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EFFECT OF DIFFERENT INOCULUM LEVELS OF ROOT KNOT NEMATODE (*Meloidogyne incognita*) ON THE GROWTH AND YIELD OF PEPPER (*Capsicum specie*).

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ABSTRACT

Pepper (Capsicum specie), is a widely grown vegetable worldwide but highly affected by root knot Nematode (Meloidogyne incognita) which poses a serious threat to pepper production. This study was conducted in the Screen House of the Department of Crop Production, Federal University of Technology, Minna, Nigeria, to investigate the effect of different inoculum levels on pepper. The experiment was laid out in completely randomized design, with seven treatments replicated four times. The inoculum levels were 0, 500, 1000, 1500, 2000, 2500 and 3000 of the second stage juvenile (J2) of root knot Nematode. Growth and yield data were collected, including Nematode population and gall index. From the results obtained, it was observed that increasing the Nematode inoculum level, resulted in corresponding increase in the number of root galls and final Nematode population.

Keywords: *Pepper, Meloidogyne specie, inoculum level, Root galls, Nematode population.*

INTRODUCTION

Pepper belongs to the genus *Capsicum* and is a member of the Solanaceae family. The genus consists of about 31 species with five domesticated species which are *C. annuum, C. Baccatum, C. Chinense, C. Frutescens*, and *C. Pubescen*. (Moscone *et al.*, 2007). Pepper (*Capsicum* spp.) is an important vegetable crop in the world. In terms of world production, Mexico ranks second with an annual production of 2,294,400 tons (Food and Agricultural Organization, FAO, 2015). There are many local cultivars grown in West Africa. Nigeria alone has more than 200 selections of pepper (Idowu-Agida *et al.*, 2012). According to Adesina *et al.* (2014), Nigeria produces 50 % of total Africa production. Peppers are grown sole or intercropped with other vegetables or in mixtures with starchy staple food crops, such as

Cassava (*Manihot* spp), Yam (*Dioscorea* spp) among others (Grubben and Tahir, 2004). Commonly produced *Capsicum* species can be divided into different groups based on fruit/pod characteristics, the characteristics ranging in pungency, colour, shape, intended use, flavour, and size. Despite their vast trait differences, most cultivars of peppers commercially cultivated in the world belong to the *C. annum* L species (Lin *et al.*, 2013). There are about 1,600 different varieties of this specie grown worldwide (Delelegn, 2011). Even though pepper is a high value commodity, which has the potential for improving the income and the livelihood of thousands of small-holder farmers in Nigeria, diversifying, and increasing Nigeria's agricultural export exchange earnings, the crop is confronted with various production and marketing related problems.

Pepper is of the tropical America origin; Peru and Mexico and spread to Europe where it is grown as shrub. From these countries it spread to other parts of the world such as African, Caribbean and Pacific countries (Ashilenje, 2013). According to Delelegn (2011), Pepper was introduced to Spain in 1493, England in 1548 and Central Europe in 1585. Currently the crop is grown in several countries of the world including India, China, Pakistan, Indonesia, Sri Lanka, Thailand, Japan, Ghana, Nigeria, Uganda, and Ethiopia among others. As important as the crop is, it's cultivation and production is faced with the common Agricultural problem of pest infestations which includes nematodes.

These Nematodes are economically important pathogens which infest mostly vegetable crops, in the tropics and subtropics they cause an estimate yield loss of 5 to 43 % in vegetable crops, (Gautam *et al.*, 2014). Among these pests whose infestations greatly affect growth and yield of pepper, is Nematodes infestations. The most notable of the nematodes is the root knot nematode (*Meloidogyne Spp.*) as stated by Delelegn (2011).

BOTANICAL DESCRIPTION AND CHEMICAL COMPOSTION OF PEPPER

Pepper matures early under low temperatures. Growth form varies from species to species. It has deep taproots with fibrous lateral roots that spread between 50 and 60 cm wide. Its flowers are small having white or purple petals (Ashilenje, 2013). Pepper flowers develop into fruits which are berries with several white coloured seeds. Fruits from different species of Pepper vary in colour, size, form and flavour, from very hot to mild or sweetly pungent.

After maturity, fruit colour can either be red, orange, yellow or purple but are commonly green before maturity. Ripe fruits of Pepper are rich in compounds with antioxidant and anticancer activities (Matapa *et al.*, 2013).

and day neutral crop of up to 45 % solar radiation. It thrives well in well drained sandy-loam top soils and pH of between 5.5 - 5.8. The nutrient requirement for Pepper production is put at 130 kg N, 80 kg P and 110 kg K while rainfall requirement for optimum growth is 600 mm (Grubben and Tahir, 2004). All members of the genus *Capsicum* accumulate carotenoids in their pericarp with cultivar-specific abundance and composition (Guzman *et al.*, 2010). The genus *Capsicum* (sweet and hot pepper) harbors incredible intra and inter-specific diversity in the following; fruit type, color, shape, taste, and biochemical content (Dagnoko *et al.*, 2013).

Pepper is an important source of capsaicin (Bello *et al.*, 2015). The capsaicin content is negligible in sweet bell peppers but highly concentrated (30,000 - 50,000 SHU) in hot chilli or jalapeno Peppers such that even handling or cutting the peppers can irritate the skin (Nwokem *et al.*, 2010). capsaicinoid alkaloids is the substances responsible for their pungency. They are characterized by a high biological activity and their pharmacological, neurological and dfetetic activities are well known, they significantly decrease serum, myocardial and aortic total cholesterol levels when used at low levels in the regular diet (Nwokem *et al.*, 2010). Components like the lectins from *C. annum* and *C. frutescens* have been reported to exhibit antifungal and sugar binding characteristics (Soumya and Nair, 2012).

Economic Importance Of Pepper

The world fresh chilli and sweet pepper production was 27.6 million tons in 2010, to which West Africa contributed 888,400 tons or 3.2 %. The biggest West African contributors are Nigeria and Ghana that ranked 8th and 13th, respectively (FAOSTAT, 2012 and Dagnoko *et al.*, 2013). The vast majority of West Africa's Pepper is sold in local or regional (Senegal, Gambia, Liberia, Sierra Leone and Mali), and international markets (Europe and North America). The crop therefore constitutes a source of income for resource poor households in rural and urban areas. In many parts of West Africa, women are the major processors, traders, buyers, and users in West African delicacies. There can benefit from the cash income potential of chilli Pepper. There are some *C. annuum* chilli varieties that are high fruit yielding, many fruits/plants, and attractive fruit colour and shape, and are easy to grow and harvest. They are suitable for use in poverty reduction programmes targeting resource poor households, which include women in developing countries. The cash income potential coupled with the fact that Peppers are easy to grow, harvest, and process makes them suitable for use in poverty reduction and food security improvement programmes (Dagnoko *et al.*, 2013).

The importance of Pepper as a food, medicinal, and industrial crop is on the increase. The pungent nature of hot Pepper makes it effective as a natural pest control product. Large amounts of Pepper are grown for export in developing countries to the European Union and other markets. This contributes to foreign exchange earnings to the respective countries and income to farmers, who are majorly small-scale growers (Ashilenje, 2013).

Pepper is widely used as a spice crop (Kim *et al*, 2014). After tomato and onion, it ranks third among the world's most important vegetable crops (Peet, 2006). It is considered as the first spice to have been used by human beings and there is archaeological evidence of pepper and other fossil foods from as early as 6000 years ago (Hill *et al*., 2013).

Peppers are important source of nutrients in human diet (Shetty *et al*., 2013; Moraes *et al*., 2013). It has high level of vitamin C (ascorbic acid), pro-vitamin A (carotene) and calcium. Intake of 50-100g of fresh pepper fruit can provide about 100 % and 60 % of the recommended daily amounts of vitamin C and A, respectively. Ripe fruits of pepper are rich in compound containing antioxidant and anticancer action (Materos *et al*., 2013). Pepper also contains other antioxidants such as chlorophyll, carotenoids, tocopherols and capsicinoids (Ornelas-Paz, *et al*., 2010). It produces neutral and acids phenolic antioxidants, which are important in plant for defense responses (Shetty *et al*., 2013).

Root-knot Nematode (*Meloidogyne* spp.) Infestations on Pepper.

Root-knot Nematodes (RKN) is a major plant pathogen, affecting several solanaceouse crops worldwide (Djian *et al*. 2007). Most species are parthenogenetic. Males of this specie can only be found under adverse condition (Jones *et al*., 2013).

In genus *Meloidogyne*, there are about 98 species but the most common species encountered by farmers are *M. Incognita, M. javanica, M. Hapla, and M. arenaria* (Jones *et al*., 2013). The root-knot nematode, *Meloidogyne incognita*, is a major plant-parasitic nematode affecting the quantity and quality of many annual and perennial crops (Wimatno *et al*., 2009). Root-knot nematodes (*Meloidogyne* species) are microscopic and parasitic in nature. They are mainly found in the roots of their host plants. They can exist either in hot climates or short winters around the world. Gill and Mcsorley (2011) reported that root-knot nematode is one of the most destructive groups of plant-parasitic nematodes and these nematodes are pests of almost all major crops. In addition, Karajeh *et al*. (2008) stated that about 5 % of the world crop production destruction is by *Meloidogyne* species every year.

According to Truggill and Blok (2001), *M. incognita* is easily found in every temperate and tropical country of the world, and it is possibly the single most damaging crop pathogen in the world. RKN are most abundant in the upper foot of soils,until a few feet deep. They are obligate biotrophic parasites and settles close to the vascular tissues in plant roots. Diseases resulting from RKN infections cause serious damage to agricultural production worldwide (Yong-hong *et al.*, 2016). They can infest more than 5000 plant species. They cause considerable quantitative and qualitative losses to crop plant (Naz *et al.*, 2013; Jaouannet *et al.*, 2013), and this lose result in an estimated N48 trillion losses worldwide annually (Ibrahim *et al.*, 2011). Nematodes are found in a wide range of habitats. Free-living nematodes live in the soil, in freshwater, marine sands and muds. In soil, they are important components of nutrient turnover. Other nematodes are parasites of almost every species of animal, humans, plant and cause enormous social and economic damage (Perry, 2011).

MATERIALS AND METHODS.

Description of the Study Location.

The research was carried out in the nursery and screen house of the Department of Crop Production, Federal University of Technology Minna, Niger State, during the 2020 cropping year. According to FAAN (2012), Niger State is located in the Southern Guinea Savannah agro-ecological zone of Nigeria and lies between latitude 6^0 8´ E and longitude 8^0 44^0 N of the equator. The State experiences distinct dry and wet seasons with an annual rainfall ranging from 1100 mm in the northern part to 1600 mm in the south with a mean of 1350 mm. The rainfall normally begins in April and ends in October, with its peak in September.

Collection and Sterilization of Soil for the Pot Experiment.

The soil was collected at a given depth from the University nursery. The collected soil was sterilized to kill harmful microorganisms and weed seeds that may be resident in the soil. The soil was sterilized using the method employed by Salaudeen and Aguguom, (2014). Using a trough, consisting of upper and lower metal piece will be perforated at the bottom, which will serve as the soil container, while the lower metal piece held the water.

To set up the trough, the bottom piece will be positioned on the metal stand having three stands for support and then half-filled with water. The upper pieces designed to fit tightly was positioned on the bottom piece filled with soil and covered with thick sacking and then moderately tight-fitted with a hole which will be made into the top of the soil. The covering was done to ensure sterilization to the soil surface.

Dry pieces of wood were set in the bottom piece, passing through the perforations at the lower part of the top pieces to effect sterilization of the soil until the soil temperature reaches 100°C.

Source of Pepper Seed.

Pepper landrace that is Borkono Danzaria and Borkono Danbauchi were purchased from seed sellers in Minna market.

Sources of *Meloidogyne incognita* Inoculums.

Galled Root of tomato plants were uprooted, washed separately in gently flowing tap water and dabbed dry with tissue paper.

RESULTS AND DISCUSSIONS

Effects of different levels of *M. incognita* inoculums on number of leaves of pepper landraces at 1 to 11 WAI are shown in (Table 4.1).

Number of leaves was significantly different among the pepper landraces at one, two, three and five WAI only. At all the sampling periods (weeks) Danzaria pepper consistently produced more number of leaves than Danbauchi which consistently produced less numbers of leaves.

The inoculation of pepper had significant effect on number of leaves at two weeks only such that pepper plants inoculated with 2500J2 of *M. incognita* inoculums had the highest number of leaves which was statistically similar to those of 500, 1500 and control while 2500J2 had the least number of leaves.

Interaction effects between different *M.incognita* inoculum levels and pepper landraces on number of levels at 6 WAI are shown in (Table 4.2).

The interaction effects of inoculum levels and pepper landraces on number of levels at 6 WAI. The combination of 1500J2 of M. Incognita inoculum with Danzaria produced the highest number of levels similar with the combination at 2500J2 with DanZaria and control with DanBauchi while all other combinations had similar lower number of levels except with the combination of 1000J2 and DanZaria.

Table 4.1 Effect of Different levels of *Meloidogyne incognita* inoculum on Number of Leaves of Pepper.

Landraces(LR)	Week(s) after inoculums										
	1	2	3	4	5	6	7	8	9	10	11
Danzaria	7.00a	11.00a	12.00a	13.00a	19.00a	19.00a	28.00a	37.00a	49.00a	64.00a	98.00a
Danbauchi	5.00b	8.00b	8.00b	9.00b	12.00b	13.00a	18.00a	25.00a	37.00a	58.00a	81.00a
SE±	0.55	0.63	0.80	1.11	2.13	2.59	4.12	6.28	8.04	10.98	15.53
Inoculums											

500	5.00a	8.00ab	10.00a	11.00a	13.00a	15.00a	20.00a	26.00a	38.00a	56.00a	96.00a
1000	7.00a	10.00ab	11.00a	11.00a	16.00a	10.00a	21.00a	30.00a	40.00a	56.00a	87.00a
1500	6.00a	10.00ab	11.00a	14.00a	22.00a	26.00a	26.00a	52.00a	67.00a	91.00a	127.00a
2000	6.00a	8.00ab	8.00a	8.00a	10.00a	12.00a	15.00a	19.00a	26.00a	34.00a	54.00a
2500	7.00a	12.00a	12.00a	13.00a	17.00a	17.00a	22.00a	28.00a	46.00a	49.00a	73.00a
3000	5.00a	7.00b	8.00a	8.00a	11.00a	12.00a	15.00a	20.00a	29.00a	41.00a	72.00a
0	6.00a	9.00ab	11.00a	13.00a	19.00a	22.00a	32.00a	41.00a	64.00a	87.00a	108.00a
SE±	1.03	1.18	1.50	2.07	3.93	4.84	7.88	11.74	15.03	20.54	78.00
Interactions (V×I)	NS	NS	NS	NS	NS	*	NS	NS	NS	**	*

Means with the same letters along the same column are not significantly differ4ence ($p \leq 0.5$) from each other by DMRT

WAI = Week(s) after inoculation, DMRT = Duncan Multiple Range Test, NS = Not Significant, * = Significant, ** = Very Significant, Vx I = Verity Interaction Inoculum, SE = Significant Error

Table 4.2 Interaction Effects Between Different Levels of *M.incognita* Inoculum and Pepper Landraces on Number of Leaves at Six WAI

	Landraces	
Inoculums	Dan Zaria	Dan Bauchi
500	13.00^{bcd}	13.00^{bcd}
1000	21.00^{bc}	10.00^{cd}
1500	36.00^{a}	8.00^{d}
2000	12.00^{bcd}	9.00^{cd}
2500	24.00^{ab}	10.00^{cd}
3000	12.00^{bcd}	10.00^{cd}
0	15.00^{bcd}	24.00^{ab}
SE±	6.85	

Means with the same letters along the same column are not significantly differ4ence ($p \leq 0.5$) from each other by DMRT. DMRT = Duncan Multiple Range Test, SE = Significant Error

Root knot nematodes (RKNs) are the most important groups of plant parasitic nematodes among which *Meliodogyne incognita* is very destructive to vegetables throughout the world (Kankam et al.,2014)

Findings from this study showed that different levels of *M. incognita* inoculums had varying effects on growth and yield of the two pepper landraces and the result on root weight, root galls and final nematode population showed that with increase in inoculums level, there was increase in both fresh and dry root weight, root gall and final nematode populations this is in line with several studies (Agaba *et al.*, 2015 and kankam *et al.*,2014

The taller plants produced by Dan Zaria pepper landrace in this study could an indication of its genetic inheritance, which may be in support of the utilization of growth factors such as water, nutrient and solar radiation and also its ability to

tolerate nematode infection. Peppers are host of *M. incognita* but the effect varies with varieties this is in line with the findings of Alejandro *et al* (2020) who reported that all Cucurbit crops are all host of *M. incognita* species but differ in host suitability, Chandra *et al* 2010 did a similar work and reported that the four members of *Cucurbitaceae* family namely; *Lageneria ciceraria, Cucumis sative, Momordica charantia* and *Cucurbita pepo*. They were found to be highly or moderately susceptible to *M.incognita*. Abass *et al* 2008 recorded variations in the effect of *M. Incognita* on the root of four cultivars of tomato.

Production of wider stem by Dan Zaria landrace in this study may be due to taller plants produced by this pepper landrace which might have enhanced it's interception of solar radiation and in turn resulted in higher photosynthetic process and hence wider stem production and may also be attributed to its genetic makeup. Varietal effect on how *M. incognita* affects plants is in conformity with the work of Bello *el al.*, 2015, their work was on seven varieties of pepper and tomatoes, at the end of the experiment, they rated the pepper and tomato as susceptible or resistant or tolerant and the rating had varying impact on their growth pattern.

Danzaria Landraces equally produced highest number of leaves, highest number of branches and higher number of pepper fruits, all this may still be attributed to the genetic make up of Danzaria which may have made it able to withstand the impact of the *M. incognita*. This is in line with the report of Alejandro *et al.*, 2020 who found out in their study that the family *cucurbitaceae* offers a remarkable genetic diversity due to their geographical origins, species domestication, vegetative and reproductive characteristics and range of adaptation to most climatic conditions.

Abass *et al.*, 2008 also worked on four different varieties reaction to *M. incognita* inoculum in different ways in their findings two varieties had better growth in terms of number of leaves flowers and show height as compared to other two cultivars used in their work. They reported that the variation in cultivars is natural because the cultivars had different genetic make up.

CONCLUSION AND RECOMMENDATION

From the result of this study, it is concluded that *M. inocognita* is a major pest of vegetables including pepper and it causes significant reduction in growth and yield of pepper. Danzaria landrace; plant height, number of leaves, number of branches and stem girth was found to perform better in all growth parameters studied than Danbanchi landraces. As the inoculum level increased there was increase in number of gall, fresh and final nematode population, however, there

was no corresponding increase in plant height, leaves number, stem girth and number of branches but at 1500J2 of the *M. incognita*, the plants performed better. Based on the context of this study, Danzaria Landrace of pepper was able to do better in terms of both growth and yield, it is recommended for the management of *M. incognita*. However, further research should still be carried out both on field and screenhouse in several growing seasons, before any recommendation to farmers can be made.

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