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Research Article

Effects of *Ricinus communis, Chromoleana odorata* and *Sesamum indicum* on the growth of Tomato Plants and in Control of Root-knot Nematodes in Daloa (Côte d'Ivoire)

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ABSTRACT

Nematodes represents a threat for the growing of tomato in Daloa (Côte d'Ivoire). This study was carried out with the aim of proposing a non-chemical solution through the use of plants with nematicidal effect as an alternative against nematode attack. The experiment was conducted on a soil already infected with nematode of the genus *Meloidogyne* sp. Aqueous extracts of *R. communis, C. odorata* and *S. indicum* biomass were used to treat the soil before tomato transplanting. The design of this study was a completely randomized block with 5 treatments. The results showed that treatment with Sesame (*S. indicum* L.), Ricin (*R. communis* L.) and *C. odorata* improved the vegetative parameters of the tomato. The combination of Sesame and *C. odorata* revealed the best results. The results also highlight that these plants had a nematicidal effect. Treatments with *C.odorata* extracts were more effective (100%) root galls reduction. These results showed that *R. communis, C. odorata* and *S. indicum* could also be used to improve tomato yield.

Key words: *Chromoleana Odorata, Meloidogyne* sp., *Ricinus communis, Sesamum indicum*, Tomato.

INTRODUCTION

Côte d'Ivoire is a country with an agricultural vocation. Its economy is partly based on products exploitation from agriculture representing more than a third of its gross domestic product (GDP). In addition to cash crops, there are also food crops including market garden products which play an important role as they play an essential role in food (Messiaen, 1997). Unfortunately, the growing of market gardeners is more and more facing difficulties affecting production. Indeed, the intensification of market gardening has favoured the development of many bio-aggressors (viruses, fungi, insects, nematodes...). Nematodes of the genus *Meloidogyne* are one of the most groups on crops in the world. They are among the most devastating pests in vegetable crops, even leading to total crop failure (Jones *et al*., 2013). Due to their very wide host range, these nematodes have a significant economic value, especially in production areas where optimal conditions for their development are met: high temperature and crop rotation involving susceptible species (Castagnone and Djian-Caporalino, 2011). The damage is difficult to quantify due to numerous interactions with other fungal and bacterial pathogens (Djian-Caporalino *et al*., 2009). Tomato (*Lycopersicon esculentum* Mill.) is one of the most widely produced crops in the field and in gardens (Salunkhe and Kadam, 1998). In Côte d'Ivoire, it is probably the crop that pays the highest price for pest attacks. (Déclert, 1990).

Nematode damage remains the most important and most damaging to the tomato crop (Sawadogo *et al*., 2000). This damage leads to a loss of about 70% of production if sanitary measures are not taken (Soro *et al*., 2017). It is very difficult to control these pests, given their extreme resistance to adverse climatic conditions (cold and drought), their high physiological variability, and the fact that they are telluric (Djian-Caporalino *et al*., 2009).

Chemicals are the most common means of control used by farmers to disinfect the soil. But they cause serious economic, environmental and health problems. Indeed, they not only pollute plants but also leave toxic residues for consumers (Cayrol *et al*., 1992). As a solution to these

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problems, the search for alternative methods to the frequent use of these products is encouraged. Thus, to reduce the use of synthetic pesticides and the damage caused by root-knot nematodes, research has been directed towards the use of plants with nematicidal effects which are of increasing interest because of their ecological advantages (Mezerket, 2009). Therefore, the aims of this study is to improve tomato production in Daloa region through the use of plant extracts.

MATERIALS AND METHODS

Study area

The experiment was conduted in Daloa within the University Jean Lorougnon Guedé (Daloa), precisely on the site for the school project field with geographical coordinates: 29°N 0783663; UTM 0765866 254 m. Daloa is located at 6°53 north latitude and 6°27 west longitude and is the capital city of the Haut Sassandra region that is located about 141 km from Yamoussoukro, the political capital city, and about 400 km from Abidjan, the economic capital.

Plant material

The plant material consisted of Ricinus communis (Castor) seeds, Chromolaena odorata leaves and biomass of Sesamum indicum (sesame) harvested within the University Jean Lorougnon Guédé of Daloa and tomato seeds certified F1 LINDO bought in an approved sales point Semivoire.

Assessment of the level of nematode infestation from the study site

Sampling of the study site which had previously been cultivated with okra and eggplant, was carried out to determine the level of galls nematode infestation in the plot. Soil and root samples of infested plants were collected. These samples were taken to the laboratory for analysis. The nematodes were extracted by the modified Baermann method or plate method, or the Whitehead plate method was used for the extraction of nematodes (Coyne *et al.*, 2010). This method provides a reliable estimate of nematodes in soil, roots, seeds and plant tissue and is easily repeatable. After extraction, the solutions were heated in a water bath at 60 c to kill the nematodes followed by binocular microscope observations. The nematodes were identified with the method of Bridge and Page (1980) and then counted.

Experimental device

The experimental device used is a completely randomized block or Ficher block with 3 repetitions. The system consisted of 15 elementary parcels. The distance between two treatments was 1 m and on the 0.5 m line. It consisted of 5 treatments and the different treatment compositions were recorded in Table 1.

Evaluation of *C. odorata*, *R. communis* and *S. indicum* on tomato root galls

To obtain the aqueous extracts of *C. odorata*, the leaves were harvested and dried under laboratory conditions for 7 days. They were then macerated in tap water. For *R. communis*, the seeds were dried for 2 days, then crushed in a mortar and the crushed material was infused with water. For *S. indicum*, the fresh aerial biomass of the 60-day old crop at the time of fruiting, was cut up and used for the treatments.

Thus, after the preparation of the *C. odorata* and *R. communis* extracts, the solutions obtained were used to treat (water) the different packets with a concentration of 50g/L each. The extracts were applied only once, four hours before transplanting the tomato plants. For *S. indicum*, the aerial biomass of the cut plants was buried in the bunches seven days before transplanting the tomato plants and regularly watered to accelerate the decomposition of the buried pieces. For the control plants, they were treated with water only. The 25-day old tomato seedlings were transplanted on the experimental plot treated with *R. communis* and *C. odorata* extracts and *S. indicum* leaves at the rate of one seedling per plot. The plants were regularly watered during their growth with two daily waterings. Manual weeding was done every 2 weeks.

The growth parameters, incidence and severity of root galls were evaluated 45 days after replanting. The growth parameters included collar diameter, number of leaves and plant height.

For the incidence and severity of root galls, tomato plants were dug up. Plants with galls were counted and calculated using the following formula:

$$Incidence = \frac{Number\ of\ diseased\ plants}{Total\ number\ of\ plants} \times 100$$

Severity was assessed using the indexing table for Gall Nematodes based on Bridge and Page (1980) in (Coyne *et al.*, 2010). The severity scale starts from 0 (no gall on the roots, all roots are healthy) to 10 (All roots have galls).

Statistical analyses of the data

Data processing was performed using XLSTAT version 2016 software. The Kruskal-Wallis Test was used to determine the effect of bionematicides on the measured parameters. The Dunn test was performed to classify the different treatments into homogeneous groups, where a significant difference was observed at the 5% threshold.

RESULTS

Level of nematode infestation at the culture site prior to treatment

Before the various treatments were applied, a diagnosis was made on the experimental plot. The number of plants of okra and eggplant with gall and the severity of the disease were determined. The incidence of disease (galls) was high (88%). The gall severity of these two plants ranged from 0 to 9 (Fig. 1).

Effect of *C. odorata*, *S. indicum* and *R. communis* on the growth of tomato plants

The different treatments had an effect on the growth parameters of the tomato plants. The diameter of the collar varied from one treatment to another. The analysis found a very highly significant difference (P 0.0001) between the treatment with sesame, *R. communis*, the combination of sesame and *R. communis*, *C. odorata* and the control. However, plants transplanted to soil treated with castor, C. odorata, S. indicum, and the combination of S. indicum and R. communis are more vigorous than control plants. The plants treated with the combination of sesame and *R. communis* had a higher mean (0. 52 cm) than that of the

Table 1: Different formulations used

N°	Treatments	Designation
1	T	Control
2	R	Aqueous extract of *R. communis* seeds
3	S	*S. indicum* biomass
4	C	Aqueous extract of *C.odorata*
5	R+S	Aqueous extract of *R. communis* seeds + *S. indicum* biomass

Table 2 : Average growth parameters of tomato plants from different treatments

Treatments	Diameter (cm)	Heights (cm)	Number of sheets
S. indicum	0 .45 ± 0.11^{b}	27.7 ± 3,44^{b}	9.1 ± 2.5^{b}
R. communis	0.47 ± 0.09^{bc}	29.17± 2,42^{bc}	9.17 ± 1.4^{bc}
R. communis +S. indicum	0.52 ± 0.09^{c}	30.7 ± 2,66^{c}	10.27 ± 1.8^{c}
C. odorata	0.44 ± 0.13^{b}	28.03 ± 4,96^{b}	8.7 ± 2.61^{b}
Control	0.15 ± 0.07^{a}	14.46 ± 4,43^{a}	4.30 ± 1.1^{a}
Average	0.41 ± 0.16	26.01 ± 6,94	8.33 ± 2.8
P-Value	< 0.0001***	< 0.0001***	< 0.0001***

*** : Very highly significant difference. Means followed by the same letter in a column are not significantly different at the 5% threshold (Dunn's test).

Table 3: Incidence and average severity of galls on the roots of tomato plants from treatments.

Treatment	Incidence (%)	Severity
S. indicum	13 ± 35^{a}	0.17 ± 0.46^{a}
R. communis	17 ± 38^{a}	0.27 ± 0.64^{a}
R. communis + S. indicum	10 ± 31^{a}	0.1 ± 0.39^{a}
C. odorata	0 ± 0^{a}	0 ± 0^{a}
Control	77 ± 43^{b}	7± 4.8^{b}
P-Value	< 0.0001***	< 0.0001***

*** : Very highly significant difference. Means followed by the same letter in a column are not significantly different at the 5% threshold (Dunn's test).

control which was 0.1 cm. The plants obtained after that treatment had a higher diameter (0/52 cm) that the individual treatments of *S. indicum*, *R. communis* and *C. odorata* whit diameters 0.45 cm; 0.47 cm and 0.44 cm respectively.

For the height of the plants evolution on the treatments was appreciated through the crown height at the apex (Hc) (45Jar). The analysis revealed a very high significant difference (P 0.0001) between the treatments and the control. The average height of untreated plants (14.5 cm) is 2 times lower than that of plants treated individually with *R. communis*, *C. odorata* and sesame, whose averages are 29.7 cm, 28.03 cm and 27.7 cm respectively. All treatments participate in the growth of plants.

For the average number of sheets, statistical analysis of the data showed that there is a very significant difference (P 0.0001) between the different treatments and the control (Table 2). Analysis of the data revealed that treatment with sesame, *R. communis* and *C. odorata* had mean values of 9.1; 9.16 and 8.7, respectively, which are twice the mean of the control (4.43). In addition, *R. communis* and sesame association contained the highest average (10.26) of leaves.

Effect of *C. odorata*, *S. indicum* and *R. communis* on the Incidence of Root Galls on Tomato

The incidence of root galls ranged from 0% to 17% for a 77% treatment for the untreated control (Fig 2). All treatments performed significantly reduced gall formation especially treatment with *C. odorata* has 100% reduction.

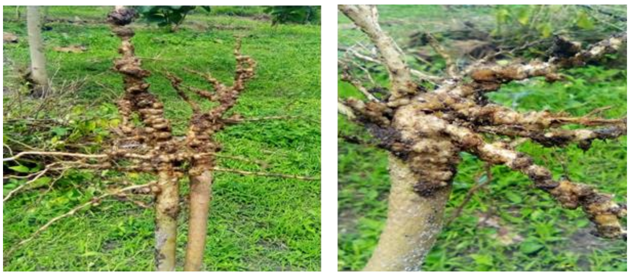

Fig. 1: Nematodes root-knot damages observed on tomato crops (A), okra (B) on the growing site.

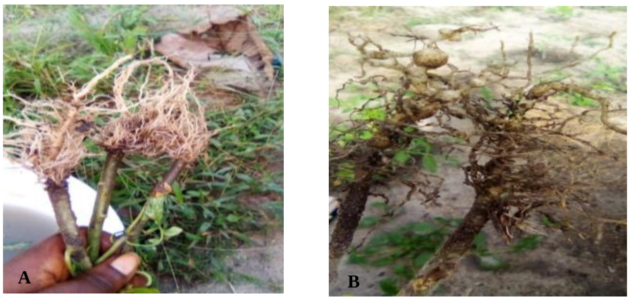

Fig. 2 : Tomato roots treated with C. odorata, S. indicum and R. communis on tomato roots. (A)root treated (B) untreated roots.

Statistical analysis of the wales incidence data showed that there is a very significant difference (P 0.0001) (Table III) between *C. odorata*, *S. indicum* or *R. communis* the different treatments and the control. Individual treatments of R. *communis* and *S. indicum* had a significant effect on gall formation with an incidence of 13% and 17% respectively, when these two plants were combined (*R. communis* and *S. indicum*), only 10% of plants were attacked by the disease. On the other hand, the treatment of the soil alone with *C. odorata* ensures the protection of the tomato against galls with 0% of the plants affected by the disease. For controls, 77% of plants had root galls.

Effect of *C. odorata*, *S. indicum* and *R. communis* on the severity of root galls of tomato plants

Statistical analysis of the severity level data showed a very highly significant difference (p < 0.0001) between the different treatments and the control (Table 3). Tomato plants were severely attacked on untreated soil (control). The mean severity was 7. After the different treatments, the galls were strongly reduced on the root system. The severity varied from level 0 to 2 for the individual treatments of *S. indicum* and castor; from level 0 to 1 for the combination of *S. indicum* + *R. communis* and level 0 for *C. odorata*. At this stage, some galls began to be visible while for other plants were few and difficult to see. However, for the treatment with the *C. odorata* extract, the galls were reduced to 100%. No galls were found on the root system and the severity level was 0 (no galls on the roots).

DISCUSSION

This study revealed that for vegetative parameters, treatment with Sesame (*Sesamum indicum* L.), Ricin (*Ricinus communis* L.), the combination sesame + sesame and *C. odorata* highlighted the best results. The gains in height, collar diameter and number of leaves could be due to the improvement of the nutrients released by the extracts of these plants. These extracts with their action on soil microorganisms allowed the plants to repel these organisms and be even more vigorous.

In fact, the combined contribution of sesame with *R. communis* oil permitted to record tomato plants with the highest heights, diameters and number of leaves. The performance of sesame combined with *R. communis* could be explained by their combined effect on tomato plants. The results are in line with those of Koffi *et al*. (2017) who recorded a gain in length of tomato plants with *R. communis* treatment. In addition, sesame would have a significant effect on the physical properties of the soil, which would justify the good growth of tomato plants. For Anon (2002), sesame provided an excellent rotation for corn, peanut, wheat and sorghum. It is an excellent soil builder by improving soil texture and moisture retention. He also posit that sesame reduces soil erosion by these networked roots. Sene *et al*. (2018) note that growing sesame allows better soil moisture retention and therefore increases the development and yield of the following crop.

Treatment with *C. odorata* also induced higher values than the control. C. odorata extract has induced the emission of plant growth. This can indicate a fertilizing activity of the soil, which explaining the fact that this plant is used in fallow land. The work of Tshinyangu *et al*. (2017) showed that for crown diameter, treatment with *C. odorata* resulted in a larger diameter than that of the control. Kra *et al.* (2009) also report that the fertilizing properties of *C. odorata* extract promote normal emission of new leaves from seedlings by limiting their early yellowing. Results from Ognalaga *et al*. (2016) showed that the ashes of *C. odorata* are used as fertilizer to improve the growth and production of Guinea sorrel (*Hibiscus sabdariffa* L.).

The use of sesame, *R. communis* extract and *C. odorata* significantly reduced the formation of galls on tomato roots. This result is due to the proven efficacy of certain plant extracts including *C. odorata* against root galls nematodes. The reduction of galls on tomato roots with of the *C. odorata* extract shows that there is an active ingredient that would inhibit the growth of nematodes. These results are similar to those of Adegbite and Adesiyan (2005) who indicated in their work that *C. odorata* has alkaloids, flavonoids and other chemicals that give it these nematicidal properties. Our results showed 100% reduction of galls on the roots of tomato plants confirming the fact that this plant has nematicidal properties. Akpheokhai *et al.* (2012) report that *C. odorata*, in addition to alkaloids, flavonoids, saponins also contains amides and ketones which are decomposition products of organic matter with an effect on nematode populations. This is confirmed by Adeniyan *et al*. (2008) who made a direct application of *C. odorata* as mulch and in natural fallows, which reduced the population of *Scutellonema* spp on yam.

Pavaraj *et al*. (2012) and Umar and Mamman (2014) highlight that the saponin and tannin contained in *C. odorata* were responsible for the inhibition of egg hatch which constitutes the pathogenicity of nematodes. Kamatchi *et al*. (2019) reveals that *C. odorata* and Annona squamosa are lethal inhibitors for juveniles and highly toxic to the hatching of *Meloidigyne incognita* eggs.

Soil treatment with sesame significantly reduced the formation of galls on the tomato roots as well. This implies that this plant contains essential elements against the attack of these aggressors. Indeed, plants such as sesame contain active substances that have a repulsive effect and can be secreted at the roots and then act either by inhibiting the penetration of juveniles, inhibiting the hatching of eggs or poisoning nematodes (Cayrol *et al*., 1992). These results are consistent with those of Sene *et al.* (2018) who showed that sesame reduced the population of nematodes attacking cotton and groundnut. The use of castor oil extract also significantly reduced the formation of galls on tomato roots. This means that castor oil would therefore contain substances that promote the reduction of galls on tomato roots. The results of Koffi *et al.* (2017) showed that castor oil treatment has an effect on reducing the incidence of the disease (36%). Villeneuve and Djian-Caporalino (2013) revealed that castor beans and sesame are non-host or immune plants that cause the death of nematodes because these plants do not cause their development.

The combination of *R. communis* and sesame practically prevents the formation of galls by 90%. These results show an added effect of the nematicidal properties that these plants possess. The combined effect of the treatments on nematodes effects has been mottled by many authors. Indeed, Koffi *et al.* (2017) showed that the two-by-two combination of cow dung with *R. communis* and other nematicide products virtually prevents the formation of galls. The efficacy of certain plants in controlling nematodes was also demonstrated by Naz *et al*. (2015). They showed that 30 g/Kg of Fumaria parviflora dry root powder soil significantly reduced the number of galls, eggs and females per gram of root.

Conclusion

The results of this study showed that all treatment modalities resulted in a greater positive response compared to the control for all parameters. The study showed that treatment with these plants (*S. indicum*, *R. communis* and *C. odorata*) improved the vegetative growth of tomato plants compared to the control and induced a reduction of galls and the level of severity of this disease on the treated plants. This gall reduction is more significant in *C. odorata* extract where the incidence was 100. The *R. communis* and *S. indicum* combination was 90% effective with a severity level that varied from 0 to 1. This field study highlighted the bionematicidal effect of Sesame, *R. communis* and *C. odorata*. The use of these nematicidal plants is a credible and viable alternative to chemical control of tomato root-knot nematodes.

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