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Soil Properties and Tomato Productivity Improvement by Use of Polyter and Turbo-Bio in Sudanese Zone of Burkina Faso

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Abstract:

In Burkina Faso, vegetable production is challenged by low soil fertility and unavailability of irrigation water associated with numerous dry sequences. The study's objective is to apprehend the performance of polyter and turbo-bio on soil and tomato productivity. A trial was set up, in a controlled environment and in vegetation vases, according to a totally randomized complete block design with four replications and twenty treatments resulting from the combination of soil type, fertilization and water stress. Observations were made on growth and biomass production assessment. Co_2 release, pH, carbon, nitrogen, available phosphorus and moisture content were measured. The results showed that the polyter and turbo-bio improved the pH, organic carbon, total nitrogen and available phosphorus of the soil. They induced an increase in moisture content from 2.57 to 113.41% and from 4 to 75.78% for roots biomass production, and from 4 to 61.97% for aboveground biomass production compared to the control. In a context of global changes, polyter and turbo-bio could be an alternative for improving soil fertility and tomato productivity in Sudanian zone of Burkina Faso.

Keywords: Polyter, turbo-bio, tomato productivity, crop biomass, water stress, soil fertility.

1. Introduction

Burkina Faso's economy is essentially based on the agricultural sector, which employs more than 80% of the active population and contributes 33% to GDP [1]. Crop production accounts for 25% of GDP. Market gardening occupies an important place in that it employs more than 2.3% of the active population and contributes more than 2.8% of the country's GDP. In 2018, tomato occupied 18.80% of market garden areas and contributed 20.28% of total vegetable production estimated at 936519 tons [2].

However, tomato production, like all vegetable crops, is characterized by low productivity due to anthropogenic and natural constraints, including insufficient irrigation water, low input use [3], extreme weather events and soil quality. The low fertility of Burkina Faso's soils had been related by some authors [4, 5]. The use of chemical fertilizers, organic amendments, chemical fertilizer-organic amendment combinations [6, 7] and the construction of irrigation systems (dams, runoff collection basins, drip irrigation, development of hydro-agricultural perimeters, market garden wells and boreholes, etc.) are alternatives for mitigating water shortages and improving soil productivity with a view to increasing crop yield. However, the exorbitant cost and availability of mineral fertilizers, the

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low integration of agriculture and livestock, the poverty of producers and the pollution of water tables [8] limit these practices. It is therefore imperative to find other fertilization and water insufficiency mitigation technologies for sustainable agriculture; hence the use of turbo-bio (liquid organic fertilizer) and polyter (hydro-retainer enriched in fertilizing elements). [9] reported on the buffering capacity of polyter under water stress conditions on a tropical ferruginous soil. However, in a context of global changes associated with the plurality of soils in Burkina Faso, further investigations are required. Our study is part of this perspective. The overall objective of the study is to apprehend the performance of these two inputs on tomato production and some parameters of two contrasting soil types.

2. Materials and Methods

2.1. Experimental site

For this study, an experiment in vase of vegetation was conducted under greenhouse conditions from April to July on the site of the Institute of Research for Development (IRD) in Ouagadougou (12°22'11'' N, 1°30'46'' W). The climate, of the Sudano-Sahelian type, is characterized by an annual rainfall of between 600 and 900 mm. The rainy season runs from June to October. The average yearly rainfall of the Ouagadougou was 974.10 mm, the averages temperatures were 35.96 for maximal, 22.95 for minimal, environment moisture was 50.44, wind speed was 2.60 and ETP 6.07.

2.2. Soils in the trial

Two types of soil were used in this study: a tropical indurated leached ferruginous soil from the Centre region (village of Gampèla) and a green eutrophic brown soil from the Plateau Central region (village of Boudtenga). Soil samples were collected from each site on the 0-20 cm layer, dried in ambient air and shade and sieved to 2 mm for the greenhouse trial. An aliquot of each composite soil sample was collected for laboratory analysis (Table 1).

2.3. Experimental plant materials

The plant material used is tomato (*Lycopersicum esculentum* Mill.) of the variety Mongal F1. The sowing-maturity cycle varies from 120 to 150 days with a yield potential between 40 and 50 t. ha-1. The choice of this variety is explained by the fact that it can be grown both in the dry season and in the rainy season and is resistant to some bacterial and fungal diseases.

2.4. Inputs used

The inputs used are:

- Cattle manure;
- NPK (14-23-14) and Urea (46% N);
- Turbo-bio: this is a liquid organic fertilizer. It is composed of vegetable oil, plant and seed extracts and inert plant compounds. It is a foliar fertilizer, fungicide and pesticide. It is 100% biodegradable with a negligible impact on the environment, used by spraying on the leaves and/or by watering the root system. It has the following characteristics: (table 2).
- Polyter: it is a hydro-retainer enriched with fertilizers and phytosanitary products. It is naturally degradable, absorbs water up to 300 times its dry volume and 500 times its dry weight. It is fixed by the roots (and moves with them as they grow) and releases water on demand by the plant. The nodules are truly bound to the roots, accompanying them by gravity as they grow, with up to 95% of the water extracted from the nodules. It has the following characteristics: (table 3).

2.5. Experimental design and management of the trial

The study used a completely randomized design with four replications and twenty treatments. It is a factorial experiment with four replicates involving the soil factor at 2 levels, the fertilization factor at 5 levels and the water stress factor at 2 levels. Each pot, with a volume of 6 liters, constituted an experimental unit.

Five (05) kg of soil was taken and placed in each pot with a bottom perforated with small holes. The tomato plants were first grown in a nursery garden for one month. Each plant was transplanted into a pot amended with manure and moistened to field capacity (850 ml for browned soil and 800 ml for ferruginous soil). Prior to transplanting, 5g of polyter was applied to each pot to receive the polyter. NPK was applied in two stages (5g/pot 14 DAT and 4.6 g/pot at the beginning of flowering) and urea (2 g/pot) 30 DAT. Turbo-bio was applied weekly by spraying and drenching. During the first week of transplanting, all plants were watered twice a day (morning and afternoon). After that, the same watering frequency was applied to the plants under normal watering; however, the plants under water stress conditions were watered every other day (morning and afternoon). Every 3 days, the pots were moved to new positions in the trial.

2.6. Soils Analysis

For soils analysis, after unpacking the plants, one composite sample was collected per treatment by mixing the soils taken from each of the four pots corresponding to the four replicates (thus 20 composite samples were collected). All the samples collected were dried in ambient air and under shade.

Moisture content was determined by the gravimetric method. This consisted of weighing the wet weight of the samples taken. The samples were then placed in an oven at 105 °C until they reached a constant weight representing the dry weight. The mass of water is deduced by the difference between the mass of wet soil and the mass of dry soil of the sample and is related to the mass of dry soil to obtain the water content or weight moisture.

The pH was measured by electrometry using a pH meter and according to the [10] in a soil/water=2/5 suspension. The measurement is made after stirring the soil with demineralized water for 1 hour.

The release of CO_2 was measured according to the following protocol: 2g of soil were placed in glass anticoagulant tubes (3 replications), and brought to an optimal humidity (200 μl of demineralized water/tube), then the tubes were hermetically sealed. They are then incubated in the dark at room temperature. After 2 hours of incubation, the first measurement of CO_2 release was carried out and then returned to darkness. The second measurement was carried out after 24 hours of incubation. The other measurements were carried out every 72 hours of incubation (twice) to 96 hours of incubation (twice) and this for 2 weeks. The "DIMARSOL" measuring device was used for the various measurements.

Organic carbon was measured by [11] method, total nitrogen by [12] method and available phosphorus by [13] method.

2.7. Measurement of plant Growth parameters

The height of each plant from the collar to the last bud were measured. The measurements were made from the second week after transplanting and were repeated every two weeks using a graduated ruler. Then, the overall increase in height was determined by the difference between the final mean values at 14 weeks and the initial mean values at 2 weeks after transplanting. The evaluation of the above-ground and root biomass were determined to assess of the yield components. The biomass assessment operation started with the dressing and collection in bags of senescent leaves as the plants grew. The estimation of the dry phytobiomass production was made from the complete harvests in each pot and per plant. These above-ground and root biomass samples were pre-dried in the sun for one week and then oven-dried at 105°C to constant weight. During weighing, the samples were kept in a PYREX desiccator to prevent moisture build-up. An electronic balance was used to determine above-ground and root dry biomass.

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2.8. Statistical Analysis

Data were analyzed by one-way analysis of variance (ANOVA) using R software. Significant differences among treatments were computed by Newman and Keuls (p=0.05).

3. Results

3.1. Influence of inputs on soils properties and tomato productivity

3.1.1. Influence of Treatments on soil moisture and pH

On both types of soil, the SH + P and SH + TB + P treatments recorded the best moisture content. On browned soil, the highest rate was obtained with the SH + P treatment (14.69%) and the lowest with the SH + TB treatment (9.93%). On ferruginous soil, the highest rate was obtained with the SH + P + TB treatment (15.75%), i.e. an increase of 113.41%, and the lowest rate was observed with the SH + FM treatment (6.05%), i.e a reduction of 18.02%. Thus, the differences between the water stress control and the polyter application are 23.44% (P) and 113.41% (TB+P) in the ferruginous soil. They are 22.04% (TB+P) and 42.62% (P) in browned soil.

The pH values of the studied soils varied significantly with the treatments. Soils treated with mineral fertiliser had low pH values while those treated with liquid organic fertiliser had high pH values (Table 6).

3.1.2. Effects of treatments on soil carbon, nitrogen and phosphorus content.

The analyses of carbon, nitrogen and phosphorus were carried out without repetition in order to understand the general trend. This is due to financial constraints. The organic carbon content of the brown eutrophic soil is generally higher than that of the ferruginous soil. Compared to the control, mineral fertiliser (MF), turbo-bio (TB) and polyter (P) recorded the highest organic carbon levels in the brown eutrophic soil. However, in the ferruginous soil, P and P+TB recorded slightly higher rates than the control. FM and TB had carbon levels slightly below the control. In general, the nitrogen content is higher in the browned soil than in the ferruginous soil. On the ferruginous soil, FM, TB and TB+P had higher levels than the control. P is identical to the control. On brown soils, TB and TB+P are higher than the control. FM and P were below the control. The C/N ratio varied from 9.30 to 14.30 in ferruginous soil and from 11.05 to 13.43 in browned soil. The available phosphorus content is higher in the ferruginous soil than in the browned soil. Except for FM, which shows an exorbitant rate on the browned soil. The polyter registers the low rate in ferruginous soil. The high rate is obtained with TB, followed by TB+P and FM. In browned soil, all treatments show higher rates than the control.

3.1.3. Effects of treatments on soil CO_2 release

The curves are not very different. They show an increasing trend until the 264 HAI. The optimal peak is obtained with the mineral fertiliser at the 96 HAI (1103.33 mgCO2.kg-1 of burnt soil; 806.67 mgCO2.kg-1 of ferruginous soil); between the 96 HAI and the 264 HAI, the mineralization curve of the turbo-bio remains above with the major peaks of 1386.67 mgCO2.kg-1 of burnt soil and 1213.33 mgCO2.kg-1 of ferruginous soil In the last measurement, all mineralization curves showed a decay phase with the turbo-bio curves above the curves of the other fertilizers (1216.67 mgCO2.kg-1 of Browned soil and 1160 mgCO2.kg-1 of ferruginous soil). They are followed by the mineral fertilizer (1103.33 mgCO2.kg-1 of soil) and the control (876.67 mgCO2.kg-1 of soil) on browned soil against the control (1013.33 mgCO2.kg-1 of soil) and the mineral fertilizer (883.33 mgCO2.kg-1 of soil) on ferruginous soil.

3.1.4. Influence of inputs on Biomass production

The treatments had a significant influence on biomass production (table 7 & 8). Thus, under normal watering conditions, mineral fertiliser (AH+FM) and Turbo-bio combined with polyter (AH+P+TB) induced the best above-ground and root biomass in both ferruginous and brown soils. They made up the first group and were statistically equal, but differed from the second group made up of the polyter (AH+P), Turbo-bio (TB) and the control (AH) which were also statistically equal. FM induced an increase in above-ground biomass production of 21.62% and 74.61% respectively in tropical ferruginous soil and brown soil compared to the control. The turbo-bio combined with polyter induced an increase in above-ground biomass of 27.23% and 61.97% respectively in tropical ferruginous soil and browned soil. Under water stress conditions, mineral fertiliser (AH+FM) and turbo-bio combined with polyter (AH+P+TB) induced the best above-ground biomass in both ferruginous and browned soils. However, it was found that polyter, turbo-bio and turbo-bio combined had the best root biomass compared to the control and even FM. The increase in above-ground biomass due to FM ranged from 46.57% in the ferruginous soil to 51.60% in the browned soil. In terms of root biomass, turbo-bio, polyter and polyter combined with turbo-bio induced 36.36%, 55.84% and 62.34% respectively compared to the control in ferruginous soil. In browned soil they induced an increase of 8.33% and 27.50% respectively compared to the control.

3.2. *Figures and tables*

Table 1. Physical, chemical and biological properties of the trial soils

	Tropical ferruginous soil	Browned soil
Clay (%)	32.26	14.42
loam (%)	25.93	33.48
Sand (%)	41.85	52.82
Texture	Clay loam	Sandy loam
Organic matter (%)	1.010	0.931
Total nitrogen (%)	0.047	0.042
Available phosphorus (ppm)	0.40	2.27
Sum of exchangeable bases ($cmol^+.kg^{-1}$)	5.67	8.53
Cation exchange capacity ($cmol^+.kg^{-1}$)	7.73	12.20
Saturation rate (%)	73	70
pH(H_2O)	7.02	6.39
pH (Kcl)	5.81	5.11
CO_2 release (ppm)	3356.67±917.84	4723.33±519.84

Table 2. Characteristics of Turbo-bio

Component	Value
Vegetable oil extracts (%)	10-20
Plant extracts (%)	10-25
Seed extracts (%)	15-25
Inert Compounds (%)	10-20
Carbon (%)	60
Nitrogen (%)	5
C/N	12
P (%)	8
K (%)	20
Ca (%)	5.5

Mg (%)	0.5
pH	6.2

Table 3. Characteristics of polyter

Parameters	**Values**
Granulometry	94% passing between the 0.315 and 1 mm
pH	6.5-7
Dry matter (%)	88.5
Saturation time	3 hours
Retention rate	160-500g
Fertilizers in minimum releasable (%)	0.5 total nitrogen (0.15 ammoniacal nitrogen, 0.35 nitrogen nitrate)
	0.8 soluble phosphoric acid
	0.2 soluble potassium
Trace element	Bo, Cu, Fe, Mn, Mo, Zn
Temperature	Withstands extreme temperatures in the soil

Table 4. Treatment description

Treatment	**Acronyms**	**Meaning**
T1	SF+AH	Ferruginous soil with watering
T2	SF+AH+FM	Ferruginous soil with Mineral Fertilizers and watering
T3	SF+AH+TB	Ferruginous soil with Turbo-bio and watering
T4	SF+AH+P	Ferruginous soil with Polyter and watering
T5	SF+AH+P+TB	Ferruginous soil with Turbo-bio, Polyter and watering
T6	SF+SH	Ferruginous soil without watering
T7	SF+SH+FM	Ferruginous soil with Mineral Fertilizers and without watering
T8	SF+SH+TB	Ferruginous soil with Turbo-bio and without watering
T9	SF+SH+P	Ferruginous soil with Polyter and without watering
T10	SF+SH+P+TB	Ferruginous soil with Polyter and Turbo-bio, and without watering
T11	SB+AH	Browned soil with watering
T12	SB+AH+FM	Browned soil with Mineral fertilizers and watering
T13	SB+AH+TB	Browned soil with Turbo-bio and watering
T14	SB+AH+P	Browned soil with Polyter and watering
T15	SB+AH+P+TB	Browned soil with Turbo-bio, Polyter and watering
T16	SB+SH	Browned soil without watering
T17	SB+SH+FM	Browned soil with Mineral fertilizers and without watering
T18	SB+SH+TB	Browned soil with Turbo-bio and without watering
T19	SB+SH+P	Browned soil with Polyter and without watering
T20	SB+SH+P+TB	Browned soil with Turbo-bio, Polyter, and without watering

Table 5. Effects of treatment on soil moisture content (%)

Treatment	TFS	BS
SH	7.38 ± 0.08^{c}	10.30 ± 0.14^{c}
SH+FM	6.05 ± 0.26^{d}	12.40 ± 0.34^{b}
SH+TB	7.57 ± 0.26^{c}	9.93 ± 0.77^{c}
SH+P	9.11 ± 0.26^{b}	14.69 ± 0.04^{a}
SH+TB+P	15.75 ± 0.21^{a}	12.57 ± 0.02^{b}
P-value	<0.0000	<0.0000

Table 6. Effects of treatments on soil pH

Treatment	TFS	BS
AH	6.43±0.04^{d}	6.79±0.02^{b}
AH+FM	5.7±0.1^{g}	5.3±0.09^{c}
AH+TB	6.25±0.04^{e}	6.97±0.04^{a}
AH+P	6.74±0.06^{a}	6.97±0.01^{a}
AH+TB+P	6.63±0.02^{b}	6.85±0.06^{ab}
SH	6.25±0.03^{e}	6.7±0.18^{b}
SH+FM	5.26±0.02^{h}	5.12±0.06^{d}
SH+TB	6.51±0.03^{c}	6.75±0.04^{b}
SH+P	6.1±0.01^{f}	6.76±0.06^{b}
SH+TB+P	5.76±0.02^{g}	6.77±0.02^{b}
P-value	<0.0000***	<0.0000***

Table 7. Influence of traitment on biomass production under water supply conditions

Treatment	TFS		BS	
	AGB	RB	AGB	RB
AH	21.30±0.14^{b}	0.95±0.42^{ab}	19.93±0.61^{b}	1.23±0.31^{a}
AH+FM	26.33±4.89^{a}	1.70±0.87^{a}	34.80±3.96^{a}	1.60±0.57^{a}
AH+TB	22.23±1.63^{b}	0.93±0.25^{ab}	25.33±2.19^{b}	1.28±0.34^{a}
AH+P	18.90±1.00^{b}	0.90±0.10^{ab}	23.25±6.67^{b}	1.63±0.38^{a}
AH+TB+P	27.10±0.96^{a}	1.67±0.38^{a}	32.28±0.85^{a}	1.70±0.22^{a}
P-value	0.0009***	0.0532	0.0001***	0.318

Table 8. Influence of the traitment under water stress conditions

Treatment	TFS		BS	
	AGB	RB	AGB	RB
SH	16.75±1.48^{b}	0.77±0.28^{b}	17.17±0.23^{b}	1.20±0.01^{a}
SH+FM	24.55±0.07^{a}	1.00±0.07^{ab}	26.03±2.94^{a}	0.80±0.17^{a}
SH+TB	18.57±1.29^{b}	1.05±0.12^{ab}	20.20±2.88^{b}	1.13±0.30^{a}
SH+P	20.07±1.57^{b}	1.20±0.17^{a}	23.15±0.35^{b}	1.30±0.28^{a}
SH+TB+P	20.70±4.89^{b}	1.25±0.24^{a}	25.40±3.84^{a}	1.53±0.21^{a}
P-value	0.0059**	0.0234*	0.0001***	0.318

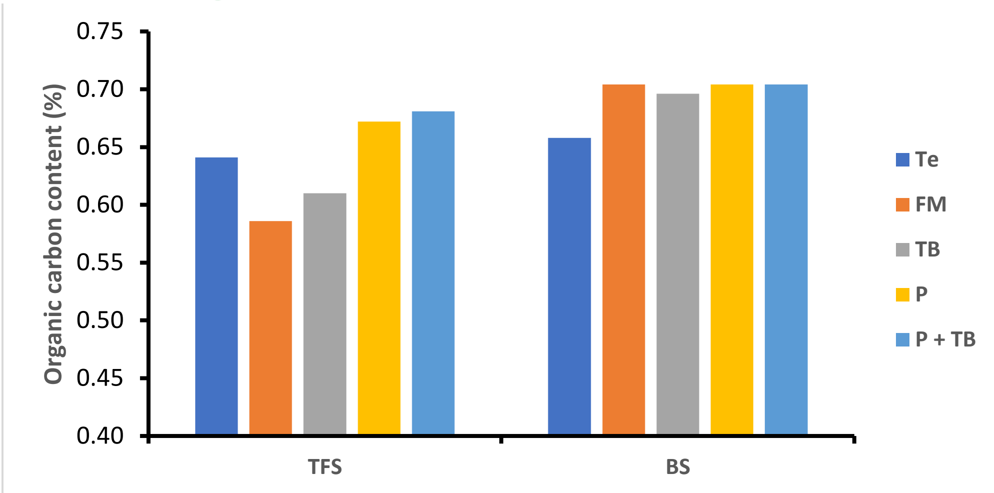

Figure 1. Effects of treatments on soil organic carbon content

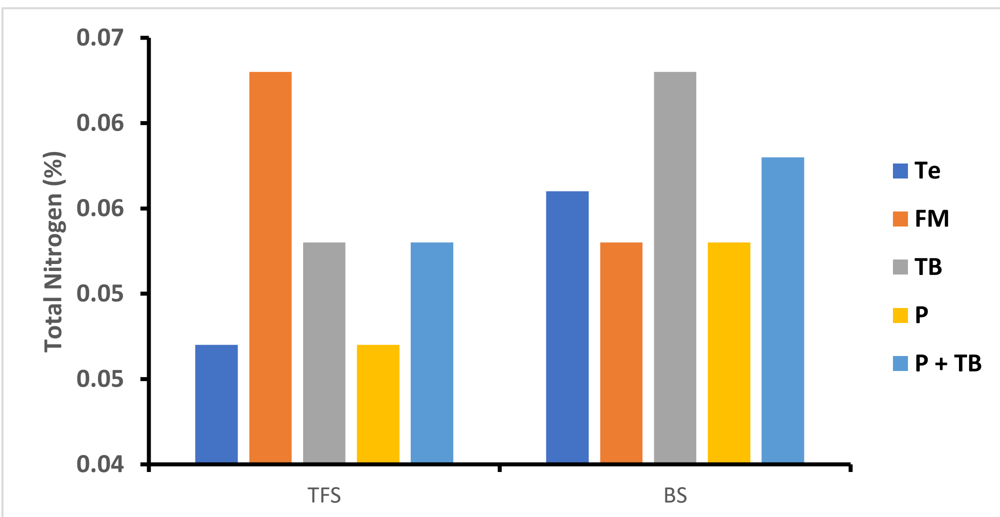

Figure 3. Effects of treatments on soil total nitrogen content

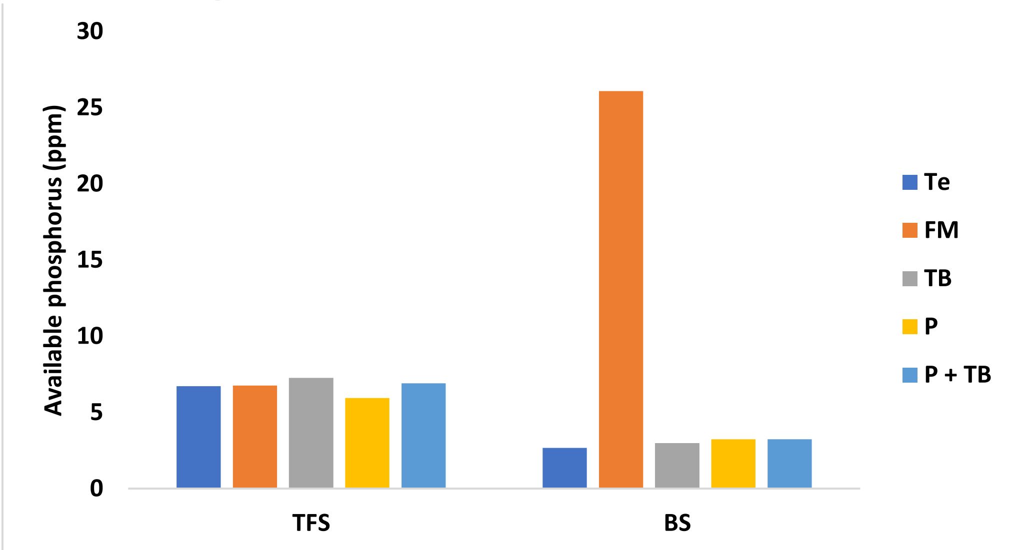

Figure 3. effects of the treatments on soil available phosphorus content

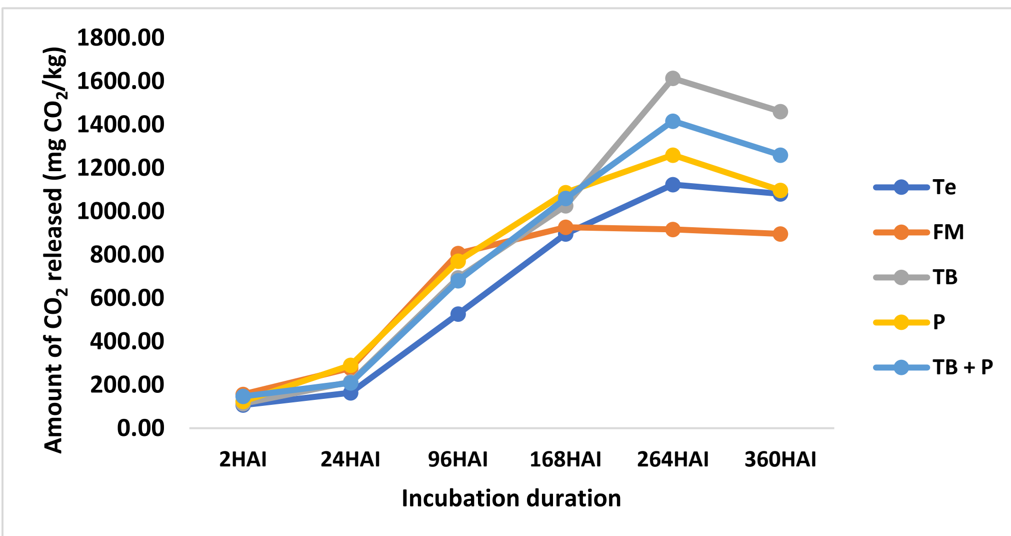

Figure 4. Effects of treatments on CO_2 release of Tropical ferruginous soil

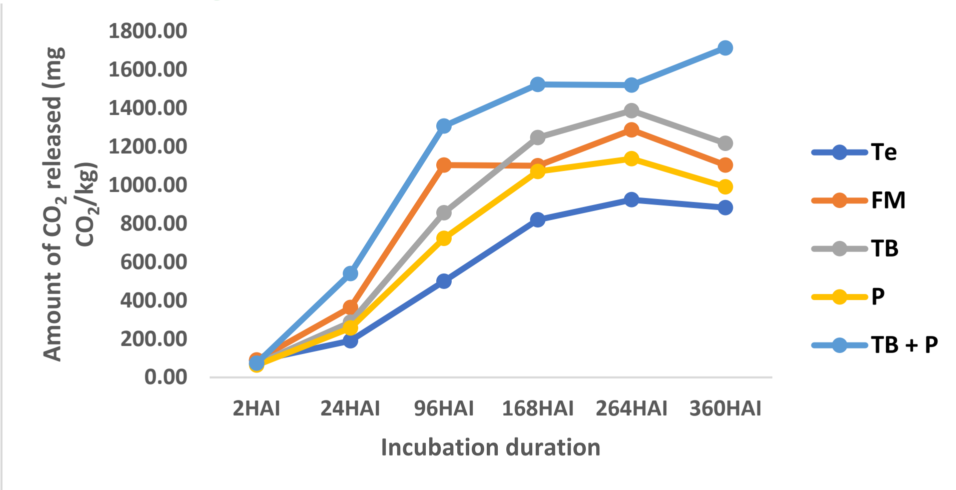

Figure 5. Effects of treatments on CO2 release of Browned soil

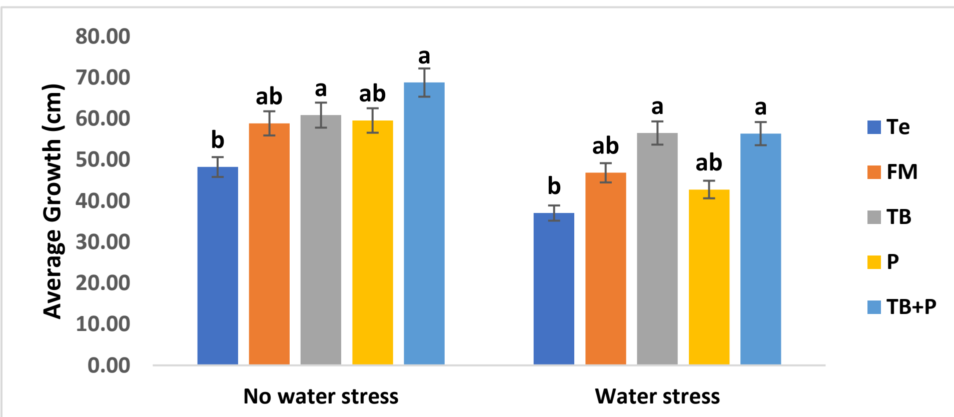

Figure 6. Influence of treatments on plant height growth in tropical ferruginous soil

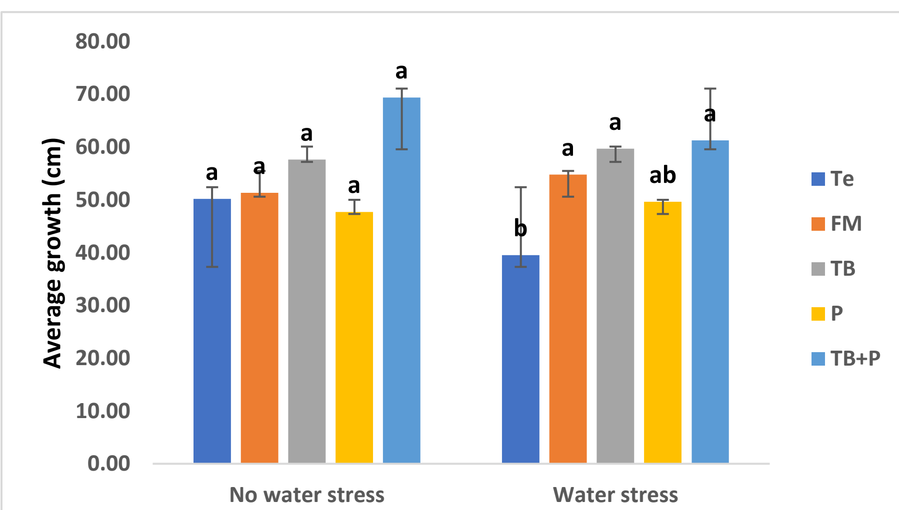

Figure 7. Influence of treatments on plant height growth in browned soil

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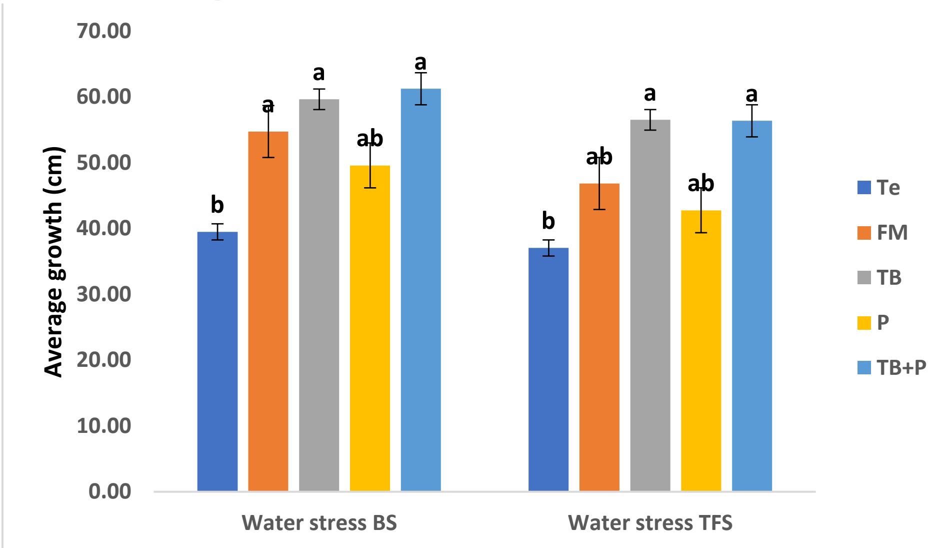

Figure 8. Influence of treatments on plant height growth in water stress conditions

4. Discussion

The highest moisture content was recorded on soils that received polyter, regardless of the soil type. This can be explained on the one hand by the hydro-retention property of polyter and on the other hand by the capacity of polyter to improve the soil structure. Indeed, thanks to their semi-permeable walls, polyter particles absorb a quantity of water that can reach 160 to 500 times their initial dry weight and constitute water reservoirs for both the plant and the soil [14]. The polyter increases the water retention capacity of the soil by reducing losses through evaporation and percolation [15]. Also its richness in K+, Ca^{2+} and Mg^{2+} cations could positively influence the improvement of soil structure [16]. Similarly, the moisture content seems to be more important in brown soils than in ferruginous soils. The physical and chemical properties of brown soil explain this difference. Thus, with a medium to fine texture (silty-clay) containing montmorillonite clay, the brown soil is able to gorge itself with water in the sheets of its clay in addition to the water stored by the polyter. However, in view of the initial characteristics of the soils, the polyter is better used on ferruginous soils than on brown soils in terms of moisture improvement. The availability of water for the plant remains to be elucidated in both cases.

The mineral fertilizer (NPK and urea) led to an increase in acidity, while the liquid organic fertilizer (turbo-bio) led to a decrease in acidity in both types of soil. Thus, soils treated with mineral fertilizer had significantly lower pH values than soils treated with liquid organic fertilizer (turbo-bio). These results are corroborated by those obtained by [17], who showed that turbo-bio raises the soil pH. The low pH recorded with mineral fertilizer could be explained by the fact that the addition of urea sometimes contributes to soil acidification. As indicated by some authors, the addition of nitrogen in the form of urea and the use of mineral [4,18,19] leads to soil acidification, a decrease in cation exchange capacity and saturation in exchangeable aluminum [20]. The higher pH obtained with the application of turbo-bio is due, on the one hand, to the organic matter it contains and, on the other hand, to its content of exchangeable bases such as calcium and magnesium. Indeed, turbo-bio contains 35 to 70% of extracts of plant origin and 103.44% of organic matter. The corrective effect of soil pH by organic matter had been widely demonstrated [21–25]. Also, the addition of calcium and magnesium is similar to liming [26-27] as they contribute to raising the soil pH.

The carbon and nitrogen levels of the brown eutrophic soil are higher than those of the ferruginous soil. The brown eutrophic soil has good characteristics: pH tending towards neutrality, richer in carbon, nitrogen, organic matter and clay than the ferruginous soil. It is the best soil in Burkina Faso [28–30], but

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it is deficient in available phosphorus (0.40 mg.kg-1). The use of mineral fertilizers, turbo-bio and hydro-retainer tended to increase the carbon and nitrogen content of the eutrophic brown soil, which created a good water condition allowing microorganisms to easily access the mineral nitrogen in its inputs; this nitrogen is therefore used to decompose the organic matter contained in the soil. Also, this increase in nitrogen could also be explained by phosphorus deficiency. Indeed, nitrogen is only used by the plant when it is well supplied with phosphorus [31]. The drop in carbon and nitrogen levels caused by the application of mineral fertilizer, turbo-bio and polyter in the ferruginous soil can be explained by its lower initial M.O content than that of the eutrophic brown soil, as well as its higher carbon dioxide release than that of the eutrophic brown soil. The higher the biological activity, the lower the turnover time of the organic stock. This decrease in the quantity of organic matter also leads to a decrease in the nitrogen content of the soil. As for available phosphorus, its content is higher in the brown soil than in the ferruginous soil. This could be due to the nature of the clay in the brown soil (montmorillonite) and its slightly neutral pH. These are among the parameters that condition an increase in phosphorus solubilisation in the soil [32-33]. In the ferruginous soil, the low content of available phosphorus can be explained by the fact that phosphorus is fixed by other elements in the soil. Indeed, the results of [33]showed that a high proportion of soil phosphorus is bound to iron and aluminum in ferruginous soil under cultivation. Furthermore, in addition, the higher levels of available phosphorus in soils treated with mineral fertilizer, turbo-bio and polyter are also due to the fact that these inputs have some available phosphorus.

The evolution of the curve, which translates the biological activity of the soil according to the treatments, is the same in terms of character. Two phases were mentioned. A first phase where the curves are slowly ascending (2 HAI to 24HAI). The low CO_2 release recorded during the 24 hours after incubation (HAI) reflects a low biological activity. This could be explained by the fact that the soil microorganisms are still in a dormant state. Similar results observed by [31] and [17] revealed that during the first four hours of incubation the microorganisms being in a latent phase, their biological activity would not be fully triggered. The continuation of this first phase which became very ascending; it is the exponential growth phase (24 HAI to 96HAI), it would correspond to the full mineralization of the easily biodegradable organic matter following the lifting of the dormancy. This degradation of organic matter and/or biodegradation of dead microorganisms during the soil drying phase [34-35] would allow heterotrophic microorganisms to meet their energy needs [36]. Moreover, this increase in release may be due to the presence in these soils of Azotobacters, which are germs with a high respiration rate [37]. For all treatments, the increasing evolution of CO_2 indicates an intensification of the respiratory activity of the soils at 96 HAI and 264 HAI. This respiration differs from the type of soil and the different treatments. Furthermore, at the optimum peak phase, the respiration intensities of the soils that received the mineral and turbo-bio fertilizers are higher than those of the control. This can be attributed to the effects of the nitrogen and phosphorus contained in the mineral fertilizer and turbo-bio. It is known that nitrogen and phosphorus are essential for the development of soil microorganisms and have a positive effect on the mineralization of organic matter [35,38,39]. Moreover, turbo-bio contains cations (K^+, Ca^{2+} and Mg^{2+}) which would allow it to play the role of a liming amendment [27] and therefore regulate the pH for a better biological activity of the soil.

By the 264 HAI, CO_2 releases from soils have reached their peak levels. At this time, the respiration levels of the turbo-bio soils are the highest. Soils under turbo-bio treatment breathe well compared to those under mineral fertilizer. This may be due to the richness of the turbo-bio in organic matter. The influence of biological activity potential by the quality and content of organic matter had already been mentioned by many authors [39-41]. Soils treated with turbo-bio would contain more organic matter in which its mineralization would stimulate the biological activity of the soil in a sustainable way. This explains why at the 264 HAI, the respiration of the soils with the turbo-bio treatment is higher than that of the soils with the mineral manure treatment.

The third phase, which is decreasing (264 HAI to 360 HAI), would indicate a weakening of biological activity, which would be justified by a decrease in the quality and quantity of easily biodegradable substances. This would be due to a drop in carbon or nitrogen content or to the presence of recalcitrant compounds that could inhibit microbial growth [35]. However, with the exception of the Browned soil under TB+B, no other soil recorded a new ascending phase, as some authors had pointed out [17,34], which would reflect a low rate of CO_2 release allocated to the degradation of complex compounds (cellulose, lignin), to the diversity of microorganisms and to the properties of the soil [34-35].

In general, the supply of fertilizers in different forms has improved the height growth of the plants. This growth is a function of the quality and quantity of the fertilizers, the type of soil and the level of their initial fertility. The results showed that the growth of tomato plants was more homogeneous on burnished soil than on ferruginous soil. This could be explained in part by the initial quality of the brown soil, notably the texture (moderately fine) and the pH water (7.02). According to the interpretation standards of [42], this pH is weakly acidic to neutral (pHwater=7.02) and favourable to plant development. The water-stressed plants showed low increases in height compared to those that were watered normally. These results corroborate those of [17], who found that plants under water stress had lower growth than those under normal watering. The water stress is at the origin of this weak growth.

In our opinion, our work has led to an interesting result, showing the buffering role played by the polyter in reducing or even neutralizing the negative effect of water stress on the two types of soil. This buffering effect had been demonstrated by [17] in tropical ferruginous soil. Through its retention property, the polyter stores water and makes it available to the plant as and when it and as it is needed. In addition, the polyter contains nutrients that are accessible to the by the plant. Indeed, the polyter particles, containing fertilizers (N, P and K), are grafted to the roots of the plants with the help of the polyter. the roots of the plants in the same way as nodules in leguminous plants and make water and nutrients and provide the plants with the water and mineral elements they need; these nutrients are then These nutrients are then available to the plant, humidity is optimal and good edaphic conditions are thus created, favouring the growth and development of crops. Nitrogen, phosphorus and potassium induce good growth, development and crop production [43,31]. In addition, polyter contains trace elements (Bo, Cu, Fe, Mn, Mo, Zn) that play an important role in plant growth and development.

Mineral fertilizers and liquid organic fertilizer induced significant increases in plants. Fertilizing elements such as nitrogen, phosphorus and potassium contained in these inputs could be responsible for these remarkable effects due to their availability to plants after dissolution. Indeed, studies have already shown that, on the one hand, nitrogen and phosphorus are the limiting nutritional factors for plant growth in tropical soils [44]; nitrogen and potassium are also essential elements for plant growth, quality and proper development [45-46]. On the other hand, phosphorus is the major element, crucial for the development and functioning of plant organisms. So their presence in these fertilizers would neutralize the limiting effect and promote the growth of tomato. Furthermore, turbo-bio contains exchangeable bases (K^+, Ca^{2+} and Mg^{2+}) whose Ca^{2+} and Mg^{2+} cations would improve soil structure [16]. This explains the fact that their contribution positively influences the growth of the tomato. This This result leads us to believe that the liquid organic fertilizer "turbo-bio" would be agronomically comparable to the chemical compound NPK fertilizer and would even have the advantage of being advantage of being less harmful to the environment, as the harmful effects of chemical fertilizers on the environment have already been demonstrated in several places in the world.

Biomass is higher on browned soil than on ferruginous soil. This better biomass production would be due to the physico-chemical and biological properties of this soil. Indeed, the browned soil initially had favourable chemical (pH=7.02) and physical (fine texture) properties. On removal, whatever the treatment and the crop, the browned soil showed higher moisture levels than the ferruginous soil, which confirmed its favourable initial chemical and physical properties.

Plants under water stress conditions showed low biomass production compared to those under normal watering. These results corroborate those of [17], who found that plants under water stress produced less biomass compared to those under normal watering. According to the Ouagadougou weather station in Burkina Faso, average temperatures ranged from 33°C to 40.07°C from January to June; this reinforced the impact of water stress. The reduction in dry matter production has been mentioned by [47]. Similarly, studies have shown that water deficit significantly influences plant growth and development [48] by reducing their biomass yield [49-50].

The addition of the polyter reduced these shortcomings. Indeed, the supply of polyter to plants subjected to water stress reduced the effects of the stress, thanks to its hydro-retention property, and reinforced the level of nutrient supply, through the release of its mineral nutrients (N, P, K, Bo, Cu, Fe, Mn, Mo, Zn) which are essential to the plant [51–53], thus leading to a good growth and a good biomass production competitive with that of plants under normal watering without polyter.

Mineral fertilizer and turbo-bio also induced an increase in biomass production compared to the controls. The effect of these fertilizers was greater with the addition of polyter than without polyter. This better production with mineral fertilizer and turbo-bio could be explained by the fact that they contain significant quantities of elements such as nitrogen and phosphorus, elements that ensure good plant growth and development and that act immediately on the development of the foliage and on the production of the plants in cultivation [43, 54]. Indeed, a good biomass production reveals an availability and a proper assimilability of nutrients by the plant, thus a correct nutritional state of the latter good nutritional status of the plant [55]. It is also likely that the synchronization of the release of nutrients from the organic matter contained in the turbo-bio and their assimilation by the crops is good. Indeed, the rate of decomposition of organic matter and the increase in yields are closely linked to the synchronization between the release of nutrients and their assimilation by the plant [56-57]. Indeed, Turbo-bio contains nutrients such as (N, P, K, Ca, Mg) that (N, P, K, Ca, Mg) that contribute to the improvement of soil fertility and plant growth [58]. It is therefore possible that Turbo-bio, polyter and their combination improve soil fertility through the release of the minerals contained in them.

5. Conclusions

This study highlighted the influence of polyter and turbo-bio on soil properties and biomass yields of tomato in order to contribute to the improvement of vegetable production in a sustainable way. Ultimately, the results showed that polyter and turbo-bio improve moisture content, pH, carbon, nitrogen and phosphorus content as well as soil biological potential, growth and plant biomass productivity of tomato. Also, the combined effect of the polyter and turbo-bio enables the regulation of soil pH, moisture and biological activity. Their effects on the environment and soil life are of paramount importance for sustainable soil productivity, as pH, moisture and biological activity are important indicators of a soil's "good health". Therefore, polyter and turbo-bio could be a good alternative for optimizing vegetable production and sustainably improving soil fertility in the Sudanian zone of Burkina Faso in a context of global change.

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