Use of vermicompost in the control of *Rhizoctoniasp*: impact on tomato (*Solanumlycopersicum* L) production.

ABSTRACT

The trial carried out at the experimental site of the Jean LorougnonGuédé University of Daloa, in west-central Côte d'Ivoire, aims to evaluate the potential of vermicompost to reduce attacks of the fungus *Rhizoctoniasp* on tomatoes and to increase their production. The experiment was conducted in a randomized Fischer blocks design where four treatments were replicated four times. Four substrates, consisting of soil mixtures and doses of vermicompost (0, 20, 40, and 60 t/ha), inoculated with the fungus, were used for growing tomato in pots. Production parameters and those related to *Rhizoctoniasp* attacks were determined on tomato plants at the end of the trial. Results showed that production increased with the addition of vermicompost, the higher the dose of vermicompost applied. The health of the tomato plants was also improved by the reduction of *Rhizoctoniasp* attacks, especially with the 60t/ha treatment. These results show that farmers can use vermicompost to improve production and control tomato diseases.

Key words: Organic amendment, biological control, vermicompost, tomato, Rhyzoctoniasp

1 INTRODUCTION

Since independence, Côte d'Ivoire has based its economy on agriculture. Today, market gardening is practiced in all agricultural production areas (1 Soro et al., 2008). However, annual tomato production, which fluctuates between 22 and 35 thousand tons (2. Sangaré et al., 2009), remains largely insufficient to cover the estimated needs of over 200 thousand tons (3. N'zi et al., 2010). These low yields are favored by low soil fertility, poor application of mineral fertilizers and poor plant development due to high pest pressure (4. Adamou et al., 2017). The parasitic concentration on food crop soils has contributed substantially to land degradation (5. Zeng et al., 2009). Telluric pathogens, mainly the fungi *Pythiumspp*, *Rhizoctoniaspp*, *Sclerotiumspp, Fusariumspp*, are responsible for seedling melting, necrosis and root rots (6. Soro, 2006). In recent years, the area planted to vegetable production in Côte d'Ivoire has increased considerably, while yields have dropped significantly. Faced with these low yields, on the one hand, mineral fertilizers have been used to improve soil fertility. But their use, often at inappropriate doses and times, has a negative impact on the environment and human health (7. FAO, 2015). Also, their expensive cost and low accessibility are a limiting factor (8. Kitabala et al., 2016). On the other hand, the use of pesticides to fight against pests and diseases also has negative impacts on the environment and human health. In addition, the emergence of resistance in certain fungi and their high cost have made their use increasingly limited and interest in other alternatives has thus increased. Both mineral fertilizers and pesticides, through their dispersion in environmental compartments, constitute, under certain conditions, pollutants of the soil, air, water or food and have ecological consequences (9. Michel, 2003) and interest in other alternatives has increased. One of them is the use of compost, a hygienic product with a stable composition, rich in humic substances. Its addition to the soil not only improves crop production but also protects plants against soil-borne diseases (10 Larbi, 2006). It has highly suppressive effects on diseases caused by soil-borne pathogens such as *Pythium, Phytophthora, Fusarium* and *Rhizoctonia*(11. Schönfeld et al., 2003). However, not all composts have the same capacity to effectively inhibit plant pathogens (12. Mouria et al., 2013). The research gap is not clearly set here It is therefore in this context that this work is carried out with the aim of contributing to the defence of the tomato crop against attacks by the fungus *Rhizoctoniasp*, by fertilizing the soil using vermicompost, for better production.

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2 MATERIELS AND METHODS

2.1 Study zone

The study was carried out on an experimental plot at the University Jean LorougnonGuédé (UJLoG), in Daloa, a city (6°84 and 6°91 North latitude and between 6°41 and 6°48 West longitude), located in center-western of Côte d'Ivoire. It is 378 km and 140 km from Abidjan, the economic capital, and Yamoussoukro, the political capital. Its climate is Guinean, characterized by an equatorial and subequatorial regime with two rainfall maxima (13. Brou, 2010). The relief is not very varied and is dominated by plateaus of 200 to 400 m in altitude (Avenard, 1971). Average rainfall is between 1400 and 1600 mm/year. The forest landscape varies progressively from semi-deciduous dense rainforest to mesophilic cleared forest (13. Brou, 2010). The soils in this area are, in general, moderately desaturatedferrallitic on farmland and sandy hydromorphic on river terraces (14. Dabin et al., 1960; 15. Zro et al., 2016). The soil used was taken from the humus-bearing surface horizon (0 - 30 cm), characterized by a sandy-clay texture (10 to 15% A), a low pH (6.2), a low cation exchange capacity (6.13 cmol/kg), and a C/N ratio of about 10.75.

2.2 Materials

2.2.1 Fertilizer materiel

The vermicompost, which is the fertilizing material used, was produced by the Department of Agro-pedology of UJLoG. It consists of major and minor fertilizing elements that improve soil fertility and boost plant growth. It was chosen because of its agronomic suitability. Table 1 shows its chemical characteristics

Table 1. Physics and chemical characteristics of vermicompost

Composition	Contents
C(%)	5.33±0.07
MO(%)	9.78±0.67
N (%)	0.63±0.11
C/N	9.04±1.49
P (g/kg^{-1})	27.17±0.13
K^+(%)	3.10±0.12
Ca^{2+}(%)	8.4±0.06
Mg^{2+}(%)	3.37±0.09
Na^+(%)	0.85±0.03
CEC(%)	15.94±0.14

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2.2.2 Plant material

Tomato plants (*Lycopersicomesculentum* M.) of the F1 variety COBRA 26 (Fig. 5) were used in the trial. This variety has a determined growth, a very good vigor and a very good productivity. This variety ensures productivity and reliability for producers in tropical and Sahelian zones. It produces abundant uniform fruits of square shape.It is resistant to TYLCV (Tomato Leaf Rolling Virus), tolerant to bacterial wilt but resistant to fusarium, TMV0 and verticilium. Its fruits have an average size of 80 to 90g with good firmness and shelf life.

2.2.3 Fungal material

The fungal material consists of the fungus *Rhizoctoniasp*, the strains of which were obtained from the laboratory of Plant Physiology and Pathology of the University Jean LorougnonGuédé of Daloa. *Rhizoctoniasp* is a Basidiomycete with sterile mycelium, not producing any form of sexual or asexual spores. The fungus produces only mycelium characterized by right-angled branches and sclerotia.

2.3 Methods

2.3.1 Experimental design and treatments

The experimental design followed the Fischer block design, with four treatments and four replications. The four blocks set up, each corresponding to a repetition, are 50 cm apart. The trial was conducted in pots, i.e. 16 pots corresponding to the 4 treatments repeated 4 times, over two growing cycles. These pots were placed randomly in each block under a plastic greenhouse. Four substrates were made up of a mixture of soil (6.5 kg) and vermicompost at four doses (0, 20, 40, and 60 t/ha). Thus, the four treatments obtained are the following:

- T0: soil without vermicompost (control),

- T20: soil + 20 t/ha of vermicompost, i.e. 89.5 g for 6.5 kg of soil,

- T40: soil + 40 t/ha of vermicompost, i.e. 179 g for 6.5 kg of soil,

- T60: soil + 60 t/ha of vermicompost, i.e. 268.5 for 6.5 kg of soil.

2.3.2 Constitution and inoculation of the culture substrates:

The soil and vermicompost were first sieved and then sterilized at intervals of 2 days at 105°C for 45 minutes during one week. The soil and vermicompost were then mixed homogeneously, according to the doses of vermicompost, and distributed in 16 plastic pots to form the culture substrates. Four batches of the four culture pots containing the substrates were inoculated with the *Rhizoctoniasp* fungus strain at 4 g per pot, followed by watering. The inoculum was mixed with the substrate in the pots to a depth of 5 cm. To avoid further contamination, the pots were sealed and placed under the greenhouse.

2.3.3 Conduct of the trial

The nurseries were carried out in two 72-cell plates for both growing cycles. In each plate, 48 cells were used, with three cells for one growing pot, in order to select the most developed seedling at the end of the nursery for transplanting. These trays were filled with the different substrates made up, according to the defined doses of vermicompost. In each tray, a tomato seed *Solanumlycopersicum* L, of the variety F1 cobra 26 was sown at a depth of about one centimeter, followed by watering. Watering was done twice a day, once in the morning and once in the evening. The seedlings were then placed under a one-meter-high shaded area in the greenhouse.

After seed germination, 4 seedlings, the most developed of the 12 for each treatment, were selected for cultivation. Thus 16 seedlings were transplanted, 4 seedlings per treatment. Transplanting of the seedlings took place on the 21st day after sowing (DAS). These vigorous seedlings, with 4 to 6 full leaves, were removed from the trays and transplanted into the various culture pots that had been watered beforehand. The plants were observed to recover one week later. The plants were staked to maintain their upright growth habit with 1.5 m high stakes.

2.3.4 Data collection

2.3.4.1 Assessment of agronomic parameters

The evaluation of the agronomic parameters was carried out on the various stages of tomato plants development.The determination of the duration of the phrenological stages was based on the dates of flowering and first harvest. The flowering date was noted when 50% of the plants in the plot had flowered. The date of the first harvest was determined when half of the plants in the plot had borne ripe fruit. The manual counting of flower buds, flowers and immature fruit was carried out every week after the appearance of flower buds and ended when the first mature fruit appeared. This counting was done during the trial. The yield was assessed from the harvests. Thus, at each harvest, the number and weight of fruits were determined. Tomato fruit harvesting started when the first ripe fruit appeared and was carried out every second day until the end of the trial. The yield was determined according to the following formula:

Rdt (t/ha) = Mass of fruit harvested per plant (Kg) x 10.000/Area occupied per plant (m^2)

Rdt = yield; 10.000 represents the conversion coefficient from kg/m^2 to t/ha.

2.3.4.2. Assesment of phytosanitary parameters

The evaluated parameters were incidence and severity of fungal diseases.Disease severity, which is the amount of infected plant tissue on a plant, is difficult to quantify. It is usually determined from a visual rating scale. For this purpose, the severity index was evaluated macroscopically on the basis of *Rhizoctonia* symptoms, using the 16. Trapero-Cassas (1983) scale :

0: Healthy, white roots, no symptoms; 1: 1-20% of plant root surface with browning/necrosis; 2: 21-81% of plant root surface with browning/necrosis; 3: 81-99% of the root surface of rotted plants with browning/necrosis; 4: Roots completely rotted, plant dead.

Thus, the severity index was determined according to the following formula (17. Song et al., 2004):

IS = (NE x NPI/ NPE x NTP) X100

IS = Severity index; NE = Scale score; NPI = Number of infected plants; NPE= higher score; NTP= total number of plants

Incidence refers to the number of new cases of a disease observed during a given period. The evaluation of symptoms is carried out on the basis of a symptom rating scale proposed by 18. Vakalounakis and Fragakiadakis (1999):

0: healthy plant; 1: slight yellowing, slight pivot and secondary root rot and crown rot; 2: yellowing of leaves with or without wilting or stunting of plants, severe crown rot and browning of stem vessels; 3: death of the plant.

The disease incidence is calculated according to the following formula (17. Song et al., 2004):

(Values x Number of infected plants / Highest value x Total number of plants) x 100

2.3.5 Statistical analysis

The collected data were subjected to analysis of variance (one factor ANOVA) for comparison of means. In case of significant difference between the studied parameters, the Newman-Keuls test was used for the separation of the means at the 5% threshold.Statistical tests were performed using Statistica 7.1 software.

3. RESULTS

3.1. Flowering and fruiting dates of tomato plants:

The table 2 shows the dates of flower and fruit appearance. Highly significant differences ($P < 0.001$) were noted between these dates, under the effect of vermicompost. The first flowers appeared early with T60 and T40, respectively, at the 14th and 16th day after transplanting, while with T0 and T20, flowering occurred at the 22nd and 37th days, respectfully. Regarding fruiting, the appearance of fruits took place, respectively, at the 30th and 34th days with T60 and T40 while it was effective at the 41st and 60th days with T20 and T0. Flowering and fruiting were late with the T0 control, but with vermicompost, the higher the dose, the earlier the flowers and fruits appeared.

3.2. Flower and fruit production:

The production of flower buds, flowers and fruits is shown in table 3. Differences in the numbers of flower buds, flowers and immature fruits were significant ($p < 0.05$), under the effect of vermicompost. The lowest numbers of flower buds (5.12), flowers (4.56) and immature fruits (1.75) were obtained with T0. With the addition of vermicompost, T60 produced the highest numbers of flower buds (45.75), flowers (41.50) and immature fruits (16.68), followed by T40 and T20. These numbers increased with the amount of vermicompost applied to the soil. In terms of harvested fruits, the differences between their numbers and masses are not significant, however, the trend that emerges is that the number of fruits and their mass increases with the dose of vermicompost.

Table 2. Flowering and fruiting dates according to treatments

Treatments	Flowering date (day after sowing)	Fruiting date (day after sowing)
T0	37 ± 7,21^{a}	60 ± 12.02^{a}
T20	22 ± 2,12^{ab}	41 ± 9.86^{ab}
T40	16 ± 1,86^{ab}	34 ± 7,39^{ab}
T60	14 ± 1,05^{b}	30 ± 7,15^{b}
P	0,0005	0,0081

T0: Control; T20: 20t/ha; T40: 40t/ha; T60: 60t/ha. Means followed by the same letter are not significantly different at the 5% threshold.

Table 3. Flower bud, flower and fruit production according to treatments

Treatments	Number of flower buds	Number of flowers	Number of immature fruits	Number of fruits harvested	Mass of fruit harvested
T0	5,12±1.05^{b}	4,56±0,87^{b}	1,75±0.75^{b}	4,57^{a}	8,32^{a}
T20	20,68±3,2^{ab}	18,02±2,09^{ab}	4,93±1,63^{b}	10,49^{a}	24,47^{a}
T40	34,5±8,4^{ab}	30,25±6,25^{ab}	10,62±1,91^{ab}	15,02^{a}	30,49^{a}
T60	45,75±11,1^{a}	41,50±7,4^{a}	16,68±3,23^{a}	18,92^{a}	35,71^{a}
P	0,0004	0,0163	0,0185	0,1278	0,1422

T0: Control; T20: 20t/ha; T40: 40t/ha; T60: 60t/ha-1. Means followed by the same letter do not differ significantly at the 5% level.

3.3. Tomato crop yield

The addition of vermicompost to the soil induced highly significant differences (p = 0.0021) between the yields of the different treatments, as recorded in table 4. The yields obtained with T60, T40 and T20 were, respectively, 5, 3 and 2 times higher than the T0 control. The higher the doses of vermicompost, the higher the yields.

Table 4: Tomato crop yields according to treatments

Are you sure that with in this short period of time can we get this significant variation of VC treatments?

Treatments	Yields (t/ha)
T0	4,32±0,87^{d}
20	10,49±1,91^{c}
T40	17,09±2,38^{b}
T60	23,02±3,23^{a}
P	0,0021

T0: Control; T20: 20t/ha; T40: 40t/ha; T60: 60t/ha-1. Means followed by the same letter do not differ significantly at the 5% level.

3.4. Disease severity indices

The disease severity indices of *Rhizoctoniasp*, presented in figure 1, were significantly different (p = 0.0068) with the addition of vermicompost. Plants from control soils were the most severely affected by *Rhizoctoniasp* with 41% while the severity was reduced with the addition of vermicompost. Thus, the higher the doses of vermicompost, the lower the disease severity indices, 15% with T60, 18% with T40 and 26% with T20.

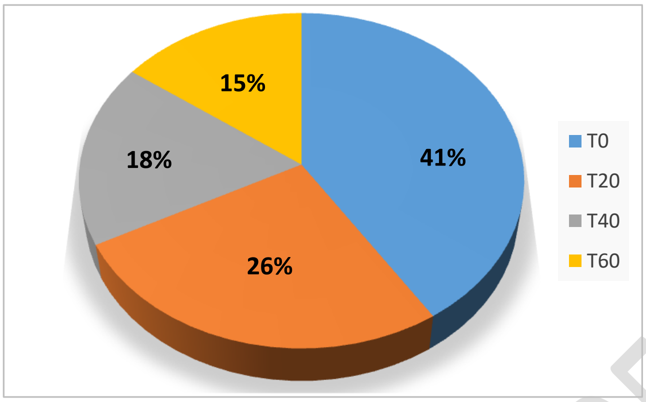

Fig.1. Disease severity indices according to treatments.
(T0: Control; T20: 20t/ha; T40: 40t/ha; T60: 60t/ha)

3.5. Disease incidence indices

Figure 2 shows the incidence of the disease caused by the fungus *Rhizoctoniasp*. The positive effect of vermicompost resulted in significantly different incidence indices (p = 0.003). It can be observed that regardless of the treatment applied, tomato plants were infected by the fungus *Rhizoctoniasp*, however, the incidence was higher without vermicompost application, with 38%. On the other hand, the addition of vermicompost reduced the incidence of the disease, with T60 plants expressing less infection (14%), followed by T40 with 20% and T20 with 28%. Thus, it appears that the higher the dose of vermicompost applied, the lower the incidence of the disease on the plants.

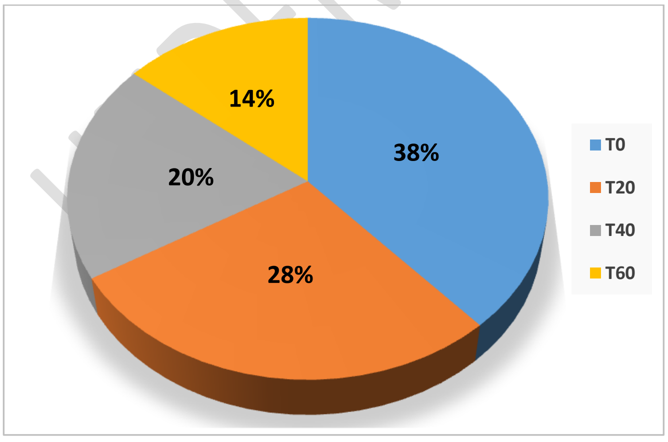

Fig. 2. Disease incidence indices according to treatments.

(T0: Control; T20: 20t/ha; T40: 40t/ha; T60: 60t/ha)

DISCUSSION

Effects of vermicompost on tomato plant production: The phrenological dates of flowering and fruiting of tomato plants were significantly different under the positive effect of vermicompost applied to the soil. Flowering and fruiting on the amended soils took place earlier than on the controls, the first flowers and fruits appeared earlier on the substrates with high doses of vermicompost (T60). The addition of vermicompost to the soil induced an earlier flowering and fruiting of the tomato plants. This could be due to the quality of the organic amendment used. The vermicompost applied to the soil, with a C/N ratio of 9.04, is low, according to the AFNOR standard, which has set this value between 15 and 20 (19. Compaoré et al., 2010). However, this low C/N value is a sign of a good level of maturity of the compost (20. Nanéma, 2007), i.e. an almost mineralized compost. This explains the relatively high content of fertilising elements (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) in this compost, which are necessary for good plant development. Indeed, the Carbon/Nitrogen ratio favors earliness, flower and fruit production (21. FAO, 2000; 22. Schiffers, 2003). However, these results do not corroborate those obtained by 23. Djidji et al. (2010) who argue that earliness is an intrinsic genetic trait specific to the variety value and is not subject to the influences of external factors.

The results of the study showed no significant effect of vermicompost doses on the number of fruits harvested and the mass of the harvested fruit. However, the yield was significantly higher with higher doses of vermicompost and the best substrate was T60. The addition of vermicompost favoured good plant nutrition, leading to a good yield of the plants compared to those grown on soil without amendment (24. Yin et al., 2012; 25. Toundou, 2016). These results can be explained by the good content and high availability of mineral elements in vermicompost. The effects of vermicompost suggest that *Eudriluseugeniae* earthworms have a greater influence on the availability of mineral elements in vermicompost. Indeed, during vermicomposting, the transit of waste through the digestive tract of the earthworms allowed for a better mineralization of the waste and, consequently, an increase in the nutrient content, hence the positive influence of vermicompost on tomato production and yield, the higher the dose (26. Ndegwa & Thompson, 2001). According to 27. Lee and Park (2003), the positive effect of compost is mainly due to the improvement of the physic-chemical and biological quality of the soil, the rate of nutrient diffusion and the water retention capacity of the soil. The more organic matter the soil has, the more fertile and productive it becomes. Our results are in line with those of 28. Hien et al. (2018) who showed that vermicompost improves agronomic parameters for vegetable farmers.

Our results showed the suppressive effect of vermicompost on the actions of the fungus *Rhizoctoniasp* by a significant reduction of its attacks. The T40 and especially T60 treatments showed excellent results: a decrease in disease severity of 85% with T60 and 82% with T40. According to (29. Ducasse, 2015), high levels of vermicompost microorganisms protect plants, competing with pathogens for resources, while also blocking their access to roots by occupying available sites. This was revealed by Edwards and 30. Arancon (2004), who tested the contribution of commercial vermicompost on diseased plants. The results showed that *Rhizoctonia*(greenhouse radish) infections were greatly reduced. Applications of vermicompost significantly reduced the incidence of this disease caused by the fungus *Rhizoctonia sp*. However, the application of vermicompost in large quantities has an important influence on plant health. This is mainly due to its beneficial microflora, and can result in a reduction of both soil-borne and foliar diseases (31. Hoitink and Grebus, 1994). The high biomass content of the compost leads to competition between the antagonistic microorganisms in the compost and the pathogen. This competition often works to the disadvantage of pathogens such as Pythium and Phytophthora (32. Fuchs, 1995).

4. CONCLUSION

This study, carried out with the aim of developing a means of biological control against the actions of the fungus *Rhizoctoniasp* for better tomato production, revealed that vermicompost has an interesting agronomic potential. At the end of the trial, the results showed that, on the one hand, tomato production and yields on the amended soils were higher than those on the control soils, the higher the dose. On the other hand, the addition of vermicompost to the soil significantly reduced *Rhizoctoniasp* attacks on tomatoes. However, T60 stood out with the best performance. Vermicompost could therefore be a means of biological control and an alternative for improving tomato production.

DISCLAIMER

The products used in this study are products commonly and predominantly used in our field of research area and in our country. There is absolutely no ~~no~~ conflict of interest between the authors and the producers of these products, as we do not do not intend to use these products as litigation but for the advancement of knowledge. Furthermore, the research was not funded by the the producing company, but rather by the personal efforts of the authors.

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