PATHOGENICITY AND CONTROL OF RENIFORM NEMATODE (*Rotylenchulus reniformis*) ON FRENCH BEAN

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Rama Prasad Misra

DEPARTMENT OF NEMATOLOGY
COLLEGE OF AGRICULTURE
ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR-751 003

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THESIS ADVISOR : DR. N. N. PADHI

DEDICATED
TO
MY PARENTS

Dr. N. R. Padhi,
Reader in Nematology,
College of Agriculture,
Orissa University of
Agriculture and Technology,
Bhubaneswar.

CERTIFICATE

Certified that the thesis entitled " Pathogenicity and control of sunflora nematode (Helicotylenchus sunflorae) on French bean" submitted to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of requirements for the award of the degree of Master of Science in Agriculture (Nematology) is a faithful record of bonafide research work carried out by Sri Ram Prasad Misra, under my guidance and supervision and no part of the thesis has been submitted for any other degree or diploma.

11.5.84

Bhubaneswar (N.R. Padhi)

A C K N O W L E D G E M E N T S

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Date 11.5.84
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Rama Prasad Mishra.
(Rama Prasad Misra)

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CHAPTER I

INTRODUCTION

I N T R O D U C T I O N

French bean (Phaseolus vulgaris L.) is one of the most important vegetables rich in protein. It is otherwise known as haricot bean or kidney bean. It is a native of South America and was introduced into India in the 19th century by the Europeans which is now very much liked by the Indians throughout the country. The vegetable is grown widely in tropical as well as temperate climates. The plant is an annual belonging to family Leguminosae. Its succulent pods are used as green vegetables and seeds of ripened pods are used as pulses. French bean contains water 11.6%, protein 21.3%, fat 1.6%, carbohydrates 61.6%, fibre 4.0%, vit-A 670 I.U., vit-B 1.08, Nicotinic acid 2.1 vit-C 2mg, vit-E 4, Potassium 1310mg, Magnesium 132mg, Manganese 20mg, Iron 9.1mg, Phosphorus 429mg and chlorine 29mg per 100g edible fresh pods (Chatfield, 1949 and 1954). Dried seeds are also highly nutritious containing about 25% protein, 50% starch, 2% fat and 3% minerals (Chauhan, 1981).

French bean is known to be attacked by a number of plant parasitic nematodes, in addition to insects and diseases. Of the various plant parasitic nematodes, the semiendoparasite, Rotylenchulus reniformis Linford and Oliveira, 1940 is an important pest of French bean, observed in large numbers in the Central farm of O.U.A.T., Bhubaneswar Owing to its wide occurrence, the present investigation was undertaken to establish pathogenicity of the reniform nematode on French bean in pot culture experiment. An

attempt has also been made to find out a suitable control measure against the reniform nematode infecting French bean. Some of the granular nematicides and organic amendments have been tested in the present investigation under pot culture condition to study their efficacy in controlling *R. reniformis*.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Linford and Oliveira (1940) described the reniform nematode, Rotylenchulus reniformis from roots of cowpea in the Hawaiian island. Subsequently, workers from different parts of the world studied its pathogenicity on different crops and also conducted studies to evolve suitable control measures.

1. PATHOGENICITY :

Linford and Yap (1940) reported Rotylenchulus reniformis as a predominant species attacking pineapple plants in Hawaii. In a study by Okabe and Apt (1961) when pineapple crowns grown in fumigated soil were inoculated with 0,50,500,5000 or 50,000 reniform nematodes per plant, even after 6 months differences were not observed in numbers of nematodes among the four levels of inoculum on root systems, whereas largest number of nematodes was obtained from the soil inoculated with the highest inoculum level (50,000/plant). The largest nematode population produced the smallest measurements of length, width and dry weight of leaf. Fibrous roots were maximum in control plants, but minimum in plants nematised with the largest number of eelworms.

In case of cotton, Jones et al. (1959) reported that injury due to reniform nematode was conspicuously observed in all the varieties tested. The nematode reduced yield, size of bolls and delayed maturity. But it had no effect on length, strength and fineness of fibre. The

nematode also increased vitality in susceptible varieties, while resistant varieties were not affected. In another study, R. reniformis also proved pathogenic on cotton causing stunting, delayed maturity and reduced yield (Hinton et al. 1960). Birchfield and Jones (1961) observed symptoms of drooping and premature decay of the root system in cotton due to infection by reniform nematode. Rooting of cotton seedlings by R. reniformis was noted by Birchfield (1962) in glass house experiments. It was again reported that Gossypium hirsutum was attacked by R. reniformis resulting in paucity of the roots and stunting of cotton plants (Birchfield, 1962b). Lyda and Reano (1963) mentioned R. reniformis to be the cause of poor growth of cotton in South Texas. Ali et al. (1972) reported reniform nematode as the most important pest of cotton because of its heavy infestation throughout the entire growing season. Nematode population was greatest on plots exhibiting poor growth of plants which caused considerable damage to root and lint yield per acre, according to Vachhrajani and Dixon (1970) R. reniformis also caused significant reductions in fresh shoot weight of cotton at inoculum levels of 5000 and 10,000 nema/150ml soil. However, differences were not detected in dry weight of shoot, but a significant reduction in dry weight of root was observed at the 10,000 inoculum level.

Mehndi and Sivakumar (1969) reported effects of stunting, discoloration and shedding of leaves in cotton plants when population density of nematode in the soil around rhizosphere of each plants was 11,000 per 500ml of soil. Chandrasekharan (1964) studied the pathogenicity of R. reniformis

on Ricinus communis and Glycine max and observed that an increased population of the nematode had a positive correlation with reduction in plant height in both cases. Pathogenic effect of the sudden nematode on castor, sweet potato, papaya and beans related in severe stunting, reduced root system with brown lesions, ultimate decay and reduced number of leaves with pale unhealthy condition of plants (Khan and Prasad, 1967). In this study castor was observed to be the most susceptible host among the plants tested. The nematode reduced roots, shoots, branches, number of leaves, height and girth. The yield of fruits from affected plants was significantly less than healthy ones. An initial inoculum of 100 nema/pot of size (30cm x 20cm) containing 2kg of soil was found to be the minimum pathogenic density which reduced yield. But the rate of nematode multiplication was the highest at initial inoculum of 10 nema/pot. Sivakumar and Bahadur (1971) in an experiment inoculated castor plants with 3 different levels 200, 2000 and 20,000 nematodes per plant keeping a control without nematodes. The nematode was pathogenic to castor at inoculum level of 200 or more nema/pot causing reduced growth, shedding of leaves, early flowering and discolouration and malformation of seeds. It affected plants which produced seeds of poor quality containing lower percentage of oil. The growth and yield of castor was correlated with the initial population level. Water absorption capacity in roots of castor infected with R. reniformis was inhibited due to poor development of roots (Ismail and Alam, 1972). The

inhibition increased with rise in inoculum density of the nematode. Israil and Saxena (1980) reported that R. reniformis at inoculum level of 1000 larvae and young females/kg soil, significantly reduced dry weights of root and shoot in castor plants.

R. reniformis has been reported as an important pathogen of pigeon pea resulting in reduction of both stem and root systems. Stunted females were attached to bacterial nodules (Ayala, 1963). Symptoms of decline were also noticed in pigeon pea infected with the nematode (Nisten and Hamaston, 1975). Panda and Khuntia (1979) tested different inoculum levels of R. reniformis like 10,100, 1000 and 10,000 vermiform nema/kg of soil to find out the pathogenic level against cowpea, mungbean and urid. Although none of the growth characters were significantly reduced with an inoculum level of 100 nematodes, only the inoculum level of 1000 nematodes adversely affected all the growth characters to a noticeable extent in mungbean and urid. In a study by Gupta and Yadav (1978) significant reductions were observed in shoot height and root weight of black gram plants in all treatments receiving initial inoculum of 1000 and more tomfera nematodes per 500g of soil. A negative correlation existed between initial inoculum density and plant growth compared to control. Nematode infestation resulted in reduced nodulation. Reproduction was maximum in inoculum level of 10; but minimum in the level of 10,000/pot. The minimum population density of 1000 nema/500g soil produced pathogenic effect on blackgram. Mishra and Gour (1981 a)

inhibition increased with rise in inoculum density of the nematode. Ismail and Saxena (1980) reported that R. reniformis at inoculum level of 1000 larvae and young females/2kg soil, significantly reduced dry weights of root and shoot in castor plants.

R. reniformis has been reported as an important pathogen of pigeon pea resulting in reduction of both stem and root systems. Natural females were attached to bacterial nodules (Vyas, 1982). Symptoms of decline were also noticed in pigeon pea infected with the nematode (Hutton and Thomston, 1975). Panda and Mohanti (1979) tested different inoculum levels of R. reniformis viz 10,100, 1000 and 10,000 vermiform nema/kg of soil to find out the pathogenic level against cowpea, mungbean and urid. Although none of the growth characters were significantly reduced with an inoculum level of 100 nematodes, only the inoculum level of 1000 nematodes adversely affected all the growth characters to a noticeable extent in mungbean and urid. In a study by Gupta and Yadav (1978) significant reductions were observed in shoot height and root weight of black gram plants in all treatments receiving initial inoculum of 1000 and more vermiform nematodes per 500g of soil. A negative correlation existed between initial inoculum density and plant growth compared to control. Nematode infestation resulted in reduced nodulation. Reproduction was maximum in inoculum level of 100 but minimum in the level of 10,000/pot. The minimum population density of 1000 nema/500g soil produced pathogenic effect on blackgram. Mishra and Gaur (1981 a)

found that in blackgram growth characters namely shoot and root lengths, fresh weights, number of leaves and pods also number of nodules were inversely correlated with the inoculum level of *R. indicus*. The nematode reduced shoot growth significantly at the level of 1000 nems per pot/1000ml soil. The effect was more pronounced on fresh shoot weight than on shoot length. Pod formation was sufficiently reduced even at the lowest level of 10 larvae/ pot and no pod was found at the highest inoculum level (10,000). In another study Mohan and Gaur (1981 b) observed that growth of cowpea (*Vigna unguiculata*) was negatively correlated with the inoculum level of *R. indicus*. Fresh weight of shoot and number of leaves were significantly reduced and the nematode also reproduced well at population density of 100. The rate of multiplication decreased drastically with increase in the level of inoculation. Pathogenic effect of the nematode was noticed at an initial level below one infective individual per g of soil.

In case of cowpea, Reyupto and Seshadri (1978) found that an inoculum consisting of 20 sterile nematodes inoculated to 7 day old seedlings caused significant damage while the rate of reproduction was highest at inoculum level of 1000 nems/ g of soil. *R. indicus* was proved to be a significant pathogen of cowpea as root weights reduced drastically when plants were inoculated with 2000, 7500 or 10,000 nems/ plant (Villanueva and Castillo, 1976). In this study the yield of dried seeds also became significantly less at population densities of 7500 and 10,000 nems while the

rate of nematode multiplication was greatest at population density of 1500 nematodes and least at 10,000. An inoculum level of 100 nematodes per litre of soil had significant pathogenic effect on cowpea (Ponde and Mahadri, 1979). In a pot experiment when larvae of H. cajani were poured around excised roots of cowpea in logarithmic series of 10,100, 1000 and 10,000/ 500 g soil significant reductions in plant height, fresh shoot and root weights were recorded with an inoculum of 1000 which was considered as the minimum pathogenic level (Gupta and Yadav, 1980). This effect increased with increasing inoculum level. The highest rate of nematode reproduction occurred in pots inoculated with 100 nematodes which coincided with the maximum number of egg mass whereas the lowest rate of reproduction took place at the highest inoculum level of 10,000.

According to Nobels and Johnson (1973) yield of dry seeds in soybean cultivars inoculated with an inoculum level of 10,000 nematodes / 3.8L soil increased in resistant varieties and decreased in susceptible cultivars, where as, a high initial population of 25000 consistently reduced yields in resistant as well as susceptible cultivars on an average by 33.3%. In the pathogenicity trial of H. cajanus on soybean cv. Jupiter there were significant reductions in the mean weight of roots and tops and plant height at 8 weeks after 3 day old seedlings were planted in soil with 304 larvae/300g soil (Singh, 1975 a). Again, when 10 day old seedlings were inoculated with 500 or 1000 larvae / pot containing 2 seedlings in sterilized soil, reductions in

root and top weights and in plant height were recorded after 10 weeks and infected plants had also leaves than those noninfected.

Okhla plants inoculated with 10,000 uniform nematode or not 20 days after sowing showed a 5 fold multiplication of the parasite within 45 days, although the plants did not show appreciable reduction in growth (Raju and Seshadri, 1969). However, when seeds were sown in infested soil (10000 nematodes/ pot) plants showed significant reductions in length of shoot, weight of shoot, root and fruit and number of leaves in comparison to nematode free controls. Presence of even a very low population of adult females in root system interfered with normal growth. Sivakumar and Mamoolmukkin (1976) observed that R. reniformis caused maximum reduction in yield of okra with an inoculum level of 1000 nematodes / pot in poor soils not provided with fertilizers.

Tomato plant inoculated with 10,000 nematodes 25 days after sowing, developed a fairly good number of adult females on the root system 75 days after inoculation, but pathogenic symptoms were not very prominent (Raju and Seshadri, 1969). On the other hand, Roe and Prasad (1970) found that uniform nematode alone could cause conspicuous damage to tomato. Similarly Seale and Oman (1976) mentioned that decline in growth of tomato plants was positively correlated with the size of nematode inoculum. In glass house experiment growth of tops and roots of tomato significantly reduced when 10 day old plant was inoculated with 2000 nematodes (Singh, 1975 b). Water absorption capacity of roots in tomato

plants was inhibited by R. reniformis due to poor development of roots (Ismail and Alam, 1979).

Brinjal plants inoculated with 10,000 nematodes at 35 days after sowing showed notable differences in length and weight of shoot within 100 days (Raja and Seshadri, 1969). In a trial on the pathogenicity of R. reniformis on brinjal, distinct symptoms like chlorosis, stunted growth, curling of outer 1 crown leaves, premature fall of flowers and sparsely developed roots were observed (Singh and Khera, 1979). Further, the nematode was highly pathogenic to brinjal at an inoculum level of 100 or more eggs per plant. Maximum nematode population was recorded from plants inoculated with 10,000 eggs, although the highest rate of multiplication was noted at the minimum inoculum level of 10.

Yield and quality of potato cultivar susceptible to R. reniformis reduced significantly due to parasitism of reniform nematode (Robbins et al., 1979). In this case development of reniform nematode was noticed on roots, but not on tubers. Nematode population in soil multiplied 3 to 19 fold in 3.5 months depending on the cultivar. According to Martin (1960) reniform nematode caused injuries to sweet potato under greenhouse condition in Louisiana. Birchfield and Martin (1965) reported damage to sweet potato by reniform nematode which varied from light to severe intensity depending on initial population of nematode and its seasonal increase. Yik and Birchfield (1979) observed a marked reduction in size and grade quality of sweet

not to occur due to R. reniformis. Yields of sweet potato were greatly reduced when initial populations were as high as 1500-10,000/500 cm^3 of soil (Clark and Wright, 1963).

Study on the pathogenicity of R. reniformis on cotton: Sharma and Saha indicated that growth of seedlings inoculated with 25000 nematodes in 200g of sterilized soil was markedly depressed compared with that of control 94 days after inoculation (Singh, 1973). In pot experiment, plants of Trifolium alexandrinum inoculated with 1000 larvae of R. reniformis per plant at one month after inoculation showed reduced growth and developed smaller leaves and thinner stems as compared to control plants (Lath et al., 1976). In such cases flowering was also delayed by 10 to 15 days in infected plants and fruit set often failed. Shoot length and fruit weight were significantly less in infected plants than control plants. Infected roots showed browning and necrosis of the cortical tissue and nematodes feeding on phloem.

In two successive crops loss of urad caused by R. reniformis due to premature death of the plants and in clover the nematode infestations were followed by decline and stunting (Thorne, 1961). Ayoub (1962) observed that R. reniformis was a significant pathogen of coffee resulting in reduction in both shoot and root systems.

2. CONTROL

Studies have been made by different workers on the control of reniform nematode in various types of crops by application of granular pesticides and chlorine to infested soils and crops.

b. Granules-

In cotton, the sorghum nematode was controlled and higher yields were obtained with DBCP, E-D, Telone, Dichlofenthion, Furadan and Mocap in field plots in Louisiana, USA (Birchfield, 1968). Again in 1971, he recorded lower counts of H. marginata from cotton soils treated with Furadan, Vydate and Temik. Bye per cropping were less in treatments of Temik, Furadan, Mocap and Furadan. In field trials on cotton in Egypt, Furadan, Temik and Nemagon were found as the most promising chemicals on account of reductions in the peak nematode population density in July, average rate of reproduction and cumulative reduction in nature compared with control (Ghaffar et al., 1970). Applications of Furadan, phorate and fenamiphothion in low doses to seeds of Cenchrus biflorus or to the surrounding soils brought down population of H. marginata by 32.45 to 40.66% (Muralidharan and Sivakumar, 1975). Administration of aldicarb 10G (2ppm), carbofuran 10G (12ppm), fenamiphothion 10G (12ppm), or methomyl 90 (6ppm) to H. marginata infected cotton plants in a pot experiment reduced nematode population (Abu Khayyam et al., 1979). It was also observed that incorporation of nematicide into the soil gave better control than surface application or side dressings. In field trial, treatment with ca 10223 (23.6kg/ha) was the most effective control measure followed by aldicarb 10G (22.4kg/ha) and carbofuran 10G (35.7kg/ha). In another early pot treatments with carbofuran 2.5kg a.i./ha followed by aldicarb 2 kg a.i./ha produced significant increase in height of plants and yield of cotton in fields of Assam naturally infected with

R. reniformis (Dhanraj and Seshadri, 1982).

In a trial on the efficacy of pesticides and plant extracts for the control of R. reniformis on castor, it was found that nematicides like Nemacur, DBCP, EDB, VC-13 and Nemagon and the plant extracts of Neem, Karanj, and Dhatura proved to be effective in reducing nematode population (Verma and Prasad, 1980).

Soil treatment with Neem and/or DBCP significantly reduced R. reniformis population and increased yield by 10% on susceptible soybean variety (Mishra and Williams,1976).

Tomato plants treated with thionazin or aldicarb were less invaded by larvae of R. reniformis and both the nematicides also reduced nematode numbers (Reddy and Seshadri, 1972). Spot application of carbofuran 0.15 and 0.3kg a.i./ha and aldicarb 0.4 and 0.8kg a.i./ha, controlled R. reniformis and increased yield in tomato (Sivakumar et al., 1976). Application of carbofuran, aldicarb and phorate at 1.2 or 3kg a.i. to the soil resulted in less build up of nematode population compared to the control (Prasad et al., 1977). Using carbofuran at 1kg/ha nematode population got reduced by 61%.

In a field trial using nematicides like carbofuran, aldicarb, OM 1223, phorate or disulfoton 0 1kg a.i./ha or phorate+disulfoton @ 0.5+0.5kg a.i./ha 15 after planting and pepper, soil populations declined by 71% to 0% after one month and 99 to 100% after 6 months. The decline in untreated plots growing red pepper was 30% and 80% at 1 and 6 months respectively (Sivakumar et al., 1979).

In field trials R. reniformis was controlled on sweet potato by row treatment with halogenated hydrocarbons and organic phosphates namely Dasanit, Nemagon, Temik etc. (Birchfield and Martin, 1960). Application of aldicarb, fensulfothion, methomyl and phorate in rows at 0.75 or 1.5 kg a.i./ha to potato after germination in a field heavily infested with R. reniformis and Meloidogyne incognita followed by irrigation reduced nematode population in particular R. reniformis within 2 to 6 weeks after application. Although populations progressively build up afterwards, they were kept lower than control plots. Aldicarb was also found to be most effective against both the nematode species, which increased yield of tubers by 55.4% and 38.1% at higher and lower dosages respectively. Improved quality of tubers and plant growth while medium levels of aldicarb in treated tubers were only 0.10 and 0.36 ppm of sulphone at two dosages respectively (Abdel Rahman et al., 1974). Incorporation of ethoprop, fensulfothion and carbofuran into the soil decreased population of R. reniformis on sweet potato in field experiments but increases in yield were obtained with fensulfothion and carbofuran (Birchfield and Martin, 1976). High yields of sweet potato were obtained with ethoprop eventhough the reniform nematode was present in the soil (Birchfield, 1962). The reniform nematode was controlled on sweet potato in fields of Louisiana, USA by addition of ethoprop (Clark et al., 1962).

In sugarcane crop infected by reniform nematode and other nematodes, nematicides increased root production, plant growth and yield and the effectiveness of these chemicals was progressively more in the following order like Nemagon 30, Diazinon 100, rice hull, baggasse, sawdust, Furadan 3G, filter cake and Temik 15G (Cleofe, 1979).

Rajendran and Naganathan (1990) mentioned that application of carbofuran, fensulphothion, phorate or aldicarb 0 5kg a.i./ha to R. *reniformis* infested grapevines produced yield increases of 14,15,14,15,13.3 and 13.5kg/vine respectively and also reduced nematode numbers.

B. Organic amendments:-

(i) Oil cakes: Water extracts of whole and deoiled cakes of castor, groundnut, rapeseed, safflower, mustard and gingilley reduced population of R. *reniformis* as they suppressed hatching of eggs (Rao and Prasad, 1980). Subsequently water soluble fractions of four oilcakes (Neem, Mahua, groundnut and castor) were found toxic to R. *reniformis* and three other plant parasitic nematodes while bitter principles of Neem viz. nimbidine and thionimone were highly effective in killing nematodes (Khan et al., 1974).

(ii) Poultry droppings & Pigeon droppings

Badra et al. (1979) tested organic compounds, 3 fatty acids and phenol for nematicidal properties against R. *reniformis* and *Tylenchulus semipenetrans*. Pigeon droppings, poultry droppings and cotton seed cake at

5, 10, 15 or 20g/L killed all nematodes of both the species. Similarly horse dung, sheep dung and rice straw at concentrations above 10g/L killed both the species. Although lethal effects varied at lower concentrations pigeon droppings and poultry droppings combined considerably toxic during decomposition. Bedra and Ethay (1979) studied the efficacy of adding 3 levels of mineral N or P combined with pigeon droppings or poultry droppings on nematode population and growth of tomato in soil infected with R. reniformis. Plant growth increased with additional mineral fertilizers as compared with plants receiving none or organic fertilizer only. Poultry droppings alone or combined with either mineral fertilizer gave better growth than pigeon droppings. Soil and root population of R. reniformis reduced with the highest dose of phosphorus combined with both organic fertilizers but to a greater extent with poultry droppings. Soil and root population in treatments receiving additional nitrogen was significantly low as the nitrogen dose was increased with both organic amendments.

CHAPTER III

MATERIALS AND METHODS

MATERIAL AND METHODS

1. THE TEST NEMATODE SPECIES :

Pratylenchus penetrans was collected from root zone of other plant grown in the Central Farm , C.U.A.E., Bhubaneswar.

A. Collection of soil samples.-

Soil samples were collected periodically from rhizosphere of other plants upto a depth of 20-25cm by means of a "khurpi", filled in polythene bags, keeping 500ml per bag, labelled and brought to the laboratory for screening out nematodes.

B. Processing of soil samples and extraction of nematodes.-

Soil samples were processed by a combination of Cobb's decanting and sieving method (Cobb, 1918) and Schindler's improved Baermann funnel technique (Schindler, 1961) with some modifications to extract nematodes by wet screening. At first soil was removed from the polythene bag into an aluminium pan to which water was added sufficiently to make a muddy suspension. Foreign materials were removed and it was stirred thoroughly. Then the suspension was allowed to settle down for 10 seconds so that sand and heavier particles got deposited at the bottom. The supernatant soil suspension was passed through a phenkara-brown wire meshed 30mesh sieve and collected in the second aluminium pan. Residue of the first pan was again mixed with water and screened. Subsequently, suspension of the second pan was passed through 200 and then 350 mesh sieves. Nematodes alongwith finer soil particles were collected on the 350 mesh sieve. The

entire catch from 350 mesh sieve was collected in a beaker by flushing with a fine jet of water from back side of the sieve.

The nematode suspension thus collected was slowly poured over a moistened double layered tissue paper, which was spread over a saucer shaped aluminium wire gauge. The wire gauge assembly was placed in petridish with sufficient water touching bottom of the wire gauge. Then it was covered by the lid to check loss of water due to evaporation and was kept undisturbed for 24 hours. In the mean time nematodes wriggled through the tissue paper and settled down at the bottom of the petridish. Different stages of the reniform nematode were handpicked by sharp bamboo splinters or collected in large numbers by sucking through micropipette attached to polythene tubing of small bore, by placing the nematode suspension under stereoscopic microscope.

C. <u>Staining and examination of root tissues</u>-

Plants from the nematode infested soil were removed alongwith adhering soil without damaging the root system. Roots were washed gently and stained in 0.1% acid fuchsin lactophenol (Goodey, 1963). The stained roots were observed under microscope to locate different stages of the reniform nematode.

2. <u>PATHOGENICITY TRIAL</u> :

The pathogenic relationship of *R. reniformis* with French bean Cv. Premier was studied in pot culture during November 1983 to January 1984.

A. <u>Preparation of soil and pots</u> :

Thirty earthen pots of(15cm x 10cm) size were rinsed with 4% formaldehyde solution, dried under sun and filled with

autoclaved soil potting 1L/pot. Surface sterilized seeds of French bean cultivar Prophet were sown in these pots. Afterwards seedlings were thinned maintaining one seedling per pot. Routine operations such as watering, staking and after care of the seedlings were attended to. The pathogenicity trial was laid out in a completely randomized design (CRD) consisting of 6 treatments with 5 replications. Treatments included were:

(i) Control (No nematodes or associated microorganism):

Autoclaved soil was used to which 15ml of sterile distilled water was added at the time of inoculation.

(ii) Associated Control (Associated microorganisms without nematodes):

At the time of inoculation, 15ml of soil suspension containing associated microorganisms free of nematodes obtained after passing 1L of field soil through 250 mesh sieve was added to each pot.

(iii) 10 nematodes per pot:

The nematode suspension containing 10 larvae of M. graminis in 15ml of sterile distilled water was poured into holes around base of the plant.

(iv) 100 nematodes per pot:

100 larvae of the meloidem nematode in 15ml of sterile distilled water was poured into holes in the rhizosphere of the plant.

(v) 1000 nematodes per pot:

1000 larvae of M. graminis in 15ml of sterile

distilled water were placed in holes around root zone of the plant.

(vi) 10,000 nematodes per pot:

10,000 larvae of the nematode suspended in 15ml of sterile distilled water were put into holes around base of the plant.

D. Inoculation:-

Larvae of the soybean cyst cells collected under a binocular microscope were surface-sterilized in mercuric chloride, passed through three changes of sterile distilled water and transferred to specimen tube containing 15ml of sterile distilled water. Nematode in the suspension were inoculated through small holes of 3cm depth in the rhizosphere of the plant. After inoculation holes were closed with mud and pots were lightly irrigated.

E. Observations:-

Sixty days after inoculation, plants were carefully removed by a pots, roots were washed several times in clear running water to make them free of soil particles and different observations were recorded.

(i) Height of the shoot :-

Height of each plant from base to the topmost portion was recorded in cm.

(ii) Root length:

Roots were straightened, values were opened and length was measured in cm.

(iii) Dry weight of shoot.

Plants without roots was first air-dried at room temperature, then placed in an oven at 80°c for 24 hours until the weight was constant, weighed and recorded in gram (g).

(iv) Dry weight of root.

Roots were oven dried as in case of shoot and dry weight was recorded in gram (g).

(v) Nematode population.

Washings of roots and soil from each pot were passed through 80, 200 and 250 mesh sieves following Cobb's sieving and decanting method with some alterations and nematodes were collected in petridish by keeping into water through double layered tissue paper. In each case total number of nematodes present in the suspension was counted in a counting dish by a stereoscopic microscope.

3. Field trial.

Effect of granular nematicides and organic amendments on the control of R. reniformis infecting French bean and consequent growth of plant was studied in a pot experiment from February to April 1984 after ascertaining the pathogenic level of R. reniformis on French bean in the previous trial.

4. Preparation of soil and pots.

Forty five earthen pots of size(15cm X 15cm) were surface sterilized with hot water, dried under sun and filled with external infested field soil containing the nematode. Soil was collected by means of a spade up to a depth of 20cm from other field of the Central Farm of G.B.P.U.A.T. infested with a heavy population of R. reniformis. It was then roughly mixed

thoroughly mixed, twenty subsamples were taken out by cone and quarter system and average number of nematodes per litre of soil was estimated. Each pot was filled with 1 litre of soil having 2000 larvae of P. penetrans. Soils in all pots were treated with chemicals and organic amendments at the recommended dosage by mixing them thoroughly. To each pot including control 10ml of sterile distilled water was added. Seven days after the application of various organics surface sterilized seeds of French bean Cv. Prabhat were sown in all the experimental pots. Finally one plant was maintained in each pot. Regular practices like watering, shading and other care of plants were carried out in time. Experimental trial on the control of meloidogyne nematode was laid out in a completely randomized design (CRD) consisting of 7 treatment each replicated at 2 times and an untreated control. In all there were 15 treatments in the trial, each replicated 3 times. Treatments in the experiment were:

(i) Untreated controls

10ml of sterile water was added at par with other treatments.

(ii) Carbofuran 0.3kg a.i./ha

37mg of Furadan 3G was mixed with 1 litre of soil in the pot.

(iii) Carbofuran 0.6kg a.i./ha

74mg of Furadan 3G was added to each pot.

(iv) Aldicarb 0.3kg a.i./ha

7mg of Temik 10G was mixed with soil in the pot.

(v) Aldicarb 0.6kg a.i./ha

15mg of Temik 10G was applied to each pot.

(vi) Rhizopus @ 2kg a.i./ha

2kg of fungi 100 was applied per L of soil per pot.

(vii) Rhizopus @ 4kg a.i./ha

18mg of fungi 100 was applied per L soil per pot.

(viii) Neem oil cake @ 1ton/ha

0.5g of neem cake was powdered and applied to 1L soil in the pot.

(ix) Neem oil cake @ 2ton/ha

One gram of powdered neem oil cake was applied per 1L of soil per pot.

(x) Karanj oil cake @ 1ton/ha

0.5g of Karanj cake was applied/ L of soil per pot.

(xi) Karanj oil cake @ 2ton/ha

One gram of powdered karanj cake was applied per L of soil per pot.

(xii) Prawn exoskeleton @ 1ton/ha

0.5g of powdered prawn scale was applied per L of soil per pot.

(xiii) Prawn exoskeleton @ 2ton/ha

One gram of powdered prawn scale was applied per L of soil per pot.

(xiv) Organic manure @ 1ton/ha

0.5g of powdered kind of host was applied per L of soil per pot.

(xv) Organic manure @ 2ton/ha

One gram of powdered kind of host was applied per L of soil per pot.

b. Observation of observation:-

At 60 days after treatment with granules and organic

treatments plants were gently removed from soil, roots were thoroughly washed and following observations were recorded.

(i) Dry weight of shoot:

Plants without roots were first air dried, then dried in an oven at 80°c for 48 hours and weights were recorded in gram (g).

(ii) Dry weight of roots:

Roots were cleaned of soil particles, air dried, dried in an oven at 80°c for 48 hours and were weighed in g.

(iii) Nematode population:

After removal of the plant, root webbings and soil from each pot were passed through 20,200 and 350 mesh sieves following Cobb's sieving and decanting method with some modifications. Nematodes and smaller soil particles were collected in suspension which was passed through double layered tissue paper placed on an aluminium wire ware in petridish containing water. Finally nematodes from each petridish was transferred to counting dish and counted under a binocular stereoscope.

4. STATISTICAL ANALYSIS:

Fisher's method of analysis of variance was followed for statistical analysis and interpretation of data recorded in different experiments. 'F' test and 't' test at 5% level of significance were used to test significance of results. Data obtained for pathogenicity test and control experiment were arranged in one way tables according to replications and treatments. Replication total and treatment total were then

analysed statistically. Analysis of variance was carried out for individual characters of different experiments and treatment means were compared following critical difference test. Standard error of treatment mean and critical difference (C.D.) were calculated by using following formula.

$$\text{Standard error of treatment mean} = \frac{\text{S.E.S}}{\sqrt{r}}$$

Where, S.E.S = Error mean square

r = number of replications.

Critical difference:

C.D. (0.05) between two treatment means
= Standard error x t (0.05) at respective error
degree of freedom

CHAPTER IV

EXPERIMENTAL FINDINGS

E X P E R I M E N T A L F I N D I N G S

Relative effect of infestation with different population levels of the meloform nematode on growth of French bean cv. Prince was studied by recording observations on plant height, root length, dry weight of shoot and dry weight of root. Final nematode counts at different levels of inoculation were also recorded at 60 days after inoculation. Observations recorded in the experiment were tabulated and subjected to statistical analysis. Analysis of variance tables are presented in appendix I to V.

1. Pathogenicity.

In the pathogenicity test it was observed that French bean plant inoculated with population of 1000 or 10,000 nema/kg soil exhibited symptoms of yellowing of leaves, stunting and sickly appearance of plants. In these plants roots were poorly developed and showed branch discolouration. Differentiating features of growth characters at different population levels of the nematode have been shown in Figure 1,2 and 3.

A. Plant height.

As height indicates plant growth, the effect of meloform nematode on this important aspect was studied. Height of French bean plant in different treatments was recorded at the time of harvest and data have been presented in Table 1 and illustrated in Fig. 1. Percentage reductions in shoot height in treatments with diffe ent levels of nematode population were calculated with reference to height of the plant in control which have been shown in Table 1 and illustrated in Fig. 4.


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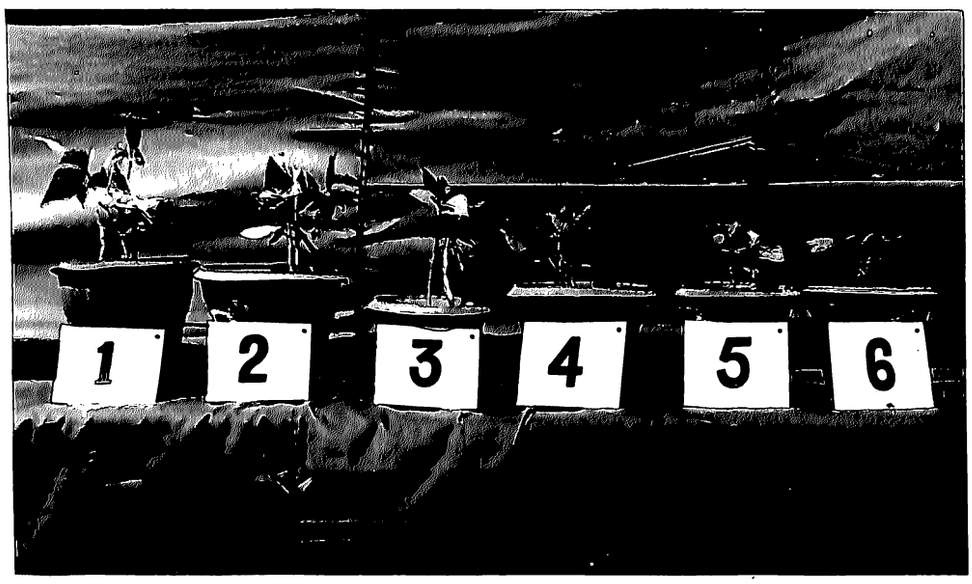
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Data recorded in Table 1 indicated that plants inoculated with 10,000 nematodes/L soil had the lowest height 13.54cm exhibiting a reduction of 42.2% over plants grown in control. In the treatment receiving basal population of 1000 nematodes/plant, mean height was 19.36cm which showed a reduction of 9% over control. On the other hand, in the control pot with no inoculation the maximum height of 21.26cm was recorded and with inoculation of associated microorganisms height of the plant was 22.04cm. Heights of the plants were 21.3cm and 19.52cm showing reductions of 0.8% and 16.0% over control when French bean plants were inoculated with 10 and 100 nematodes respectively.

Statistical analysis of recorded data has indicated that there was no significant difference in plant height between control and associated control and also between nematode inoculation of 10 nems/pot and 100 nems/pot and between 1000 and 10,000 nems/pot. However, there was significant difference in height of plants between control and various nematode inoculations of 10,100, 1000 or 10,000 nematodes/plant (Appendix.I).

b. Root length:-

Observations in Table 1 showed that root lengths of French bean plants were 20.42cm and 19.36cm in the control and associated control pots respectively. In the treatment with 10 nematodes per plant, average root length was 19.02cm showing a reduction of 7.6% over control. With inoculation of 100 nems per plant the mean root length was 17.04cm indicating a reduction of 12.6% over control. But plants inoculated

Table 1. Pathogenic effect and population build up of *R. reniformis* on French bean Cv. Premier

Sl. No.	Mean observations[a]	Nematode inoculation/1.0 L soil						Standard error of mean	Critical difference (0.05)
		0	Associated microbes only	10	100	1,000	10,000		
1.	Shoot height (cm)	23.45	22.04	21.30	19.52	15.36	19.54	0.575*	1.36
2.	Root length (cm)	20.42	19.56	18.82	17.84	14.12	12.30	1.026*	2.37
3.	Dry weight of shoot (g)	1.92	1.84	1.63	1.47	0.88	0.81	.264*	0.55
4.	Dry weight of root (g)	1.17	1.12	1.05	0.98	0.75	0.63	.089*	0.18
5.	Nematode number			72.42 (1.856)	571.32 (2.754)	4383.68 (3.642)	2230.13 (4.507)	.031*	.07

a Mean of 5 replications

* show significance at 0.05 level

() Figures in parentheses are logarithmic numbers

with 1000 and 10,000 nematodes per pot had mean root lengths of 14.12cm and 11.9cm respectively resulting in reductions of 30.9% and 39.0% over control.

Statistical analysis of the data has pointed out that there was no significant difference among the first four treatments. On the other hand, root lengths of plants treated with 1000 and 10,000 nematodes were significantly different from the control and other three treatments, although there was no statistical difference between the root lengths of these two treatments (Appendix-II).

C. Dry weight of shoot:-

Observation on dry weight of shoot in Table 1 have indicated that the meliform nematode adversely affected growth of French bean cv. Premier at different cyst(on levels. Dry weight of shoot was 1.92g and 1.84g when French bean plants were grown in pots with control and corrected control treatment respectively. In treatments which received 10 and 100 nems per pot, mean dry weights of shoot were 1.65g and 1.47g respectively with corresponding reductions of 14.1% and 23.4% over control. But the dry weight of shoot was sufficiently less amounting to 0.88g when 1000 nems were released per plant resulting in a reduction of 54.2% over control. At the highest inoculum of 10,000 nems per pot, the dry weight of shoot was 0.81g with a reduction of 57.8% over the uninoculated control.

Analysis of data have shown that the meliform nematode significantly reduced the dry weight of shoot at inoculum levels of 1000 and10,000 nems/L soil compared with lower inoculum levels and both the controls, although there was no significant

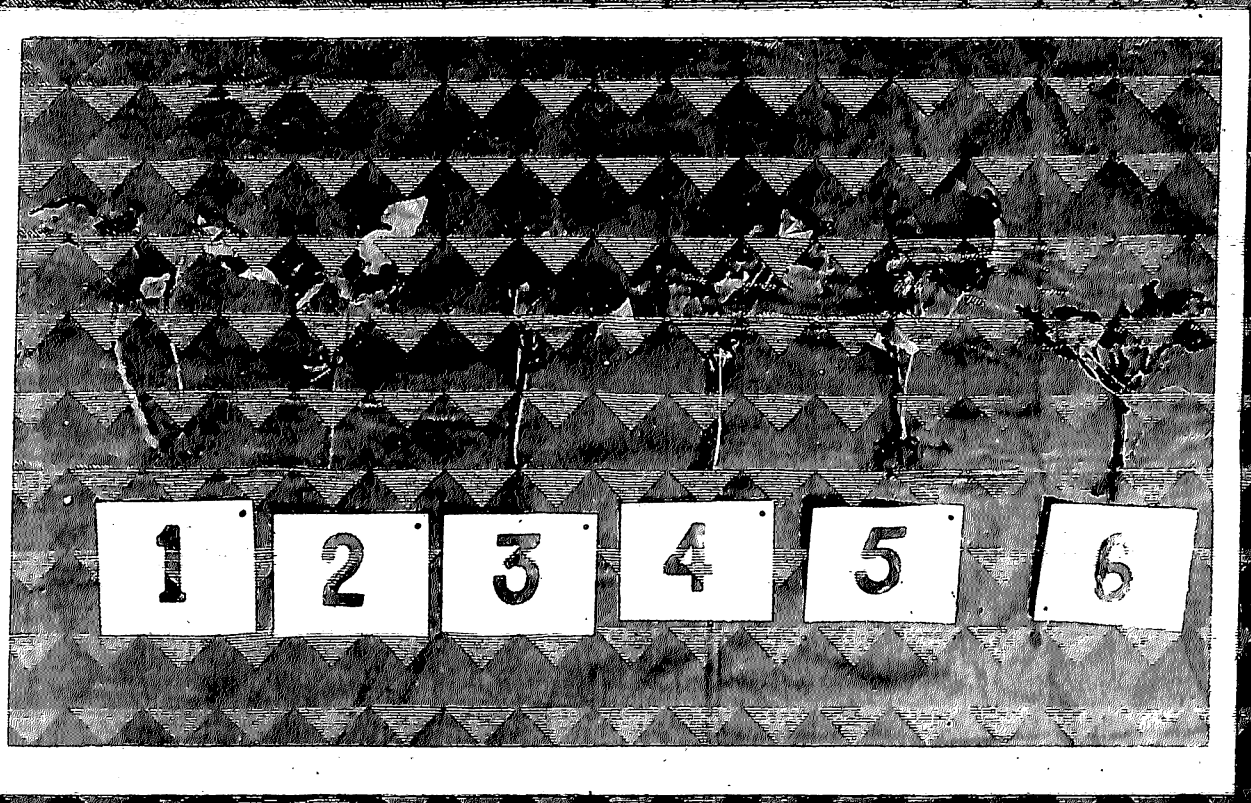
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Fig. 4. RELATIVE EFFECT OF DIFFERENT INOCULUM LEVELS OF *R. reniformis* ON GROWTH CHARACTERS OF FRENCH BEAN AND CORRESPONDING INCREASE IN NEMATODE NUMBERS

TREATMENTS

NEMAS NIL + MICROBES } — A
NEMAS (10/POT) — B
NEMAS (100/POT) — C
NEMAS (1000/POT) — D
NEMAS (10,000/POT) — E

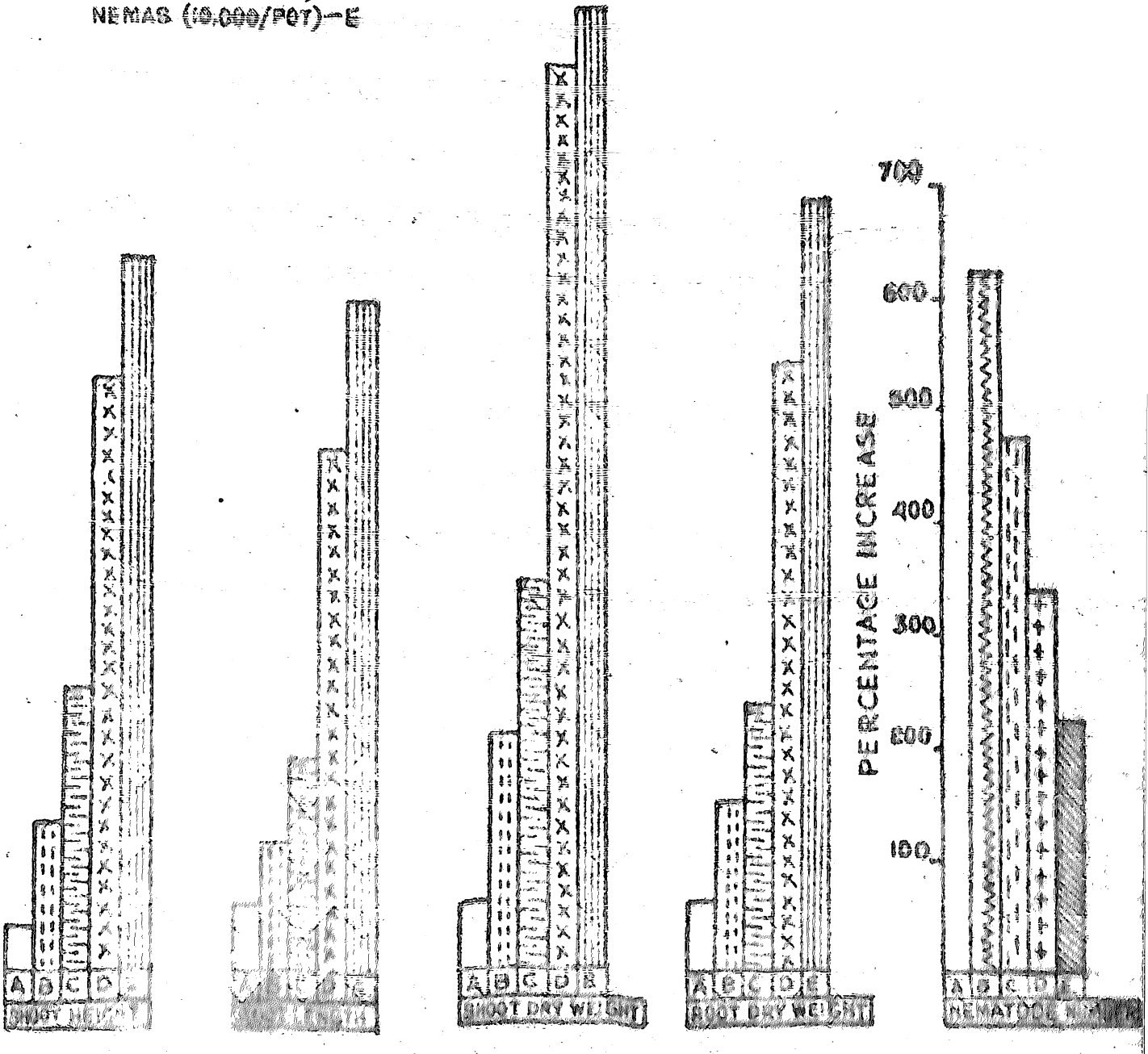
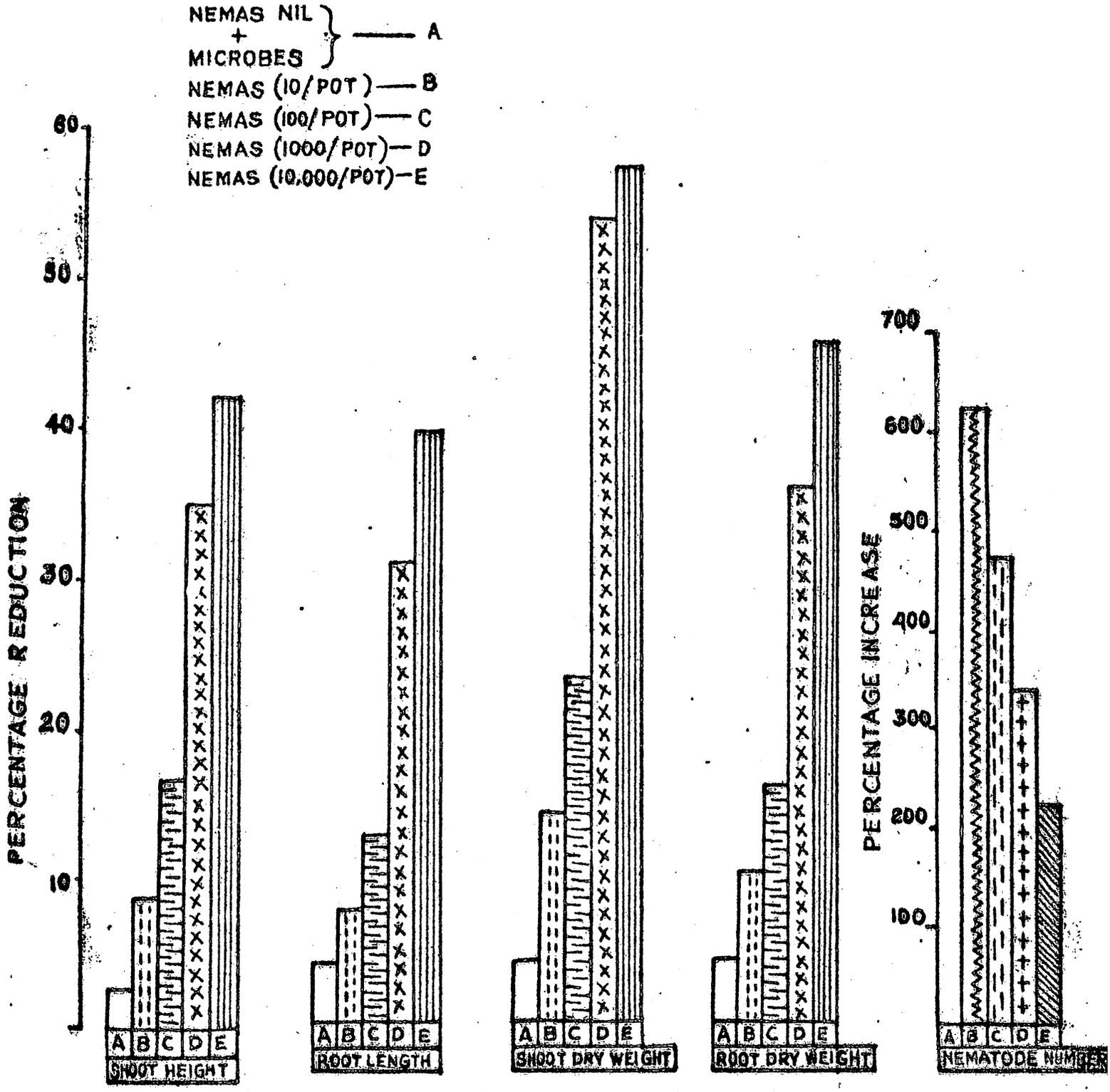


Fig. 4. RELATIVE EFFECT OF DIFFERENT INOCULUM LEVELS OF *R. reniformis* ON GROWTH CHARACTERS OF FRENCH BEAN AND CORRESPONDING INCREASE IN NEMATODE NUMBERS



1. Nematode multiplication :-

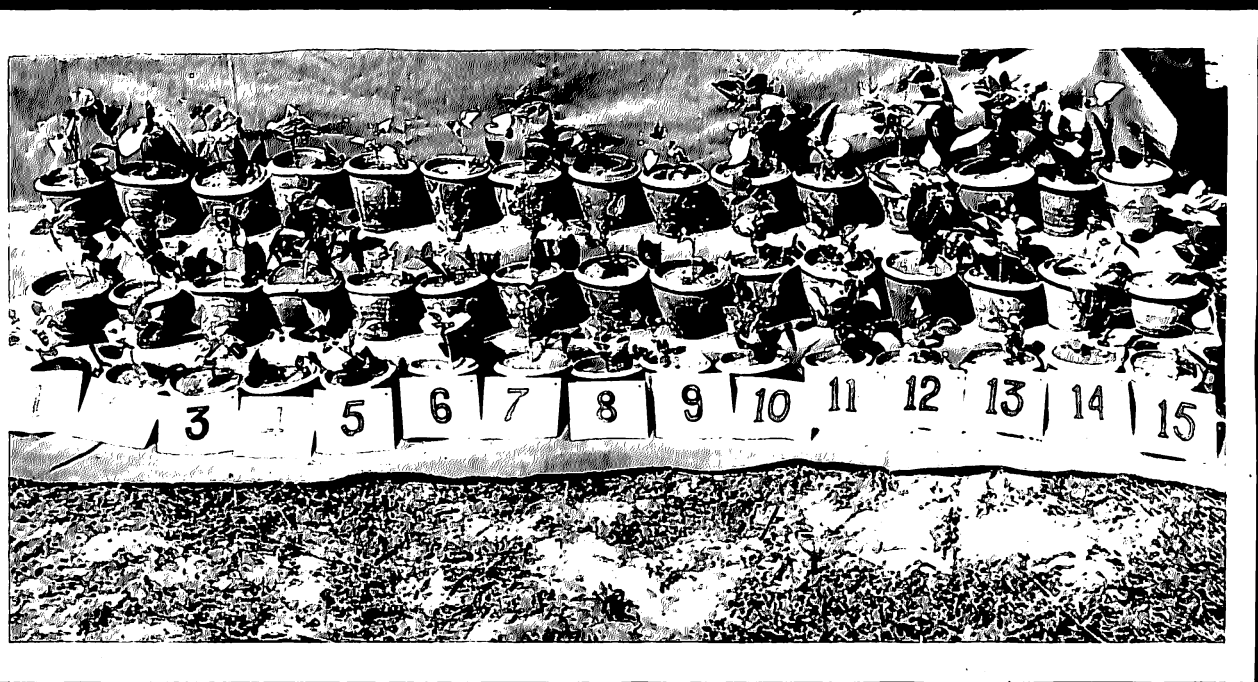
At termination of the experiment, number of nematodes were counted in all the inoculations and relevant data on nematode counts have been mentioned in Table 1. Corresponding percentage of increase in nematode populations and rates of multiplication over initial population have been shown in Table 2. There were increases in numbers of nematodes at all the inoculum levels.

The largest population of nematodes was recorded in the highest inoculum level of 10,000 nematodes/2 soil, but the rate of multiplication was minimum i.e. 3.2 times of initial population with the least increase of 219%. On the other hand, although minimum number of nematodes was observed in the treatment of 10 nems/pot, the maximum rate of multiplication of 7.24 times of initial population with the highest increase of 624% were recorded. Nematodes multiplied by 5.7 and 4.4 times of initial population with corresponding increase of 471.3% and 339% at inocula levels of 100 and 1000 nematodes respectively.

Statistically there were significant differences in final populations of nematodes among the treatments of 10,100, 1000 and 10,000 nems/2 soil (Annexure-V).

2. Control :

With regard to control of R. reniformis infecting French bean, data on dry weights of shoot and root and nematode counts were recorded 60 days after application of different compounds to study the relative efficacy of different granular compounds and organic amendments. Data presented in Table 3 and illustrated in Fig. 8.3 were statistically analysed and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analysis of variance has been contained in APPENDIX-VI to VIII.

A. Nematode population:-

Results on effect of different granular nematicides and organic amendments on the final recovery of *P. penetrans* presented in Table 3 and illustrated in Fig. 8 have indicated that all the compounds considerably reduced nematode numbers as compared to rise in nematode population in the control. However, among different compounds tested, Furadan (2ton/ha) followed by Furadan (1ton/ha) proved to be most effective in controlling the nematode as the lowest number of nematodes. 276.53 and 336.53 respectively with corresponding reductions of 86.2% and 83.2% over the initial population were obtained from these two treatments. Application of carbofuran (4kg a.i./ha), aldicarb (4kg a.i./ha), neem oilcake (1ton/ha), phorate granules (2ton/ha), Furadan oilcake (1ton/ha) also resulted in a considerable decrease of nematode population by bringing down final nematode counts to 492.33, 509.70, 602.10, 730.33 and 757.10 respectively with corresponding reductions of 77.4%, 72.2%, 69.9%, 63.0% and 62.2% over initial population. Treatment with carbofuran (2kg a.i./ha), aldicarb (2kg a.i./ha), ethoprop (4kg a.i./ha), organic manure (2 ton/ha) and neem oilcake (1ton/ha) failed to reduce the nematode population below 50%. Minimum reductions in number of nematode were observed in application of ethoprop (2kg a.i./ha) and organic manure (1ton/ha) with recoveries of 1600.37 and 1601.33 and reductions of 19.6% and 19.5% respectively over the initial population which were also found ineffective in controlling


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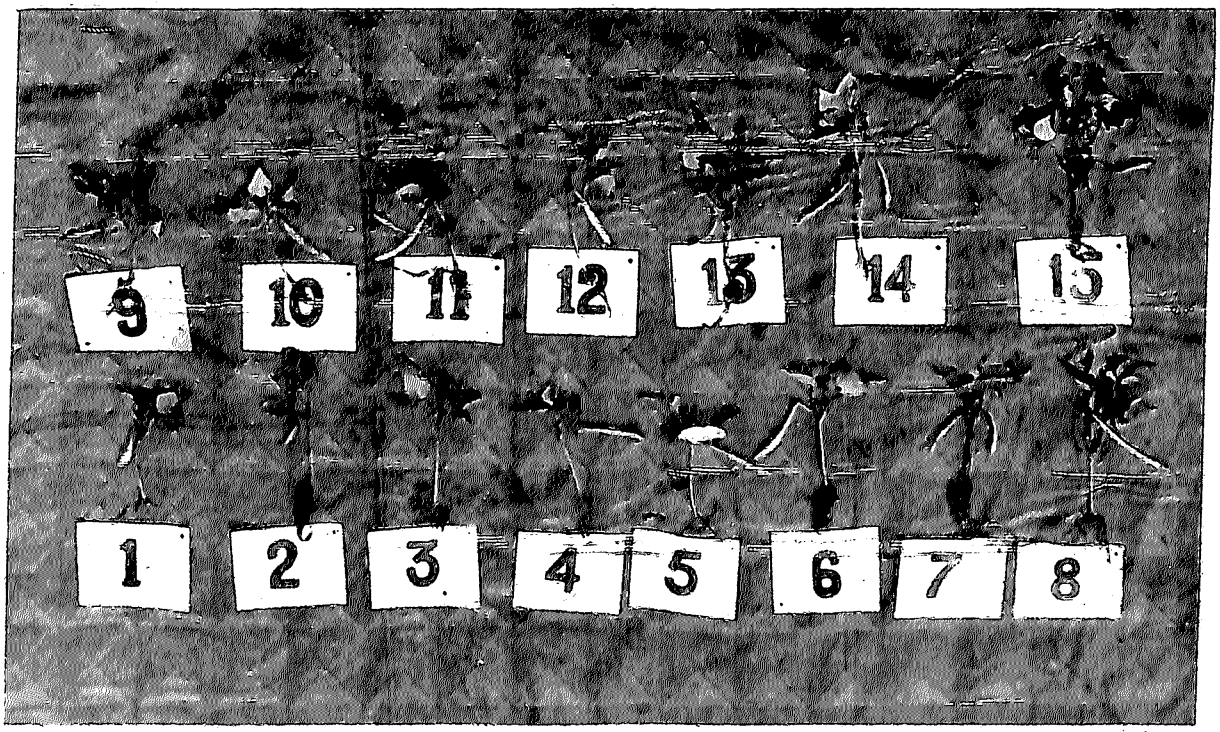
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the nematode. On the other hand, in the control nematodes multiplied by 3.61 time over initial population of 2000/L soil with a final mean recovery of 7220.70 nematodes.

Statistical analysis of the data has shown that nematode populations recovered in different treatments were significantly less than that of control. Nematode counts obtained in application of neem oilcake (2ton/ha) and karanj oilcake (2ton/ha) were significantly less than other treatments and the control, although there was no significant difference between these two treatments. Similarly there was no significant difference in number of nematodes between treatment of carbofuran (1 kg a.i./ha) and aldicarb (1kg a.i./ha). Regarding the control of H. multicinctus, significant difference was not observed among the treatments of aldicarb (1kg a.i./ha) and neem oil cake (1ton/ha), Pongo oilcake (1ton/ha) and karanj oilcake (1ton/ha). Compounds like ethoprop (1kg a.i./ha), carbofuran (1kg a.i./ha), aldicarb (1kg.a.i./ha) and organic manure (1ton/ha) were statistically categorized into one group and oil cake manure (1ton/ha), (2ton/ha), ethoprop (1kg a.i./ha) and neem oilcake (1ton/ha) into another group as there were no significant differences among the final nematode counts in different treatments of each group.

D. Dry weight of shoot:-

Observations on dry weight of shoot mentioned in Table 3 and illustrated in Fig. 9 pointed out that there were marked increases in all treatments in comparison to the control. The percentage increase of dry weight of shoot in each treatment

was calculated over the control and presented in Table3. Maximum dry weight of shoot (1.52g) was obtained in the treatment of prawn meal applied at the rate of 2 ton/ha followed by 1.42g in the application of neem oil cake @ 2 ton/ha showing an increase of more than 3 times over the control i.e. 210.5% in the former and 203.3% in the latter. Dry weight of shoot became greater i.e. more than 2 times in the descending order with the applications of carbofuran 4kg a.i./ha, karanj cake 2 ton/ha, Aldicarb 1kg a.i./ha, organic manure 2ton/ha. and neem cake 2ton/ha showing corresponding increase of 133.6%, 105.4%, 175.0% , 162.5% and 104.2% respectively. Treatments with neem oil cake 1ton/ha, carbofuran 2kg a.i./ha, karanj cake1ton/ha, aldicarb 2kg a.i./ha and organic manure 1ton/ha, reduced dry weight of shoots amounting to 0.92g, 0.89g 0.80g, 0.64g and 0.63g respectively with corresponding increase of 91.7%, 85.4%, 69.3% 37.5% and 31.3% over the control. Application of ethoprop 0 2kg a.i. and 4 kg a.i./ha resulted in the minimum dry weight of shoot amounting 0.56 and 0.55g respectively compared to other treatments as against 0.48g of control with corresponding increase of 4.16% and 14.58% only over control.

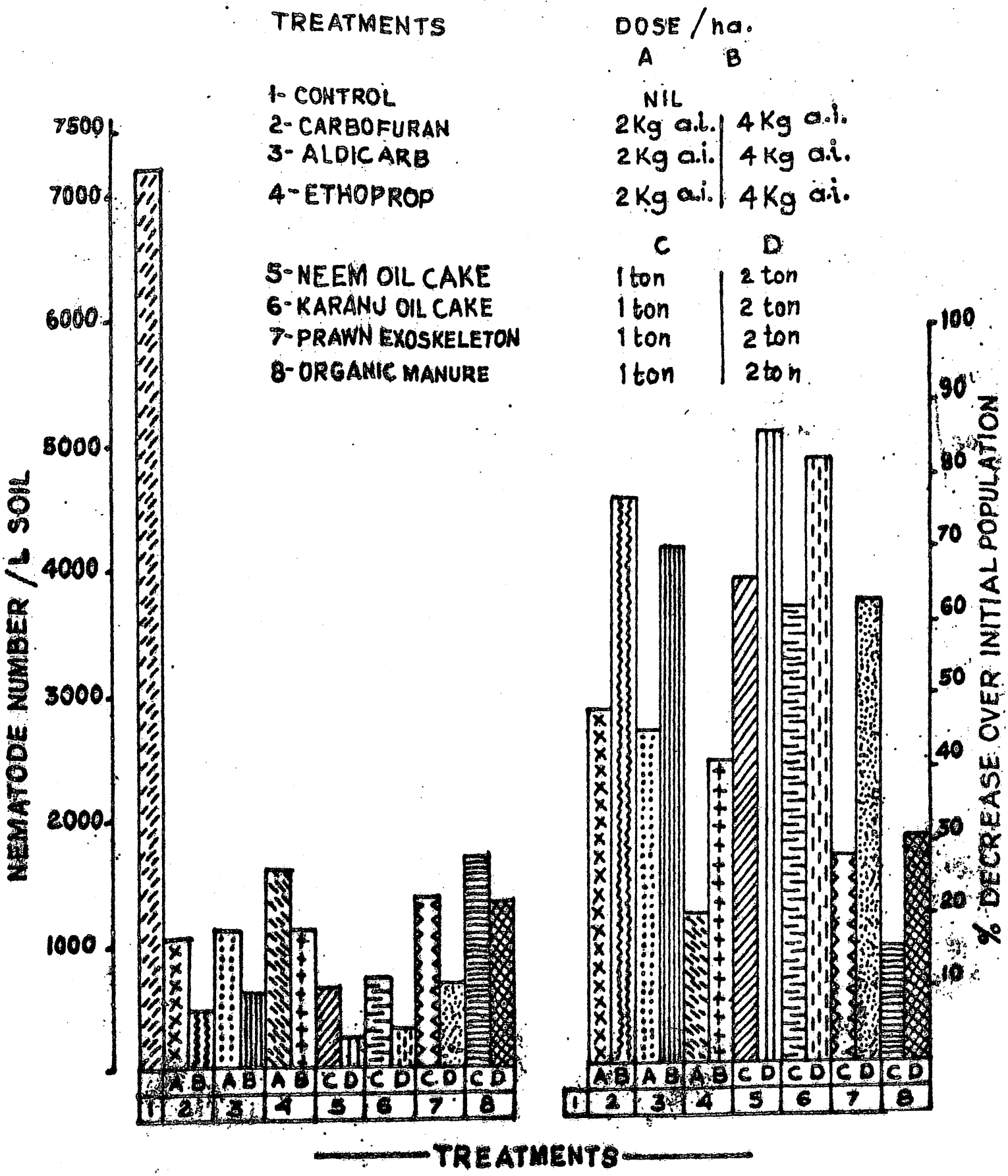
Statistical analysis of data on dry weight of shoot revealed that in French bean plant it was significantly greater in treatments of prawn meal 1 ton or 1 ton/ha, neem oil cake 1 ton or 2 ton/ha, Karanj cake1ton or 2ton/ha, carbofuran 2kg or 4kg a.i./ha, organic manure 2ton /ha and aldicarb 4 kg a.i./ha, than the control. But there was no significant difference among treatments of prawn meal 2ton/ha, neem oil cake 2ton/ha, carbofuran 4kg a.i./ha, Karanj oil cake 2 ton/ha, an

Karanj oil cake 2 ton/ha, organic manure 2 ton/ha and aldicarb 1kg a.i./ha. Similarly dry weight of shoots in treatments of neem seed 1ton/ha, Neem oil cake 1ton/ha, carbofuran 2kg a.i./ha and Karanj oilcake 2ton/ha did not differ significantly from each other (Annexure-VI).

C. Dry weight of roots:-

Data in table 3 indicated that dry weight of root was greater in all the treatments compared with the control. It was maximum i.e. 0.94g in the treatment of organic manure 2 ton/ha followed by 0.84g in the treatment of neem seed applied @ 2ton/ha, 0.78g in the application of Neem oilcake 2ton/ha and 0.78g in the application of carbofuran 2kg a.i./ha showing an increase of 161.1%, 133.3%, 116.7% and 102.8% respectively i.e. more than two times over the control. Dry weight of root was comparatively greater i.e. 0.69g in the treatment of aldicarb 1kg a.i./ha, 0.61g in the treatment of Karanj oil cake 1ton/ha, 0.52g in the treatment of neem seed 1ton/ha, 0.39g in the application of organic manure 1ton/ha, 0.51g in the treatment of Neem oilcake 1ton/ha, 0.48g in the treatment of carbofuran 1kg a.i./ha, 0.45g in the treatment of aldicarb 1kg a.i./ha and 0.44g in the treatment of Karanj oilcake 1ton/ha showing corresponding increase of 91.7%, 69.4%, 63.9%, 52.8%, 41.7%, 33.3%, 25.0% and 22.2% over control. However dry weight of root was sufficiently low in the treatment of ethoprop amounting to 0.4g in the application of 2kg a.i./ha and 0.41g in 1kg a.i./ha increasing only by 11.1% and 13.9% respectively over the control.

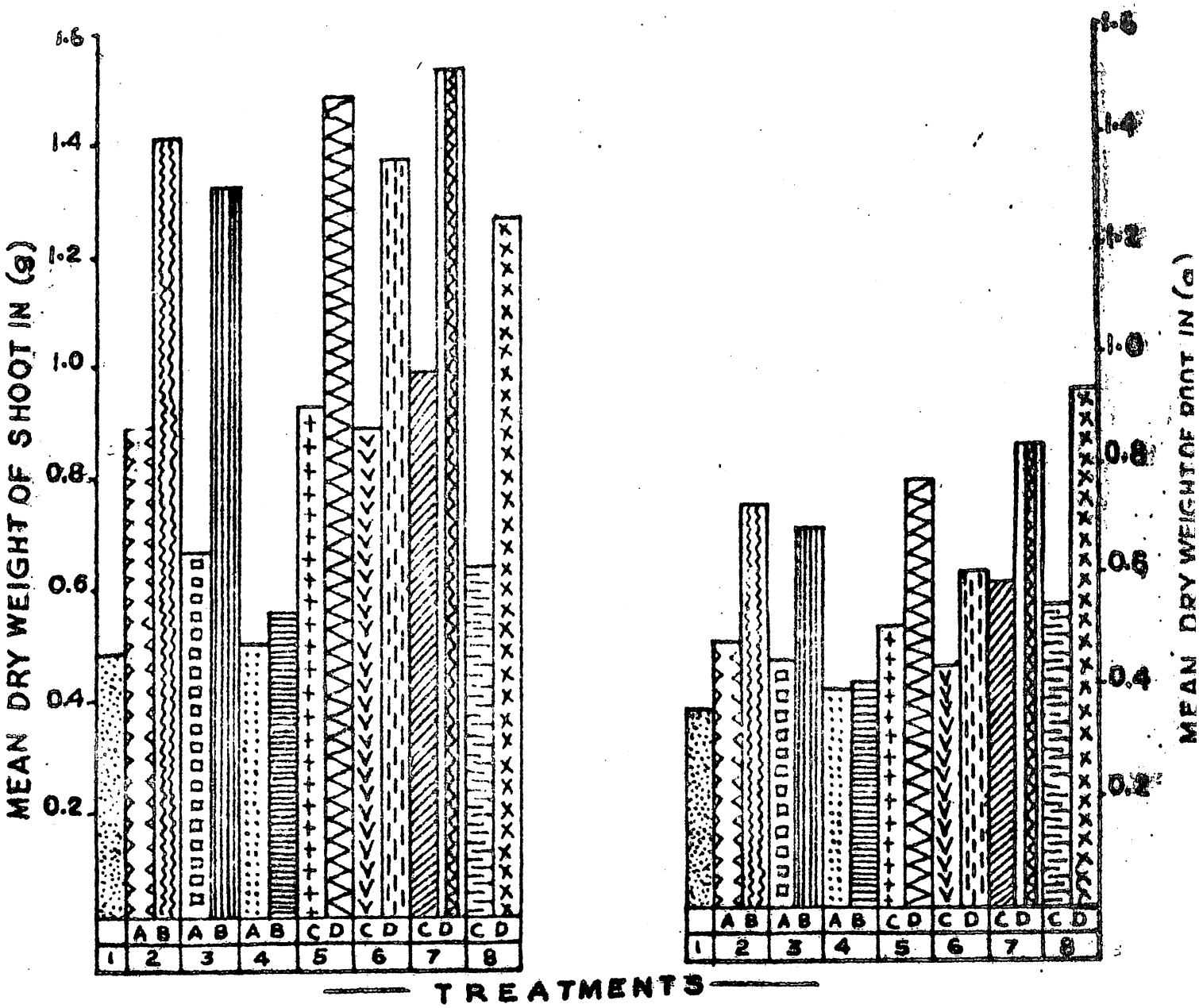
Fig. 8. EFFECT OF DIFFERENT NEMATICIDES AND ORGANIC AMENDMENTS ON THE POPULATION OF *R. reniformis* IN FRENCH BEAN



Statistical analysis of the data indicated that dry weight of root in French bean plant was significantly more in treatments with organic manure @ 5 ton/ha, neem cake @ 3 ton/ha, neem oil cake @ 2 ton/ha, carbofuran @ 0.1 g/kg soil and phorate @ 0.1 g/kg soil and normal oil cake @ 3 ton/ha than the control, although there was no significant difference among first four treatments and between these two treatments mentioned above. In the rest 3 treatments dry weight of root did not differ significantly from the control (Appendix VII).

ig.9. EFFECT OF DIFFERENT NEMATICIDES AND ORGANIC AMENDMENTS ON GROWTH OF FRENCH BEAN INFECTED BY *R. reniformis*

TREATMENTS	DOSE /ha A	B
1- CONTROL	NIL	
2- CARBOFURAN	2 Kg a.i.	4 Kg a.i.
3- ALDICARB	2 Kg a.i.	4 Kg a.i.
4- ETHOPROP	2 Kg a.i.	4 Kg a.i.
	C	D
5- NEEMOILCAKE	1 ton	2 ton
6- KARANJOIL CAKE	1 ton	2 ton
7- PRAWN EXOSKELETON	1 ton	2 ton
8- ORGANIC MANURE	1 ton	2 ton



CHAPTER V

DISCUSSION

DISCUSSION

In view of the cosmopolitan nature of Rotylenchulus reniformis and its association with a variety of vegetable crops, pathogenic relationship of the nematode was established with French bean taking into account the growth characters affected by different inoculum densities of the nematode. Experimental data furnished in Table 1 and Table 2 have pointed out that the nematode species produced significant reduction in various growth characters of French bean at population density of 1000 and 10,000 nematodes per litre of soil, although there was no significant difference between these two treatments. At lower inoculum levels of 10 or 100 nematodes/kg soil the nematode did not adversely influence growth characters of French bean significantly. Therefore, the inoculum density of 1000 nema/kg soil was considered as the minimum pathogenic level of R. reniformis on French bean producing significant decreases in growth parameters like plant height, root length, dry weights of shoot and root. Infected plants showed sickly appearance, unthrifty growth and had yellowish leaves and roots with brownish discolouration. Similar lowering of pathogenic effect by the reniform nematode at inoculum level of 1000 nema/pot has also been observed by Singh (1975 a) on soybean, Nath et al. (1976) on potted gram, Pande and Sachdeva (1979) on mungbean and urid, Gupta and Yadav (1980) on cowpea, Mishra and Gaur (1981) on black gram. Therefore findings of the present study on

pathogenicity of *H. spinicauda* on French bean are in conformity with the results obtained by earlier workers on different plant species especially the legume.

Regarding the rate of nematode multiplication, it was found to be dependent on initial nematode density. Although, maximum population was recovered from the plant inoculated with 10,000 nematode the rate of multiplication was minimum in comparision to other inoculum levels. On the other hand, nematode multiplication was found to be maximum at initial density of 10 nematodes per plant. Therefore, the rate of nematode multiplication decreased with increase in the level of inoculation. The trend observed in nematode multiplication can be attributed to the greater competition and lesser availability of feeding site at the maximum population level (10,000 nema/ plant) as against lesser competition and greater availability of the feeding site at the lowest inoculum level (10 nema/ plant). Results in the present study find support with the findings of Verma and Prasad (1967) on castor, Gupta and Yadav (1979) on Mucuna, Singh and Khan (1979) on brinjal, Gupta and Yadav (1980) on cowpea, Nisha and Gour (1981 b) on moth bean.

Relative efficacy of different granular nematicides and organic amendents was tested to find out a suitable control measure against the root knot nematode infecting French bean. Experimental findings presented in Table 3 clearly indicate that application of Neem oilcake (2ton/ha) or Karanj oilcake (2ton/ha) significantly reduced the

nematode population to the minimum in comparison to all other treatments. Next to these two, application of carbofuran (1kg a.i./ha) or aldicarb (1kg a.i./ha) resulted in significant reduction of nematode population. Statistically application of neem oilcake (1ton/ha), neem concentrate (1ton/ha) and karanj oilcake (1ton/ha) were categorised in the third group so far as their efficacy in reducing the nematode population was concerned.

Data of dry weight of root recorded in Table 3 show that application of organic manure (1ton/ha), neem concentrate (1ton/ha), neem oilcake (1ton/ha), carbofuran (1kg a.i./ha) significantly increased the dry weight of root over control but they were categorised into one group as there was no significant difference among these 4 treatments. Organic manure increased growth of the root system without bringing down the nematode population below pathogenic level as it was supplemented with different micro and micronutrients but it did not have sufficient toxic effect on the nematode. Application of aldicarb (1kg a.i./ha) and karanj oil cake (1ton/ha) also increased dry weight of root considerably over the control. Observations on dry weight of shoot recorded in Table 3, pointed out that application of neem concentrate (1ton/ha), neem oilcake (1ton/ha), carbofuran (1kg a.i./ha), karanj oilcake (1ton/ha) and aldicarb (1kg a.i./ha) significantly increased it over the control to a great extent but were categorised into one group basing on statistical analysis.

In the study on the control of the meloidogyne

nematode. application of Neem oilcake (2ton/ha) proved to be the best treatment in reducing the nematode population while increasing growth of root and shoot substantially. Relative efficacy of Neem oilcake might have been due to bitter principles of Neem namely, nimbidine and thienimone which were reported to be highly effective in killing nematodes (Khan et al.,1974). Application of Karanj oilcake (2ton/ha), Carbofuran (4kg a.i./ha) and aldicarb (4kg a.i./ha) also proved to be effective in decreasing the nematode population and increasing growth characters to great extents. Treatment of infested soil with Neem oilcake (1ton/ha), Prawn exoskeleton (2ton/ha) and Karanj oilcake (1ton/ha) decreased nematode population and increased growth characters but were found less effective than the above four treatments although they proved better than the rest seven treatments and control. Application of Karanj oilcake and prawn exoskeleton successfully controlled the reniform nematode increasing the growth of French bean plants as the toxic byproducts released on decomposition were harmful to the nematode and they also supplied nutrients to the soil. These two organic amendments have been found for the first time to control the reniform nematode. Results on efficacy of granular nematicides in controlling thereniform nematode, similar to the present study were also reported by Birchfield (1968 and 1971) on cotton, Otaifa (1970) on cotton, Reddy and Seshadri (1972) on tomato, Muralidharan

and Sivakumar (1975) on cotton, Prasad *et al.* (1977) on tomato, Abu Elomayem (1979) on cotton, Rajendran and Nagenathan (1980) on grapevine.

CHAPTER VI

SUMMARY AND CONCLUSION

S U M M A R Y A N D C O N C L U S I O N

Pathogenicity of the reniform nematode, Rotylenchulus reniformis on French bean and its control by application of granular nematicides and organic amendments were studied under pot culture conditions in the Department of Nematology, Orissa University of Agriculture and Technology, Bhubaneswar (India). The nematode was collected in large numbers from the rhizosphere of other plant grown in the Central farm of the University.

Pathogenic relationship of the semiendoparasite, R. reniformis was established on French bean Cv. Premier by releasing different populations of the nematode consisting of 10,100,1000 and 10,000 nemas/pot in root zone of 10 day old plants in earthen pots (20cm X 20 cm) measuring 1 litre of autoclaved soil per pot. Keeping one treatment as complete control without any inoculation and another treatment as associated control by inoculating with associated microorganisms only under similar conditions for comparison. At 60 days after inoculation, growth attributes of French bean plant and nematode numbers in different treatments were recorded. The nematode species produced significant stunting effect on French bean at minimum population density of 1000 nemas/pot/L soil accounting for reductions of 35% in shoot height, 30.9% in root length, 54.2% in dry weight of shoot and 35.9% in dry weight of root over control. Further decreases in growth characters were also observed at the highest inoculum level of 10,000 nemas/pot. There was a

general increase in nematode numbers at all inoculum levels. But maximum multiplication of the nematode i.e. 7.24 times of the initial population occurred at the lowest population level of 10 nemas as against the minimum rate of multiplication of 3.22 times at the highest level of 10,000 nemas. It may be concluded from the recorded observations that the reniform nematode is a potential pathogen of French bean, at minimum inoculum density of 1000 nemas per litre of sterilized soil due to its stunting effect on the plant.

With a view to find out suitable measures for effective control of R.reniformis on French bean Cv.Premier, application of carbofuran, aldicarb and ethoprop at two levels, each at 2 kg a.i./ha and 4 kg a.i./ha and Neem oilcake, Karanj oilcake, prawn exoskeleton and organic manure at two levels, each at 1 ton/ha and 2 ton/ha to the soil, 7 days prior to sowing of seed in earthen pots (15 cm x 15 cm) measuring 1 litre of naturally infested soil with a basal population of 2000 nematodes/pot were included in the test keeping one treatment without any application serving as control. The experiment was terminated at 60 days after application of various compounds. Nematode numbers and growth characters of French bean plants in different treatments were recorded after termination of the experiment. To control the reniform nematode infecting French bean, treatment of infested soil with any of the granular nematicides or organic amendments included in the test reduced nematode population against its steep rise in the control and in many instances treatments also improved plant growth. Application of Neem oilcake

(2 ton/ha) was found to be the best treatment as it reduced the nematode population but increased growth of root and shoot substantially. Next to it were applications of Karanj oilcake (2 ton/ha), carbofuran (4 kg a.i./ha) and aldicarb (4 kg a.i./ha) which also decreased nematode populations and increased growth characters to great extents. Treatment of infested soil with Neem oilcake (1 ton/ha), prawn exoskeleton (2 ton/ha) and Karanj oilcake (1 ton/ha) brought down nematode populations and increased growth parametres conspicuously. Rest of the seven treatments were found ineffective in controlling the nematode as they did not bring down the nematode population below 1000 nemas/L soil which was found to be the minimum pathogenic density of R.reniformis on French bean in the earlier test.

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APPENDIX

EFFICACY TRIAL (French bean Cv. Rambo)

APPENDIX - I

Table 1. ANOVA of shoot height

Sl.No	Source	D.F	S.S	M.S	Fc	Ft
1	Treatment	3	436.9	83.33	40.07*	2.62
2	Error	24	49.07	2.04		
3	Total	29	465.97			

APPENDIX - II

Table 1. ANOVA of root length

Sl.No	Source	D.F	S.S	M.S	Fc	Ft
1	Treatment	3	252.32	52.46	7.05*	2.62
2	Error	24	160.20	6.40		
3	Total	29	492.21			

APPENDIX - III

Table 1. ANOVA of Dry weight of shoot

Sl.No	Source	D.F	S.S	M.S	Fc	Ft
1	Treatment	3	5.72	1.144	6.53*	2.62
2	Error	24	4.2	.175		
3	Total	29	9.91			

APPENDIX IV

Table 1. ANOVA of dry weight of shoot

Sl. No.	Source	D.F.	S.S.	M.S.	Fc	Ft
1.	Treatment	5	5.72	1.144	6.91*	2.62
2.	Error	24	4.2	.175		
3.	Total	29	9.92			

APPENDIX - V

Table 1. ANOVA of Nematode Number

Sl. No.	Source	D.F.	S.S.	M.S.	Fc	Ft
1.	Treatment	3	19.531	6.510	3255*	3.24
2.	Error	16	.032	.002		
3.	Total	19	19.563			

CASHEL TRIAL (French bean Cv. Prudence)

APPENDIX VI

Table 1. Analysis of Variance of dry weight of shoots

Sl. No	Source	D.F.	S.S.	M.S.	Fc	F_t
1.	Treatment	14	6.00	.42	21.00*	2.04
2.	Error	30	0.85	.02		
3.	Total	44	6.85			

APPENDIX-VII

Table 3 Analysis of Variance of Dry weight of Roots

Sl.No	Source	D.F	S.S	M.S	Fc	Ft
1.	Treatment	14	1.32	0.04	4.06*	2.04
2.	Error	30	0.30	.010		
3.	Total	44	1.00			

APPENDIX-VIII

Table 3 Analysis of Variance of Nematode Number

Sl. No	Source	D.F	S.S	M.S	Fc	Ft
1.	Treatment	14	5.04	.36	51.42*	2.04
2.	Error	30	.216	.007		
3.	Total	44	5.256			

* Significant at 0.05 level