Effect of *Alchornea cordifolia*, *Tithonia diversifolia* and *Mezoneuron benthamianum* treatment time on agromorphological parameters of tomato in Daloa (Côte d'Ivoire)

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Abstract— The cultivation of tomato (Solanum lycopersicon L.) is confronted with many production problems related to the strong parasite pressure and especially to the fertility of soils. Thus, the effectiveness of powdery extracts of three plants (Alchornea cordifolia, Tithonia diversifolia and Mezoneuron benthamianum) was evaluated on the tomato crop and their ability to improve agromrphological parameters. Quantities of 5 g and 15 g of these extracts were used to treat the cultivation soil one month, one week and the day of transplanting of tomato plants. The results showed that A. cordifolia, Tithonia diversifolia and Mezoneuron benthamianum significantly improved the growth parameters and development of the plants at the amounts of 5 g and 15 g, on. The efficacy of the extracts varied depending on the plant used, the concentrations and the period of soil treatment. These plant extracts have biostimulatory properties and can be used as renewable resources for healthy and sustainable agriculture.

Keywords— Alchornea cordifolia, Tithonia diversifolia, Mezoneuron benthamianum, extracts, symptoms.

I. INTRODUCTION

Tomato (*Solanum lycopersicon*) is one of the most important vegetable crops in the world (Naika et al., 2005). According to the Food and Agriculture Organization of the United Nations (FAO), it is the second most important vegetable crop after potatoes. It is cultivated in more than 170 countries of the world in various climates, including relatively cold regions thanks to the development of crops under cover (FAO, 2007). Global tomato production has grown significantly since 1978, when it increased from 48 million tons to over 180 million tons in 2017 (FAOSTAT, 2018). Tomato, is grown for its fleshy, highly sought after fruit, rich in phenolic antioxidants and then mineral elements such as lycopene, carotenoids, vitamins A, C and E (Daniel et al., 2012; Ignace et al., 2015). Tomato is one of the most important fruit vegetables in the human diet as it

contributes to a healthy and balanced human diet that can be consumed fresh or processed [6] (Willcox et al., 2003).

En Côte Ivoire, fresh tomato production was estimated by the FAO in 2014 at 32,364 tons per year and increased to 44078 tons in 2018.Tomatoes are one of the main revenue crops in vegetable farming because many actors (producers and traders) make a living from tomato production and marketing (Coulibaly et al., 2019). However, environmental degradation is occurring due to the use of chemicals for both soil fertilization and plant treatments to increase tomato production.

In an effort to significantly reduce the use of chemicals, several studies have been conducted on biological control with satisfactory results. A study focused on composting showed that it improves crop yields compared to chemical fertilizers (Outéndé, 2016). In addition, the cost of compost

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is low compared to the purchase of chemical fertilizers. Another study conducted on natural plant extracts showed that plants such as Moringa oleifera and Azadirachta indica can be used respectively in the control of aphids and caterpillars as well as for soil fertilization and (CORAF, 2010). It is in this context that our work aims to improve the cultivation of tomato through the use of plant extracts.

II.   MATERIAL AND METHODS

Collection and treatment of plant material

The plant material consisted of leaves of Alchornea cordifolia, Tithonia diversifolia, and Mezoneuron benthamianum. These leaves were collected in the locality of Daloa during the month of May 2020 and were used for the treatment of the tomato crop soil.

Fresh harvested leaves were shade dried at room temperature in the laboratory (25 to $27°c\pm2$) for three weeks, as exposure to sunlight often reduces their efficacy (Anjarwalla et al., 2016). Furthermore, the dried leaves were powdered separately using a grinding machine (RETSCH type: SK100/C Gusseinsen) to obtain the powdered ones**.**

Setting up the experimental plot

For the realization of the experiment, a plot of 68 m2 was weeded with a machete and then weeded with a daba. Then 6 ridges of 3 m by 3.5 m were made. On each ridge 7 lines separated by 40 cm were made and on each line 6 sowing points separated by 50 cm were also made. The experimental set-up consisted of two completely randomized blocks of 6 ridges. Each ridge constituted a treatment and each treatment consisted of 7 lines. Each treatment was repeated twice.

Treatments

 Quantities of 5 and 15 g of *Alchornea cordifolia, Tithonia diversifolia,* and *Mezoneuron benthamianum* powders were weighed for the treatment of the crop soil at the level of the pits. These treatments were performed as follows:

- Treatment 1: cultivation soil treated with the powdery extracts on the day of transplanting

- Treatment 2: cultivation soil treated with powdery extracts one week before transplanting

- Treatment 3: cultivation soil treated with powdery extracts one month before transplanting.

Transplanting of plants

Tomato plants aged 21 days were transplanted at the level of the sowing points made with the different treatments. Watering was done twice a day for eight weeks and once a day until harvest. Regular weeding was done to maintain the

plot. The staking of the plants was carried out four weeks after transplanting.

Data collection

Plant survival rate, growth and yield parameters were evaluated. Plant survival rate was recorded at three days, seven days and two weeks after transplanting. The survival rate was calculated according to formula (1).

$$\mathbf{Ts}= \frac{nps}{np} \times 100 \quad (1)$$

Ts: survival rate, nps: number of surviving plants, np: total number of plants

Growth parameters such as number of leaves per plant, plant height (cm), leaf area (cm^2) and number of branches were recorded from three weeks (21 days) after transplanting and the operation was repeated every two weeks until fruit ripening. The mean values were then calculated according to the formula (2) :

$$\mathbf{y_m} = \Sigma x_i/ x_p \qquad (2)$$

ym: average observed parameter; xi: observed parameter; xp: total number of plants observed.

Yield parameters were recorded from four weeks for the number of flowers and five weeks for the number of fruits.

Statistical Analysis

Data were subjected to a multi-factor analysis of variance (ANOVA) using STATISTCA 7.1 software. ANOVA was used to evaluate the effect of the extracts of the three plants on the agro-morphological parameters and the incidence and severity of diseases. When a significant difference was observed ($P<0.05$) between the different factors, multiple comparisons were performed using the LSD Fisher test at the 5% threshold.

III.   RESULTS

Effect of *A. cordifolia*, *T. diversifolia* and *M. benthamianum* extracts on tomato plant survival rates

The survival rates of tomato plants ranged from 80.50 to 100 %. These rates were higher for the *A. cordifolia*, (94.44 to 100 %) and *T. diversifolia* (91.67 to 97.17 %) treatments one week and one month before transplanting. On the other hand, for *M. benthamianum*, it is rather the treatments on the day of transplanting and one week before transplanting at the quantity 5 g that gives the best survival rates. However, statistical analysis showed that there was no significant difference ($P>0.05$) between the survival rates with the different treatments of the extracts of the three plants (Table 1

Table 1 : Survival rates of tomato plants according to treatments, concentrations and extracts of A. cordifolia, T. diversifolia and M. benthamianum

Traitements	Quantity	A. cordifolia	T. diversifolia	M. benthamianum
	C0	93,28	93,28	93,28
1	C1	80,50	94,33	97,17
	C2	88,67	100	100
2	C1	97,17	91,67	100
	C2	100	97,17	88,67
3	C1	94,33	97,17	88,83
	C2	100	97,17	80,50
P		0,11	0,64	0,25

P: Probability; 1, 2, 3: soil treated on the day of transplanting, one week and one month before transplanting CO: Control; C1: 5 g dose; C2: 15 g dose.

Effects of *A. cordifolia, T. diversifolia* and *M. benthamianum* extracts on agromorphological parameters of tomato

The effectiveness of the plant extracts used varied according to the plant species and agromorphological parameters studied. Thus, statistical analysis showed a significant difference ($P < 0.05$) in the span, leaf area and number of flowers. However, plant size, number of leaves, crown circumference, number of branches and number of fruits were not influenced by the type of extract ($P > 0.05$) (Table 2). Also, *Alchornea* obtained the highest values in some parameters.

Table 2: Agromorphological parameters of tomato according to plant extracts

Plantes	TM	NFE	EM	SFM	DM	NRM	NFL	NFR
Achornea	25.70±1.10	21.60±1.08	51.76±1.87[a]	590.37±30.04[a]	5.60±0.19	4.75±0.31	9.90±0.64[a]	6.513±0.54
Tithonia	24.72±1.11	20.10±1.02	48.60±1.79[b]	527.72±28.23[b]	5.37±0.17	4.16±0.26	9.03±0,59[ab]	5.83±0.55
Mezoneuron	25.30±1.12	19.57±1.05	49.12±1.83b	544.75±29.50[ab]	5.32±0.18	4.18±0.26	8.21±0.56[b]	5.65±0.50
Témoin	23.89±3.24	19.19±2.5	47.20±5.14c	509.70±76.45c	5.15±0.46	4.12±0.61	8.88±1.43b	5.42±1.28
P	0.49	0.12	0.03	0.02	0.13	0.11	0.04	0.28

P: probability ; Values with the same letters in the same column are statistically equal. TM: mean plant size; NFE: mean number of leaves; EM: mean plant span; SFM: mean leaf area of plant; CM: mean crown circumference; NRM: mean number of branches; NFL: number of flowers; NFR:

Effects of *A. cordifolia* extracts on agromorphological parameters of tomato

Agromorphological parameters of tomato plants treated with *A. cordifolia* varied with concentration and soil treatment period. Thus, the concentration 15 g (C2) of the soil treated one week before transplanting (treatment 2) recorded the highest values for the agromorphological parameters, except for the number of branches, whose highest value was obtained at the concentration 5 g (C1) of the soil treated one month before transplanting (treatment 3). The smallest values were obtained at the concentration 15 g (C2) of the treated soil on the day of transplanting (treatment 1). Statistical analysis showed a highly significant effect ($P < 0.01$) of the treatments performed on the different parameters studied (Table 3).

Effects of *T. diversifolia* extracts on agromorphological parameters of tomato

The effect of *T. diversifolia* also varied according to concentrations and treatments on agromorphological parameters. Statistical analysis showed a highly significant difference ($P < 0.01$) among the studied parameters. The concentration 5 g (C1) of the soil treated one month before transplanting (treatment 3) recorded the highest values for the different parameters, except for the number of flowers, neck circumference and number of fruits, for which the highest values were obtained at the concentration 15 g (C2) of the same treatment (Table 4).

Table 3 : Agromorphological parameters of tomato plants treated with Alchornea cordifolia powder extracts according to treatments and concentrations

T	QT	TM	NFE	EM	SFM	DM	NRM	NFL	NFR
	C0	23.89±3.24ac	19.19±2.52ac	47.20±5.14ab	509.70±76.45c	5.15±0.46c	4.12±0.61ac	8.88±1.43bc	5.42±1.28ab
1	C1	25.45±3.48cd	21.28±3.23ab	55.47±6.11b	643.0695.44bd	5.37±0.54c	4.46±0.77ac	8.03±1.34ed	6.34±1.52ab
	C2	20.25±3.09d	18.59±2.54ac	45.03±5.88ac	480.00±90.80ef	4.44±0.45bc	3.21±0.59ac	4.91±1.13j	3.19±0.99ac
2	C1	26.42±3.76bc	21.97±3.37ab	53.56±5.50bc	572.09±81.31cd	5.34±0.48c	3.83±0.63ac	9.03±1.52bc	7.09±1.66b
	C2	30.58±3.59a	32.44±4.35a	65.56±6.07a	903.47±115.93a	7.26±0.66a	5.92±0.78b	13.92±2.00a	12.97±2.28a
3	C1	27.46±2.85ab	24.72±4.26b	52.53±5.95c	574.69±81.26cd	6.30±0.56b	7.75±1.62a	14.78±3.34a	7.28±1.95b
	C2	29.46±3.18b	18.47±2.31ac	52.06±4.55c	610.62±81.76ab	6.25±0.44b	5.21±0.92ab	12.00±1.92c	5.50±1.19ab
P		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

P: Probability; Values with the same letters in the same column are statistically equal. TM: average size; NFE: average number of leaves; EM: average span; SFM: average leaf area; DM: average diameter at the crown; NRM: average number of branches; NFL: number of flowers; NFR: number of fruits. 1, 2, 3: soil treated on the day of transplanting, one week and one month before transplanting; CO: Control; C1: 5 g dose; C2: 15 g dose; QT: Quantity, T= Traitement

Table 4 : Agromorphological parameters of tomato plants treated with Tithonia diversifolia powder extracts according to treatments and concentrations

T	QT	TM	NFEM	EM	SFM	DM	NRM	NFL	NFR
	C0	23.89±3.24ac	19.19±2.52ac	47.20±5.14ab	509.70±76.45c	5.15±0.46c	4.12±0.61ac	8.88±1.43bc	5.42±1.28ab
1	C1	20.42±3.06c	20.31±3.17ac	46.28±5.65bc	480.62±74.03bc	5.00±0.52ab	3.62±0.63ab	7.59±1.44ac	4.44±1.20ac
	C2	20.29±3.51c	22.78±3.55b	54.81±6.34b	587.34±91.37ab	5.57±0.58ab	5.08±0.69b	9.50±1.50ab	5.59±1.34ab
2	C1	27.29±3.02b	15.19±2.12c	42.84±4.23ac	414.90±73.02bc	4.81±0.44c	2.50±0.63c	4.97±1.08c	3.75±1.18ec
	C2	27.42±3.27b	17.69±2.61c	45.87±4.94bc	477.12±72.73bc	5.17±0.43ab	2.67±0.61j	5.47±1.03bc	4.22±1.29ac
3	C1	28.67±4.15a	22.62±3.33b	55.75±6.07a	679.81±114.62a	5.97±0.53b	5.79±1.06a	14.59±2.76a	7.69±1.59b
	C2	26.71±3.14b	25.37±4.16a	50.28±4.87ab	580.62±83.90a	6.35±0.65a	5.08±0.92b	12.75±2.15b	10.50±3.15a
	P	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

P: Probability; Values with the same letters in the same column are statistically equal. TM: average size; NFE: average number of leaves; EM: average span; SFM: average leaf area; DM: average diameter at the crown; NRM: average number of branches; NFL: number of flowers; NFR: number of fruits. 1, 2, 3: soil treated on the day of transplanting, one week and one month before transplanting; CO: Control; C1: 5 g dose; C2: 15 g dose; QT: Quantity, T= Traitement

Effects of *M. benthamianum* extracts on agromorphological parameters of tomato

As for *M. benthamianum*, statistical analysis also showed a highly significant difference (P<0.01) between agromorphological parameters (Table 5). Thus, the soil treated one week before transplanting (treatment 2) recorded the highest values of the agromorphological parameters at concentration 5 g (C1), except for the number of flowers whose highest value was obtained at concentration C2 of the soil treated one month after

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transplanting (treatment 3). The smallest values were obtained at concentrations C1 and C2 of the treated soil on the day of transplanting (treatment 1).

Table 5 : Agromorphological parameters of tomato plants treated with Mezoneuron benthamianum concentrations powder extracts according to treatments and concentrations

T	QT	TM	NFE	EM	SFM	DM	NRM	NFL	NFR
	C0	23.89±3.24ab	19.19±2.52bc	47.20±5.14bc	509.70±7.,45e	5.15±0.46b	4.12±0.61ab	8.88±1.43bc	5.42±1.28ab
1	C1	22.00±3.32bc	15.03±2.38ac	48.65±5.76bc	481.34±77.56c	5.14±0.54b	2.62±0.46ac	4.72±1.15bc	2.19±0.81c
	C2	19.81±3.71c	16.82±4.32ac	37.61±5.44c	325.36±61.53bc	3.85±0.56c	2.28±0.90c	3.21±1.22c	3.14±1.56ac
2	C1	32.71±3.28a	28.75±4.21a	65.09±6.13a	846.50±11.42a	6.60±0.62a	6.62±0.86a	10.94±2.05b	11.34±2.22a
	C2	24.08±3.41ab	20.37±3.88ab	44.78±6.09bc	528.78±108.20ab	4.65±0.59ac	3.75±0.86ac	5.16±1.27bc	4.94±1.63ac
3	C1	27.87±3.30b	16.66±1.86ac	52.34±4.81b	585.78±74.68ab	5.73±0.42b	4.67±0.58ab	11.00±1.83b	5.92±1.09ab
	C2	28.87±3.24b	21.25±2.69b	50.56±4.31ab	578.50±77.65ab	6.27±0.52a	5,04±0,83b	11.81±1.87ab	6.72±1.27b
P		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

P: Probability; Values with the same letters in the same column are statistically equal. TM: average size; NFE: average number of leaves; EM: average span; SFM: average leaf area; DM: average diameter at the crown; NRM: average number of branches; NFL: number of flowers; NFR: number of fruits. 1, 2, 3: soil treated on the day of transplanting, one week and one month before transplanting; CO: Control; C1: 5 g dose; C2: 15 g dose; QT: Quantity , T= Traitement

IV. DISSCUSSION

Tomato is a very demanding crop in terms of water but also in terms of mineral elements, which makes the periodic replenishment of the soil reserves in these elements essential to maintain a good productivity. The powdery extracts of *T. diversifolia, A. cordifolia* and *M. benthamianum* were used to improve the fertility parameters of tomato growing soil.

The results show that the survival or recovery rates of the seedlings did not vary from one treatment to another, but the values remained high (80 to 100%). This result shows that the treatments performed influenced the recovery of the seedlings or that the vigor of the seedlings used favored their recovery. Indeed, the work of Ojetayo et al. (2011) and Musas (2012) showed that the recovery rates of vegetable plants from the nursery does not depend on the mineral elements contained in the soil but rather on the vigor of the plants. Also the work of Soro et al. 2008 showed that the age of transplanting of nursery tomato plants influences the mortality rate of the plants. These authors showed that plants aged 21 to 25 days are more resistant to attacks by *Pythium* sp. responsible for the death of young plants. Treatments performed on tomato plants showed that the powdery extracts of the three plants applied four weeks before transplanting of the plants was more effective on morphological and production parameters of tomato. This could be explained by the synchronization of nutrient release from the extracts during their decomposition and assimilation by the plant. Indeed, Cobo et al. (2002) showed

that the rate of decomposition of organic matter and the increase in yields was closely related to the timing between the release of nutrients and their assimilation by the plant. The various extracts incorporated into the soil thus appear to have a suitable decomposition rate that allowed the plant to assimilate a large proportion of the nutrients released during the decomposition of the organic matter. Also, an increase in parameters such as, number of flowers, spread and leaf area was recorded on the plants whose soils were treated with Alchornea cordifolia. This would result from the importance and the quantity of nutrients such as phosphorus, nitrogen, potassium contained in this extract which contribute to the nutrition of the plant. Indeed, Alchornea cordifolia is a plant that is found in Ivorian fallow soils and contributes to increase the organic matter of the soil. The effectiveness of the extracts varied according to the plants and the concentrations. Thus, *A. cordifolia* was more effective at the 5g concentration (C2), while *T. diversifolia* and *M. benthamianum* were more effective at the 15g concentration (C1). This seems to be due to the fact that the plant extracts would have different effects on the growth parameters and development of the plants. This is in agreement with the results of NARC work on Garcinia kola in 2012 which found a variation in growth parameters depending on the substrate. The improvement of the growth parameters suggest that these extracts have inhibitory properties of soil pathogens. The anti-parasitic effects of plant extracts have been reported by different authors. Thus Kankam & Sowley (2006), demonstrated that

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the amendment of infested chilli plants by extracts of A. indica leaves allows a significant decrease of nematode populations. These results concur with those of Asare-Bediako et al. (2014) who highlighted the ability of extracts of *A. indica, C. papaya, Allium* sp., *Capsicum* sp. (Solanaceae), Anacardium sp. (Anacardiaceae) to minimize the severity of whitefly virosis and increase the yield of treated plots. This is explained by the fact that the extracts of these plants contain chemical substances such as terpenoids, steroidal heterosides, flavonoids, tannins, saponins, carbohydrates that act on the pest population and thus reduce their infections.

V. CONCLUSION

The results of this study showed that the powdery extracts of *A. cordifolia, T. diversifolia* and *M. benthamianum* had satisfactory effects on the improvement of growth and development parameters of tomato plants. However, only the Alchornea treatments had more significant effects on the studied parameters. For the different concentrations of plant extracts studied, C1 (5 g) gave the best results. It is therefore the optimal dose for treatment efficiency. The results also showed that the treatment of the soil one week before transplanting gave the best agromorphological parameters for *A. cordifolia* and *M. benthamianum* contrary to T. *diversifolia* which records the highest parameters when the treatments are done one month before transplanting. The work carried out showed the capacity of the extracts of these plants to be used to boost quantitatively and qualitatively the production of tomato

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