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Effect of *Tithonia diversifolia, Alchornea cordifolia*, and *Mezoneuron benthamianum* on Tomato (*Lycopersicon esculuntum*) Nursery in Daloa (Côte d'Ivoire)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Research of alternative solutions to the use of synthetic pesticides.
Study Design : Randomized block.
Place and Duration of Study: Jean Lorougnon Guédé University (Daloa, Côte d'Ivoire), January to February 2020.
Methodology: Extracts of *Alchornea cordifolia*, *Tithonia diversifolia* and *Mezoneuron benthamianum* were evaluated *in vitro* and in the nursery at 5 g/l, 15 g/l and 25 g/l. *In vitro*, the blotting paper method was used on tomato seed germination. In the nursery, the powdery extracts were added to the nursery soil bags with four treatments (5 g/l, 15 g/l, 25 g/l and control) and six bags per treatment with five tomato seeds per bag. Germination rate, number of leaves, height and the health status of the plants as well as the incidence and severity of root galls were evaluated.

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The results showed that *in vitro* the control had the highest average germination rate (98.5%) followed by *T. diversifolia* (43.03 to 98.5%), *A. cordifolia* (35.33 to 68.67%) and *M. benthamianum* (37.66 to 67.55%). However, in the nursery, *T. diversifolial* recorded the highest average treated seed germination (38 to 78.33%) and seedling emergence (12.78 to 38.33%) rates compared to the other treatments. Concerning growth parameters, the number of leaves (5.38 to 13.21) and height (5.71 to 15.64 cm) of tomato plants were influenced by the extracts type and concentration. The incidence of root galls was low for treated plants (0-60%) compared to controls (100%). The severity of the galls was significantly reduced by the extracts, however the extracts of *T. diversifolia* were the most effective. Extracts were more effective at low concentrations in improving agromorphological parameters of tomato, in contrast to the incidence and severity of galls which were reduced at high concentrations. Results suggest that these locally available plants could be used as biofertilizers and control method against root-knot nematodes.

Keywords: Symptomatology; tomato; Alchornea cordifolia; Tithonia diversifolia; Mezoneuron benthamianum.

1. INTRODUCTION

Market gardening occupies an important place for human consumption and contributes significantly to the income of families in West Africa [1]. They also play a key role in most nutrition and poverty reduction programs [2]. In Côte d'Ivoire, market gardening is now practiced in all agricultural production zones [3]. The tomato represents the second fruit vegetable in the range and in relative importance after the variety "N'drowa" (*Solanum aethiopicum* L.) of the traditional vegetables found on the Ivorian markets [3,4]. Its production, initially limited to small village plantations, has developed very rapidly since the establishment of large market garden areas by SODEFEL [5]. However, these vegetable crops in tropical areas are subject to strong parasitic pressure from various origins (bacteria, fungi, insects, nematodes, etc.) [6], favored by the heat and humidity conditions. The pressure of these pests has been identified as the major constraint due to the extent of crop losses inflicted on market gardeners [7]. Among these pests, nmatodes of the genus *Meloidogyne* are the most formidable and can cause significant losses, or even wipe out all production. The damage of *Meloidogyne* or knotty root- nematodes are recognizable easily by symptoms produced [8]. In addition to pests and diseases, we are witnessing the decline in soil fertility which is mainly due to strong demographic pressure and poor land management practices which subsequently lead to depletion of soil nutrients [9]. Indeed, soil fertility has several components including organic matter and the C / N ratio which conditions the mineralization process. Numerous studies carried out on natural plant extracts have shown the effectiveness of plants such as *Pawpaw* and *Azadirachta indica* used in soil fertilization and in the control of crop pests [10]. Also The success of a tomato crop largely depends on the quality of the plants produced in the nursery. To ensure seed protection, it is therefore necessary to adopt methods that are environmentally friendly, efficient and accessible to producers in order to increase the productivity of tomato soils by optimizing the nursery. It is in this context that our work falls under the theme "Effect of extracts of *Tithonia diversifolia*, *Alchornea cordifolia*, and *Mezoneuron benthamianum* on tomato in the nursery".

2. MATERIALS AND METHODS

2.1 Biological Material

Plant material consisted of the leaves of *Tithonia Diversifolia*; *Alchronia Cordifolia* and *Mezoneuron Benthamianum* used for soil treatment and tomato plants of the variety Cobra 26. The cultivation soil was taken from a tomato cultivation site that had suffered a heavy attack of root-knot nematodes.

2.2 Methods

2.2.1 Preparation of plant extracts

The leaves of three plants species (*T. diversifolia; A. cordifolia* and *M. benthamianum*) were collected in the vicinity of the University Jean Lorougnon Guédé (UJLOG) for the production of extracts. These leaves were dried in the shade at room temperature in the laboratory (25-27 ° C ± 2), as exposure to sunlight often reduces effectiveness [11]. They were then powdered separately.

2.2.2 Evaluation of the effect of the extracts *In vitro* on seed germination

Laboratory test was carried out to assess the influence of the extracts on seed germination. For each plant extract, tomato seeds are cultured in 90 mm kneaded dishes containing variable concentrations (5 g / L, 15 g / L and 25 g / L). method used to seeds germination rate assess is the blotting paper consisting of placing 10 grains on sheets of blotting paper previously soaked with the desired aqueous extract and then leaving them in incubation at the laboratory temperature (25 to 27 ° c ± 2). An alternating 24-hour watering cycle with distilled water is carried out throughout the experiment and germination rate was assessed after ten days.

2.2.3 Evaluation of the effect of extracts in the nursery

Seeding was done in nursery bags each containing a substrate treatment consisting of the growing soil and powders of the three plants. The quantities of 5, 15 and 25 g of powder were weighed and mixed with 1000 g of growing soil constituting three treatments (T1, T2 and T3 respectively). The resulting mixture was placed in nursery bags at a rate of two kg per bag. For each treatment, six bags were used. The experimental setup is a completely randomized block with two sub-blocks. Each sub-block consisted of four treatments (control + three different concentrations 5 g/l, 15 g/l and 25 g/l) and each treatment was repeated three times. Ten seeds per bag were sown at a depth of 0.5 to 1 cm in the bags containing the different formulations at a rate of six bags per treatment. The cultures were incubated under a mosquito shelter for 21 days.

2.2.3.1 Germination and growth parameters

Germination rate and number of emerged seedlings were assessed 5, 10, and 15 days after sowing. Germinated seeds were evaluated according to treatments and concentrations for each plant. The rate of seedling emergence (Cv) was assessed according to [12].

$$Cv = \Sigma Ni / \Sigma NiTi$$

Cv: Speed of emergence of seedlings; Ni: Number of seeds germinated per treatment; Ti: Time at which the seed germinates

The growth parameters of the number of leaves per plant and the height of the plants (cm) were recorded 3 weeks (21 days) after sowing.

2.2.3.2 Sanitary parameters

The general condition of the tomato plants was noted during the experiment, as well as the incidence and severity of root galls. Tomato plants were gently dug up 5 weeks after sowing for evaluation of root galls. Plants with galls were counted and severity was calculated according to [13].

$$\text{Incidence} = \frac{\text{number of sick plants}}{\text{total number of plants}} \times 100$$

Severity was assessed according to the index table for root-knot nematodes after [14]. The severity scale starts from 0 (no galls on the roots, all roots are healthy) to 10 (All roots have galls).

2.3 Data Analysis

Analysis of variance (ANOVA) was performed using STATISTCA 7.1 software. Shapiro-Wilk normality tests were applied to all variables before performing all analyzes. This analysis of variance test (ANOVA) made it possible to see the effect of the treatments on the parameters studied. The LSD Fisher test was used for comparison of variables in case of difference ($p < 5\%$) between treatments. The differences are significant for a probability value less than 5%.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Effect of powdery extracts of *T. diversifolia, A. cordifolia* and *M. benthamianum* on germination

3.1.1.1 Germination rate In vitro

The study of the effect of the aqueous extracts of the three plants in vitro showed that the germination rate varies depending on the plant extracts and the concentrations used. Indeed, seeds treated with *T. diversifolia* offer germination rates which vary from 43.03 and 98.5% unlike *A. cordifolia* and *M. benthamianum* whose germination rates vary respectively from 35.33 to 68.67 and from 37.66 to 67.55. The observation in Fig. 1 shows that whatever extract is used, the highest concentrations give the lowest germination rates, and the lowest

concentrations offer the best results. In terms of treatments, observation shows that seeds treated with *T. diversifolia* have the highest germination rate. As for *A. cordifolia* and *M. benthamianum*, they similarly give the same germination rates.

3.1.1.2 Germination rate in the nursery

The germination rates of seeds treated with extracts from the three plants varied from 23.89 to 62.22% (Fig. 2). Statistical analysis showed that there is a significant difference between the different treatments ($P < 0.05$). The seed germination rate is significantly influenced by the different formulations. The concentrations (C1 and C2) gave the highest germination rates. However *T. diversifolia* recorded the highest germination rates for the concentrations C1 (78.33%) and C2 (70%) followed by *A. cordifolia* and MB at the concentration C1 with respectively rates of 63.66% and 60%. Average values were recorded for *A. cordifolia M. benthamianum* at concentration C2 with respective germination rates of 50 and 55%. Finally, the C3 concentration recorded the lowest germination rates for the three plants.

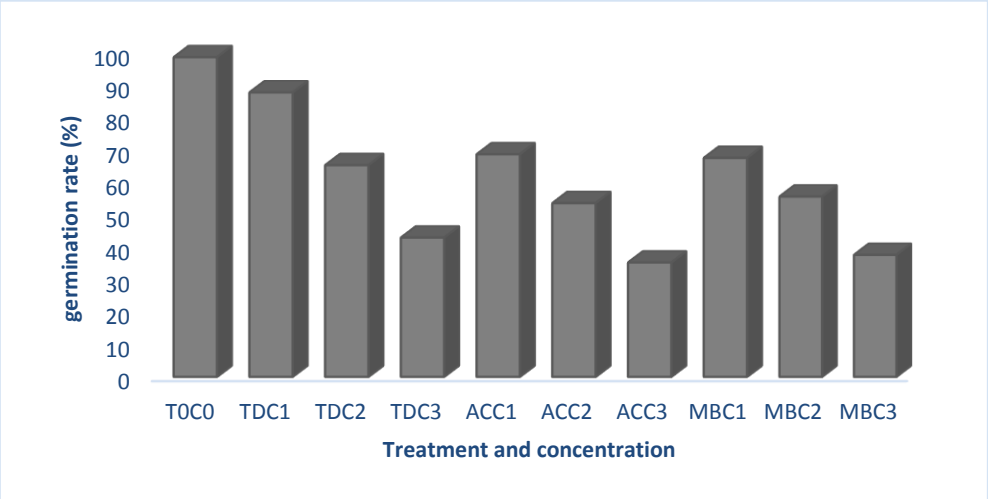

Fig. 1. Effect of plant extracts on *in vitro* germination tomato seeds C0, C1, C2 and C3 : Concentration, 0 g, 15 and 25 g/l of plant extracts T0 : ; TD : *T. diversifolia* ; AC : *A. cordifolia* and MB : *M. benthamianum*

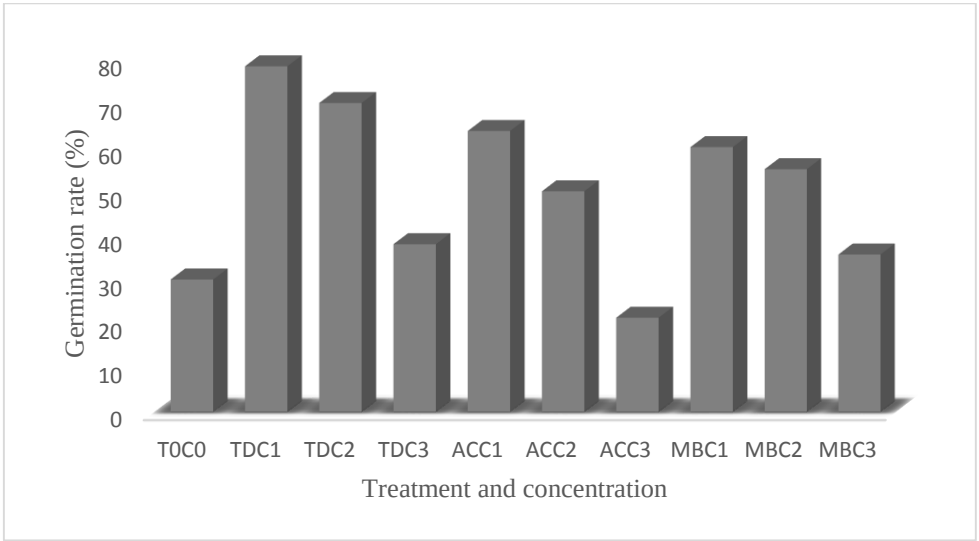

Fig. 2. Effect of plant extracts on the germination rate of tomato seeds in the nursery C0, C1, C2 and C3 : Concentration, 0 g, 15 and 25 g/l of plant extracts T0 : ; TD : *T. diversifolia* ; AC : *A. cordifolia* and MB : *M. benthamianum*

3.1.1.3 Seedling emergence speed

In terms of germination speed, it varied between 0.15 and 36.33 seeds / day (ie 1 to 3 seeds / day). The lowest germination rate was recorded at the level of the control while the highest was observed at the level of the formulation of *Thitonia* at concentration 1. Whatever the formulation, the seeds treated at a concentration of 5 g / l emerge the fastest, followed respectively by that of 15 g / l and 25 g / l. The seeds in culture on the control substrates emerge with difficulty (less than 1 seed / day). For the same amounts of powdery extract contained in the substrates, seeds treated with *T. diversifolia* appear more quickly (Fig. 3).

3.1.2 Effect of powdery extracts of *T. diversifolia, A. cordifolia* and *M. benthamianum* on vegetative parameters

3.1.2.1 Average number of leaves

The average number of leaves corresponds to the number of leaves per plant for each formulation. The results show that after three weeks in the nursery the average number of leaves appeared varied from 5.38 to 13.21 (Fig 4). The average number of leaves was influenced by the type of extract (P =0.000) with and *T. diversifolia* (10, 15) obtained the highest number of leaves compared to *A. cordifolia* (7.78) and *M. benthamianum* (7.29). Also the concentration 5 g /l resulted in the highest number of leaves. Statistical analysis showed that the number of leaves was significantly influenced by the concentration (P = 0.000). The statistical analysis also revealed that there was no interaction (P = 0.085) between type of extract and concentration.

3.1.2.2 Average height of plants

The mean height of tomato seedlings varied among treatments and concentrations (Fig. 5). Two-factor ANOVA statistical analysis at the 5% threshold showed that there was no interaction (P = 0.051) between treatment and concentration. However, soil treatments with the extracts had a significant effect on seedling height as a function of extract type and concentrations (P=0.000). The mean height of seedlings treated with *T. diversifolia* (11.8 cm) was significantly higher than those of *A. cordifolia* (9.38 cm) and *M. benthamianum* (8.61 cm). The 5 g/l concentration for all treatments resulted in the highest mean heights.

3.1.3 Effect of *T. diversifolia, A.* cordifolia and *M. benthamianum* on the incidence and severity of tomato root galls

Three weeks after sowing, the treated and untreated plants show different health aspects. Indeed, the plants emerged on substrates added to the powdery extracts present a good sanitary state unlike the untreated plantlets, some of which present aspects of wilting during the hot hours of the day. From the fifth week in nurseries, yellowing symptoms were observed on untreated tomato leaves. The dug up plants showed galls on the roots. These root galls were present on control plants as well as on some treated plants (Fig. 6). Thus, the evaluation of the disease showed an incidence that varied from 0 to 60% depending on the treatments (Table 1). The highest concentrations recorded low incidences (Concentration 3) for the three plants used to treat the soil.

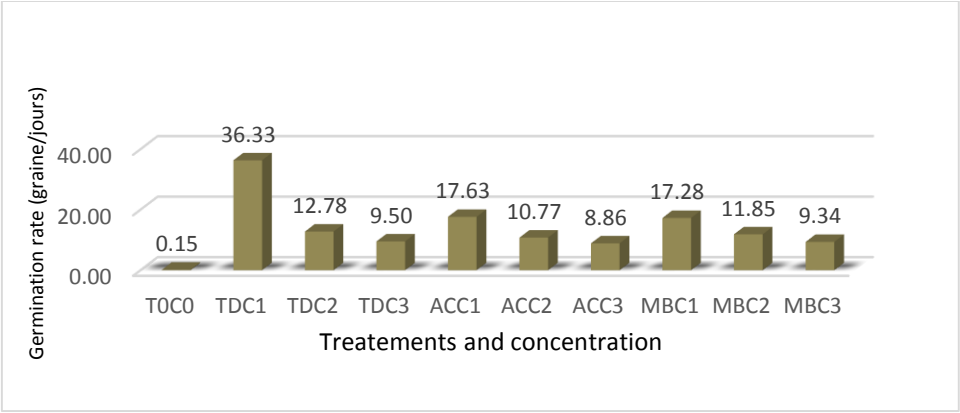

Fig. 3. Effect of plant extract on seed emergence speed of tomato
C0, C1, C2 and C3 : Concentration, 0 g, 15 and 25 g/l of plant extracts
T0 : Control ; TD : *T. diversifolia* ; AC : *A. cordifolia* and MB : *M. benthamianum*

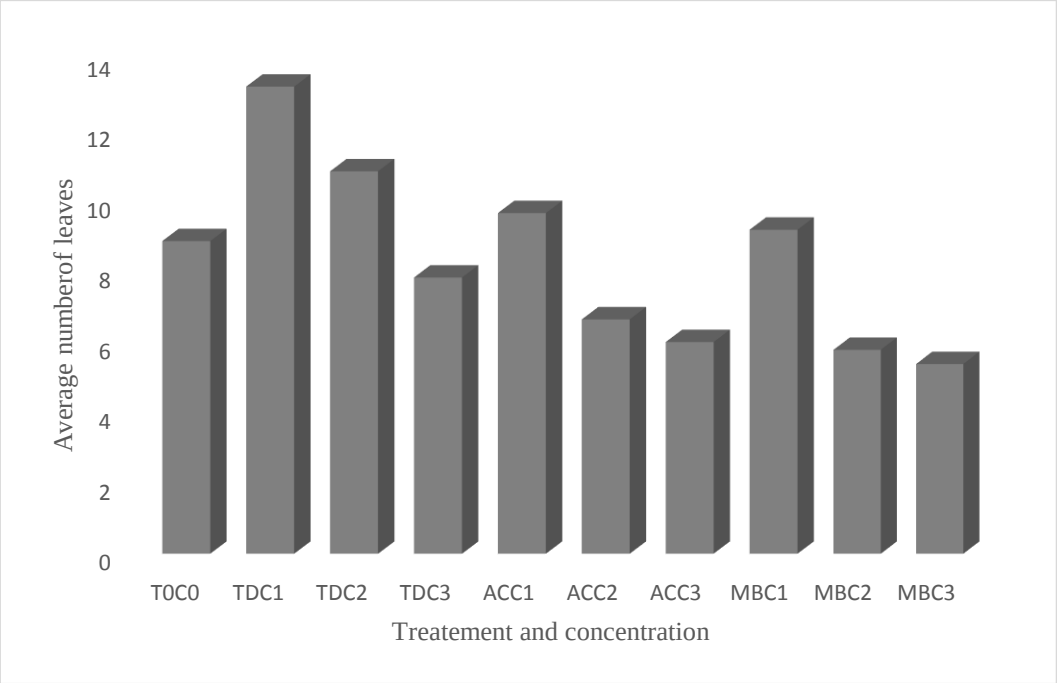

Fig. 4. Effect of plant extracts on Average number of tomatoes leaves
C0, C1, C2 and C3 : Concentration, 0 g, 15 and 25 g/l of plant extracts
T0 : Control ; TD : *T. diversifolia* ; AC : *A. cordifolia* and MB : *M. benthamianum*

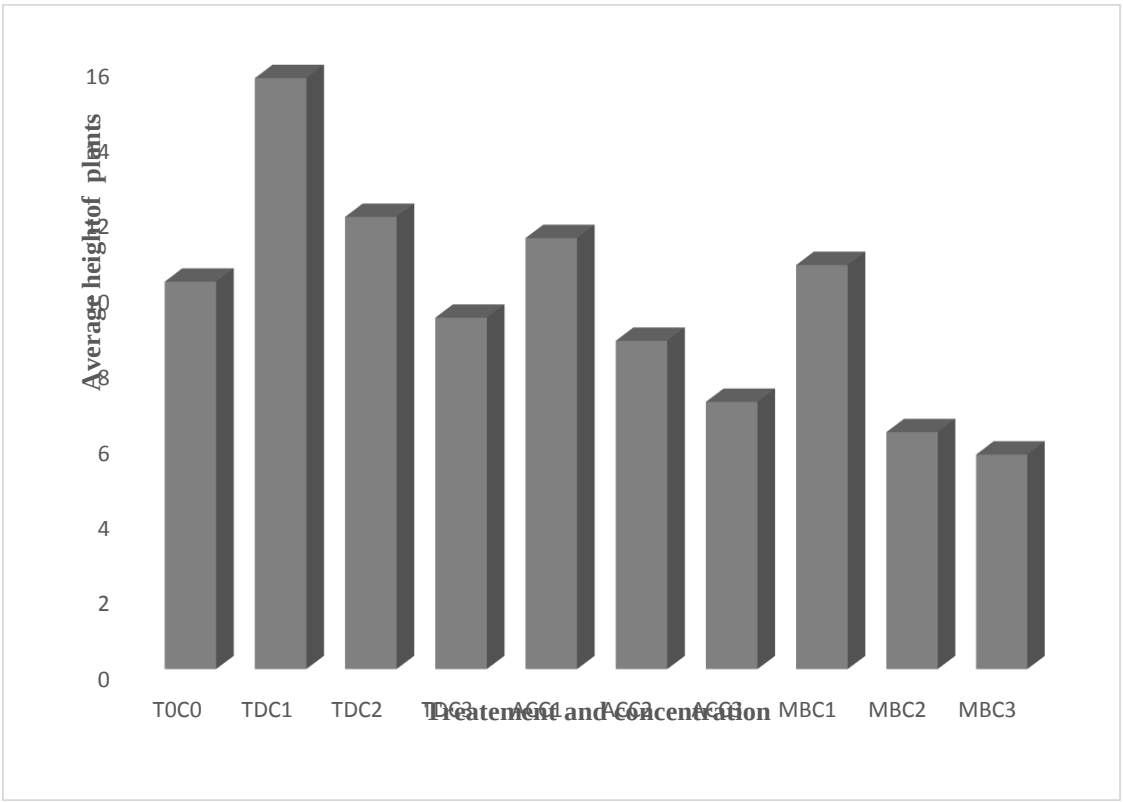

Fig. 5. Effect of plant extracts on Average height of tomatoe plants
C0, C1, C2 and C3 : Concentration, 0 g, 15 and 25 g/l of plant extracts
T0 : Control ; TD : *T. diversifolia* ; AC : *A. cordifolia* and MB : *M. benthamianum*

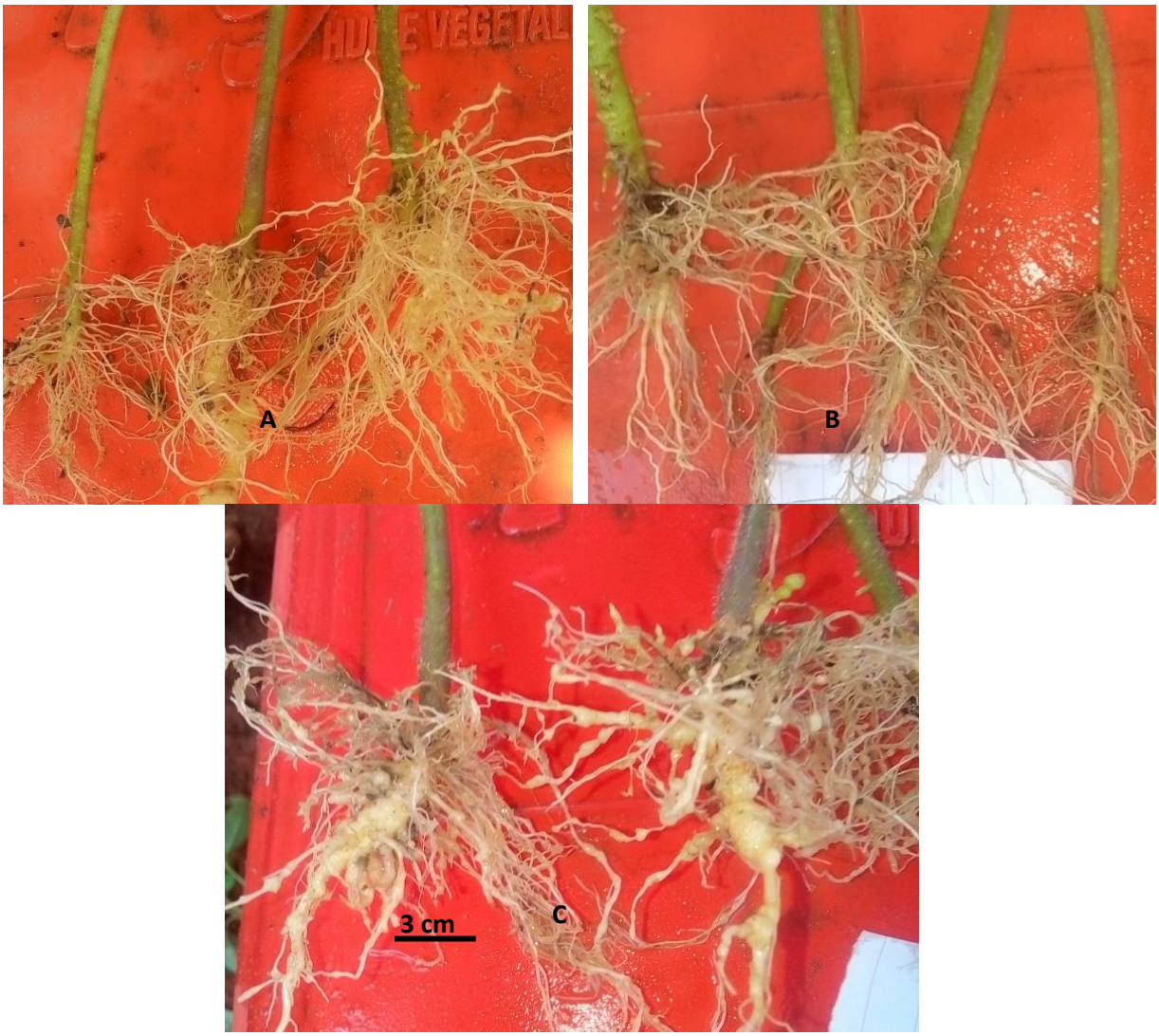

Fig. 6. Root galls on five week old tomato plants in the nursery
A : Galls not very visible on the treated plants, B : No galls on the plants ; C : Numerous galls on untreated plants

Table 1. Average root gall index (%) as a function of treatments and concentrations

	M. benthamianum	*T. diversifolia*	*A. cordifolia*
Concentrations			
0	100		
5 g / l	44	55	55
15 g / l	60	0	28
25 g / l	0	0	12

Table 2. Average severity of root galls depending on the plant

Plants	Severity	P-value
T. diversifolia	1,25a	
A. cordifolia	1,60ab	0,008
M. benthamianum	2,33b	

All means in the same column bearing the same letters are not significantly different at P=0.05

Table 3. Average severiy of root galls depending of concentrations

Concentrations	Severity	P-value
C1 (5 g / l)	2,60b	
C2 '(15 g / l)	1,00a	0,00
C3 (25 g / l)	0,25a	
C0 (0 g / L)	3,20b	

All means in the same column bearing the same letters are not significantly different at P=0.05

As for the severity of root galls, it also varied according to the plants and the concentrations. Statistical analysis showed a significant difference between the plants used to treat crop soils as well as the concentrations. However, there is no interaction between concentration and plants (P = 0.46). Thus, the tomato plants treated with *T. diversifolia* presented a lower mean severity (Table 2). In terms of concentrations, the lowest severities were observed for 15 g / l and 5 g / l (Table 3).

3.2 Discussion

This study allowed us to test the efficacy of powdery extracts of *T. diversifolia*, *A. cordifolia* and *M. benthamianum* on the germination, growth and development of tomato plants as well as their effects on health status. Regarding seedling germination, analysis of the data obtained shows that seeds sown on infectious soil added to powdery extracts of *T. diversifolia, A. cordifolia* and *M. benthamianum* give germination rates higher than the control substrate (T0 = ground only). The increase in the germination rate in the formulations could probably be due to the improvement in the physicochemical properties of the soil generated by the elements released by the extracts of these plants and their effects on soil microorganisms. Indeed, these extracts with their actions have helped to improve soil fertility and repel harmful soil organisms in order to promote seed germination. These results are in agreement with those of [15], who showed that plant residues undergo physical, chemical and microbiological transformations resulting in humic substances influencing soil properties and interacting with germination and plant growth. These results are supported by the work of [16] who showed that the leaves of *T. diversifolia* improved the physical and chemical properties of the soil. The increase in the germination rate of the treatments compared to the controls shows that the extracts of the three plants have an effect on soil pests which inhibit the germination of seeds. Indeed, the results of preliminary work have shown damping-off of tomato seedlings in the nurseries surveyed. The plant extracts used for the treatments inhibit the action of soil parasites, thus promoting good plant emergence.

For each formulation, the results showed that those with the lowest concentration (C1 = 5 g / l) give the best results. This could be explained by the fact that at high concentrations, the extracts in addition to improving soil fertility and repelling harmful organisms, inhibit the germination power of seeds. A similar observation was made by [17] who demonstrated that for tomatoes, humic substances turn out to be phyto-toxic when they are applied in excess. On the other hand, the germination rate increases with a lower dose. The variations between the germination rates noted at the level of the formulations were also noted on *Jatropha curcas* [18]. The latter justified these differences by showing that seed germination varies according to the substrates used. During this study, the speed of seed emergence as well as the effect of different extracts on the growth parameters of tomato plants were evaluated. These growth parameters are among others, the number of leaves and height of the tomato plants. Regarding the rate of emergence and the growth parameters, the results showed that only the substrates which received a contribution of *T. diversifolia* are statistically significant. Plant extracts would therefore have different effects on growth parameters and plant development. These gains observed in *T. diversifolia* could be due to the high rate of nutrients released by the latter and to the improvement in soil fertility that it would generate. This result is similar to those obtained in Kenya by [19] who showed that the plots having received the biomass of *T. diversifolia* gave the highest maize yields (5.5 and 5.4 t / ha). Likewise, [20] reported that maize grain yields were higher on plots of *Tithonia* alone compared to plots that received only chemical fertilizers. At the health level, the powdery extracts of *A. cordifolia*, *T. diversifolia* and *M. benthamianum* plants have been used as a treatment against certain pathogens of tomato in the nursery. In general, these extracts had a reducing effect on the rate of contamination of the treated plants.

Indeed, the results obtained after experimentation showed that unlike the treated seedlings, the control plants showed symptoms of disease (wilting). This would be due to the inhibitory effects of these extracts on the pathogen present in the soil collected for the experiment. [21] also demonstrated that the amendment of chilli plants infested with powdered *Azadirachta Indica* leaves induces a significant drop in nematode populations resulting in better growth of treated plants, unlike untreated plants. Many works confirm this capacity of plant extracts to control crop pests. [22]. On the roots, the symptoms are manifested by the presence of galls. These galls reduce the root system. All treatments influenced the symptoms on the root system of the tomato plants. The low incidence of galls observed could be explained by the fact that the nematodes were not in sufficient numbers on the roots of the tomato. This could be related to treatments carried out which did not allow the root-knot nematode population to grow. The powdery extracts of the three plants used induced varying degrees of severity depending on the plant and the concentration used. These results indicate that *T. diversifolia*, *A. cordifolia* and *M. benthanianum* contain compounds with nematocidal effects. These results are in agreement with those of [23] who showed the potential of plant extracts to reduce the density of populations of root-knot nematodes. The application of *T. diversifolia* powder showed a significant severity index on the galls, compared to *M. benthaninum* and *A. cordifolia*. The fact that the severity indices are zero at concentrations C2, C3 for *T. diversifolia* extracts could be explained by the accumulation of different substances toxic to nematodes. These results corroborate those of [24] who showed that the crude extract of *Piliostigma thonningii* was the most effective against eggs and juveniles in vitro and In the field condition on eggplants treated to reduced galling indices and final nematode population.

4. CONCLUSION AND PERSPECTIVES

This study was carried out on the effectiveness of powdery extracts of *T. diversifolia, A. cordifolia*, and *M. benthamianum* in tomato nurseries. The powdery extracts had satisfactory effects on the health of the seedlings as well as the improvement of the germination and growth parameters of the tomato plants. However, only the formulations based on *T. diversifolia* had significant effects on the parameters studied. For the different concentrations of plant extracts studied, C1 (5 g / l) gave the best results. It therefore turns out to be the optimal dose for effective treatment. The results also showed that the different extracts (*A. cordifolia, T. diversifolia* and *M. benthamianum*) have an inhibitory effect on the action of tomato pathogens in the nursery. Unlike the effect of plants on growth parameters, the high concentrations induced a higher reduction in the incidence and severity of tomato galls This study demonstrated the biostimulatory and biopesticide properties of these extracts as a resource renewable for healthy and sustainable agriculture. However, studies on the efficacy of powdery extracts of *A. cordifolia*, *T. diversifolia* and *M. benthamianum* against diseases encountered by tomato during other vegetative phases should be considered in order to assess their efficacy. in the open field.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yarou BB, Komlan FS, Mensah A, Alabi T Vershggen F, et al. Pesticide plants and the protection of vegetable crops in West Africa. Biotechnol. Agron. Soc. About. French. 2017;21(4):288-304.
   DOI: 10.25518 / 1780-4507.16175
2. Ildefonse N. West African subsistence agriculture through the case of the Ivory Coast, vegetable crops, Institut des Savanes, Abidjan, Ivory Coast. French; 1995.
3. Soro S, Doumbouya M, Koné D, Kouadio YJ. Infectious potential of tomato (*Lycopersicon esculentum* Mill.) Soils under shelter and the effect of transplanting age on plant vigor against *Pythium* sp. in Songon Dabou in Ivory Coast. Tropicultura, French. 2008;26(3):173-178.
4. Yolou FI, Yabi I, Kombieni F, Tovihoudji PG, Yabi JA, Paraïso AA, Afouda F. Urban gardening in Parakou in North Benin and its economic profitability. Int. J. Innovation Sci. Res. French. 2015;19(2):290-302.
5. Walter B, Thouvenel JC, Fauquet C. Tomato viruses in Côte-d'Ivoire Ann. Phytopathol. 1980;12(3):259-275.
6. De Bon H, Fondio L, Dugué P, Coulibali Z, Biard Y. Etude d'identification et analyse des contraintes à la production maraîchère

selon les grandes zones agro-climatiques de la Côte d'Ivoire. Rapport d'expertise PS n°009/FIRCA/DCARA/PRO2M/2018. Frenc h; 2018.

7. Kanda M, Akpavi S, Wala K, Boundjou GD, Akpagana K. Diversity of cultivated species and production constraints in market gardening in Togo. Int. J. Biol. Chem. Sci. French. 2014;8(1):115-127. Available:https://doi.org/10.4314/ijbcs.v8i1.11
8. De Guiran G, Netscher C. Nematodes of the genus *Meloidogyne*, parasites of tropical crops. ORSTOM notebook. French. 1970;11:151-185.
9. Henao J, Baanante, CA. Agricultural production and soil nutrient mining in Africa. Summary of IFDC Technical Bulletin, IFDC, Muscle Shoals, Alabama, USA; 2006.
10. Okereke VC, Wokocha RC, Godwin-Egein MI. Evaluation of *Trchoderma harzianum*, some botanicals and Fongicide on *Sclerotium* Wilt of Potted Tomato. Agri. Newspaper. 2007;2(4):453-456. Available:https://medwelljournals.com/abstract/?doi=aj. 2007.453.456
11. Anjarwalla P, Belmain S, Sola P, Jamnadass R, Stevenson PC. Guide to pesticide plants. World Agroforestry Center (ICRAF), Nairobi, Kenya, French; 2016.
12. Farooq M, Basra SMA, Saleem BA, Nafees M, Chishti SA. Enhancement of tomato seed germination and seedling vigor by osmopriming Pak. J. Agri. 2005;42(3-4):36-41.
13. Kayani MZ, Mukhtar T, Hussain MA, Haque MI, Perveen R. Incidence and severity of root-knot nematodes (*meloidogyne* spp.) On cucumber in district rawalpindi. Pak. J. Phytopathol. 2012;24(2):122-128.
14. Coyne DL, Nicol JM, Claudius CB. Plant nematodes: A practical guide to field and laboratory techniques. SP-IPM Secretariat, International Institute of Tropical Agriculture (IITA), Cotonou, Benin. French; 2010.
15. Abdelghani T, Jacqueline D, Philippe D, Philippe T. Physico-chemical and biological properties of humic substances in relation to plant development. Biotechnol. Agron. Soc. About. French. 2014;14(3):259-275.
16. Lele BN, Kachaka SC, Lejoly J. Effect of biochar and leaves of *Tithonia diversifolia* combined with mineral fertilizer on the cultivation of maize (*Zea mays* L.) and the properties of a ferralitic soil in Kinshasa (DRC) . Biotechnol. Agron. Soc. About. French. 2016;20(1):57-67.
17. Outéndé T. Evaluation of the chemical and agronomic characteristics of five waste composts and study of their effects on the chemical properties of the soil, the physiology and the yield of maize (*Zea mays* L. Var. Ikenne) and tomato (*Lycopersicum esculentum* L. Var. Tropimech) under two water regimes in Togo. Doctoral thesis: University of Lomé, University of Limoges. French; 2016.
18. Touckia GI, Yongo OD, Abotsi EK, François W, Kouami K. Germination and growth test at the juvenile stage of local strains of *Jatropha curcas* L. in the Central African Republic, European Scientific. French. 2015;15(11):160-176.
19. Muna-Mucheru M, Mugendi D, Kung'u J, Mugwe J, Bationo A. Effects of organic manure and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South District, Kenya, Agroforestry Systems. 2007;69:189-197. Available:http://dx.doi.org/10.1007%2Fs10457-006-9027-4
20. Jama B, Palm CA, Buresh RJ, Niang AI, Gachengo C, Nziguheba G, et al. Tithonia as a green manure for soil fertility improvement in Western Kenya. Agroforestry Systems. 2000;49:201-221. Available:http://dx.doi.org/10.1023/A:1006339025728
21. Kankam F, Sowley ENK. Evaluation of neem (Azadirachta *indica* L.) products for the control of root-knot nematode of chilli pepper (*Capsicum annum* L.). Arch. Phytopathol. Plant Prot. 2016;49(5-6):111-119. Available:https://doi.org/10.1080/03235408.2016.1157379
22. Gurjar MS, Ali S, Akhtar M, Singh KS. Efficacy of plant extracts in plant disease management. Agricultural Sciences. 2012;3(3):425-433. Available:http://dx.doi.org/10.4236/as.2012.33050
23. Loumédjinon SE. Nematode of vegetable crops in the south benign: Effectiveness of orange and cassava peelings in the control of root-knot nematodes infested with carrot (*Daucus carota*) and African nightshade (*Solanum macrocarpum*). Thesis for obtaining the Diploma of Advanced Study

(EDA). University of Abomey-calavi (Benin). French; 2006.

24. Mamman A, Umar I, Malgwi AM, Ojo GT. Efficacy of leaf extract of *Piliostigma Thonningii* for control of root-knot nematode (*Meloidogyne javanica*) on Eggplant. J. of Experimental Agricult. Int. 2021;43(6):45-52. Available:http://dx.doi.org/10.9734/JEAI/2021/F43 obey 0701

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