratylenchus, Meloidogyne, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera, Xiphinema* and *Aphelenchoides* Also, twenty (20) genera of plant parasitic nematodes were recorded in the soil and six from the root of Jatropha during September 2013 survey. Thus, those not found associated with Jatropha in September are *Telotylenchus, Pratylenchoides, Telotylenchoides and Rotylenchoides.* Emeh, (2012), recorded seventeen (17) genera of plant parasitic nematodes to be associated with *Jatropha curcas* accessions in Zaria. These comprise all the genera reported in this study except *Aphelenchus, Paratylenchus, Heterodera, Aphelenchoides, Tetylenchus, Dorylaimus, Tylenchulus, Telotylenchus, Pratylenchoides, Telotylenchoides and Rotylenchoides*. The increase in nematode genera due to these findings may be increase in number of sampling locations, change in time and Jatropha accessions.

Scutellonema was the most abundant plant parasitic nematode found on *Jatropha curcas* in all the fields. It was recovered from the soil as well as from the roots. This finding corroborates the findings of Emeh, 2012, that *Scutellonema* spp. had the highest population

The frequency of occurrence and prominence value of *Meloidogyne* in this study corroborate Begum (1996) report that *Meloidogyne* spp. may be important on Jatropha.

Xiphinema, Longidorus and *Trichodorus* were recorded in this study. Mekete (2010) reported the association of these nematode species among others with biofuel crops. The importance of these nematodes as vectors of plant viral diseases is well documented (Brown *et. al.,* 1993). Kashina *et al.* (2013) reported the occurrence of begomovirus in *Jatropha curcas,* the frequenct association of these nematodes in this study asserts that they may be vectoring this disease.

Generally, more plant parasitic nematodes were recorded in the soil and root of Jatropha in July, 2013 than in of September, 2013. The values reported for the indices of similarity in the soil and roots indicate that there are more similarities in number of nematodes recorded in July, 2013 than September, 2013. This might be attributed to the fact that plant parasitic nematode population will be greater with the abundance of soil moisture (Agrios, 2005). Therefore decline in nematode population in the September compared to July may be due to difference in the amount of soil moisture between July and September, 2013. In orchards, Jatropha fields were constantly clear of unwanted plants, fertilizers were applied and watering of plants was done. The plants were well taken care of whereas no such treatments were given to Jatropha plants on the farmer's field. The higher number of nematodes found in the Orchards compared to the farmer's field might be due to these management practices that may tend to favour population build up in orchards than other farms.

Based on the index of similarity values across all locations, nematode genera encountered are similar. Differences observed in plant parasitic nematode communities where it exists can be attributed primarily to the different management practices in each of the location which in turn disturb soil nematode community structure and function (Neher, 1995; Neher and Cambell, 1994).

The pathogenicity test shows that *Meloidogyne incognita* did not significantly reduce the growth of all the Jatropha accessions used as there were no significant differences in the growth parameters of both inoculated and un-inoculated accessions. *Meloidogyne incognita* reproduced maximally on tomato which was used as standard check but maximum reproduction was hindered in the roots of Jatropha accessions. Inability of *Meloidogyne incognita* to reproduce well on the Jatropha may be due to pest and pathogens repellant toxins described by Heller (1996). The Jatropha accessions tested appears to be tolerant to *Meloidogyne incognita* infections. Begum (1996) reported that *Jatropha podagrica* is a parasite of *Meloidogyne incognita.* The apparent discrepancy between the findings in this study and that of Begum (1996) may be due to differences in varieties and the *Meloidogyne* species. It is possible that the accessions used in this study are fairly resistant to *Meloidogyne incognita.* There is therefore the need to screen more cultivars against the nematode, *Meloidogyne incognita.*

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

A study was conducted to determine the genera, frequency and prominence value of plant parasitic nematodes associated with *Jatropha curcas* in Sabon Gari, Kudan, Giwa and Zaria Local Government areas of Kaduna State, Nigeria. Twenty-four genera of plant parasitic nematodes were recorded in all the locations. Plant parasitic nematodes recovered include *Scutellonema, Hoplolaimus, Pratylenchus, Aphelenchus, Meloidogyne, Tylenchoryhnchus, Rotylenchus, Longidorus, Helicotylenchus, Paratylenchus Heterodera Xiphinema, Tylenchus, Criconemoides, Hemicycliophora, Aphelenchoides, Tetylenchus, Trichodorus, Dorylaimus, Tylenchulus, Telotylenchus, Pratylenchoides, Telotylenchoides, and Rotylenchoides.* The most prominent nematode from the soil were *Scutellonema* with prominence value of 81.09, followed by *Meloidogyne* and *Rotylenchus* with prominence values of 46.50 and 39.60, respectively and those from the roots were *Scutellonema, Meloidogyne* and *Rotylenchus* with prominence values of 77.15, 50.93 and 26.94, respectively

Screen house experiment was conducted to determine the pathogenicity of *Meloidogyne incognita,* on four *Jatropha curcas* accessions. Data on plant height, stem girth and number of leaves together with gall index and nematode reproduction were collected.

Evaluation of four accessions of *Jatropha curcas* (IARJAT2009020, IARJAT2009011, IARJAT2009041 and IARJAT2009016) shows that these Jatropha accessions are resistant to *Meloidogyne incognita*.

6.2 Conclusion

The study has demonstrated that twenty-four genera of plant parasitic nematodes are associated with *Jatropha curcas* accessions in Sabon Gari, Kudan, Giwa and Zaria Local Government areas of Kaduna State, Nigeria. IARJAT2009020, IARJAT2009011, IARJAT2009041 and IARJAT2009016 prove to be resistance to *Meloidogyne incognita*. It can therefore be concluded that although plant parasitic nematodes were recorded in the soil and root of Jatropha in sampled areas, *Meloidogyne incognita* is not pathogenic on *Jatropha curcas* accessions used. IARJAT2009020, IARJAT2009011, IARJAT2009041 and IARJAT2009016 can therefore be used in mixed crop combinations to manage *Meloidogyne incognita* infected soils.

6.3 Recommendations

Based on the findings of this study,

1. Further pathogenicity test of other important nematodes to the harvest of the crop need to be determined in order to ascertain the damage caused by nematode that will translate to yield loss of Jatropha.

2. Screening of more accessions of Jatropha against *Meloidogyne incognita* and other prominent nematodes should be carried out.

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Appendix ANOVA Tables

ANOVA Effect of *Meloidogyne incognita* infection on plant height of four accessions of Jatropha

2 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	338.2764583	48.3252083	6.48	<.0001
Error	40	298.3083333	7.4577083		
Total	47	636.5847917			

4 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	313.9466667	44.8495238	5.53	0.0002
Error	40	324.2833333	8.1070833		
Total	47	638.23			

6 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	215.6347917	30.8049702	3.57	0.0045
Error	40	344.885	8.622125		
Total	47	560.5197917			

8 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	FValue	Pr > F
Model (Accessions * Treatments)	7	214.558392	30.651199	1.42	0.2237
Error	40	862.300333	21.557508		
Total	47	1076.858725			

ANOVA 14 Effect of *Meloidogyne incognita* infection on stem girth of four accessions of Jatropha

2 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	0.22	0.03142857	3.07	0.011
Error	40	0.40916667	0.01022917		
Total	47	0.62916667			

4 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	0.30411458	0.04344494	3.87	0.0027
Error	40	0.44958333	0.01123958		
Total	47	0.75369792			

6 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	0.45286458	0.06469494	3.39	0.0062
Error	40	0.76291667	0.01907292		
Total	47	1.21578125			

8 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	1.31453125	0.18779018	3.71	0.0035
Error	40	2.02375	0.05059375		
Total	47	3.33828125			

ANOVA Effect of *Meloidogyne incognita* infection on numbers of leaf counted on four accessions of Jatropha

2 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	8.3125	1.1875	2.88	0.0156
Error	40	16.5	0.4125		
Total	47	24.8125			

4 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	35.3125	5.04464286	5.02	0.0004
Error	40	40.16666667	1.00416667		
Total	47	75.47916667			

6 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	58.3125	8.3303571	2.15	0.0603
Error	40	155.1666667	3.8791667		
Total	47	213.4791667			

8 Weeks After Inoculation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	7	107.8125	15.4017857	1.66	0.1458
Error	40	370.1666667	9.2541667		
Total	47	477.9791667			

ANOVA Table for Gall number of inoculated *Meloidogyne incognita* Jatropha accessions and Tomato (Roma VF).

Number of Galls

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	4	698176.2000	174544.0500	42.16	0.0001
Error	25	103510.5000	4140.4200		
Total	29	801686.7000			

ANOVA Table for Nematode Population of inoculated *Meloidogyne incognita* Jatropha accessions and Tomato (Roma VF).

Nematodes Population

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model (Accessions * Treatments)	4	4153278.902	1038319726	215.22	0.0001
Error	25	120613.841	4824.554		
Total	29	4273892			