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Effect of flamboyant flower (*Delonix regia)* powder on root knot nematodes (*Meloidogyne incognita)* infestation on tomato plant (*Solanum lycopersicum)* in Yola, Adamawa State

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Abstract

Plant Parasitic Nematodes (PPN) are regarded as one of the major challenges of sustainable tomato production in the world. Their control which involves the use of synthetic chemicals is being restricted because of their toxicity coupled with the environmental risk associated with their use. To this effect this study was carried out to evaluate the effect of flamboyant flower powder on *M. incognita* inoculated on tomato plants as an alternative control strategy of PPN. Screen house experiment (potted experiment) was conducted at the landscape garden of Modibbo Adama University Yola to evaluate the efficacy of plant powder for the control of root- knot nematode in tomato plant. The experimental design used was the Completely Randomized Design (CRD) with five treatments replicated three times. *D. regia* powders were incorporated at different levels into the bucket each containing 4kg of sterilized soil. The plant powder was incorporated at the rate of 40g, 30g, 20g and 10g (T_1, T_2, and T_3) respectively and T_4 with no level of powder 0g. *D. regia* powder and 40g gave the best effect on *M. incognita* in the potted experiments as higher plant height, number of leaves; fresh shoot weight, galling index and least final nematode of both soil and roots were recorded. Therefore, from these findings, *D. regia* at 40g exhibited nematicidal effect on *M. incognita* in tomato plant followed by 30g, 20g, and 10g respectively. The nematicidal characteristics exhibited by this plant material (flamboyant flower) might be due to some phytochemical constituents present in the plant material. The control plant has least plant height, number of leaves, fresh shoot weight, plant fruit and higher fresh root weight as well as galling index and highest final root and soil nematode population.

Keywords: *Delonix regia*, *M. incognita*, Nematicidal, Flower powder

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INTRODUCTION

Tomato (*Solanum lycorpersicum* L.*)* is one of the most widely grown vegetables in the world and regarded as one of the top priorities vegetables which is widely cultivated in tropic, sub-tropical and temperate climates according to FAO (2006). It originated in Andean region of South America and Central America. Nigeria is reported to be the second largest producer of tomato in Africa after Egypt and 13^{th} in the world with a production of six million tons annually (Ebimieowei, 2013). Tomato is adapted to a wide range of climatic conditions however the optimum temperature range for growth and development is 20 – 27^0C. It can also be grown in many types of soil but prefers deep well drained sandy soil with good organic matter confers with pH range of 5.5 – 7.0 (Vander vosson *et al.,* 2004).

Tomatoes are being consumed freshly in salads or cooked in sauces, it is also used as raw materials in food processing industries to process value added products like tomato paste, puree, ketchup and canned products (Ajagbe *et al.,* 2014). Tomato fruits contributes to healthy wellbeing of human because it is rich in minerals (potassium, magnesium, calcium, iron and zinc), protein (essential amino acids), citric acid, sugars, dietary fibers (pectin) and high levels of vitamins (A, B and C), Lycopene, and beta-carotene which serve as anti-oxidants against oxygen radicals that probably cause cancer, ageing and arteriosclerosis (Naika *et al.,* 2005). It is also regarded as the most profitable crop providing a higher income to small scale farmers compared to other vegetable crops (Bawa *et al.,* 2014).

Despite the importance and benefit of tomato, its production has been limited by so many factors such as its susceptibility to various pest and diseases. Among the various pest and diseases limiting the production of tomato are Plant Parasitic Nematodes (PPN). Plant Parasitic Nematodes (PPN) are being regarded as one of the major challenges of sustainable agricultural production in Nigeria and the world at large. 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). Root-knot nematodes (RKNs) (*Meloidogyne sp*.) are one of the groups with the highest pathogenic capacity and has the greatest number of hosts with about 105 described species in the genus *Meloidogyne*: *M. arenaria, M. hapla, M. incognita,* and *M. javanica* (Ghaderi, and Karssen, 2020). These RKN species attack the root vascular system of a plant, causing water and nutrient transport deficiencies, which results to wilting and chlorosis, and eventually retard plant growth, and reducing yields (Tapia-Vázquez *et al*., 2022). In addition, they suppress the host defense system, making plants more susceptible to other plant pathogens such as bacteria, fungi, and viruses (Goverse and Smant, 2014).

Application of chemical nematicides have been found to be an effective measure for the control of nematode but due to its toxic and residual effect (Aktar, 2014), couple with their non-availability besides the requirement of skilled labour for application, however, discourage its use, especially by small farmers who produced more than 70% of vegetables in Nigeria (Yusuf *et al.,* 2006). Because of the harmful effect of synthetic chemical nematicides on beneficial micro-flora and fauna in the soil, it is expedient to develop an alternative nematode control strategy (Bawa *et al.,* 2014). One of the alternative controls is 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 flamboyant flower powder on *M. incognita* inoculated on tomato plants.

MATERIALS AND METHODS

Experimental site

The experiment was carried out in the month of May/June, 2022 in the laboratory of Crop Protection Department Faculty of Agriculture, Biochemistry Laboratory Faculty of Life and potted experiment was carried out at landscape Garden of Modibbo Adama University Yola. Yola lies between Latitude 8^0 N and longitude 11.5^0 and 13.5^0 S at an altitude of 185.9m, above the sea level (Google GPS).

Source of experimental materials and preparation of flamboyant flowers' powder

Tomato seed Roma: VF was purchased from Agro-chemical shop in Jimeta ultra-modern market Yola, Adamawa state. And Flamboyant flowers were collected within the premises of Modibbo Adama University of Yola. Flamboyant Flowers Powder were prepared using the method described by Umar and Mohammed (2013). The flowers were shade dry under room temperature for seven days after which it was ground into powder.

Inoculum source and extraction of nematode juvenile

Second stages of juvenile (J_2) of *M. incognita* was extracted from an infested tomato plant using the modified Baermann method (Whitehead and Hemming, 1965); The roots of infested tomato plants were washed in fresh tap water. After that the roots were cut into 1-2 cm length and put in a sieve then gently placed in a large tray which had water in it. The setting was allowed undisturbed for 24 hours and active nematodes passed through sieve and sank to the bottom of the tray.

Treatment and experimental design

The experiment consists of five treatments (T_1, T_2, T_3, T_4, and T_5) replicated three times and was arranged in Completely Randomized Design (CRD) in the laboratory. (Ononujo and Nzewa 2011).

Soil sterilization

Sandy loam soil was collected from the landscape Garden of Modibbo Adama University, Yola at the depth of 1 – 10 cm. The soil was sterilized in a large metal drum for 4hours and was allowed to cool for 72hours (Gautam and Goswani, 2007), after which 4 kg from the soil was weighed and filled into each of the experimental bucket.

Incorporation of plant powder

Ground powder of about 10 g, 20 g, 30 g, and 40 g was weighed and mixed thoroughly with sterilized soil and was allowed to decompose for 2weeks before transplanting of tomato seedlings into each of the experimental bucket.

Nursery preparation

Tomato seedlings were raised on a plastic tray containing sterilized soil for 3 weeks before transplanting into the experimental bucket. Tomato 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 tomato plant was irrigated at the interval of three days and weeding was done manually with hand at two-week interval after transplanting.

Inoculation of *M. incognita*

The second stage juvenile extracted was used to inoculate each of the tomato stands contained in the bucket with approximately 1000 J_2 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 of each plant for all treatments were measured weekly starting from one week after inoculation (WAI) for six weeks with a measuring tape. The measurement was done from the base of the plant to the tip of the innermost leaves. The number of leaves of each plant for all treatments were counted weekly starting from a week after inoculation of seedlings for the period of 6 weeks after inoculation. Number of Fruits from each plant were counted after 6 weeks after inoculation. Also, fresh roots from each bucket were up-rooted separately; the root was separated from shoot and weighed using electric weighing balance. The fresh root weight from each bucket was determined by removing soil adhering to the root in order to avoid additional weight. The fresh root was weighed with an electric weighing balance. After getting the fresh root weight, the root was sun dried for two weeks properly and weighed using an electric weighing balance.

Nematode parameters

At harvest, tomato plants were uprooted and the number of galls were rated using a scale described by Anwar *et al.* (2007).
0 = no galls
1 = 1 – 2 galls
2 = 3 – 10 galls
3 = 11 – 30 galls
4 = 31 – 100 galls
5 = more than 100 galls.

Final nematode population

The final nematode population was determined from both soil (250 cm^3) and root (5 g). For the soil, 250 cm^3 from each pot was used to determined final nematode population (Coyne *et al., 2007*). A tissue paper was placed underneath a sieve and the soil was poured into the sieve. 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 which passed through sieve were collected and were counted using a grid line Petri dish under a microscope and their numbers were recorded. Similar procedure but without the tissue paper was adopted for extracting nematodes from root, using 5g of roots from each pot.

Data analysis

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

RESULTS

Mean plant height (cm) at 6 weeks after inoculation

Result of the screen house experiment presented in Figure 1, shows a progressive growth on the tomato plant that are treated with *D. regia* flower powder, compared to the untreated (control). Treatment with the highest level of *D. regia* flower powder (40g *D. regia* flower powder) had the highest mean plant height; (32.38) at 6 weeks after inoculation while the control (0g level of *D. regia* flower powder*)* recorded the lowest plant height (10.50).

Mean number of leaves at 6 weeks after inoculation

Tomato plant treated with 40g of the *D. regia* flower powder produced the highest mean number of leaves (36.28), followed by 30, 20 and 10g level of *D. regia* flower powder which recorded 27.16, 20.17 and 17.65 respectively. While the control (0g level of *D. regia*) had the lowest number of leaves (11.50) (Figure 2).

Mean fresh shoot weight (g)

The result shows that there is a significant difference between the treated and untreated tomato plants as shown in Table 1. Tomato plant treated with 40g *D. regia* flower powder recorded the highest shoot weight of 108.17 while 10 g recorded 50.22 and control recorded the lowest shoot weight of 14.47.

Mean fresh root weight (g)

The highest root weight was recorded in the control (0g) untreated pot/plant (19.07g). While the treated tomato plant recorded the lowest or least root weight (66.13g). The highest root weight recorded in the control could be as a result of numerous galls that were on the root due to (*M. incognita*) infestation that leads to the increase in the root weight (Table1).

Mean number of fruits at 6 weeks after inoculation

Tomato plant treated with 40g of *D. regia* flower powder recorded the highest number of fruits (23.67), followed by 30g which recorded (14.33), While the control (0g) recorded the lowest number of fruits (3.33) (Table 1).

Mean galling index

There is significant difference between the treated and the untreated tomato with *D. regia* flower powder. Treated tomato plants had significantly lower galling index than the control plants. Forty gram treated tomato plants recorded galling index of 1.00, followed by 30 and 20g which recorded 2.33, 2.67 respectively. The control recorded the highest galling index of 5.00 (Table 2).

Mean final nematode population in roots

The result shows that there is significant difference between the treated and untreated tomato plant as shown in Table 2. Tomato treated with *D. regia* flower powder recorded fewer final nematode population than the untreated plants. Forty gram treated tomato plants recorded 4.00, followed by 30g treated tomato plant which recorded 9.00 and the control recorded the highest final nematode population of 93.00 (Table 2).

Mean final nematode population in soil

Result on final nematode population in soil shows that there is significant difference between the treated and untreated tomato plants. Tomato plant treated with 40g of *D. regia* flower powder recorded the lowest final nematode population (10.0) while the control recorded the highest final nematode population (229.1) (Table 2).

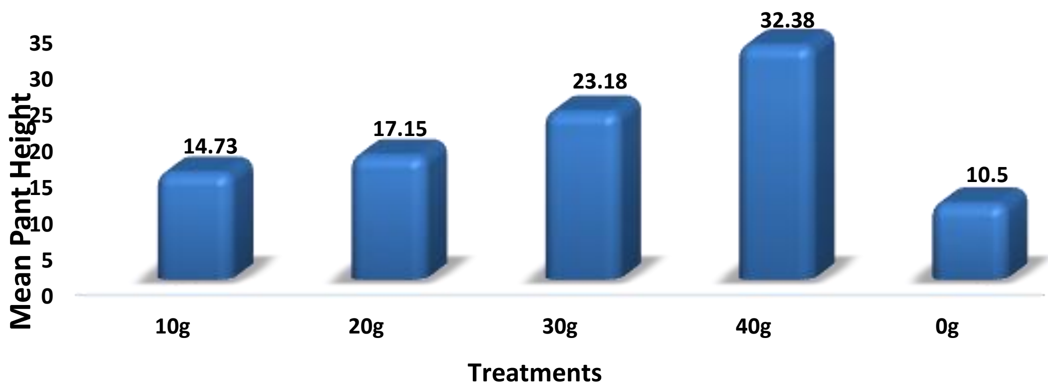

Figure 1: Effect of different levels of *delonix regia* flower powder on plant height at weeks after inoculation (cm)

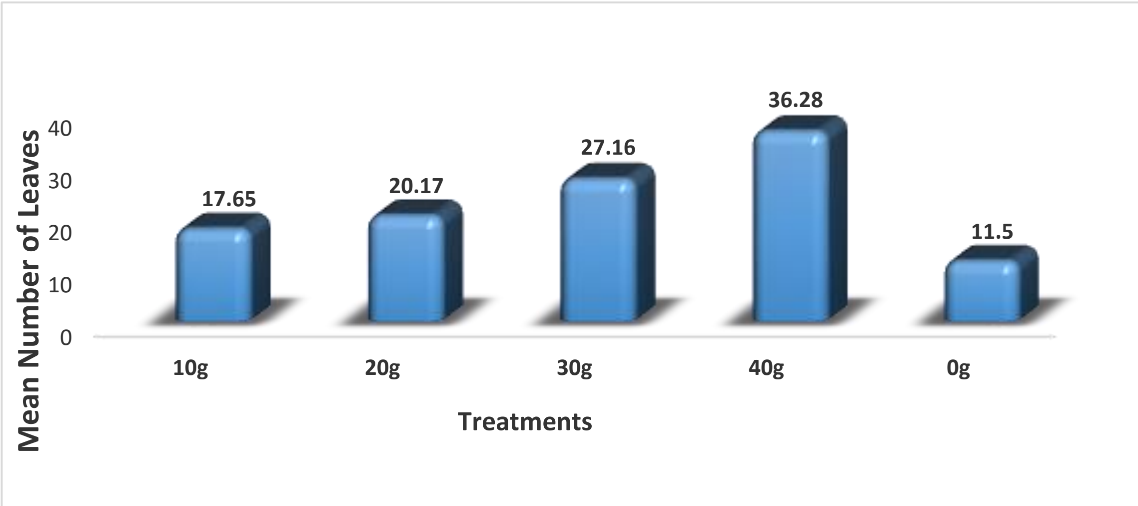

Figure 2: Effect of different levels of *Delonix regia* flower powder on number of leaves at 6 weeks after inoculation

DISCUSSION

Several plants have been screened for nematicidal bioactivity, and the most dominant species among them are; *Azadirachta indica*, *Melia azedarach, Eucalyptus* spp., *Ricinus communis*, *Satureja* spp., *Solanum* spp., *Allium* spp., *Thymus* spp., *Citrus* spp., and *Artemisia* spp., and of these, *A. indica* accounts for 16% (Mwamula *et al.,* 2022). The addition of organic material to the soil can be an effective alternative to the environmentally unsafe chemical treatments that are used to control plant parasitic nematodes (Marek and Peter, 2015). Utilizing plant extracts for suppressing nematode pests was previously investigated by several researchers including El-Nuby *et al.,* (2021); Alm and El-Nuby, (2019); Abdel-Rahman *et al.,* (2017).

The result of screen house experiment obtained from this study revealed that *D. regia* flower powder significantly reduced the population of *Meloidogyne incognita* in the soils of the experimental pots and in the roots of the test plant (tomato plant) which resulted to a corresponding increase in the plant growth and development (increase in plant height, number of leaves fresh shoot weight and number of fruits) after six (6) weeks of inoculation. Root damage was equally reduced in all treatments in proportion to the levels of *D. regia* flower powder and significantly different from the control treatments. This result conforms with those of earlier researchers such as Chitwood (2002) and Oka and Yermiayahu (2006) who reported the effectiveness of various plant extract used in their various experiments in suppressing both root and soil population buildup of nematode and consequent reduction in the root damage in the tested crops. The low performance of the control pots might be due to the absence of *D. regia* powder which resulted in the increase of the nematodes population (Aktar and Malik, 2000; Ahmed *et al.,* 2004).

Table 2: Effect of different levels of *D. regia* flower powder on some growth parameters on tomato plant

Treatments (g)	FSW (g)	FRW (g)	N F
10g	50.22	17.33	6.28
20g	60.11	15.87	10.00
30	88.22	14.33	14.33
40g	108.17	9.07	23.67
0g	42.60	66.13	3.33
SE	2.96	2.54	1.87
LSD	6.61	5.65	4.35

Key: FSW = Fresh Shoot Weight, **FRW** = Fresh Root Weight, **DRW** =Dry Root Weight, **NF=** Number of Fruit; **SE** = Standard Error**, LSD**= Least Significant Difference

Table 3: Effect of different levels of *D. regia* flower powder on the galling index and final nematode population on tomato plants

Treatments (g)	GI	FNP in roots (10 g of root)	FNP in soil/ 250 cm^3 of soil
10g	3.32	20.00	38.77
20g	2.67	11.00	33.03
30g	2.33	9.00	23.3
40g	1.00	4.00	10.0
0g	5.00	93.00	229.1
SE	0.86	3.18	19.54
LSD	1.94	7.08	43.54

Keys: GI = Galling Index, FNP = Final Nematode, SE = Standard Error, LSD= Least Significant Difference

Finding from this study indicates that Tomato plants treated with 40g level of *D. regia* flower powder produced highest number of leaves and fresh shoot weight than the control. This could be as a result of some of the phytochemicals present in *D. regia* flower powder which leads to an increase in quantity level of the test plant. The available nutrients and water help in facilitating the effect of the powder on plant root which resulted in increased in the growth and development of the plants. This agree with the findings of Aktar and Malik (2000) who discovered that organic amendment have advantageous effects on the soil physical and chemical conditions of plant. The control plants had the least number of leaves and the leaves appeared yellow due to nematode infestation at the root which hindered uptake of water and nutrients and in turn affected the production of leaves, thereby reducing the plant rate of photosynthesis which may consequently lead to discoloration of leaves and stunted growth. These agrees with the assertion of Tapia-Vázquez *et al.* (2022) who stated that Root Knot Nematode (RKN) species attack the root vascular system of a plant, causing water and nutrient transport deficiencies, which results to wilting and chlorosis, and eventually retard plant growth, and reduces yield.

Result on fresh and dry root weight revealed that highest root weight was recorded in control (untreated pot/plant). While the treated tomato plants recorded the lowest or least root weight. The highest root weight recorded in the control could be as a result of numerous galls that were on the root of the plants due to *M. incognita* infestation. This result is in line with the findings of Kumar *et al.* (2010), who discovered that galls otherwise known as root-knot causes increase in root weight of many Malvacious and Solanacious crops. Lowest root weight might be due to nematicidal ability and property of the powder in suppressing nematodes infestation (Javed *et al.,* 2008). Similar trend was observed in the result of galling index as well as final nematode population in the roots and soil of the tomato plants. Using 250cm^3 of soil and 5g of tomato root from each experimental pot. The result shows that the control pots/plants had the highest galling index which translate to higher nematode population in the soil and root of the plants compared to treated pots/plants. The presence of relatively high population of *M. incognita* in the control pots/plants might be attributed or ascribed to non-application of the *D. regia* flower powder at different levels which would have help in suppressing or inhibiting nematode penetration into the plant roots. The findings from the current study confirm with those from Ahmed *et al.* (2010); Adegbite, *et al.* (2005) and Umar and Aji (2013) who discovered that the use of botanicals of *A. indica, A. pavonina, L. leycocephala* and *Eucalyptus* species as treatments prevented the multiplication of nematode, there by reduces the severity of galls formation on the roots of tomato plant and enhanced plants growth due to their toxicity on *M. javanica.*

Result on yield per plant showed that tomato plant treated with *D. regia* flower powder were significantly different from the control (untreated plant) in terms of yield quantity. This significant increase in the production of fruit might be due to the toxic effect of the treatments on nematodes which in turn suppress their multiplier effect, thereby promote an increased soil fertility which facilitate or promote the performance of the plants to produce more fruits. These findings are in agreement with that of Olabiyi *et al.* (2013) whose finding revealed that leaf powder of pawpaw, tobacco and nitta significantly suppress the population of nematode and subsequently promote the production of tomato fruits.

Conclusion and Recommendations

Results from this study revealed the potency of *Delonix regia* flower powder as a viable alternative to harmful synthetic nematicide in controlling Root Knot Nematode; *Meloidogyne incognita.* Based on the findings from this study, it can be established that the extract of *Delonix regia* flower powder is effective not only in inhibiting egg hatch and causing juvenile mortality of *Meloidogyne incognita*, but it also improves the overall growth and development (increase in plant height, number of leaves fresh shoot weight and number of fruits) of tomato crops in screen house. Therefore, the adoption of these plant extract on Agricultural soil will serve as a better option to replace the hazardous and expensive synthetic nematicide found in the market today. However, further studies should be conducted to identify more active compounds in *Delonix regia* flower powder using other solvent (Ethanol, Methanol, *n*-Butanol) and also field experiment should be conducted to ascertain its efficacy.

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