Effect of Root-knot nematode, Meloidogyne incognita (Koford and white) on different cultivars of Splanum melongena L.

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A thesis submitted in partial fulfilments of the requirement for a degree of Master of Science in Botany, to the Postgraduate School. Ahmadu Bello University, Zaria.

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SEPTERMBER, 1987

DECLARATION

I declare that this work is wholy the author's and has not been part of any presentation for any other degree.

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CERTIFICATION

This thesis entitled "Effect of Root-knot nematode, Meloidogyne incognita Goeldi on different cultivars of Solanum melongena L." by GEORGE, SALAMATU JUMMAI (MRS) meets regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

Affectionately dedicated to my children, MAIMUNA, GARBA and MARYAM.

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ABSTRACT

A preliminary survey in some parts of Kaduna State namely Birnin Gwari, Funtua, Jemaa, Kaduna, Katsina, Wanka and Zaria showed that most vegetable crops were infested by Neloidogyne, incognita except for Birnin Gwari where Meloidogyne javanica was extracted from the roots of Okra, Hibiscus esculentum.

Ten different cultivars of Splanum melongena were tested for susceptibility against root-knot nematode, M. incognita and Solanum melongena var Zaria (SMZ-1) was found highly susceptible with root-knot index rated as 5.0 while Solanum melongena Var. Ilorin (SMI-1) was immune with root-knot index rated 0.

Histological slides of infected roots showed damages done to the cortical regions of the roots as well as parts of the stelar regions.

Four Neinaticides were tested for the control of root-knot nematodes on eggplant. Basamid was feund effective but stays too long in the soil and phytotoxio to. the plants. DD was also very effective but it has adverse effect on mammalian health and also it's application requires great labour and , skill from the farmers. Mocap was quite effective in the control of root-knot nematode, but phytotoxic.to plants above recommended dosage.

Oxamyl was the most effective compound,in the trials in terms of root-knot index and fruit yield increase, but it has a high oral toxicity., though its dermal toxicity is low.

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ABBREVIATIONS CITED

a.i.	active ingredient
DD	Dichloropropane dichloropropene
FAA	Formal acetic acid
g	gram
ha	hecta
kg	kilogram
l	litre
PP	pages
spp	species
wt	weight

CHAPTER 1

1. INTRODUCTION

The root-knot nematode, Meloidogyne species constitute one of the most important groups of plant parasitic nematodes which infest almost every type of field crop, causing considerable losses in yield. Staple food crops in the tropics and virtually all vegetables, fruit trees and ornamental plants grown in the mediterranean and sub-tropical countries are subject to the attack of various species of this nematode. In temperate regions, crops grown even under glass house conditions may suffer damage due to the infestation of several Meloidogyne species. In addition to the direct damage caused by root-knot nematodes, many species have been found to predispose plants to the secondary infestations of pathogenic fungi and bacteria.

The problems caused by root-knot nematodes often start from the seedbeds. The seedlings are readily attacked by nematodes and their roots develop the characteristic galls. This prevents the normal development of the root system. Consequently, the translocation of water and nutrients to the aerial parts of the plant is hampered and the plant growth is retarded (Oteifa and Elgindi, 1962). The reductions in yield due to the infestation of pests like nematodes in tropical countries have generated work on breeding especially against root-knot nematodes for the screening of resistant cultivars in a number of crops like tobacco, tomato, pepper, beans and cowpeas.

At present, because of limited research in this area, few nematode resistant varieties of plants are available to the Nigerian farmers such as cowpea vita-3, root-knot resistant tomato, Roma ven, Braces and Ronita.

Generally, control of root-knot nematodes is based on two principles. First, to reduce damage in already infested fields and later preventing further spread of nematodes to non-infested fields (Anon, 1968; Bos, 1978). To achieve these goals, cultural methods, introduction of resistant varieties and chemical sterilization of the soil are being used.

Cultural methods usually involve crop rotation, fallowing of land, flooding, use of organic manure, etc. These methods, however, have their limitations because of the fact that very limited number of acceptable non-nusceptible crops are available for inclusion in the crop rotation cycle (Bos, 1979).

Fallow is combination with repeated turning over of the soil may be suitable in certain parts of northern Nigeria where the long dry season and often very high soil temperature c n kill root-knot nematodes through dessication and heat. This practice is not easily accepted by the farmers because of the economic reasons.

Flooding as a means of controlling nematodes in soil is effective under certain conditions. The flooding of soil during the wet season in West cameroun helped to control root-knot nematodes (Praquin and Marchand, 1970). Moreover, flooding of rice fields for three months gave effective control of M. incognita for two following crops of vegetables, (Thames and Stoner, 1953). It has also been observed that fields along the rivers and streams in northern Nigeria which are abandomed for some portion of the wet season are mostly free from nematodes (Bos, 1979).

In order to achieve effective control of root-knot nematodes, flooding for twelve to twenty-two months are required (Anon, 1968).

This method of controlling has great limitations because of the availability of water and the length of time for which farmland remains submerged in water. These conditions are not easily acceptable to a farmer.

The use of resistant varieties of crop plants is regarded as one of the best methods which is most economical and effective for the control of nematodes. (Anon, 1968; Taylor 1971). This is particularly true in developing countries where farmers are yet to acquire sufficient skill in handling chemicals. Varieties selected for this purpose must be resistant to specific nematode species prevalent in the region besides having acceptable agronomic qualities like early maturation periods and high yields.

Presently, Nematicides are considered as the easiest and quickest ways to control plant parasitic nematodes (Taylor and Sasser 1978a). However, chemical sterilisation of soil alone is by no means the final answer to the control of root-knot nematode. Oosten-brink (1972) has suggested an integrated control method combining the use of chemicals with proper crop rotation scheme, and introducing resistant varieties.

The Agricultural Extension and Research Liason Service (AERLS), A.B.U., Zaria recommended Nemagon 20 to the farmers throughout northern Nigeria for the control of nematodes. However, this nematicide has recently been removed from the market and manufacturing discontinued. This is because of its reported linkage with male sterility. There are also reports about the possibility of carcinogenic actions of residues of the chemicals in treated vegetables (Anon, 1977).

Because of the above problem, the non-fumigant nematicides have now been introduced into the market.

This group comprises chemicals having contact action and are known to act systemically in the plant. The non-fumigant chemicals are often applied in granulated forms and have the advantage of low phytotoxicity and volatility. However, they show high level of toxicity in mammals.

Most of the work done on root-knot nematode in Nigeria is reported from the Southern part of the country. Moreover, no investigations have so far been done on egg plant, Solamum melongena in this country. Similarly, other vegetables such as okro and spinach have also received very little attention.

The present research project was aimed at carrying out investigations on the following aspects of root-knot nematodes.

1. To survery the incidence of root-knot nematode in association with vegetable crops in Kaduna State so as to study the distribution of nematodes in various parts of the State.
2. To develop and maintain pure laboratory cultures of Meloidogyne incognita for the purpose of experimentation on eggplant.
3. Histopathological studies of damaged root system of collected material as well as those developed in the laboratory conditions.
4. Screening of ten different cultivars of Solanum melongena to evaluate resistance against root-knot nematode infestation.
5. To evaluate the economic feasibility of different nematicides for the control of the nematode.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 AGRICULTURAL IMPORTANCE OF ROOT-KNOT NEMATODE

It has been reported that vegetable crops suffer about 11% annual loss due to the infestation of nematodes in the United States (Jensen, 1972). Netscher (1970, 1971) showed that the presence of root-knot nematode, Meloidogyne spp, can be a limiting factor in vegetable farming in Senegal. Praquin and Marchand (1970) referred to Meloidogyne spp. and other nematodes as the most severe technical impediment to vegetable production in Western Cameroun. They estimated that tomato infested with Meloidogyne spp. had yield reductions of 50-70 percent.

In Nigeria, Bridge (1972) estimated 40% yield reduction in plants like tomato, cucumber and melon heavily infested with nematodes. Bos (1978) however reported a much more pessimistic figures in respect of French Bean raised by Bud-Hollond at Kadawa. Crop yields obtained were only about three tons per hectare against an expected eight tons per hectare, due to the infestation of root-knot nematode. He observed that, the seedlings of a susceptible cultivar of tomato at Kadawa were transplanted as late as 10-12 weeks after sowing against the normal period of 3-5 weeks because of the nematode attack at an early stage.

2.2 CLASSIFICATION OF THE ROOT-KNOT NEMATODE

A full review on the history and nomenclature of root-knot nematode, genus Meloidogyne Goeldi, 1887 has been provided by Frankling (1957), Whitehead (1968) and Omiyi (1976). Over the years the genus Meloidogyne has been classified in various ways regarding its assignment to higher categories. Earlier, it was included under

the family Heteroderidae with the cyst nematode (Filipjev 1934). Later, Skaĭbilovich (1947) created two subfamilies, Heteroderinae and Tylenchilinae under Heteroderadae. Thorne (1949) redefined the family Heteroderidae and recognised Heteroderinae as the only subfamily with three genera, Heterodera, Meloidogyne and Meloidodera. Chitwood and Chitwood (1950) recognised three subfamilies, Heteroderinae, Hoplolaiminae, and Naccobinae under the family Heteroderidae. Skaibilovich (1959) redescribed Heteroderidae by its sexual dimorphysm and included it in five subfamilies, Heteroderinae, Tylenchilinae, Sphaeronematinae, Naccobinae and Meloidogyninae. Paramonova (1967), Wouts and Sher (1971), recognised only two subfamilies, Heteroderidae and Nacobbinae in this group.

Golden (1971) raised the status of family Heteroderidae to superfamily Heteroderoidae which included two families, Heterodae and Nacobbidae in it. In addition to Heteroderoderinae and Meloidogyninae, he proposed a new subfamily, Meloidoderinae to accommodate genus Meloidogyne. Wouts and Sher (1971) amended Thorne's definition of the family Heteroderidae and redefined the two subfamilies Meloidogyninae and Heteroderinae. These authors recognised Meloidogyne as the only genus of Meloidogyninae.

Meloidogyne indica Khan and Hussain (1972) a cycstforming species with predominantly Meloidogyne like characters was placed by Hussain (1976) in a new subfamily Meloidoderallinae. Presently, there are three monotypic sub-families in the Meloidogynidae with the genera Meloidogyne, Meloinema and Meloidoderella.

2.3 HOST PARASITE RELATIONSHIP

The root-knot nematode Meloidogyne species differ from other sedentary endoparasitic nematodes by having wide most range and peculier in formation on intercalary knot or gall on the roots of

susceptible hosts (Taylor and Sasser, 1978b). More than 2,000 different plants are known as the susceptible hosts to this nematode, but only in relatively few cases, have host-parasite relationships been investigated.

Plants affect the life cycle of Meloidogyne prior to egg hatching (Viglierchio, 1968). Once second stage juveniles leave the egg masses, they infect nearby galled roots or locate new roots of susceptible plants to continue their life cycles. Second stage juveniles are the only juveniles of Meloidogyne that migrate in the soil free from host tissue and hence constitute the infective stage. Although juveniles may survive in the soil in a quiescent state for an extended period of time, their food reserves are limited and their infectivity decreases with the depletion of these reserves (Bird, 1967). Research shows that Meloidogyne second stage juveniles do not find roots by random movement, but are attracted to plants in response to stimuli emanating from roots (Green, 1971). These juveniles possess well-developed, innervated cephalic sensory organs that are thought to be chemoreceptive and presumably serve to locate roots (Coomas, 1979). The cephalic sensory organs comprise six inner labial sensilla and two amphids. The amphids, because of their large size and structural complexity, are considered to be the principal sensory organs for second stage juveniles (Wergin, 1976). Plant parasitic nematodes were considered capable of migrating only a few centimeters per year (Prot, 1980). However, recent studies with second stage juveniles of Meloidogyne indicated they could be attracted to and migrate to host roots 25cm vertically in 10 days (Prot, 1978).

Second stage juveniles are also attracted to apical meristem points where lateral roots emerge. Penetration sites of other

juveniles are cut surfaces of roots (Bird, 1960). The nature of stimuli produced by roots and perceived by second-stage juveniles is not clear. The rhizosphere is greatly modified by growing roots and associated microorganisms (Russell, 1977). Many organic and inorganic compounds excreated by roots of microorganisms form gradients from the root surface out into the soil and may influence nematode at attraction over short distances. Klingler (1965) regards certain amino acids and Co_2 as the most important root excretions for attracting plant parasitic nemeatodes. Some of these compounds act as attractants to Meloidogyne juveniles in vitro (Bird, 1959).

The mechanism of penetration may involve action by thrusting of the stylet (Linford, 1942). Cellulolytic or pectolytic enzymes may also be involved in penetration, however, the roles of specific enzymes in the penetration process is still unclear (Bird, 1960).

2.4 HOST-RANGE AND GEOGRAPHICAL DISTRIBUTION OF ROOT-KNOT NEMATODE

Root-knot nematodes are known to attack a wide range of plants of economical importance all over the world, especially in tropical and sub-tropical regions. The host list continues to increase which includes vegetables, ornamental plants, trees, shrubs and herbaceous plants of various families.

Marcinowski (1909) listed 236 host plants susceptible to root-knot nematodes. Two years later, Bassey (1911) provided list of 480 such plants. By 1938 over 1,300 plants were recorded as susceptible hosts to this nematode. Raski (1951) listed 2,000 plant species infested with root-knot nematode which included tomato, eggplant, okro, beans, cabbage, papaya, yams, tobacco, coffee, rice, carrot, etc.

In Africa, surveys were conducted by some research workers to determine the host range of Meloidogyne species (Edward, 1955, 1956; Martin 1958; Wilson, 1962; Caveness 1965; Addoh, 1971; Bridge 1972 and Bos 1978). It has been suggested that Meloidogyne species have considerable over-lapping host ranges. In Ghana; Addoh (1970) studied 141 plant species representing 36 families of which, 126 plant species were found susceptible to root-knot infection of varying degrees. The remaining fifteen plant species were either "Poor hosts", or "non hosts". He concluded that the most susceptible cultivated crops were found in the families Solanaceae, Cucurbitaceae, Malvaceae, Cruciferae, Umbelliferae and to some extent Dioscoreaceae. However, non-hosts or poor hosts cultivated crop plants occured in the Gramineae, Papilionaceae, Sterculiaceae and Liliaceae. Wilson (1962) listed 108 plant species as susceptible hosts of root-knot nematodes in northern Nigeria. Bridge (1972) reported 14 crops attacked by root-knot nematodes in irrigated fields in northern Nigeria. The crops represented the plant families, Solanaceae, Cucurbitaceae Comporitae, Cruciferae, Leguminosae, Umbelliferae, Liliaceae, Gramineae and Passifloraceae.

Caveness (1976) provided a list of 140 cultivated and uncultivated plants susceptible to root-knot infestation in Nigeria. Besides field crops of economic importance, many weeds are also known to be susceptable to root-knot nematodes infestation. Odihirin and Adesina (1975) reported that weeds representing more than 20 plant families harboured root-knot nematodes after the maturation of annual crop in Southern part of Nigeria. Omiyi (1976) reported 11 weeds belonging to the plant families, Solanaceae, Compositae, Euphorbiaceae, Cyperaceae, Caesalphiniaceae, Malvaceae

and Cucurbitaceae as hosts of root-knot nematodes in irrigated fields at Zaria and Kadawa. Bos (1978) also listed 22 weed hosts from Kadawa Irrigation Scheme.

Taylor and Sasser (1978b) classified the described Meloidogyne species in accordance with their host range. They observed that some Meloidogyne species have restricted host range which may be confined to one or few plant families, such as grasses, woody plants or species of one genus. Such species may have other host plants, but the probability of their occurance in the fields are comparatively low. On the other hand some Meloidogyne species appear to have cosmopolitan distribution with wide host range.

Godfrey (1926) considered the climatic conditions as the major limiting factor in the distribution of root-knot nematodes. In the hot interior deserts of the South Western United States, Meloidogyne species have been observed to develop at soil temperatures ranging between 30-35°C (Krusbery and Nielson, 1958). According to Thomson and Lear (1961) most of known species of root-knot nematodes are native to tropical regions and reproduce best at soil temperatures ranging between 25-32°C.

Caveness (1976) also regarded environmental conditions as possible factors affecting distribution of Meloidogyne species in Nigeria. He reported that among the three species, Meloidogyne incognita, M. javanica and M. arenaria found in Nigeria, M. arenaria was found most frequently in the former Western region while M. javanica was common in the North. However, the distribution of these species cannot be associated with any particular environmental factor like temperature, rainfall and vegetation.

Olowe (1978) reported that M. javanica was more prevalent on cowpeas in the Savannah zone of Nigeria than in the forest zone, while M. incognita was mostly found in the forest zone of this country.

2.5 RESISTANCE IN PLANTS TO ROOT-KNOT NEMATODES

The nature of plant resistance to root-knot Nematodes has been investigated by many workers even though the actual definition of resistance as it applies to the study of plant parasitic nematodes had often been debated.

Steiner (1925) defined resistance as "the ability of roots to resist penetration of nematodes". Barrons (1939) recognised resistance as "any perceptible ability on the part of a plant to grow in nematode-infested soil without the formation of galls". He speculated that resistance in plants may be developed due to certain chemicals within the roots of such plants that counteract or neutralize the giant-cells inducing effect of the salviary secretions by the nematode. However, Christie (1939) suggested several bases for host resistance to root-knot such as:-

(i) Lack of larval entry

(ii) Failure of plant to respond to larval secretions with giant-cell formation and

(iii) Root-tissue necrosis (hypersensitivity) during early stages of parasitism

Sanner and Giles (1957) found considerable necrosis in root tissues without any symptons of gall formation or development of the nematode larvae in invaded resistant peanut roots. Rigg and Winstead (1959) observed that the factors for resistance or susceptibility to the root-knot nematode, Meloidogyne incognita in tomato to were not translocated across a graft union.

Larvae of root-knot nematodes were also observed to penetrate the roots of resistant plants as freely and as rapidly as they penetrated roots of susceptible plants. They, however, concluded that the invasion of resistant tissues resulted in the death of the tissues around the invading larvae and the death of the larvae.

Unny and Jerath (1966) reported root-knot nematode on yam, Dioscorea spp in Eastern parts of Nigeria. They however, did not indicate anything about the damage done to the crop.

Amosu and Franckowiak (1974) studied the inheritance of resistance against root-knot nematodes in cowpeas. They observed that when resistant cultivars are crossed with the susceptible ones, in F_2 generation, single dorminant factors govern resistance, with the result that various levels of galling formed in susceptible plants.

Olowe (1976) recorded wide distribution of root-knot nematode in cowpea growing areas of Imo, Anambra and River States in early 1974. He also found the occurrence of this nematode in association with maize crop during 1975-76 in maize growing areas of Oyo, Ondo Ogun, Bendel, Anambra, Imo and Plateau States.

Odihirin (1976) reported root-knot nematode on cowpea (New era) from the gardens of the University of Ibadan, involving three species, M. incognita, M. javanica and M. arenaria. He also observed that M. incognita was responsible for decaying yam tubers in Cross River and Bendel States. Moreover, several grasses like Axonopus compersus and Mariscus umbellatus were found as the source of alternate hosts for root-knot infections in the absence of susceptible crop.

Caveness (1976) reviewed the root-knot nematode situation in Nigeria and observed that this nematode was practically found in

all parts of the country with maximum rate of infection in the West followed by Eastern and Northern regions. Amosu (1976) tested several cowpea and tomato cultivars for resistance against M. incognita. He listed 36 different cowpea cultivars and lines showing high degree of resistance especially Mississippi Silver which was found free from nematode infection. However, Mak 1/1 and victor K.798 showed resistance in Wet season. These cultivars developed few galls during the dry season.

Adesiyan and Odihirin (1978) observed that yam tubers grow in Mid-Western, East Central, South East and Rivers States were mostly infested with M. incognita. However, those grown in West and Kwara States were infested with M. javanica. They recorded highest rate of infection in water yam, D. alata in the six states. Yellow yam, D. cayenensis on the other hand showed no symptons of root-knot nematode infection.

Ogunfowora (1976) in one of his screening reports on resistance against root-knot nematodes in tomato cultivars indicated that Ibadan local, Camp.ble 135, Ife-2, Marzoma, New Yorker, Pusa early dwarf and Harvester were most susceptible to nematode attack. However, Namerad was recorded as moderately susceptible to the infection of root-knot nematode. They graded Rossol, Nematex Rossol, Nematex and Enterprizer as slightly resistant, whereas Ronita, VFN 8 were reported as the resistant cultivars against M. incognita. In another similar studies, Amosu and Babalola (1976) observed that Ife-1 (improved) Line 76 (6210-10), Nematex, Rossol, Atkinson, VEN 8 VEN were resistant to M. incognita whereas Ronita, Ouunui and Nemarod were tolerant to some extent against this nematode. Hussain (1980) screened fourteen different tomato cultivars against root-knot nematode, Meloidogyne incognita.

He found some resistance in Red-river, Lafayette, VF-198 (improved) and pomodorasanmazano. Resistance in Roma-VFN, Rossol and Ronita was confirmed. However, Roma was recorded as the most susceptible cultivar against root-knot infestation.

Khan (1985) recorded M. incognita and M. javanica in association with 15 different fruit trees within the radius of 25kms in Zaria area. He observed that M. incognita was more prevalent as compared to M. javanica.

2.6 USE OF RESISTANT PLANT VARIETIES

Use of plant resistant varieties is regarded as an extremely feasible method for controlling root-knot nematodes. It is an effective, economical and environmentally safe means of reducing losses from diseases caused by these pests. Selection of resistant plants enable the farmer to control the root-knot disease without increasing production costs associated with the purchase of expensive chemicals, applicators and overall operational costs involved in production of a crop. Introduction of resistant varieties is especially valuable in controlling root-knot nematodes in low value crops and minor crops which can increase crop yields equal to that obtained by soil fumigation (Good, 1972; Netscher and Maubboussin 1973). The benefits derived by growers using resistant tobacco 'Nc 95' variety introduced in 1961 have been reported to be spectacular, saving millions of dollars (Moore et al. 1962).

Successful development of root-knot resistance requires the manipulation of genetic systems to transfer resistant genes from a resistant plant to a susceptible agronomic or horticulturally acceptable type. Significant accomplishments have been made in this area of study over the past sixty years.

This is evident from the available information that about 235 cultivars representing 15 major crops have shown resistance against one or more Meloidogyne species (Table 1). Most of these crops have, however, developed resistance specifically against M. incognita with regards to cultivars of tomato, tobacco, cotton, soybean, cowpea, and sweet potato. Resistance in more than one species has been found in tomato, cowpea, Bermuda grass, Peach and Grapevine (Good 1972).

2.7. TYPES OF RESISTANCE

Resistance to root-knot nematodes may operate within the soil environment, preinfectional or within the root system, postinfectional. Pre-infectional resistance is also referred to as passive. Pre-existing or natural resistance which operates before the nematode penetrates the surface of the root (Wallace, 1973). This type of resistance may be associated with root exudates that either repel the infective stage larvae from the roots or are toxic to them (Rohde, 1972). Pre-infectional resistance may be restricted to one nematode species. Sasser (1954) reported that M. incognita larvae do penetrate oats and rye but M. incognita larvae do penetrate in the roots of these plants. Plants exibiting pre-infectional resistance could be called 'non-hosts'.

Post-infectional resistance is the most common type manifested after the nematode penetrates into the plant tissues. A definite host-parasite relationship is established that determines the fate of the host plant and the nematode (Wallace. 1973).

Table 1: RESISTANCE DEVELOPED IN CROPS AGAINST ROOT-KNOT NEMATODE, MELOIDOGYNE SPP.

Name of crop	Scientific Name	Root-knot nematode Meloidogyne spp	No. of Cultivars
Tomato	Lycopersicum esculentum L.	M. incognita M. javanica M. aurenia	65
Cowpea	Vigna ungulata L	M. incognita M. javanica M. arenaria	30 4 4
Sweet Potato	Ipomoea batatas L	M. incognita [illegible] M. arenaria	17 3 7
Soybean	Glycine max L	M. incognita	19
Tobacco	Nicotiana tabacum	M. incognita	14
Cotton	Gossypium spp L	M. incognita	12
Pepper	Capsicum annuun spp L.	M. incognita M. javanica M. arenaria	3 6 7
Pole bean		M. incognita	8
Lema bean	Phaseolus lunatus	M. incognita	4
Grapevine	Vitis vinefera (L.)	M. incognita M. javanica. M. arenaria	4
Alfalfa	Medicago Sativa L.	M. incohnita M. javanica M. hapla	3 2

Name of crop	Scientific Name	Root-knot nematode *Meloidogyne* spp	No. of Cultivars
Lespedeze	L. *Striata* L.	*M. incognita*	3
Lupin	*Lupinus* L.	*M. javanica* *M. hapla* *M. arenaria*	1
Bermuda grass	*Cynodon dactylon* pers.	*M. incognita* *M. javanica* *M. hapla* *M. arenaria*	- - 2 -

Plants are generally categorised as being immune, resistant, tolerant or susceptible to diseases. These are relative terms that represent interactions between the nematode species and the host plant. An immune host plant is the one that is able to prevent infection with no disease symptons showing absolute resistance. A susceptible plant on the other hand cannot overcome or withstand the injurious effects of the nematode and permits it to develop to its fullest capacity. A resistant plant cannot prevent entrance of the parasite but is able to prevent, restrict or retard its development. However, tolerant plants endure invasion by the nematode without appreciable symptoms or damage.

2.8 THE EGG PLANT

The eggplant, Solanum melongena L, a vegetable crop, is widely grown throughout Nigeria. It belongs to the family Solanaceae which includes several other economically important crops such as tomato, Lycopersicum esculentum, the chilli and bell peppers, Capsicum spp. It is a perennial shrub usually grown as annual, self compatible and highly fertile crop. The flowers are solitary or in clusters of two or more opposite leaves. The fruit is a berry differing in size and form. The colour varies from being green dark purple, red, white or yellow (Grubben, 1977).

Garden eggs are raised in nursery and later transplanted to the field. Seeds are sown in nursery beds and they germinate in 7-10 days and are transplanted 4-6 weeks later. The plant continues to grow up to about 18 weeks. Regular harvesting at weekly intervals is essential to encourage further fruiting and to avoid over maturity. The size and number of yields progressively declines after the second and third harvests (Nsowah, 1969).

Different views have been expressed about the origin of eggplant. Vavilov (1928) suggested that its centre of origin was Indo-Burma where large number of genetic varieties were found. However, Bhaduri (1951) and Omidirin (1976) suggested that Solanum melongena possibly evolved independently in different Parts. of the world.

2.8.1 PRODUCTION AND USES

The total world production of eggplant in 1980 was recorded as 4.5 million tones, produced over 323,000 hectares of land, giving an average yield of 13.9 t/ha, (FAO 1980).

Eggplant is widely consumed as one of the vegetables throughout the warmer regions of the world. (Choudhuri, 1976). It supplements starchy foods in addition to being cheap source of protein, minerals and vitamins. Kogbe (1981) reported S. indicus, S. nigrum and S. aethiopcium which are grown because of their leaves. On the other hand, S. ferox in South-East Asia, S. forum and Solanum gilo in Africa are largely cultivated because their immature fruits are chewed raw, cooked as vegetables and also for seasoning other foods (Purseglove, 1969, Tologbonshe, 1984).

Some Solanum species are used in native medicine throughout the tropics. The alkaloid 'Solanine' extracted from the roots, leaves and fruits is well known for its therapeutic value (Choudhuri, 1984). Solanum aviculare and S. khasianuns have also gained importance as a source of Solasidine used for synthesis of steroid hormone. Among these, S. gilo appears to be more widely grown by farmers in Nigeria both for consumption and for market purposes probably because of its prolific fruit production and its ability to transport and store well.

2.9 THE ROLE OF NEMATICIDES IN NEMATODE MANAGEMENT

Nematicides are one of the most important and reliable means of controlling a wide variety of nematodes. Commercial use of nematicides began about 1945, and suitable application methods have been devised for several highly effective nematicides like Basamid, DD, Oxamyl and Mocap. Their use increased rapidly during the last 15 years. The principal use of nematicide is for control of nematode populations in the soil before planting crops. Nematicides are used to protect a number of highly susceptible crops from nematode infection.

Phillips (1974) reported that the root-knot nematode, M. javanica on tomatoes was effectively controlled by the nematicides EDB, DD, DI-trapex and Terracur, resulting in considerable increase in yields. Taylor and Sasser (1978a) recommended the use of Methyl Bromide in seed-beds and nurseries for the control of plant parasitic nematodes, Fungi, Bacteria etc.

However, the farmer in Nigeria may still find it difficult to afford or cope with the requirements for the effective administration of the nematicides because of their handling and operational problems.

2.9.1 TYPES OF NEMATICIDES

The mode of action of Nematicides depends on the type of nematicides used. It has been reported that both fumigants and non-fumigant nematicides dissolve in water to some extent and enter nematode bodies through the cuticle (Taylor and Sasser, 1978a). However, further nematicidal action in nematodes depends on the nature of the chemical involved.

Soil fumigants are usually formulated as liquids which form vapours that pass through soil pores. These nematicides have a broad spectrum of biocidal activity and may kill fungi and other

organisms. They may show phytotoxic effects when applied at high dosage levels. A waiting period of two to three weeks is required between application of soil fumigants and planting. Fumigants are organic halides or organic sulfurs and may be referred to as alkyl halides.

Non-fumigant nematicides are formulated as granules but some are available as liquids, for spraying on soil. These nematicides move by percolation in soil water and have a narrower biocidal activity. They are non-phytotoxic and are active at lower dosages.

2.9.2 MODE OF ACTION OF NEMATICIDES

Castro and Thomason (1971) studied the effect of fumigants on Aphlenchus avence, a fungal feeding nematode and observed that the nematode cuticle acts as a barrier for the penetration of nematicides. The equilibrium concentration of nematicides in the worms exceeds that in the external solutions. Thus, the equilibrium concentration of ethylene dibromide in Aphelencus avenae exposed to a 0.53×10^{-2}M solution was found to be 1.34×10^{-2}M, and the nematode remained alive for hours under this condition. These workers, further observed that there are many places for the action of any biocide on a living systems. In an attempt to explain the toxic action of the alkyl halide nematicides, they showed that at concentrations under 200ppm, nematodes become quiescent and then die slowly. The slow death was probably caused by interference of the nematicides with the iron containing enzymes of the respiratory sequence. At concentrations above 200ppm. there was shrinkage of the nematodes body and rapid death occured by alkylation at numerous places within the nematode body. Nestcher (1971) gave a simpler explanation to the toxic action of the alkyl halide nematicides,

that "when these products (DD, EDB, and DBCP) are introduced into the soil, they evaporate slowly and saturate the pores of the soil, thus killing the nematodes by asphyxiation".

2.9.3 NON-FUMIGANT NEMATICIDES

The non-fumigant nematicides are mainly organo-phosphoros and carbamate compunds; have differert mode of action. Rhode (1960) demonstrated the presence of an esterase which hydrolysed acetylcholine (synaptic transmitter) in Pratylenchus penetrans, and showed that the enzyme was inhibited by organo-phosphorus insecticides. Lee and Atkinson (1965) reported that Aldicarp, a carbamate derivative rapidly inhibited body activities of Heterodera larvae and caused enzyme hydrolysis ir the body.

It has been generally accepted that the action of organo-phosphorus and carbamate compounds in insects inhibit the hydrolysis of acetylcholine by the enzyme acetylcoline esterase (Corbett 1974). Bunt (1975) studied the effect and mode of action of oxamyl on nematodes and observed muscular contractions, paralytic crinkling and stylet protrutions; indicating poisoning of nerve system.

Badra et al. (1980) studied the efficacy of non-fumigant nematicide for the control of root-knot nematode in yam in Nigeria. They applied Oxamyl 10G at the rate of 6kg/ha in row treatment for Meloidogyne incognita under field conditions. This resulted in the increase of yield by 49 percent.

2.9.4 PROPERTIES AND ACTIVITIES OF SOME SELECTED NEMATICIDES

2.9.4.1 BASAMID (DAZOMET)

The chemical is composed of tetrahydro 3, 5-dimethyl-1,3,5 thiadiazime - 2-thione. It breaks down in moist soil to various degradation products which gives this compound a very broad spectrum activity.

Basamid was first introduced in 1952 by the Union Carbide Corporation under the trade mark 'MYLONE', and by Bayerische Anilin under Soda Fabriken AG (BASF) under the trade mark "Basamid". The solubility of Basamid in water is 1.2g/litre at 30°C. It has moderate stability but is sensitive to heat above 35°C and to moisture.

Basamid formulations are either dust (859g a.i/kg) or granules (950g and 980 a.i/kg). Originally, Basamid was formulated as powder, but the growing need for this product which could be distributed mechanically resulted in the development of a granule formulation (Lush et al 1967). The chemical is strongly phytotoxic and soil treated with it is generally not planted until it becomes free from the compound and its decomposition products. This can be monitored by germination of cress seed sown as sample on the treated soil (Lush et al 1967).

High moisture contents of the soil and low temperatures tend to prolong persistence of the chemical in the soil. The compound is not recommended for use when the soil temperatures are below 7°C (Lush et al 1967).

The BASF give advantages of Basamid granules. It produces no drift from the wind, can spread evenly, the uniformity of application is readily visible, requires no complicated methods needed to 'seal' the soil, no unpleasant odour during application, no side effects, the gases donot form until the product and the soil are mixed and have a broad spectrum activity at the standard application rates.

Basamid is reported effective for the control of nematodes as well as soil fungi such as Pythium, Fusarium, Verticillium and

Colletotricium when incorporated into glasshouse soils. They are said to suppress the growth of weeds and fight against wireworms (Chabra et al 1976). Basamid has been successfully used to reduce damages due to root-knot nematodes, and fungal attacks a on tomato plants. Ogunfowora (1979) observed that sufficient waiting period should be allowed prior to sowing so that phytotoxicity could be prevented in the seedlings.

2.9.4.2 DD (Dichloropropane) dichloropropene)

The most active ingredient dichloropropane dichloropropene is halogenated aliphatic hydrocarbon. The product, introduced by Shell Development Co. in 1942 is often referred to by its trade marks 'DD'. Its first use as a soil fumigant was described by Carter (1943). Pure dichloropropene is sold as telone by the Dow Chemical Company.

DD is a clear liquid, with a pungent odour. Its solubility in water at room temperature is low but soluble in hydrocarbon and halogenated solvents. The mixture is stable up to 500°C. It is strongly narcotic but low concentrations cause irritation in respiratory tract.

Preplant application of DD is effective against most of the soil nematodes including root-knot nematode, Meloidogyne incognita. The mixture of the nematicide is usually applied by injection into the soil or through tractor drawn hollow lines, to a depth of 15 to 20cms. The soil for treatment should contain high moisture level before application. Surface of the soil should be properly sealed by rolling a heavy object over it. Being phytotoxic, the fumigant should be allowed to escape by opening up the sealed soil before sowing.

The waiting period has been recommended between two to four weeks before planting. The waiting period could be reduced in light soils, warm soils and soils of low moisture content, but it is longer in wet or cold soils and in heavy clay soils (Tu, 1971)

2.9.4.3 MOCAP

Mocap was introduced as a nematicide in 1963 under the trade mark 'Prophos' and 'Mocap'. Mocap is a clear liquid with yellow tint having vapour pressure of 0.00035mm Hg ($26^{\circ}C$) and specific gravity of 1.094. The compound is soluble in most organic solvents. It is stable in acidic aqueous medium between $25^{\circ}C$ - $100^{\circ}C$ but rapidly hydrolyses in basic medium at $25^{\circ}C$. Mocap is commonly formulated as an emulsion concentrate (700g a.i/l) or as granules 100g or 200g a.i /kg or 10 percent and twenty percent granular respectively. Mocap is a non-fumigant, non-systemic contact pesticide with good soil movement and residual properties. It can be applied immediately before or at the time of planting or be used for treatment of established plants (Feldmesser, 1978). Mocap provides effective nematode and soil insects control on a wide range in vegetables and ornamental crops.

2.9.4.4. OXAMYL (VYDATE)

Oxamyl is the common name for, methyl-N-dimethyl-N.

The product was introduced in 1969 under the trade mark 'vydate'. Oxamyl is a white crystalline in appearance with a slight sulphuruous odour, vapour pressure is 2.3×10^{-4} mmHg at $25^{\circ}C$. It is stable in solid form and in most solutions, but decomposes to innocuous material in natural waters and in soil. Aeration, sunlight, alkalinity and higher temperatures increase the rate of decomposition.

Oxamyl is reported to control nematodes by contact and systemic action. It systematically provides some degree of protection from nematodes when applied as a foliar spray or through the roots of the plant. In the soil, low concentrations of oxamyl inactivate parasitic nematodes and inhibit feeding during exposure. Oxamyl has been shown to provide good control of a wide range of parasitic nematodes.

2.9.5 FACTORS AFFECTING THE EFFECTIVENESS OF NEMATICIDES

The factors which affect the efficacy of the nematicides in the soil includes:-

(a) Soil type

(b) Soil moisture

(c) Soil temperature

(d) Soil PH.

2.9.5.1 SOIL TYPE

The diffusion of volatile nematicides in the soil is influenced by the soil type. Sandy loam soils or soils with low organic and clay contents are the types in which volatile nematicides as well as non-fumigant types are most effective in controlling nematodes. (Allen and Raski 1950).

Clay particles or excessive organic matter can absorb the nematicide and reduce its dispersion in the soil. Moreover, the poor spaces in clay soils are relatively small and likely to be filled with water which blocks the spread of the nematicide. Clay soils, therefore, require 20-50% more fumigant than sandy soils for effective treatments (Khair and Mcleod 1974). Relatively due to large pore spaces in sandy soils, the nematicides applied spread rapidly (Hagan, 1941). For most of the chemical treatments, proper soil preparations are very important in order to acheive

best results. The soil should be free from lumps and clods as a good number of nematodes can hide in them. Ogunfowora (1976) observed that the development of root-knot nematode is favoured by light soils and adequate moisture for plant growth.

2.9.5.2 SOIL MOISTURE

Hagan (1941) indicated that soil moisture is the most important limiting factor for the diffusion of fumigant nematicides. As the soil moisture increases, soil pores are filled with water which impedes diffusion of gases, resulting in poor distribution and prolonged retention of the fumigants. (Khair and Mcleod 1974). Most recommendations call for a soil moisture content above field capacity in sandy soils (Allen & Raski, 1950) The moisture should not be more than 85% or less than 50% of field capacity (McBeth and Bergeson, 1955).

2.9.5.3 SOIL TEMPERATURE

The diffusion of fumigant nematicides, also depends on the soil temperature. Caveness (1965) suggested that the application of soil fumigant can be accomplised if the soil temperature at 15cm depth is above 29°C. This is because, due to excessive heat, rapid dispersion of fumigant cannot give good results. Similarly, there is also a lower limit of temperature beyond which fumigants cannot work. Castro and Thomason (1971) observed that soil temperature should be above 7°C for the application of DD and above 16°C for EDB. However, Khair and Mcleod (1974) reported an optimum temperature as 21°C for fumigant application. Soil temperature, on the other hand does not seem to have adverse effect on the efficacy of non-fumigant nematicides. Khair and Mcleod (1974) suggested that non-fumigant nematicides could be applied when temperature and other soil factors are unsuitable for the application of fumigants.

2.9.5.4 SOIL PH

Soil pH does not show major effects on the toxicity of alkyl halide nematicides. In many non-fumigant nematicides, pH exerts certain effects on their hydrolytic stability. For instance, Mocap is stable in acid aqueous media between 25°C to 100°C, and hydrolyses moderately fast in basic medium at 25°C and rapidly at 100°C (Anon. 1973). Oxamyl decomposes to Inocuous materials in soil water. The rate of decomposition is increased by alkalinity, aeration, sunlight and higher temperatures. The rate at which Basamid breaks down in soil to methyl iso-thiocyanate appears to be increased in soils with low pH (Khair and Mcleod, 1974).

CHAPTER THREE

3. MATERIAL AND METHODS

3.1 SURVEY

During the course of General Survey of root-knot nematodes, vegetable plants showing diseases symptions were uprooted and the roots were examined for the infection of root-knot nematode. Such samples were collected from some vegetable growing areas of Birnin Gwari, Funtua, Jema'a, Kaduna, Katsina, Wanka and Zaria.

The infected roots of Okra (Hibiscus esculentum), spinach (Celosia argentea), tomatoes (Lycopersicum esculentum), eggplant (Solanum melongena) and pepper (Capsicum spp); showing the symptons of galls on them were carefully placed along with adhering soil in Polythene bags. Each sample was tagged with necessary information in respect of the name of the host plant, locality, date of collection before they were brought to the laboratory for further examination.

3.2 ISOLATION

Root samples along with the soil were brought to the laboratory for further examination. The adhering soil particles were removed from around the roots, by placing them in water, in a plastic bucket. The infected roots containing galls were then examined under the steroscopic binocular microscope in a Petridish. The root-knot index in respect of each samples was determined and rated according to the scale suggested by Taylor and sasser (1978a). This 0-5 scale represent the following infestation classes.

0 = No root-knot infestation. Roots free from galls and egg masses of root-knot nematodes.

1 = Very light infestation. Galls and eggmasses usually inconspicuous, require a careful search.

2 = Light infestation with numerous small scattered galls and egg-masses.

3 = Moderate infestation with numerous small scattered galls and eggmasses.

4 = Severe infestation with few large galls and eggmasses.

5 = Very severe infestation with numerous large galls and egg masses. Often the root system is rotted.

3.3 IDENTIFICATION OF NEMATODES

The infected roots containing adult females were stained by the following method.

(a) A staining solution, lactophenol in cotton blue was boiled for about a minute in which the infected roots were placed for about three minutes. During this process both plant tissue and nematodes embedded in them were stained.

(b) The roots were then removed from the staining solution and washed with cold water.

(c) They were later transfered in a clear lacto-Phenol solution until properly destained. In this medium the plant tissues became some what translucent leaving the nematodes stained and clearly visible.

The stained nematodes were then carefully removed from the plant tissues with the help of needles and mounted on glass slides for identification.

3.4 PREPARATION OF PERINEAL PATTERNS FOR THE IDENTIFICATION OF OF MELOIDOGYNE incognita spp

Identification of various species of root-knot nematodes is based on the structural difference of the perineal patterns (Plate 1). The following method was adopted for the preparation of perineal pattern of preserved adult females.

Mature females from the root galls were selected and placed in Petri dish containing tap water. The cuticle of the female was ruptured near the neck and body surface containing vulvar and anal region representing the perineal pattern which was transferred in a drop of glycerin on a clean glass microscope slide. Coverslip was gently placed on it. Excess of glycerin was absorbed with a piece of filter paper and then the slide was examined under the microscope.

3.5 DEVELOPMENT OF PURE CULTURE OF MELOIDOGYNE INCOGNITA

In order to obtain enough inoculum for subsequent studies, pure culture of root-knot nematode population was maintained in pots raised from egg masses of Meloidogyne incognita. This was done on the most susceptible variety of tomato plants in sterilized soil.

After a period of about 55 days, infected tomato plants containing egg masses of Meloidogyne incognita were carefully up-rooted and washed to remove the adhering soil particles under a gentle stream of tap water. Nematodes and egg masses were collected from the galled root system by putting them into a blender with about 100cc of water and the blender was operated for 10-15 sec. The crushed roots containing mixture of egg masses, nematodes and root tissues was passed through a coarse 20-40 mesh sieve by washing gently with a stream of water. Residues on the coarse sieves were discarded, and the ones collected on the fine sieve (200-250 mesh) were examined for nematodes and eggmasses of M. incognita.

3.6 SUSCEPTIBILITY TRIALS

The egg masses of Meloidogyne incognita raised in pots were removed from the galled roots. The material was transferred in a measuring cylinder of 1 litre containing 200ml of 0.5% sodium

hypochlorite (clorox) solution. The jar was vigorously shaken manually for 3 minutes. This dissolved the gelatinous matrix of the egg masses. The eggs were not exposed to the clorox solution for longer than 4 minutes (Taylor and Sasser, 1978b). This was then transferred into water. The water thus containing eggs was passed through two sieves of 75um and 25m mesh sizes respectively. Eggs separated from the egg masses passed through the first sieve with 25m opening were washed under a slow stream of tap water. The eggs were then raised into a 1-litre flask.

The concentration of eggs in the suspension was determined by counting the number of eggs in 1 ml aliquots of the stock suspension. The average of the three counts was taken as the number of eggs per ml. Some 20-30,000 eggs per pot were used as inoculum.

3.6.1 PREPARATION OF EXPERIMENTAL PLANTS

Ten different cultivars of Solanum melongena L, were raised seperately in nurseries. The soil used was sterilized before the seeds were sown. The germinated seeds were transplanted after six weeks into experimental pots.

3.7 EGGPLANT VARIETIES TESTED

The following varieties of Solanum melongena were used during the suceptibility trial against root-knot nematode, Meloidogyne incognita.

Type 1 - Solanum melongena var. Giwa-1 (SMG-1)
Tall, leaves deeply lobed, fruit round and green

Type 2 - S. melongena var. Giwa-2 (SMG-2) Dwarf,
Leaves slightly lobed, fruit round and white in colour.

Type 3 - S.melongena var. Zaria-1 (SMZ-1) Dwarf,
leaves deeply lobed, fruit long and oval, white in colour and pointed at ends.

Type 4 - S. melongena var. Basawa-2 (SMB-2) Dwarf, leaves slightly lobed, fruit short, oval and white.

Type 5 - S.melongena var. Basawa-1 (SMB-1) Dwarfish, leaves deeply lobed, fruit long oval, white with green stripes.

Type 6 - S. melongena var. Ilorin-1 (SMI-1) Dwarfish, leaves slightly lobed, fruit short oval, roundish, white white with green stripes.

Type 7 - S. melongena var. Ilorin-2 (SMI-2) Dwarfish, leaves slightly lobed, fruit round, white with green stripes.

Type 8 - S. melongena var Bomo (SMBM) Dwarfish, leaves deeply lobed, fruit long oval, white round at the end.

Type 9 - S. melongena var. Akabe (SMA) Dwarf leaves, deeply lobed, fruit long oval green white mosaic with purple splash, flower purple.

Type 10 - S. melongena var. Ogunmo (SMO) Dwarf, leaves deeply lobed, fruit round, mosaic green with blue purple splashes.

3.8 NEMATICIDAL TRIALS

Susceptible varieties of Solanum melongena were selected to determine the efficacy of Basamid, DD, Mocap and Oxamyl for the control of root-knot nematode.

The experiments were done during the month of April 1986. The population densities of the second stage active larvae were assessed three weeks after the application of the nematicides. Each nematicide was applied in three different doses as follows

Basamid, half dose 0.2Kg/Pot, Standard dose 0.04Kg and double dose 0.08kg/Pot.

DD, half dose 0.15L/Pot, Standard dose 0.030 /Pot and double dose of 0.06 /Pot.

Mocap was applied at the rate of 0.005kg/Pot, 0.010Kg/Pot and 0.020Kg/Pot for the half dose, standard dose and double dose respectively.

In the case of Oxamyl half dose was 0.025Kg/Pot Standard dose was 0.05Kg/Pot and for double dose. .110 Kg/Pot was applied.

For each of the nematicides used, the required amount needed for each pot was weighed prior to its application, DD was applied with a hand-injector, while the other chemicals all in granules were broadcast and incorporated into the soil with a hand hoe to a depth of about 8-18cm. After the recommended waiting periods, the Solanum melongena seedlings were transplanted into the pots.

The pots were regularly watered very morning. Routine weeding was done and 5gms of DDT powder was applied to protect against insect and fungal diseases. Three weeks after the planting, N.P.K. fertiliser (15,15,15) was applied at the rate of 10gms per pot.

Six weeks after transplanting, the heights of plants per treatment were taken. Yields data were also recorded of matured harvested fruits. After the last picking, the plants were up-rooted to determine the incidence of root-knot infestation using the root-not index 0-5.

3.9 HISTOLOGICAL STUDIES OF THE DAMAGED ROOT SYSTEM BY ROOT-KNOT NEMATODE MELOIDOGYNE INCOGNITA.

Histological Studies were done after preparing permanent mounts of the infected root system. The following procedure was adopted to prepare the slides.

3.9.1 FIXATION AND DEHYDRATION

Few galled roots were fixed in FAA for 24 hours. They were later dehydrated in 70, 95 and absolute alcohols for 2 hours in each grade.

They were later passed through the series of chloroform/ absolute alcohol mixture in the following order:

(a) 25% chloroform in absolute alcohol for 2 hours

(b) 50% chloroform in absolute alcohol for 2 hours

(c) 75% chloroform in absolute alcohol for 2 hours

(d) pure chloroform for 2 hours (twice).

2.9.2 INFILTRATION

The dehydrated galled roots in pure chloroform were transferred in parafin wax at 60°C until the wax started to jel in the chloroform. It was left overnight in the same medium for proper infilteration of wax in the plant tissues. During this period the chloroform was completely evaporated.

3.9.3 EMBEDDING

The galled roots were positioned in the cooling paraffin so that it was sectioned easily after hardening. The embedding mold was greased with glycerine before the paraffin wax was poured into it. After hardening, the paraffin was removed from the mold and mounted on the microtome.

3.9.4 SECTIONING

Sectioning of the paraffin block containing the galled roots was done on a rotatory microtome equipped with a knife. As the sectior were cut, the edge of each section adhered to the previous section thereby forming a ribbon. Fine Micron sections of the galled roots were obtained.

3.9.5 MOUNTING

Sections obtained were placed on the slides and labeled. The surface of the slides were coated with a small amount of Haupt's adhesive.

Before the adhesive dried up, the slides were flooded with a 2-3% formalin solution. The flooded slides were then placed on a warming tray held at 35 to 40°C. As the slides warmed up, the ribbons flattened out and the liquid evaporated and the slides were removed when they were completely dried.

3.9.6 STAINING

The staining procedure was carried out using the safraning and fast Green stain method in the following way (Sass, 1951).

The slides were placed in to a solution of Xylene, xylene-absolute ethanol (1:1), 95% ethanol, 70% ethanol, all at 5 minutes each, then they were placed in safranin solution for 24 hours. The slides were then rinsed in tap water and placed into 1% aqueous methyl violet 2B solution for 10-15 minutes after which they were rinsed again in tap water 95% ethanol - methyl cellosolve-tetiary butyl alcohol (1:1:1) was prepared in which the slides were placed for 15 secs and then into Fast green FCF Solution for 10-15 minutes, then in 95% ethanol-tertiary butyl alcohol (1:1) plus 0.5% glacial acetic acid for 15 secs after which they were placed in orange G solution for 3 minutes.

After this process slides were carefully placed into clove oil-methyl cellosolve - 95% ethanol (1:1:1) and then clove-oil absolute ethanol-xylene (1:1:1) for 15 seconds each. Finally the slides were placed in xylene solution for 5 minutes twice.

3.10 PREPARATION OF SOIL FOR EXPERIMENT

The type of soil used for the experiment was soil with low organic and clay contents since clay particles and organic matter can absorb the nematicide and reduce its dispersion.

The soil sample was sieved thoroughly and put into a soil steriliser where it was heated to a temperature of about 120°C before it was cooled off and poured into pots.

20Kg of Sterilised Soil was measured into each pot and the temperature of the Soil at the start of the experiment was noted to be 29°C; Likewise, the PH of the Soil was found to be 6.5 with the help of a PH hydrometer.

CHAPTER FOUR

4. RESULTS

4.1 SURVEY

A preliminary survey was conducted in eight different localities of Kaduna State to determine the incidence of root-knot nematode infestation in association with five different vegetable crops including egg plants, Solanum melongena (Table 2). It was observed that most of the vegetables were susceptible to the infection of nematode. On identification, Meloidogyne incognita was recorded as the most dominant species of nematode in these areas except for one location at Birnin-Gwari where okro, Hibiscus esculentum was found infected with M. javanica. The nematode species showed two different types of perineal patterns. In the case of Meloidogyne incognita, the perineal pattern was characterised by the presence of a high, squarish dorsal arch with a distinct whorl in the tail terminal area. The striae were smooth to wavy, sometimes zigzagged while M. javanica displayed ridges that divide the dorsal and ventral striae. Generally, the ridges run the entire width of the pattern, but gradually disappear near the tail terminus (Plate 1).

In most of the areas surveyed, tomatoes, Lycopersicum esculentum were found heavily infested with M. incognita galls showing root-knot index between 4.5 and 5.0. This was followed by okro, Hibiscus esculentum with root-knot index generally ranging between 4.0 to 5.0 except for samples collected from Birnin Gwari where the root-knot index in okro plant was 3.0. Severe root-knot infestation was also recorded in egg-plants, Solanum melongena with root-knot index ranging between 3.5 to 4.5. Moderate to severe infection was recorded in spinach, Celosia argentea with root-knot

Plate 1: Perineal patterns



Fig. 1: Meloidogyne incognita



Fig.2: Meloidogyne javanica

index ranging between 2.5 to 4.00. The pepper plants, Capsicum spp were collected from Zaria and Katsina with root-knot index 2.5 and 3.00 respectively (Table 2).

Table 2: Root-knot Nematode, Meloidogyne incognita infestation on vegetable crops surveyed in some Parts of Kaduna State.

Common Name	Scientific Name	Locality	Root-knot index	Date of collection
Okra	*Hibiscus esculentum	Birnin Gwari	3:0	18/1/86
Spinach	Celosia argentea	"	2.5	18/1/86
Tomato	Lycopersicum esculentum	"	4.5	18/1/86
Tomatoes	Lycopersicum esculentum	Daura	5.0	21/1/86
Okra	Hibiscus esculentum	"	5.0	
Eggplant	Solanum melongena	Funtua	4.0	25/1/86
Tomatoes	Lycopersicum esculentum	"	4.5	
Spinach	Celosia argentea	Jemaa	3.0	30/1/86
Eggplant	Solanum melongena	"	4.5	
Eggplant	Solanum melongena	Kaduna	3.5	30/1/86
Tomatoes	Lycopersicum esculentum	"	5.0	
Spinach	Celosia argentea	"	4.0	
Peppers	Capsicum spp	Katsina	3.0	1/2/86
Okra	Hibiscus esculentum	"	5.0	
Tomatoes	Lycopersicum esculentum	Wanka	4.5	3/2/86
Eggplant	Solanum melongena	"	3.5	
Egg Plant	Solanum melongena	Zaria	3.5	
Peppers	Capsicum spp	"	2.5	3/2/86
Tomatoes	Lycopersicum esculentum	"	5.0	
Okra	Hibiscus esculentum	"	4.0	

* Meloidogyne javanica

4.2 Reaction of Solanum melongena Cultivars against root-knot nematode Meloidogyne incognita.

Ten different varieties of Solanum melongena were tested against root-knot nematode, Meloidogyne incognita and the degree of susceptibility rated. The data obtained during these trials indicate that SMI-1 was immune to the infestation of root-knot nematode as it did not develop any galls on the root system. The root weight of ten inoculated and control plants has been more or less the same as 0.97gm and 0.95gm respectively. Four varieties SMB 1, SMB 2, and SMO were found highly resistant to the infection of this nematode with root-knot index as 1. The variety SMI-2 was rated as resistant because of its root-knot index 2. Two r varieties, SMG 1 and SMG-2 were tolerant to root-knot nematode with root-knot index as 3. Solanum melongena var Bomo (SMBM) was found susceptible and SMZ-1 was highly susceptible to the nematode attack with root-knot index 4 and 5 respectively. (Plate II).

It was further observed that the increase in rate of infection and extensive gall formation resulted into the gradual increase in root weight against the control plants (Table 3).

The infected roots were observed to have more weight than those under control as shown in the table above. In addition, more fruits were harvested from the control Solanum melongena plants than from the infected ones (Table 4).

PLATE II



Fig. 1: Solanum melongena var. Zaria (SMZ-1) showing infected roots.

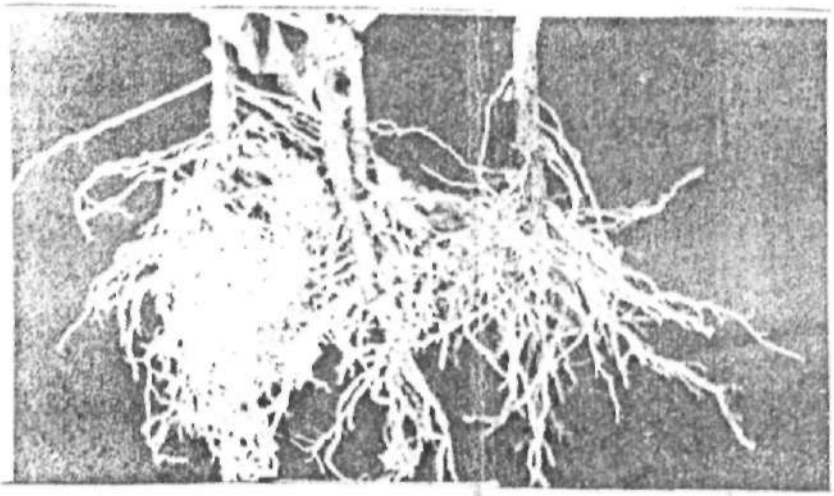


Fig. II: Solanum melongena var. Ilorin (SMI-1) showing gall free roots.

Table 3: The reaction of Solanum Cultivars to root-knot nematode Meloidogyne incognita

Plant Variety	Root-knot index	Fresh weight of ten roots in(Kg)			Dry weight of ten roots (Kg)		
		Infected	Control	% increase	Infected	Control	Percent increase
SMG-1	3	1.25	0.99	26.26	0.20	0.16	25.00
SMG-2	3	1.20	0.93	29.03	0.19	0.15	26.67
SMZ-1	5	2.15	0.98	119.39	0.22	0.15	46.67
SMB-1	1	0.99	0.96	03.13	0.19	0.17	11.76
SMB-2	1	1.02	0.98	04.08	0.21	0.19	10.53
SMI-1	0	0.97	0.95	02.11	0.19	0.18	05.26
SMI-2	2	1.16	0.92	26.09	0.18	0.16	12.50
SMBM	4	2.01	0.96	109.38	0.21	0.15	40.00
SMA	1	0.97	0.93	04.30	0.19	0.18	05.26
SMO	1	0.92	0.89	03.37	0.21	0.20	05.00

Table 4: The effect of root-knot nematode, Meloidogyne incognita on the yield of Solanum melongena varieties.

Plant Varieties	Root-knot index	Average number of fruits harvested		Average weight of ten fruits (Kg)		Percentage Loss(Weight)
		Infected	Control	Infected	Control	
SMG-1	3	20	27	0.31	0.39	20.51
SMG-2	3	18	24	0.29	0.38	23.68
SMZ-1	5	37	53	0.23	0.47	51.06
SMB-1	1	40	42	0.25	0.28	10.71
SMB-2	1	28	29	0.22	0.25	12.00
SMI-1	0	41	40	0.36	0.36	0. 0
SMI-2	2	11	15	0.21	0.26	19.23
SMBM	4	32	43	0.29	0.45	35.56
[illegible]A	1	12	10	0.31	0.36	13.89
SMO	1	14	16	0.36	0.41	12.20

Figure 1: Percentage Loss of Solanum melongena yield of the ten varieties studied.

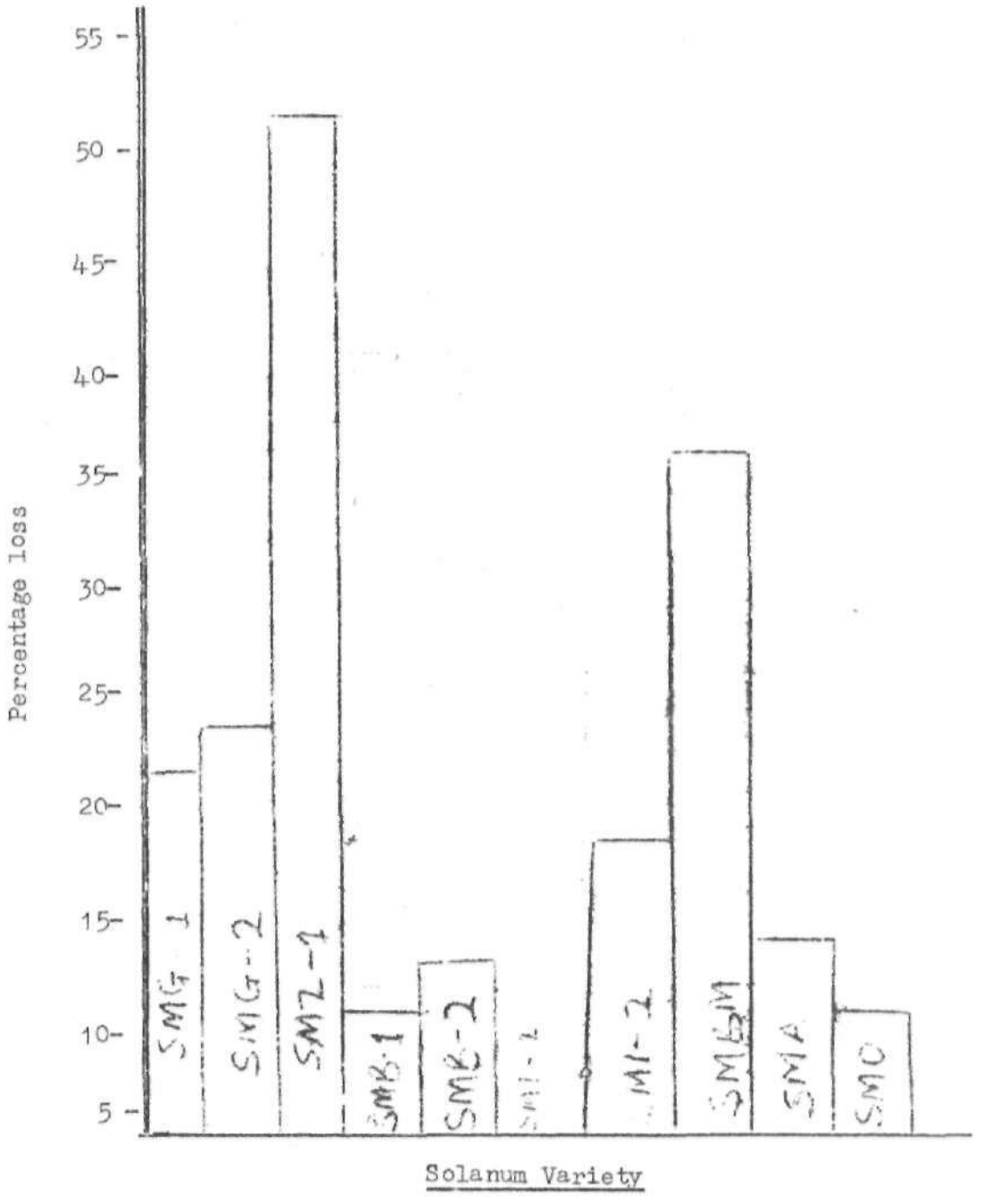


Table 5: The effect of root-knot nematode Meloidogyne incognita on the vegetative growth of Solanum melongena at six weeks after transplanting.

Plant Variety	Root-knot index	Average height of Plant in (cms)			Average length of leaves.		
		Infected	Control	% Loss	Infected	Control	% Loss
SMG-1	3	9.5	9.9	4.04	8.8	9.9	11.11
SMG-2	3	9.8	10.1	2.97	8.8	9.8	10.20
SMZ-1	5	9.1	11.2	18.75	8.3	9.6	13.54
SMB-1	1	10.0	10.2	1.96	8.7	9.0	3.33
SMB-2	1	9.9	10.1	1.98	8.8	9.0	2.22
SMI-1	0	10.3	10.4	0.96	9.0	9.1	1.09
SMI-2	2	9.7	9.9	2.02	8.9	9.8	9.18
SMBM	4	9.1	10.4	12.50	8.5	9.7	12.37
SMA	1	9.8	10.0	2.00	8.6	8.9	3.37
SMO	1	9.8	9.9	1.01	8.4	8.7	3.44

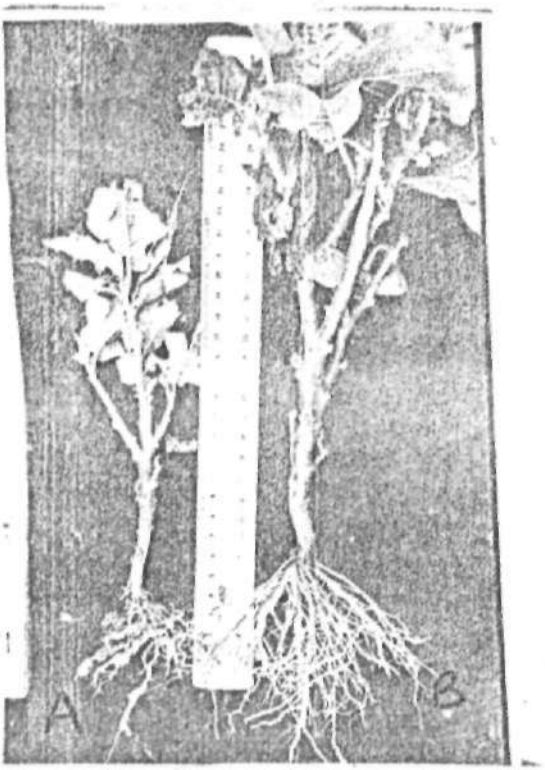


Fig. I: STUNTED GROWTH due to heavy root infestation in A.

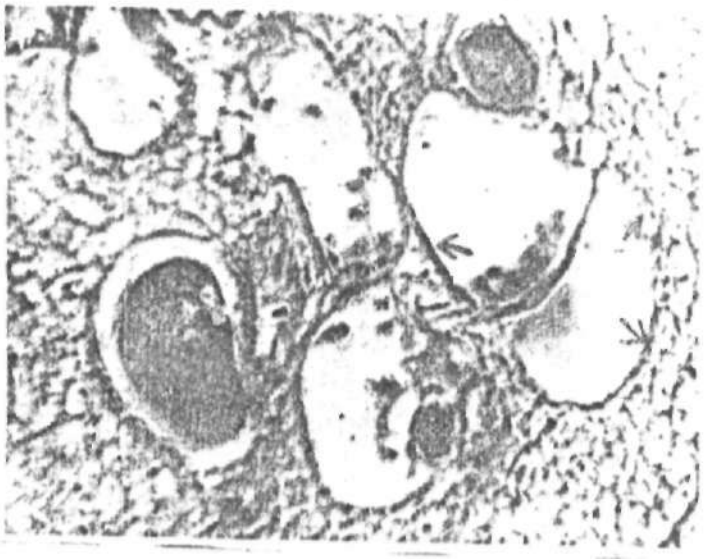


Fig. II: Giant cell formation in infected Solanum melongena roots.

magnification x 40

PLATE IV

The root-knot nematode, Meloidogyne incognita also affected the begetative growth of the Plants. The susceptible variety showed stunted growth, yellow Patches on the leaves and general dryness (Plate III Fig. 1)

The most susceptible variety of eggplant, Var. Zaria-1 (SMZ-1) showed some difference between the plant height and the leaf size as compared to Solanum melongena variety Ilorin (SMI-1) which was immune. (Table 5).

4.3 ANATOMICAL CHANGES IN ROOT SYSTEM DURING GALL FORMATION

Histological slides prepared from the infected roots showed that the galls were formed by hypertrophied cortical cells surrounding the nematode. The presence of the nematodes induced the giant cell formation mostly in the cortical region (Plate IV, Fig. 1). The giant cells were multinucleated having dense cytoplasm and highly invaginated cell walls. It has been observed that cell wall break down occured at the initial stages of gall formation and at the later stages of development (Plate IV, Fig. 2).

Most of the damaged tissues in the cortical regions showed fragmentation in cell walls (Plate IV). In some cases, branching of the cell walls were observed resulting into continuous plasmalemma. Some giant cells contained upto eight nuclei. (Plate V, Figure 2).

PLATE IV



Fig. I: Giant cells in cortical region of infected Solanum melongena roots.

magnification x 40

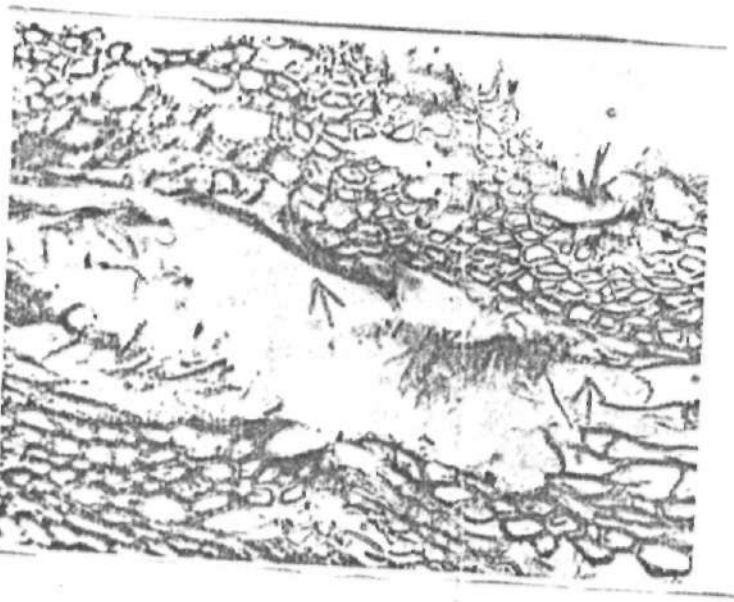


Fig. II: Cell wall break-down in cortical region of Solanum melongena roots.

magnification x 40

4.3.1 DAMAGE IN TISSUES IN INFECTED ROOTS

The root caps and the epidermal tissues are mostly destroyed at the entry points by nematode larvae. The cortical cells were found to seperate along the middle lamella resulting in cell rupture. Most of the cells became compressed. The juveniles were found at the cortical region resulting in more damages done on the cells.

In some parts of the vascular tissues, few nematode larvae were found. primary Phloem and mostly the phleem parenchyma were mainly damaged due to giant cell formation alongside to the phloem (Plate V).

The stelar Parenchyma cells and Pericycle cells showed division of nuclei without cell division.

4.4 EFFICIENCY OF NEMATICIDES FOR THE CONTROL OF ROOT-KNOT NEMATODES

The trials carried out to test the efficiency of four different nematicides, Basamid, DD, Mocap, Oxamyl revealed a general reduction in galling. Three different doses were tried, half the recommended dose, standard dose, while the trial was carried on the most susceptible variety SMZ-1.

PLATE V

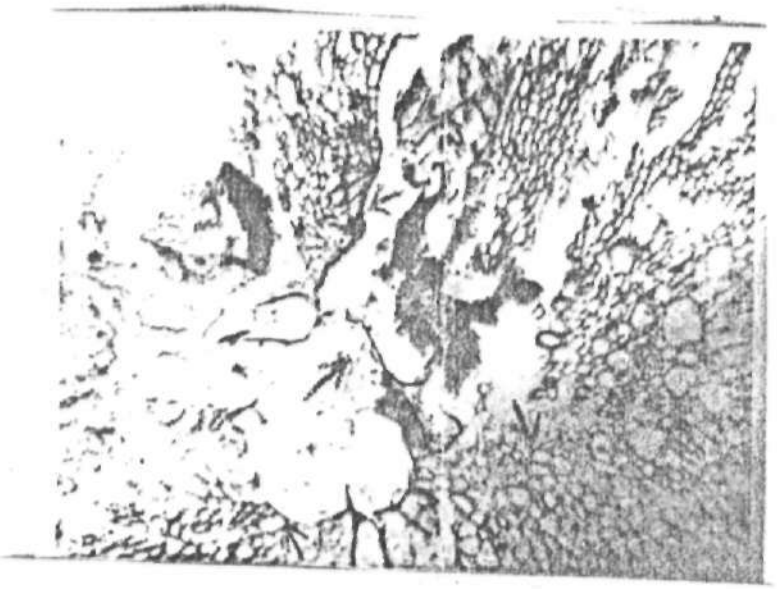


Fig. I: Primary phloem and phloem parenchyma cells damaged in infected Solanum melongena roots.

magnification x 40

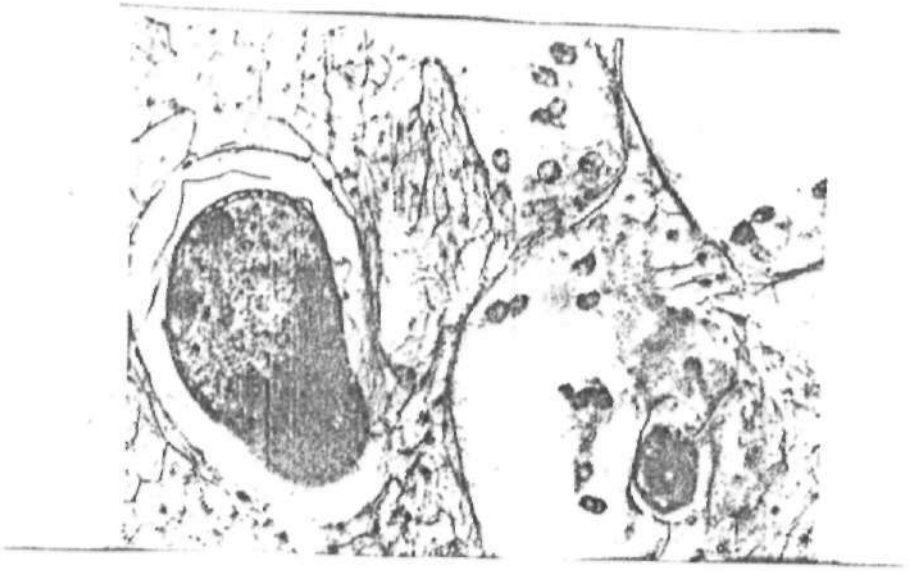
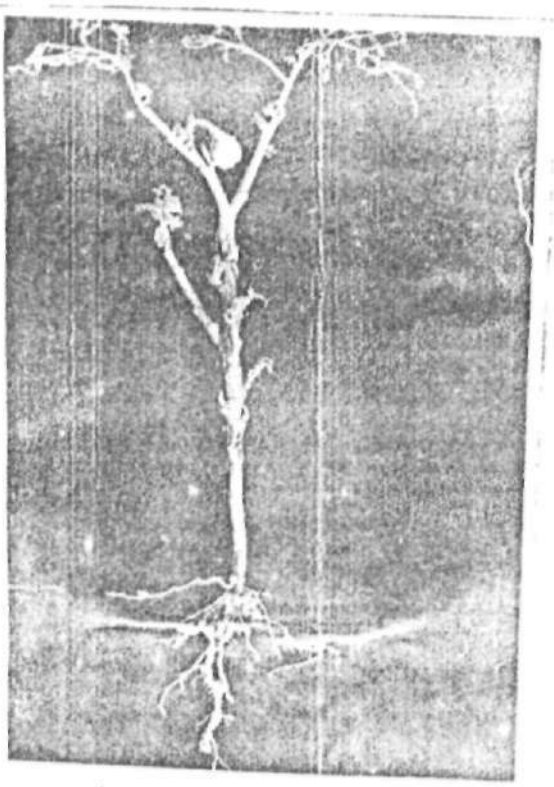


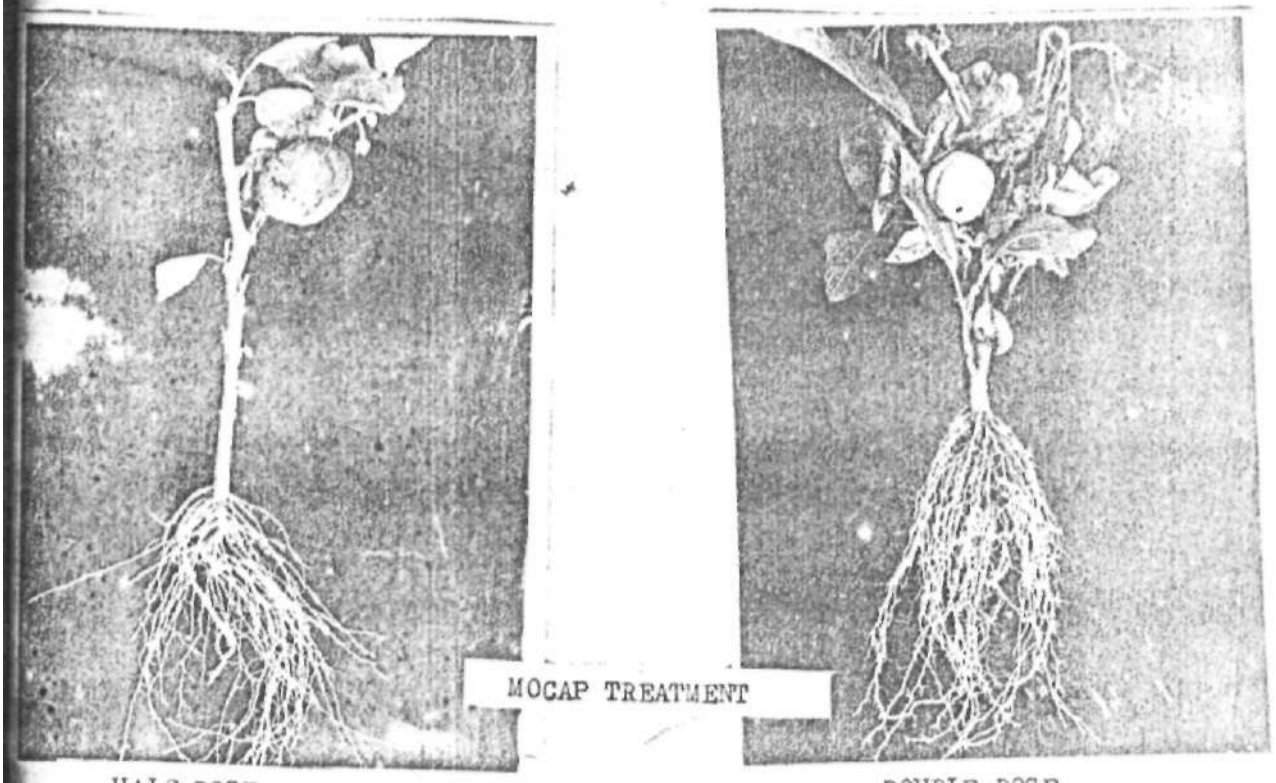
Fig. II: Formation of multinuclei within a giant cell in infected roots of Solanum melongena.

magnification x 40

PLATE VI



INFECTED PLANT WITH POOR YIELD

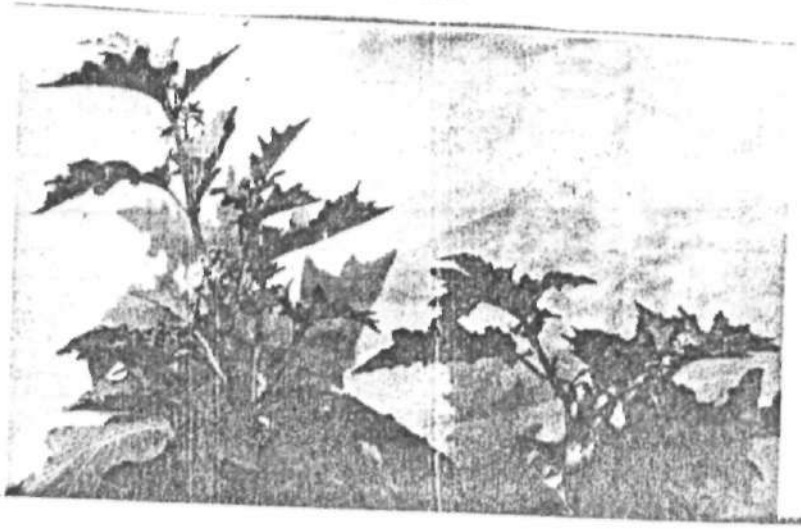


MOCAP TREATMENT

HALF DOSE

DOUBLE DOSE

Plate VII



Half dose — Effect of Mocap on plant height — Double dose

Fig. 1: vegetative growth reduces with increase in dosage.



Half dose — Standard dose

Fig. 2: Oxamyl treatment, increase in both vegetative growth and fruit size at Standard dose.

FIG 2

EFFECT OF NEMATICIDE ON ROOT-KNOT INDEX OF EGGPLANT SOLANUM MELONGENA VAR. SMZ-1

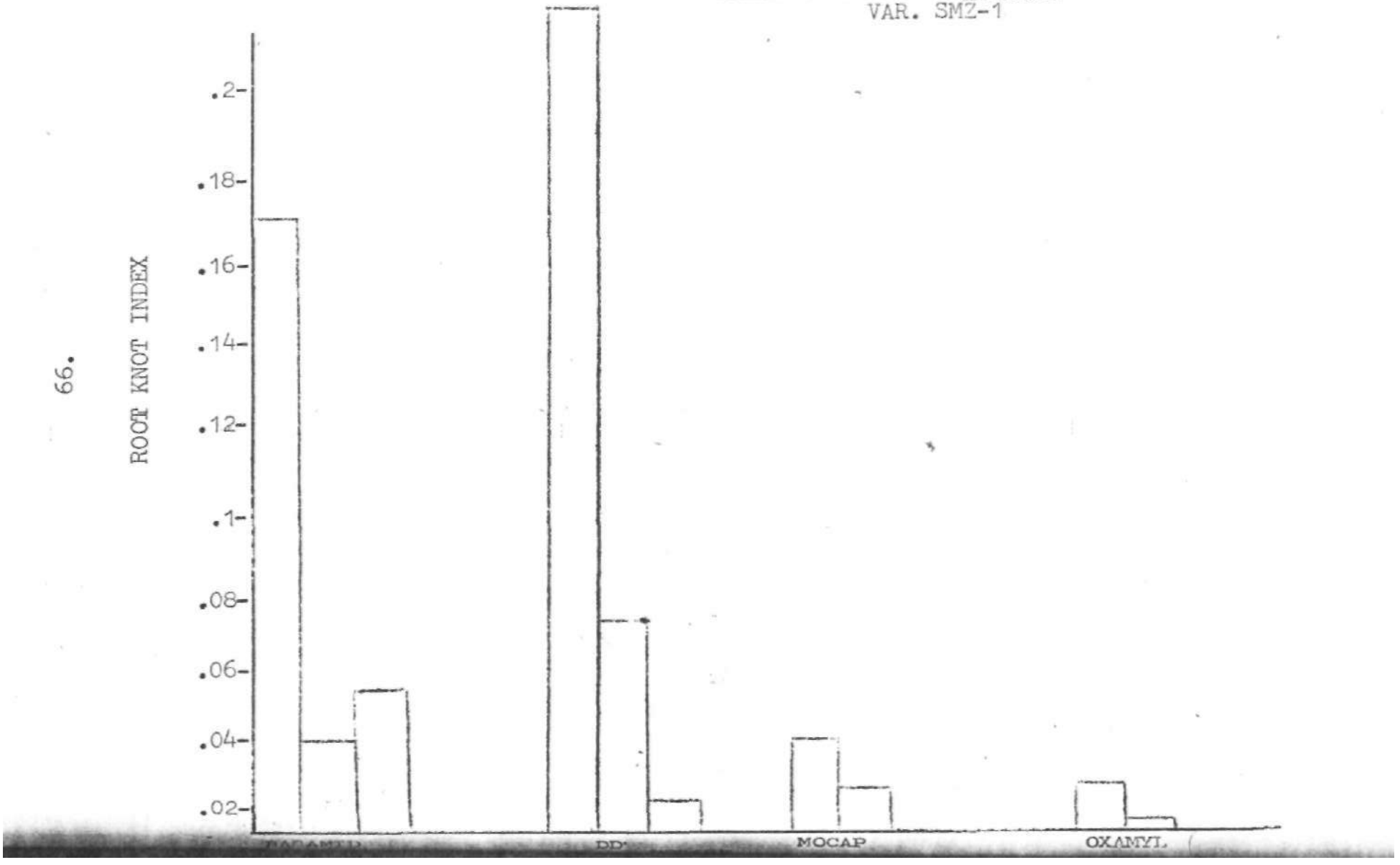
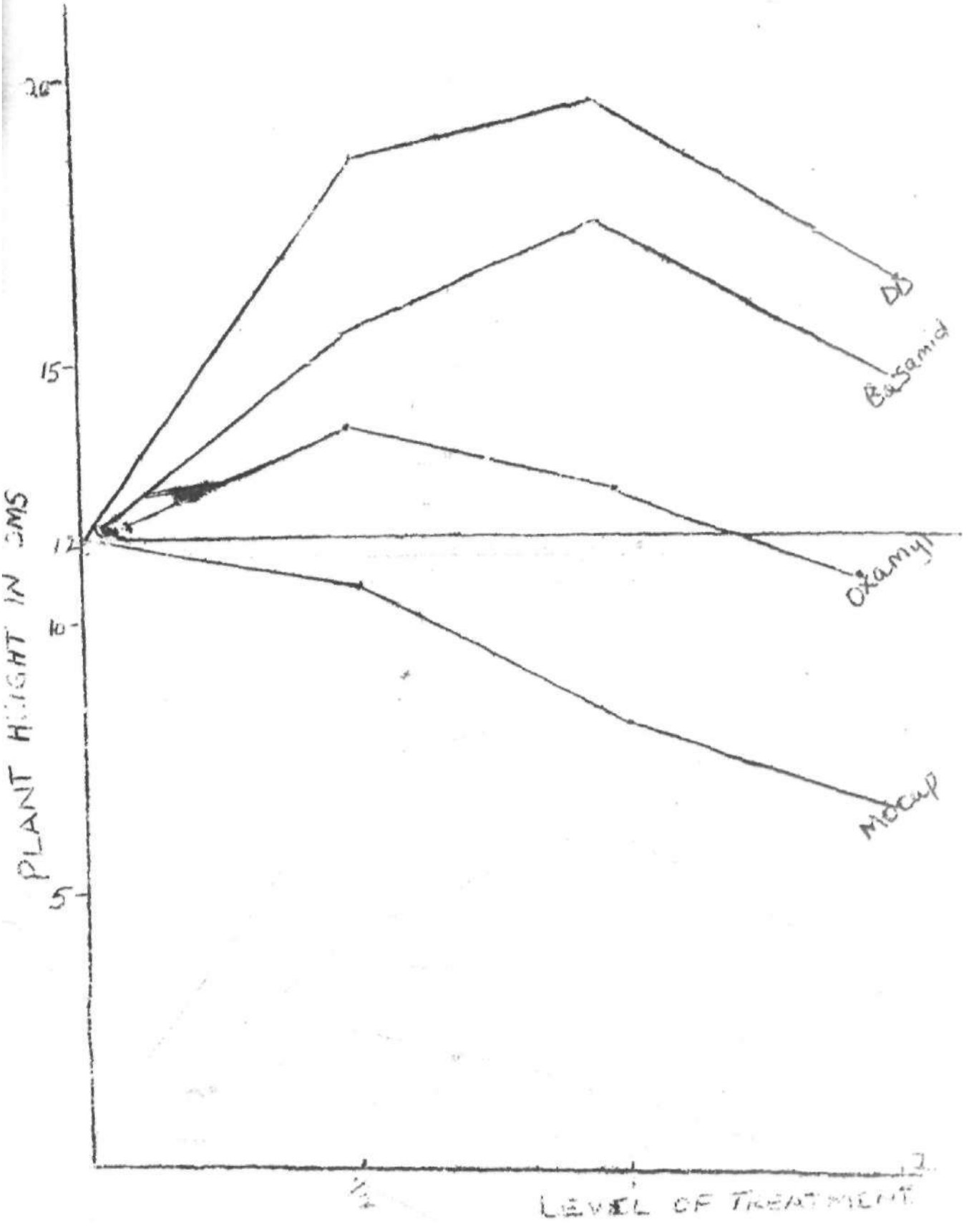


Table 6: EFFECT OF NEMATICIDE ON THE DEVELOPMENT OF ROOT-KNOT NEMATODE MELOIDOGYNE INCOGNITA, SIX WEEKS AFTER TRANSPLANTING

Nematicidal treatment	Dosage	rate of application (K_G)/Pot	Average root-knot index	Average plant height (Cms).
Basamid	Half	0.02	0.17	16.6
	Standard	0.04	0.04	17.7
	double	0.08	0.05	16.3
DD	Half	0.015	0.28	18.8
	Standard	0.030	0.07	19.1
	Double	0.060	0.02	17.8
M Mocap	Half	.005	0.04	11.2
	Standard	.010	0.03	9.1
	Double	.020	0.00	7.8
Oxamyl	Half	.025	0.03	14.6
	Standard	.050	0.01	13.0
	Double	.110	0.00	11.5
Control		.00	1.21	12.4

Fig 4 PLANT HEIGHT PER TREATMENT AT FIVE WEEKS AFTER TRANSPLANTING



4.4.1 EFFECT OF NEMATICIDES ON DEVELOPMENT OF NEMATODE

The development of root-knot nematode in all treatments was reduced to a considerable extent. The root-knot index varied between 0 - 0.28 in different treatments against 1.21 in control plants. Of all the treatments Oxamyl was found to be most effective nematicide followed by Mocap and DD. It has been observed that the recommended dose of each nematicide gave effective control of nematodes in terms of root-knot index. However, there was very little difference in root-knot index between the half dose and the normal recommended dose in Mocap and Oxamyl. (Table 6).

4.4.2 EFFECT OF NEMATICIDES ON PLANT HEIGHT

The application of various nematicides during pot experiments on plant height after five weeks of transplanting showed that Mocap, gradually declined the plant heights from the low level to high levels. The maximum height under half dose was recorded as 11.2cms and the minimum 7.8cms at the double dose (Table 6) (Plate, VI, Figure 3).

In the case of Oxamyl, the plant growth in response to various treatments is slightly taller than the control treatments. The seedlings attained a maximum height of 14.6cm at 0.027kg (half dose) level of treatment and 11.5cm at 0.11kg (double dose) level of treatment, (Plate VII, Figure 2).

There was a general increase in the height of all plants treated with half dose and single dose of Oxamyl over those of control pots (Figure 3).

Basamid and DD treated Pots produced plants significantly taller than those of the control pots. (Figure 3).

4.4.3 EFFECT OF NEMATICIDE ON FRUIT YIELD

With the exception of Mocap at half dose which gave 4.3%, a small increase in yield, all other treatments resulted into a significant increase in yield at all levels of treatments, which ranged from 39.1 percent to 47.8 percent in Basamid, 43.5 percent to 69.5 percent in DD, 4.3 percent to 17.3 percent in Mocap and 28.3 percent to 30.4 percent in Oxamyl. The higher level of Basamid, Mocap and Oxamyl reduced the root galling in the treated plants but did not increase the yield (Plate VI).

DD treatment resulted in both reduction in root galling and increase in fruit yield at high levels of treatment (Plate VII, Figure 1). DD also gave better result in terms of vegetative growth and the fruiting quality of eggplant.

Mocap on the whole, produced much smaller fruits than the other chemicals.

Plate VIII



Half dose Double dose

Fig. 1: DD treatment, increase in yield at higher level of treatment.

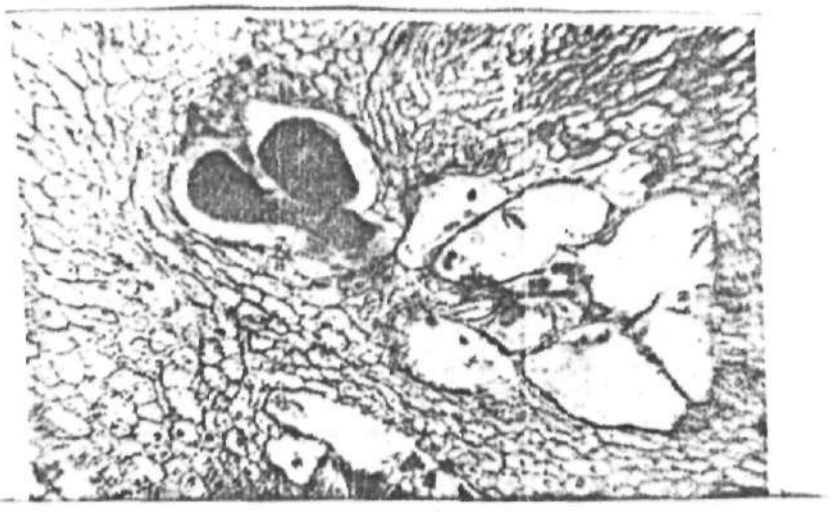


Fig. 2: Thick and thin portions on giant cells of infected roots of Solanum melongena.

magnification x 40

Table 7: EFFECT OF NEMATICIDAL TREATMENTS ON FRUIT YIELD OF EGGPLANT

Nematicidal treatment	Dosage	Rate of application (Kg) Per pot	Average weight of 10 fruits (Kg). AT 12 weeks.	Percentage increase of yield over control
Basamid	Half	0.02	0.64	39.1
	Recommended	0.04	0.65	41.3
	Double	0.08	0.68	47.8
DD	Half	.015	0.66	43.5
	Recommended	.030	0.71	54.3
	Double	.060	0.78	69.5
Mocap	Half	.005	0.48	4.3
	Recommended	.010	0.56	21.7
	Double	.020	0.54	11.3
Oxamyl	Half	.00275	0.59	28.3
	Recommended	.0055	0.66	43.5
	Double	.0110	0.60	30.4
Control		00	0.46	00

CHAPTER FIVE

5. DISCUSSIONS

5.1 Survey

A Preliminary survey in some parts of Kaduna State showed that root-knot nematode, Meloidogyne incognita infestation was commonly found in most vegetable crops. The minimum root-knot index was rated 3.0 which shows that most of the soils surveyed were heavily infested by nematode larva. The nematode species, Meloidogyne incognita was identified from all the samples collected, except for the one collected from Okra, Hibiscus esculentum at Birnin Gwari which was identified as M. javanica. Meloidogyne incognita is more dominant than the other species in most parts of the State. However, Wilson (1962) while working in the northern part of Nigeria found Meloidogyne javanica as the most dominant species representing 68.5 percent against Meloidogyne incognita ranked second with the incidence rate of 49.1 percent. Since the survey work during the present investigation was restricted to a very limited number of places, the possibility of other species in association with field crops cannot be ruled out. However, the presence of these nematodes is likely to lead a general crop yield loss in most of the vegetable growing areas resulting into the annual losses of hundreds of thousand Naira.

The possibility of further spread of Meloidogyne incognita in the agricultural lands cannot be under estimated in the North, because fof the cropping pattern and other environmenal factors for development of nematode. Susceptible crops such as tomato, beans and other vegetables are grown throughout the year, which

may enhance the chances of very high population build up. Other tropical crops such as yam, cassava and sugarcane require rather longer period to mature, thus providing even greater opportunity for Meloidogyne species to increase and spread in nearby areas. Moreover, in the absence of the normal crop, weeds often serve as an alternate suitable hosts for the development and spread of root-knot nematodes.

Another favourable factor for root-knot nematode development is the availability of susceptible varieties. Resistant varieties are not widely used or are not available, and rotations designed to reduce the nematode density are not economical. This may result into lower yield and poor quality of agricultural products.

Earlier Meloidogyne javanica was reported to be most prevalent species in the northern parts of Nigeria especially in the Savannah Zone and Meloidogyne incognita in the forest Zone (Caveness, 1975, Olowe, 1978). However, the situation seems to have been changed and M. incognita seems to become a dominant species in the Northern region especially Kaduna State.

A regular survey of root-knot nematode in vegetable growing area is likely to provide information about the changing pattern of distribution and would be helpful to form bases for forecasting population build up and effective pest control system.

5.2 SUSCEPTIBILITY TRIALS

It is quite evident that so far no work has been done on the the nematodes of eggplants in Nigeria.. Like any other vegetables, this crop is also susceptible to root-knot infestation.

In order to identify the resistant cultivars, ten varieties of Solanum melongena were tested against root-knot nematode Meloidogyne incognita in susceptibility trials out of which Solanum melongena var. Zaria - 1 (SMZ - 1) was found to be the most susceptible to the infection of nematode with root-knot index rated at 5.0. On the other hand, Solanum melongena variety Ilorin-1 (SMI-1) was found as the most resistant to this root-knot infestation. The harvested infected roots of SMZ-1 had an average weight of 2.15kg for 10 infected roots against its control 0.98kg also for 10 roots. This was due to the presence of adult nematodes in the root system and their eggs and the larva which added to the weight of the host plants. However, roots of the control plants had more feeder roots. In a similar experiment carried out on cowpea by Ogunfowara (1976), the heavily galled roots had more weight than the less galled ones. The highly resistant variety (SMI-1) had more or less similar average weight of 0.97kg for ten roots, for infected as against 0.95kg for the control.

The degree of galling on the roots also showed marked effects on the fruits. The maximum yield loss of 51.06 percent was recorded in SMZ-1 while the no significant loss was observed in variety SMI-1 because of absence of galls on the root system. The great yield loss from SMZ-1 can be attributed due to the heavy infestation of root-knot nematode resulting in a decrease in growth as well as yield. Sasser (1976) recorded 25 percent loss in yield in tomato, 23 percent in eggplants and 28 percent in cowpea due to the infestation of root-knot nematode.

Similarly, Bridge (1972) estimated yield loss up to 40% in tomatoes. The infected plants with root-knot nematode showed a general decline in growth as compared to the control plants. The most susceptible variety SMZ-1 gave an average plant height of 9.1cms at six weeks after transplanting in the infected plants, against 11.2cms for the control six weeks after transplanting. However, no difference was observed in the height of the highly resistant variety SMI-1. The inoculated SMI-1 plants measured 10.4cms, six weeks after transplanting. (Table 5).

5.3 ANATOMICAL CHANGES DURING GALL FORMATION

Gall formation on the root system is one of the most common symptoms of root-knot nematode infection. Galls are described as pathologically developed cells, tissues or organs of plants that have arisen mostly by hypertrophy (overgrowth) and hyperplasia (cell proliferation) under the influence of parasitic organisms like nematodes (Martin, 1958). It has been suggested that galls may result from the introduction of growth regulators from adjacent tissues (Balasubramanian, 1962).

Giant cells formed during the infestation of root-knot nematode vary anatomically with their developmental period. In tomato roots infected with Meloidogyne larva, after the period of 24 hours, nuclear divisions could be detected in parenchyma cells up to two cell layers from the head of the nematode (Jones, 1978).

Since the vascular parenchyma rarely undergoes mitosis under normal conditions, the nuclear divisions are presumably stimulated by the nematode.

These divisions are considered to be the first detectable signs of giant cell formation. Jones and Payne (1978) observed that at anaphase, vesicles lined up initially between the two daughter nuclei to form a new cell plate. Golgi bodies, endoplasmic reticulum (ER), mitochondria and small vacuoles are found accumulate around the partially formed cell plate. Contrary to normal mitoses, however, the vesicles aggregated along the presumptive cell plate are posteriorly dispersed; resulting in abortion of the new cell wall formation.

The binuclei of a young giant cell undergo rapid, synchronous divisions without subsequent cytokinesis. Thus giant cells with upto eight nuclei can be found within 48 hours of nematode infecti Such situation was observed in the most susceptable variety SMZ-1 (Plate III, Figure 2). Nuclei within a giant cell were highly variable both in size and in shape. The were generally irregularly lobed and amoeboid in form (Plate III), with tremendously increase surface area. Linkages between neighbouring nuclei by the lobes were also common. The variability in nuclear size and profile be attributable to the irregular fusions of neighbouring metaphase plates, uneven distribution of chromosome sets at anaphase and lack of spindle orientation and to the incomplete migration of anaphase chromosomes (Huang and Maggenti 1969). The cytoplasm of developing giant cells were reminiscent of active meristematic cel Golgi apparatus, mitochondria, ribosomes, polysomes and ER were abundant (Jones et al. 1975). As parenchyma cells were transform to a developing giant cells, the predominant central vacuole grad disappeared and small vacuoles prevailed in the cyto plasm (Jones Payne, 1978).

The walls of giant cells were apparently continuous and without gaps or perforations. There are, however, alternating thick and thin areas on the same wall (Plate III). Plasmodesmata were found only in thin portions of the wall (Huang and Maggeti, 1969). The thick portions of the wall were associated with secondary ingrowths jutting into the giant cell cytoplasm. The ingrowths varied in shape and in size ranging from simple rods to extensive funger-like branchings (Jones and Northcote, 1972). The ingrowths are most extensive on the giant cell walls adjacent to xylem elements and on walls between giant cells next to sieve elements (Huang and Maggeti, 1978).

5.4 EFFICIENCY OF THE NEMATICIDES FOR THE CONTROL OF ROOT-KNOT NEMATODE

For the control of nematodes, four nematicides namely, Basamid, DD, Mocap and Oxamyl were used at three different doses, half the recommended dose, standard dose and double the recommended dose.

5.4.1 BASAMID

Generally less galling and increase in plant height in the infected plants were recorded. Basamid reduced the root-knot index of SMZ-1 from 5 to a minimum of 0.08 at double dose, the plant height was recorded to range between 16.3cm at double dose to 17.7cms at standard dose. This showed that Basamid can effectively control root-knot infection.

Basamid is known to be broad spectrum chemical, effective against nematodes, soil fungi and weeds. Its effectiveness on root-knot has been specifically reported (Lush et al 1967).

The increase in yield per plant by Basamid was 39.1% at half recommended dose, 41.3% at standard dose and 47.8% at double dose. The chemical when applied to soils require a waiting period of 3-6 weeks, before planting. It may even take longer period during Wet season (Lush et al, 1967).

Basamid has been used by various workers for the control of nematodes. Shephard (1975) tested granular Basamid on tobacco seedlings and found it to be 98% efficient.

5.4.2 DD

DD a fumigant nematicide was found to be effective in the Control of root-knot nematodes. Plant heights attained a maximum height of 19.1cms at 0.03 /pot (recommended dose) and 17.8cms at 0.06 /pot (double dose). It reduced root galling to a minimum of 0.02 root-knot index. It also increased the yield by 43.5% at half dose, 54.3% at standard dose and 69.5% at the double dose. Hemeng (1977) also found DD as most effective nematicide in controlling Meloidogyne incognita on a susceptible tomato plant. Dandria et al. (1977) demonstrated DD when applied at the rate of 300 /ha for treatment of Meloidogyne incognita gave most effective results. Similarly, Ogunfowara (1979) while testing four different nematicides Nemagon 75, Basamid, Vapam and DD both in Nurseries and in the fields for the control of root-knot nematode on tomatoes, observed that DD gave the most effective control results This compound is, however, now allegedly being withdrawn from the market for health reasons. The application of DD to the soil also calls for great labour and a certain skill from the farmer.

5.4.3 MOCAP

Mocap, a non-fumigant organo-phosphorous compound was found to be rather phytotoxic to eggplant. A general decline in the plant height was noticed from 11.2cm at half dose, 9.1cm at recommended dose of 0.010kg/pot and 7.8cms at double dose of 0.020kg/pot. However, an increase in yield was recorded ranging between 4.3% to 21.7% (Table 7). A decrease in plant height was, however, noticed with increase in the amount of Mocap applied. At half dose (0.005kg/pot) an average of 11.2cms was recorded, while an average height of 9.1cms was recommended at the standard dose of 0.01kg/pot. At double dose of 0.020kg/pot, the average plant height was recorded as 7.8cms. The decrease in plant height is due to the phytotoxic effect of Mocap on the plants. This could be connected with the fact that our soils are acidic (PH 6.5) and the hydrolysis of Mocap is slow in such mediums thereby the plants pick up traces of Mocap.

Arganer and Feldmesser (1978) investigated the up-take of Mocap in ten different vegetables grown in treated soil for the control of nematodes. Soils were treated one week before planting with 3.4, 6.7 and 13.4kg/ha of Mocap 10% granules. At harvest, the traces of chemical were found at levels above -.01ppm in onion bulb, (0.12, 0.52, 1.34ppm), carrot (0.14, 0.34, 0.81ppm), radish (0.12, 0.33, 0.66ppm) and eggplant (0.027, 0.044, 0.086ppm). However, it was detected (i.e lower than 0.01ppm) in beetroot, cabbage head, pea and tomatoes. The results of these investigations indicated the systemic action of nematicide and its safe use on common crops like tomato, peas and cabbage.

Vasheislivili (1976) found that Mocap used at the rate of 75-100kg/ha showed low efficiency for the control of Meloidogyne incognita on tomato in Georgian USSR.

Later Mcleod (1977) tested several granular nematicides against Meloidogyne spp. On tomatoes, and observed that the best results were obtained with Mocap and Oxamyl.

Mocap is easy to apply by broadcasting and slight incorporation controlling root-knot or increasing fruit yield, when applied to soils with high population of Meloidogyne infestation.

5.4.4 OXAMYL

Oxamyl is also a systemic nematocide. It controlled root-knot nematode with root-knot index to a minimum of 0.59 at half dose, 0.66 at standard dose and 0.60 at double dose. The yield increase ranged from 28.3% at half dose to 43.5% at standard dose. There was also an increase in the plant heights which ranged from 11.5cms to 14.6cms. A slight decrease in plant height was noted as the rate of chemical increased. This explains the toxic effect of Oxamyl on the plants.

Oxamyl is easy to apply in normal farming situations. It can can be spread easily and evenly on the soil surface, be incorporated into the soil with simple hand tools and the crop can be planted immediately after its application.

From the foreging characteristics, of Oxamyl, this nematicide appears to be best in terms of effectiveness, phytotoxic risk, and easy application.

CHAPTER SIX

6. SUMMARY AND CONCLUSION

6.1 SURVEY

The preliminary survey of some parts of Kaduna State showed that root-knot nematode, Meloidogyne incognita was the most common nematode species found on almost all the vegetable crops sm sampled. This is likely to explain the great yield loss in most vegetable growing areas resulting into annual losses of hundreds of thousand Naira. There is a great danger of further spread of Meloidogyne incognita in our soil because susceptible varieties such as tomatoes, beans, Okra etc. are grown throughout the year and this may enhance high population build up. Weeds are also found to harbour these nematodes when susceptible crops are not available and also tropical crops such as Yam, Cassava, Sugarcane etc. require longer period to mature thereby giving Meloidogyne spp more opportunity to mature and build up.

6.2 SUSCEPTIBILITY TRIAL

Ten different cultivars of Solanum melongena were tested against root-knot nematode, Solanum melongena var. Zaria (SMZ-1) was found to be the most susceptible variety with root-knot index rated at 5.0, while Solanum melongena var. Ilorin (SMI-1) was found most resistant to this root-knot infestation with root-knot index rated at 0.

The degree of galling on the roots showed marked effects on the fruits. The maximum yield loss of 51.1 percent was recorded in SMZ-1 while no significant loss was observed in variety SMI-1.

Plants of the susceptible variety SMZ-1 gave an average plant height of 9.1cms at six weeks after transplanting as compared to SMI-1 which measured 10.2cms six weeks after transplanting.

6.3 ANATOMICAL CHANGES

Sections made from infected roots showed great damage done to the cells. The cortical cells suffered great damages such as cell wall breakdown, giant cell formation and also formation of eight nuclei in a single giant cell. Linkages between neighbouring cells were also common. Ingrowths from the secondary walls of the cortical cells extented adjacent to the Xylem elements thereby distrupting the easy flow of nutrients in the xylem cells.

6.4. EFFICIENCY OF THE NEMATICIDES FOR THE CONTROL OF ROOT-KNOT NEMATODE.

Four Nematicides namely, Basamid, DD, Mocap, and Oxamyl were used at three different doses, half the recommended dose, standard dose and double the recommended dose.

6.4.1 BASAMID

Basamid reduced the root-knot index of SMZ-1 from 5 to a minimum of 0.08 at double dose. The plant height was recorded to range between 16.3cms at double dose to 17.7cm at standard dose. The increase in yield per plant by Basamid was 39.1% at half recommended dose, 41.3% at standard dose and 47.8% at double dose. However, Basamid requires a waiting period of 3-6 weeks before planting on treated soils.

6.4.2 DD

DD was found to be the best nematicide out of the four nematicid tested during present investigation. Plant heights attained a :

maximum height of 19.1cms at 0.03kg/pot (recommended dose) and 17.8cms at 0.06 g/pot (double dose). It reduced root galling to a minimum of 0.02 root-knot index. It also increased the yield by 43.5% at half dose, 54.3% at standard dose and 69.5% at the double dose.

This chemical is however being withdrawn from the market for health reasons. The application of DD to the soil also calls for great labour and a certain skill from the farmer.

6.4.3 MOCAP

Mocap was found to be phytotoxic to eggplant. A general decline in the plant height was noticed from 11.2cms at half dose, 9.1cms at recommended dose of 0.010kg/pot and 7.8cms at double dose of 0.020kg/pot. The decrease in plant height is due to the phytotoxic effect of Mocap on the plants.

Mocap is easy to apply by broadcasting and slight incorporation controlling root-knot or increasing fruit yield, when applied to soils with high population of Meloidogyne infestation.

6.4.4 OXAMYL

Oxamyl controlled root-knot nematode with root-knot index of 5 to a minimum of 0.59 at half dose, 0.66 at standard dose and 0.60 at double dose. The yield increase ranged from 28.3% at half dose to 43.5% at standard dose. An increase in plant height was noted which ranged between 11.5cms to 14.6cms.

Oxamyl is easy to apply in normal farming situations, it spreads easily, and crops can be planted almost immediately after its application. On the whole, Oxamyl appears to be the best in terms of effectiveness, phytotoxic risk, and easy application.

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