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Impact Assessment of Banana Fruit Peels Powder on *M. incognita* inoculated on Sweet Pepper (*Capsicum annuum* L) plants

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ABSTRACT

A screenhouse experiment was conducted at the landscape garden of Modibbo Adama University, Yola, to evaluate the efficacy of Banana fruit peel powder for the control of root-knot nematode on sweet pepper. The experiment consisted of five treatments replicated four times and was laid out in a Completely Randomized Design (CRD). Banana Fruit peel powder was incorporated at different levels into the bucket containing 4kg of sterilized soil. The plant powder was incorporated at 20, 25, 30 and 35g and tagged T1, T2, T3 and T4. Respectively. T5 was the control treatment with no level of powder. In the potted experiments, treatments with 35g of banana fruit peel powder had the best effect on M. incognita. Higher plant height, stem girth, number of leaves, galling index and least final nematode of both soil and roots were recorded. Therefore, from these findings, banana fruit peel powder at 35g exhibited a nematicidal effect on M. incognita in pepper plants, followed by 30, 25, and 20g, respectively. It was concluded that banana fruit peel powder, in addition to its nematicidal effect, is not phytotoxic on sweet pepper plants, providing a safe and effective solution for crop protection. More so, the nematicidal characteristics exhibited by this plant material might be due to some bioactive constituents present in banana fruit peel powder.

Keywords: Banana Fruit Peels Powder, *M. incognita*, Nematicidal, sweet pepper.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) is a cultural plant in tropical Central and South America, and it originates from Mexico and Guatemala (Nizomov and Khushvaktov, 2018). It is ranked third in the world after tomato and onion (FAOSTAT, 2012; Mustapha *et al*., 2021). It is one of the essential classes of vegetables extensively cultivated in sub-Saharan African countries (Baba *et al*., 2014; Obayelu *et al.,*2021). In Nigeria, pepper is the second most cultivated vegetable (Abu *et al*., 2020), which accounts for almost half of the African production, and it is grown all year round (under rain feed and irrigation) (Ayo-John and Odedara, 2017; Mustapha *et al*., 2021).

However, it thrives well under irrigation due to its sensitivity to abundant moisture and excessive temperatures (Almuktar *et al.,* 2015). It can also be grown in well-drained, fertile loam soil. However, it grows optimally at a temperature range between 21o C and 29o C (Nickels, 2012). It is sensitive to high salinity levels but thrives well in salinity conditions below 1280 mg L-1 (Food and Agriculture Organization FAO, 2003). According to Haifa Chemicals (2016), peppers produce well in light and well-drained soil rich in organic matter, such as sandy loam or loams with a pH value between 6.5 and 7.5.

Fresh pepper is usually used for salad and other meals, and most of it is used in processed form and also for the production of various preparations, condiments and powders (Nizomov and Khushvaktov, 2018). Pepper is a vital commercial crop cultivated for vegetable, spice, and value-added processed products (Kumar and Rai, 2005). Besides vitamins A and C, the fruits contain various antioxidants, notably carotenoids, ascorbic acid, flavonoids and polyphenols (Nadeem *et al*., 2011). This makes it an essential constituent of many foods, adding flavour, colour and spice and an important source of human nutrition. Its average consumption per person per day is about 20% (Ogunbo *et al*., 2015).

Although pepper is valuable and essential in the human diet, its production could be optimized to meet the market demand all year round. In Nigeria, the low production of pepper is attributed to many factors, such as poor varieties, poor cultural practices and the prevalence of pests/pathogens and diseases. Among such pests are Plant Parasitic Nematodes (PPN). Plant Parasitic Nematodes (PPN) significantly reduce crop yields in quantity and quality, a growing economic concern for the global agricultural industry (Shakeel *et al.,* 2022). These nematodes were reported to have caused about 8.8–14% of the annual crop losses worldwide at an

estimated cost of approximately USD 173 billion (Ahuja and Somvanshi, 2021). The three most economically significant groups of PPNs include cyst nematodes, lesion nematodes, and root-knot nematodes, which infect and proliferate on a wide range of plant species (Sikora, 2018) Root-knot nematodes (RKNs) (*Meloidogyne*sp.) are one of the groups with the highest pathogenic capacity and have the most significant number of hosts with about 105 described species in the genus *Meloidogyne: Meloidogyne arenaria, Meloidogyne hapla, Meloidogyne incognita, and Meloidogyne javanica,* in particular parasitize many vital crops (Ghaderi and Karssen, 2020). These RKN species attack the root vascular system of a plant, causing symptoms of water and nutrient transport deficiencies, which results in wilting and chlorosis, and eventually retard plant growth and reduce yields (Tapia-Vázquez *et al*., 2022). Control and management have become necessary considering the economic losses and damage caused by plant parasitic Nematodes.

For decades, the control of Plant Parasitic Nematodes largely relies on synthetic nematicides. However, the use of synthetic nematicides such as methyl bromide, 1, 3-dichloropropene, carbamates (oxamyl), and organophosphates (fenamiphos), among others, is being restricted because of their high toxicity coupled with the environmental risk associated with their use. (Walia *et al*., 2018). As a result of this, there has been an increased interest in the development of alternative methods of nematode control, and such alternatives include the use of plant parts in the control of plant parasitic nematodes. These plant parts can either be in extracts or powder form (Oka *et al*., 2000). Therefore, this study evaluates the effect of dry banana fruit peel powder on *M. incognita* inoculated on pepper plants.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out in May/June 2022 in the laboratory of the Crop Protection Department, School of Agriculture and Agricultural Technology, Biochemistry Laboratory, School of Life Science. The potted experiment was carried out at the landscape Garden of Modibbo Adama University Yola. Yola lies between Latitude 90 12'30.20" N and Longitude 120 28' 53.26" E at an altitude of 185.9m above sea level (Google GPS).

Source of experimental materials and Preparation of Banana Fruit Peels Powder

Sweet Pepper seeds were purchased from an Agrochemical shop in Jimeta's ultra-modern market in Yola, Adamawa state. And banana fruits were purchased from the market. Two

hundred and sixty-five grams (265 g) of banana fruit Peels were washed, chopped into smaller pieces and were covered with black cloth, kept under sunlight for (8) eight days and ground into powder using pistil and mortar (Otaviana and Atmaka, 2011).

Inoculum Source and Extraction of Nematode Juvenile

The second stages of juvenile (J2) *M. incognita* were extracted from an infested tomato plant cultured earlier in the landscape garden Modibbo Adama University Yola. The roots of the tomato were washed under running tap water. Clean roots were cut into 1-2 cm lengths, put in a sieve (25 mm pore), and gently placed in a large tray with water in it. The setting was undisturbed for 24 hours, and active nematodes passed through a sieve and sank to the bottom of the tray.

Treatment and Experimental Design

The experiment consisted of five treatments (T1, T2, T3, T4, and T5) replicated four times and was arranged in a Completely Randomized Design (CRD) on the laboratory bench the laboratory. (Ononujo and Nzewa, 2011).

Soil Sterilization

Sandy loam soil was collected from the landscape Garden of Modibbo Adama University, Yola, at a depth of 1 – 10 cm using a hand trowel. The soil was sterilized on fire in a large metal drum for 4 hours to get rid of another pathogen that may influence the plant growth. The soil was allowed to cool for 72hours, after which 4 kg from the soil was weighed and filled into each of the experimental buckets (Gautam and Goswani, 2007; Nkechi *et al.*, 2016),

Incorporation of Plant Powder

Ground powder of 20, 25, 30 and 35g were weighed and mixed thoroughly with sterilized soil and was allowed to decompose for 2weeks before transplanting Sweet pepper seedlings into each of the experimental pots.

Nursery Preparation

Sweet pepper seedlings were raised on a plastic tray containing sterilized soil for three weeks before transplanting into the experimental bucket. The seedlings were transplanted after 21 days of emergence into the experimental buckets containing 4 kg of sterilized soil mixed with the plant materials. Two seedlings were transplanted into each bucket after a week. The pepper

plants were irrigated at interval of three daysand weeding was done manually with hand at two-week interval.

Inoculation of *M. incognita*

The extracted juveniles (J2) of *M. incognita* were used to inoculate each of the pepper stands contained in the bucket with approximately 100 J2 of *M. incognita* contained in 100 ml suspension after two weeks of transplanting. The suspension was applied using 10 ml syringe into the root zone of the plant.

Data Collection

The data were collected on some growth, yield and nematode parameters.

Growth Parameters

Plant height and stem girth (cm) of each plant for all treatments were measured weekly starting from one week after inoculation (WAI) at an interval of one week for five weeks with a flexible measuring tape. For plant height, the measurement was done from the base of the plant to the terminal bud (Sowley *et al.,* 2013). The stem circumference of each plant in the pots was measured to obtain stem girth measurement. The number of leaves of each plant for all treatments was counted weekly, starting from one week after inoculation of seedlings at an interval of one week for a period of five weeks. The number of fruits from each plant was also counted at harvest.

Nematode Parameters

At harvest, sweet pepper plants were uprooted, and the number of galls was rated using a scale described by Bridge and Page (1980), which involved the use of a gall rating chart as follows:

0 = no knots on roots
1 = A few small knots difficult to find
2 = small knots only but clearly visible; main roots clean
3 = some larger knots visible, but main roots clean
4 = larger knots predominate, but main roots clean
5 = 50% of roots knotted; knotting on parts of main root system
6 = knotting on some of the main roots
7 = majority of main roots knotted

8 = all main roots knotted; few clean roots visible

9 = all roots severely knotted; plant usually dying

10 = all roots severely knotted; no root

Final Nematode Population

The final nematode population was determined from both soil (200 cm3) and root (5g). For the soil, 250 cm3 from each pot was used to determine the final nematode population (Coyne *et al*., 2007). A tissue paper was placed underneath a sieve, and soil was poured into it. The sieve was then placed in a tray, and water was poured gently on the tray, and the setting was left undisturbed for 24 hours. Active nematodes that passed through the sieve were collected and counted using a grid line Petri dish under a microscope, and their numbers were recorded. A similar procedure but without the tissue paper was adopted for extracting nematodes from the root, using 5g of roots from each pot.

Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA), and the means were separated using Least Significant Difference (LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Effect of Dry Banana Fruit Peel Powder on Growth and Yield of Sweet Pepper

Plant Height at 6 and 8 Weeks After Inoculation

The result shows that there was a significant difference ($p \leq 0.05$) between the treated and untreated (control) sweet pepper plants (Figure 1). Sweet pepper plants treated with 35g of banana fruit peel powder had the highest mean plant height, 39.21 and 42.18 cm, at 6 and 8 weeks after inoculation (WAI), respectively. The control (treatments with no powder) recorded the shortest plant height, 5.39 and 6.24 cm at 6 and 8 WAI, respectively (Figure 1). This indicates that applying plant powder into the experimental pots created a conducive and enabling edaphic condition for the plant to thrive and flourish. The control treatments clearly show the interruption of the growth potential of the plants as a result of the presence of PPN nematodes, whose action causes water and nutrient transport deficiency and eventually retard plant growth (Tapia-Vázquez *et al*., 2022).

Stem Girth at 6 And 8 Weeks After Inoculation

There were significant differences ($p \leq 0.05$) between the treated and untreated pots (control) at 6 and 8 WAT. However, sweet pepper plants treated with 35g of banana fruit peel powder had the widest stem girth (3.2 and 3.8 cm at 6 and 8 WAT), followed by those treated with 20, 25, and 30g which recorded 2.1, and 2.2 cm, 2.2 and 2.4 cm, 2.6 and 2.8 cm at 6 and 8 weeks respectively. In contrast, the control (0g of banana fruit peel powder) had the tiniest stem girth (1.3 and 2.6 cm at 6 and 8 weeks, respectively) (Table 2). This result is in line with that of earlier researchers (Sowley *et al.,* 2013; Solomon and Constance, 2018 and Ikram *et al*., 2022;) whose study revealed that the addition of plant powder to nematode-infested pots reduced nematode population density and increased the growth and performance of the test plant. Similarly, Oka (2010) observed that using plant parts can alter the physical structure and fertility of the soil, resulting in greater plant tolerance to nematode infection in terms of plant growth.

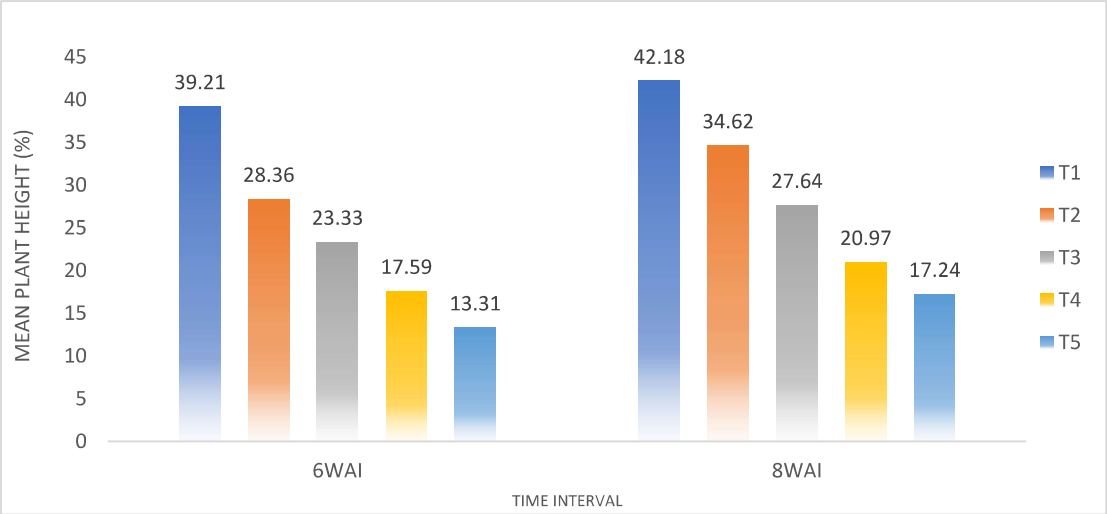

Figure 1.: Effect of Dry Banana Fruit Peels Powder on Plant Height

T1= 35g Dry Banana Fruit Peels Powder, **T2=** 30g Dry Banana Fruit Peels Powder

T3= 25g Dry Banana Fruit Peels Powder, **T4=** 20g Dry Banana Fruit Peels Powder

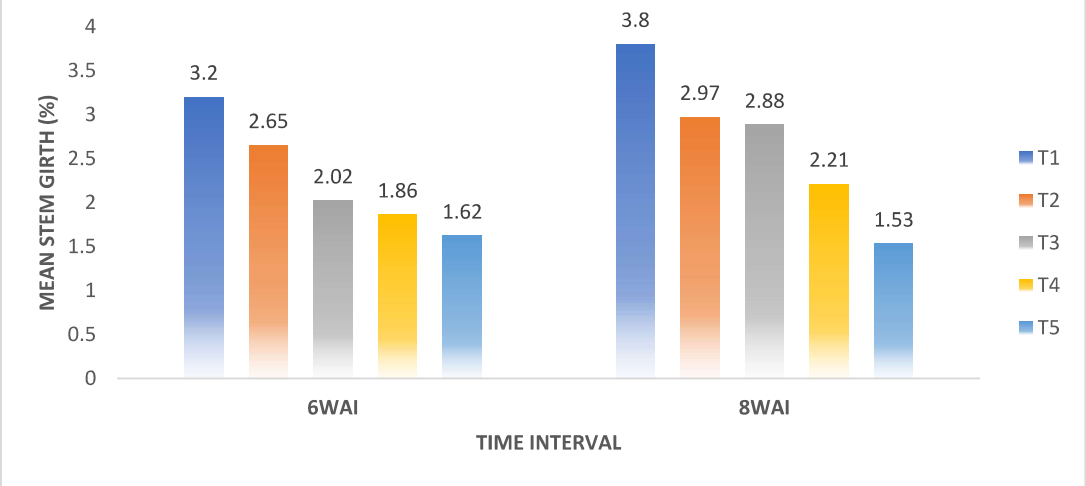

Figure 2. Effect of Dry Banana Fruit Peels Powder on Stem Girth

T1= 35g Dry Banana Fruit Peels Powder, **T2**= 30g Dry Banana Fruit Peels Powder

T3= 25g Dry Banana Fruit Peels Powder, **T4**= 20g Dry Banana Fruit Peels Powder

Number of Leaves and Fruits

The application of various levels of banana fruit peel powder had a significant impact on the test plant, particularly in terms of the number of leaves and fruits at 6 and 8 WAI. Notably, treatments with 35g of plant powder demonstrated the highest number of leaves (18.2 and 22.3) at 6 and 8 WAI and the highest number of fruits (19.36) at harvest. This promising result suggests that the application of the plant powder can significantly ($P \leq 0.05$) influence both the leaves and yield parameters. This aligns with the findings of Aktar and Malik (2000), who observed that organic amendment of plant powder can have beneficial effects on the soil physical and chemical conditions of plants, including the number of leaves, number/weight of fruit, stem girth, and plant height of the test plant.

The control plants, unfortunately, exhibited the least number of leaves, and the leaves appeared yellow due to nematode infestation at the root zone. This infestation hindered the uptake of water and nutrients, leading to the production of unhealthy leaves and a reduction in the plant's rate of photosynthesis. This sequence of events can ultimately lead to leaf discoloration and stunted growth. This observation is in line with the findings of TapiaVázquez *et al*. (2022), who highlighted the destructive nature of Root Knot Nematode (RKN) species. These nematodes attack the root vascular system of a plant, causing water and nutrient transport deficiencies, which result in wilting and chlorosis, and eventually retard plant growth and reduce yield.

Table 1. Effects of powder on No. of leaves and No. of Fruits After Harvest

Treatments	Effects of powder on No. of leaves		Effects of Powder on No. of Fruits After Harvest
	6WAI	8WAI	
35g	47	58.13	19.36
30g	38.33	48.62	14.25
25g	27.66	36.17	11.28
20g	11.66	17.64	8.71
0g (control)	8.74	13.42	4.35
P<F (p-value)	0.02	0.01	0.05
Standard Error	7.90	10.63	8.25

Effect of Dry Banana Fruit Peel Powder on Nematode Parameters

Galling Index

The results revealed significant differences between the treated and untreated plants with banana fruit peel powder. The treated pepper plants had a significantly lower galling index than the control pots. Plants treated with 35g of banana fruit peel powder recorded a galling index of 2.1, followed by 30 g and 20g, which recorded 3.5 and 4.2, respectively. The control recorded the highest galling index of 5.00 (Table 2).

Final Nematode Population in The Roots and Soils

The result indicated that the control pots (0g powder) had the highest nematode population in the test plants' roots and the experimental pots' soil compared to the treated pots. This could be due to the absence of banana fruit peel powder, which has the potential to inhibit nematodes in the test plants' roots.

The population of nematodes in the soils of the experimental pots was significantly ($p \leq 0.05$) reduced by all the banana fruit peel powder levels. As a result, the number of galls formed on the roots of the sweet pepper plants was also reduced. This could be due to the direct contact of the powder with the juveniles, which ensured that the active ingredients in the plant powder were essentially released to the juveniles. This result coincides with that of Godwin *et al*.

(2015), who discovered that the use of botanicals of *Azadirachta indica*, *Vernonia amygdalina*, *Manihot esculenta, Carica papaya*, and *Citrus sinensis* prevented the multiplication of nematode on sweet pepper, thereby reduces the severity of galls formation on the roots and enhanced plants growth due to their toxicity level.

Table 2. Effect of Dry Banana Fruit Peels Powder on Galling Index and Nematode Population

Treatments	Effects of powder on Nematode Population		Effects of Powder on Galling Index
	In Roots	In Soils	
35g	19.16	13.66	0.33
30g	31	23.13	1.29
25g	48.63	36.83	2.66
20g	73.21	50.31	3.36
0g (control)	89.72	79.38	6.48
P<F (p-value)	0.04	0.02	0.01
Standard Error	6.19	4.25	0.37

CONCLUSION AND RECOMMENDATION

The results of this study, which revealed the toxic nature of banana fruit peel powder to PPN and its role in enhancing the growth and yield of sweet pepper plants, offer promising benefits for the field of plant science. The potential bioactive compounds in banana fruit peel powder that proved lethal to *Meloidogyne incognita* in the experimental pots present a hopeful prospect for future research. Therefore, it is recommended that this study be replicated under field conditions with higher levels of plant powder (banana fruit peels) to determine its efficacy in the field.

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