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EFFECTS OF ORGANIC AND MINERAL FERTILIZERS ON THE PRODUCTIVITY OF TOMATO (SOLANUM LYCOPERSICUM.) IN NIGER

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ABSTRACT

Soil poverty constitutes one of the main constraints which limit the productivity of crops and particularly vegetable crops in Niger. The rational use of organic and mineral fertilizers is necessary not only to overcome low soil fertility but also and above all to correct nutrient deficiencies due to poor soil management practices. This study was conducted, aiming to assess the effects of organic fertilizers (compost and biochar) and mineral fertilizers (NPK 15 15 15 and UREE) on the productivity of tomato (*Solanum lycopersicum*) cv Tropimech. The study is carried out at the Saga experimental. in a completely randomized block design consisting of three repetitions and six treatments including a control treatment (T0). treatments are: T0 (without fertilizer); T1 (10t/ha of compost); T2 (0.5t/ha of Biochar); T3 (5kg/ha of Grower Fertilizer); T4 (25kg/ha of Urea + 125kg/ha of NPK 15 15 15); T5 ((10t/ha of compost+0.5t/ha of Biochar+5kg/ha of FertilizerGrower+25kg/ha of Urea +125kg/ha of NPK 15 15 15). The results showed that the biomass yields (40.89±15.06t/ha) and fruit yields (14.93±7.79t/ha) recorded for the treatments T0 (without fertilizer) are part of the low yields recorded in the study and that All doses of fertilizers administered gave good yields (21.39±15.48t/ha to 32.05±25.20t/ha). Treatments T1 and T2 gave satisfactory results and good fruit quality (86.20±10.227% and 79.93±12.470%) with only respective doses of 10t/ha of compost and 0.5t/ha of biochar. On this basis, we can admit that a reduction in the dose of mineral fertilizer and a sufficient supply of organic manure will be essential to ensure a better yield of tomato fruits.

INTRODUCTION

In Niger, agriculture is the primary source of income for farmers and also the main economic activity of the country. The chronic food insecurity that crosses the country has oriented agricultural policy towards the promotion of irrigated crops including vegetables which increasingly occupies a place of choice in Nigerien agriculture and, since the drought of the 1980s [1], with 48,000 hectares or 68% of irrigated areas, and the most laudable crops are onion (*Allium cepa* L.), sweet potato (*Ipomoea batatas* L.), cabbage (*Brassica oleracea* L.), cassava (*Manihot esculentus* L.), potato (*Solanum tuberosum* L.) and tomato [2]. The latter is one of the most important crops in the world and in Africa both in terms of its place in production systems as well as its consumption and nutritional value [3]. Tomatoes (*Lycopersicum esculentum*) are grown in all regions of Niger [4], with production of fresh tomatoes in 2008 estimated at 50,958t for an area of around 5,118 ha and an average yield of 9,957 tons / Ha. (DNSA/MDA, 2009). However, tomato production remains much lower [4]. This low yield, favored by poor plant development, is due to high disease pressure, plant-parasitic nematodes and harmful insects [5] and low soil fertility [6] The use of organic and mineral fertilizers is necessary to correct nutrient deficiencies due to poor soil

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management practices. But also, the use of synthetic (mineral) fertilizers is limited by their exorbitant and increasing price on the market and especially by the acidification of soils caused by their long-term applications [7] and groundwater pollution [8]. For this, two organic fertilizers (biochar and manure) and two mineral fertilizers (NPK + Urea and Grower) were used to carry out this study in order to evaluate their effectiveness on the yield of the tomatoes.

MATERIALS AND METHOD

Study site and soil structure

The study was undertaken in the Saga experimental site (figure 1) located in "Kaffa Koira"in commune II of Niamey between (13°27"36.34236'N, 2°9"28.05804 E). The choice of this site is justified by the environmental conditions similar to tomato growing areas to ensure expression of the agronomic characteristics of the Tropimech variety.

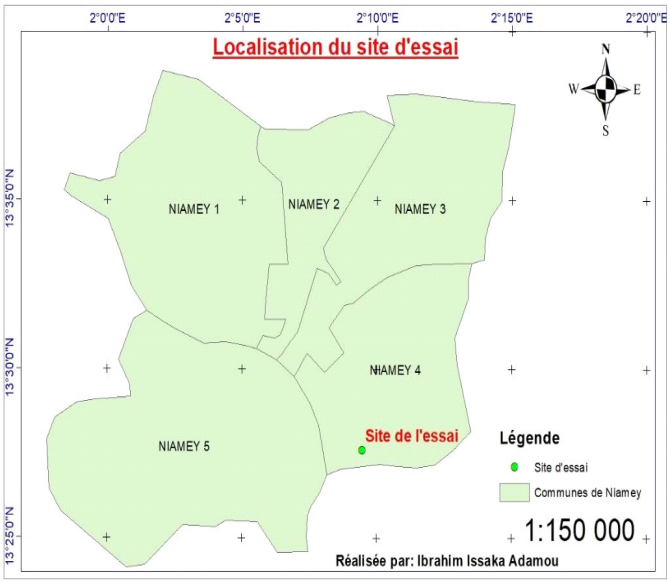

Figure 1. Localisation of experimental site

The experimental design used was a completely randomized block consisting of three repetitions and six treatments including a control (T0) (without any fertilizer application). The elementary plot (EP) is a board 1.5 m x 1 m e.g. 1.5 m² of surface area. The distance between tow plots was 0.5 1 m between the blocks. The tomato plants were transplanted following spacings of 50 cm between the rows and 50 cm between the plants (50 cm x 50 cm) (Figure 2).

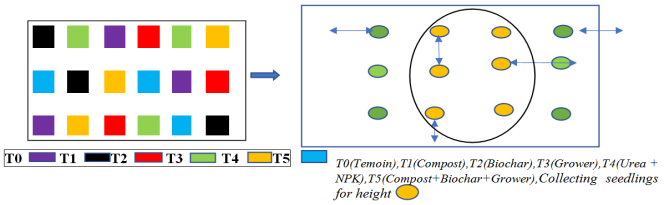

Figure 2. Experimental setup

Plant material

The plant material consists of seeds of the tomato variety, Tropimech, which is very resistant to *Verticillium*, *Fusarium* 1-2, *Stemphylium* and *Alternaria*. Its cycle, from planting to maturity, is 70 to 75 days. Vigorous and productive, the plant produces rounded, red-colored tomatoes weighing 50 to 60 g on average which can reach 10 to 12 cm. Their flesh is firm, soft and contains little water and is of good quality. The choice of this variety is made on the basis of five criteria:

- Flavor,
- Precocity,
- Excellent conservation
- Resistance to disease and transport
- The importance of production in Niger.

Conduct of the test and maintenance

The trial was conducted during the 2021-2022 dry season. The tomato was sown in the nursery on October 25, 2021 in previously disinfected soil with deep plowing by exposing the clods to the sun (heat) against tomato diseases and pests and better phytosanitary management of seedlings. The soil preparation (ploughing, crumbling, making the beds) was done on December 8, 2021 and the compost and biochar were added as background manure to the plots depending on the treatments. The tomato seedlings were transplanted on December 10, 2021, approximately 45 days after sowing. The top dressing fertilizers (NPK, Urea and Gower) were applied on 12/21/2021, 01/5/2022, 01/19/2022 and 02/3/2022 also depending on the treatments. Manual weeding was carried out on demand. The first harvest took place on March 30, 2022. A total of five harvests have been done for each treatment.

Table 1. Doses of fertilizers used

Treatments	Formulation		Application periods
T0 (Witness)	0 kg		
T1 (Compost)	1 kg / m²	10t/ha	Soil preparation
T2 (Biochar)	50 g/ m²	0,5t/ha	Soil preparation
T3 (Grower)	0.5 g/ m²	5kg/ha	Flowering and at fruiting stages
T4 (Urea + NPK)	2,5g/m² + 12,5g / m²	25kg/ha + 125kg/ha	Flowering and at fruiting stage
T5 (Compost+Biochar+Grower)	1 kg / m²+ 50g / m²+0.5g/m²	0,5t/ha5kg/ha150kg/ha	Soil preparation (compost and biochar) and flowering and at fruiting (grower)
NB: For mineral fertilizers, the contributions are localized (at the plant level)			

Observations and data collection

- Observations and data collections were made in each plot. The parameters measured were:
- The height of the leaves: it was measured at the flowering stage;
- The number of fruits per plot: the fruits are harvested and counted at each harvest
- The weight of fruit per plot: the harvested fruits are weighed at each harvest
- Weight of biomass per plot: fresh biomass is harvested and weighed at the end of the five harvests.
- The yields per hectare in fruit and biomass were obtained by the following formula: ((PMP X 10,000) / SPE) / 1000; PMP: average weight per plot; SPE= elementary plot area.

Statistical analyzes

Analysis of variance (ANOVA) was carried out with SPSS VERSION 22 software on the data to compare the agronomic parameters between the different treatments. The Tukey test at the 5% threshold was used to compare the means two by two.

RESULTS

Effect of fertilizer doses on plant height

Analysis of variance showed a significant effect between treatments (Figure 3). The application of 50 mg/m² of Biochar influenced the growth of tomato plants with a height of 58.578±12.7227 cm compared to the other treatments. The heights obtained by the treatments T1(53.261±14.817), T3(51 .822±11.7720),T4(53.083±15.0484) and T5(53.333±10.3312) and T0 (51.428±12.1822) are statically identical. The T3 treatment (Grower fertilizer) did not give good results on the height growth of the plants (51.822±11.7720) because it was identical with the T0 treatment (51.428±12.1822).

T0 (Témoin), T1(Compost), T2(Biochar), T3(Grower), T4(Urée + NPK), T5(Compost+ Biochar+ Grower)

Effect of fertilizer doses on the number and quality of fruits

Table II presents the effect of fertilizer doses on the number of fruits per plot and per plant and the quality of fruits per plot. The analysis of the results shows us that the average number of fruits harvested varied from 37.40±30.829(T0) to 75.13±55.959 fruits (T4) The number from 3 to 6 fruits per plant. These results did not show significant differences, except at the level of the T0 treatment which differs from the others with a statically different number of fruits (37.40±30.829). The control plot and the plots having received organic fertilizer treatments such as compost (T1) and biochar (T2) recorded a higher percentage in terms of fruit quality respectively of 81.40±13.642%, 86.20± 10.227% and 79.93±12.470%.

Table 2. Effect of fertilizer doses on the number and quality of fruits

Traitements	ANFP	NFP	QFP
T0	37,40±30,829	3	81,40±13,642
T1	51,40±37,919	4	86,20±10,227
T2	66,13±48,561	6	79,93±12,470
T3	58,67±40,635	5	72,13±27,430
T4	75,13±55,959	7	71,47±21,441
T5	68,93±68,193	6	72,67±30,554

T0(control),T1(Compost),T2(Biochar),T3(Grower),T4(Urea + NPK),T5(Compost+Biochar+Grower) ANFP: Average number of fruits per plot; NFP: Number of Fruits per plant; FAQ: Fruit quality per plot

Effect of fertilizer doses on yield parameters

Table 3 presents the average weights of fruit and fresh biomass per plot as well as the yield. The analysis shows that the average weight of fruits varies from 2.2393±2.02966kg to 4.8080±4.08388kg (Table III). Treatments T4 (4.8080±4.08388) and T2 (3.9507±3.07809) are significantly higher. It is statically similar for treatments T1 (3.2080±2.78712), T3 (3.3667±2.41769) and T5 (2.9840±2.73825). This parameter is significantly low for the T0 treatment (2.2393±2.02966). The highest average weights of fresh biomass were recorded by treatments T2 (8.100±2.01) and T4 (7.033±0.84). And are statically identical for the other treatments. The total fruit yield varies from 32.05±25.20t/ha (for the T4 treatment) to 14.93±7.79t/ha (for the T0 treatment) and the biomass yield from 40±2.00 (for treatment T3) at 54±13.38t/ha (for treatment T2). The compost at 10t/ha made it possible to have a fruit yield of 21.39±15.48t/ha. The treatment T2 (biochar) (Figure 4) allowed for a significantly high fruit yield (26.34±15.30t/ha)

Table 3. Effect of fertilizer doses on yield parameters

Traitements	AWFP (kg)	AWBP (kg)	AFY (t/ha)	ABY (t/ha)
T0	2,2393±2,02966	6,133±2,26	14,93±7,79	40,89±15,06
T1	3,2080±2,78712	6,133±3,36	21,39±15,48	40,89±22,41
T2	3,9507±3,07809	8,100±2,01	26,34±15,30	54±13,38
T3	3,3667±2,41769	6,000±0,30	22,44±14,87	40±2,00
T4	4,8080±4,08388	7,033±0,84	32,05±25,20	46,89±5,59
T5	2,9840±2,73825	6,233±1,72	19,89±12,15	41,55±11,48

T0 (Control),T1(Compost), T2(Biochar), T3(Grower), T4(Urée + NPK), T5(Compost+ Biochar+ Grower) , AWFP: Average Weight of Fruit per Plot; AWBP: Average Weight of Biomass per Plot; AFY: Average Fruit Yield; ABY: Average Biomass Yield

and biomass yield (54±13.38t/ha).

DISCUSSION

The results on vegetative development show that the height of the plants varies from 51.428±12.1822 to 58.578±12.7227cm depending on the treatments. which is consistent with the findings of [9] who obtained heights varying from 52, 66±1.90 to 59.33±8.57. The heights obtained with T1 (53.261±14.817), T3(51.822±11.7720), T4 (53.083±15.0484) and T5(53.333±10.3312) are statically identical with T0 (51.428 ±12.1822). According to [9], it is likely that the nutrients present in the soil were sufficient for the tomato growth and development. And also, the compost and mineral fertilizers have greater agronomic efficiency ([10], [11], [12]), because they present an immediate source of nutrients assimilated by the plant, thus promoting its nutrition [13] According to studies conducted on tomatoes, the combination of mineral and organic fertilizers is also a factor that promotes nutrient assimilation. ([14]; [15]). The average number of fruits harvested ranged from 37.40 ± 30.829 to 75.13 ± 55.959 fruits depending on the treatments applied, or 3 to 7 fruits per plant. [16] obtained 4 to 10 fruits per plant when comparing organic fertilizer doses on two tomato varieties from Ivory Coast (a local variety called Buffalo and an improved variety called Topaze). [13] in his study on the Mongal F1 tomato variety obtained a number of fruits per plant ranging from 10 to 20 fruits, and [6] on the Roma VF variety obtained a number of fruits ranging from 6 to 35 fruits. These differences in results may be due to the use of different varieties and the low doses of fertilizer used in this study. The control plot and the plots having received organic fertilizer treatments such as Compost (T1) and Biochard (T2) recorded a higher percentage of fruit quality of 81.40±13.642%, 86.20± respectively. 10.227% and 79.93±12.470%, the use of compost could allow both the sustainable increase in horticultural production and the reduction environmental pollution by chemical fertilizers [17]. The total fruit yield varies from 14.93±7.79t/ha (for treatment T0) to 32.05±25.20t/ha (for treatment T4). [6] obtained yields ranging from 10.02 t/ha to 24.3 t/ha with the Roma VF variety. The same observation was made with a yield varying from 8.38 t/ha to 33.24 t/ha in a study carried out by [12] with NPK granules at different doses. Compost with a dose of 10t/ha provided a fruit yield of 21.39±15.48t/ha higher than the result obtained by [7] (15.01±7.8t/ha). ha) with 30t/ha of compost. The yield per hectare decreases with the increase in the dose of organic fertilizer [7]. But a contrary result from [17] who showed that onion yields increase with increasing doses of compost.

The treatment based on the organic fertilizer "Biochar" recorded 26.34±15.30t/ha and a biomass (54±13.38t/ha) with only 0.5t/ha; this result is higher than that obtained by [13] (21.0 ± 4.6 t/ha) with the use of a biofertilizer (5 tons/ha of Mycosol compost + 1.5 Kg/ha of Mycotri + 4 liters/ha of Mycoplus) (organic fertilizer). Indeed, the application of biochar or manure, particularly in soils with low organic matter content, would be more efficient in regulating the physical, chemical and biological properties of the soil and improving agricultural production [18].

CONCLUSION

The study consisted of evaluating the impact of five types of fertilizers including two organic, two mineral and the combination of two types of fertilizers (mineral fertilizers and organic fertilizers). The results of this study showed that the yields of biomass and fruits recorded for the treatments without fertilizer are among the low yields recorded in the study. All doses of fertilizers administered gave good yields compared to the control on this basis, we can admit that a reduction in the dose of mineral fertilizer and a sufficient supply of organic manure will be essential to ensure a better fruit yield. Even beyond improving the yield and quality of fruits, the use of organic fertilizers such as biochar and compost would contribute significantly to the restoration and maintenance of soil fertility in order to ensure their sustainable exploitation.

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