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Short term effects of chicken manure application on soil physicochemical properties cropped with silage maize

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ABSTRACT: The main objectives of this study were to evaluate the short-term effect of chicken manure on soil properties of cultivated horizon (0-20 cm) under silage maize. The field experiment was conducted using a randomized complete block design. In total, twelve plots were arranged; it consisted of four treatments and three repetitions. Applied treatments included a control (C) and spreading of chicken manure at 5 t / ha (T1), 10 t / ha (T2) and 15 t / ha (T3). The results obtained showed that the application of chicken manure improves several soil properties. It induced a significant increase in the soil electrical conductivity (EC), the phosphorus and nitrates content (NO3-) depending on the amount applied. A slight acidification was recorded after manure application. This acidification is probably due to mineralization of organic matter activated after incorporation of manure into the soil. Trends of increasing soil organic matter (OM) were registered. Its contents ranged from 4.60%, 5.65%, 5.57% and 5.66% for C, T1, T2 and T3 respectively. The total nitrogen and potassium content were higher after application without marking a significant difference. The nitrogen contents varied from 0.20 to 0.23% and those of potassium from 277 to 350 ppm. The production of corn silage was significantly higher in plots (T3), with a production of 17.8 t/ ha. For other treatments, production has not registered a significant difference. They ranged from 10.7 to 13.4 ton per hectare.

KEYWORDS: Spreading, chicken manure, physicochemical, soil properties, amendment.

1 INTRODUCTION

The Region of Chaouia-Ouardigha produces approximately 200,000 tons of chicken litter each year. These wastes present environmental and Health Risks Because of their high contents of nitrogen and high density of pathogens [1]. Agricultural intensification and livestock have a negative impact on soil quality. High inputs of chemical fertilizers contribute to soil degradation, damage to the environment and loss of biodiversity [2].

Soil is one of our most precious natural resources. Careful soil management is the key to sustainable agriculture [3]. In arid and semi-arid areas, low soil organic matter (SOM) content and water availability are often the main limiting factors for plant growth and production [4]. The organic amendments are increasingly used for their potential to restore biological, physical and chemical soil properties [5].

Application of organic manures such as poultry manure is important for maintaining soil quality. It is a relatively cheap source of both macronutrients and micronutrients [6]. These manures show promising effects on improving soil properties.

Assessing physical, chemical and biological soil properties is very important to studying soil quality [7]. This quality can be defined as the capacity of the soil to function within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality and promote plant, animal and human health [8].

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The objective of this study is to evaluate the short-term impact of chicken manure on soil physicochemical properties and yield of maize silage.

2 MATERIALS AND METHODS

2.1 SITE DESCRIPTION AND EXPERIMENTAL DESIGN

The study was conducted at the center of agricultural qualification Ouled moumen, Settat, Morocco in North West of Africa. The region has a semi arid climate. The area is situated at 32°57'54"N - 07°39'42"W.

The field experiment was conducted using a randomized complete block design with three replications. Poultry manure was collected from poultry farm at Settat. There were 4 treatments: control (unfertilized plots) (C), 5 t/ha (T1), 10t/ha (T2) and 15t/ha (T3). Poultry manures were incorporated in soil.

In total, twelve plots were arranged. On each elementary plot of 30 m2 (3*10m), the maize was sown with a 45 cm row spacing and 15 cm between plants within each row.

2.2 POULTRY MANURE AND SOIL ANALYSIS

Soil samples were obtained and analyzed for some characteristics before the initiation of the experiment (Table 1). Soil samples were collected from each plot at 0 to 20 cm depth from 6 different locations and mixed well.

After sampling, a sample of about half kg of soil was taken, air dried and passed through 2mm sieve and used for the determination of physical and chemical characteristics.

Bouyoucous' densimeter method was used to determine soil texture, which was obtained by fitting the percentages of clay, silt and sandy fractions. The texture of soil was loam clay sandy. pH and electrical conductivity (1:2 w/v Sample-water extract) were measured using a pH meter electrode (McLean, 1982)[9] and a conductivimeter respectively.

Organic carbon (OC) was determined by titration using potassium dichromate. The Walkley-Black Wet digestion method was used for the determination of soil organic matter [10]. The latter was calculated according to the equation (OM = 1,724 OC). Organic nitrogen concentrations for soil and manure were determined according to the Kjeldahl method. Nitrates are determined by complexation with chromotropic acid and measuring the absorbance in a spectrophotometer at 410 nm [11]; ammounium was determined colorimetrically at 636 nm; phosphorus was determined by colorimetry at 882 nm [12] and potassium by extraction with ammonium acetate and determination using a flame photometer [13].

Table 1. Properties of soil at depth (0-20 cm) before experimentation.

Property	Valeur	Standard deviation
Clay (%)	18	0,17
Silt (%)	57	0,39
Sand (%)	25	0,23
CaCO3 (%)	15.1	0,77
Organic matter (%)	4.77	0,02
Total nitrogen (%)	0.18	0,02
Nitrates (ppm)	40.5	0,00
Phosphorus (ppm)	12.3	2,73
Potassium (ppm)	196.6	4,81
pH	7.47	0,61
Electrical conductivity (dS/m)	0.28	0,18

The chicken litter used in the present study was collected from two poultry farms located in Settat (a province of Chaouia-Ouardigha region). The litter was transported to the Center of Agricultural Qualification Ouled Moumen (CAQ), the site of the experiment, where mixed homogeneously. We have taken five composite samples air-dried for physicochemical analysis (Table 2).

Table 2. Composition of chicken manure applied on soil experimentation.

Property	Mean	Standard deviation
PH	7,80	0,20
MS (%)	66,52	0,25
CE (mmhos/cm)	5	0,00
CO (%)	35,46	2,90
MO (%)	61,14	5,00
N total (%)	4,04	0,10
C/N	8,78	0,52
NO3 (ppm)	964,32	37,54
NH4 (ppm)	6373,25	569,57
NH4/NO3	6,61	0,90
Phosphore (ppm)	6581,25	850,30
Potassium (ppm)	1419,17	69,87

3 RESULTS AND DISCUSSION

Addition of broiler litter to soil has an effect on several soil properties. The impact of the application of manure on soil properties is quite difficult to assess. This difficulty is due to the fact that the soil has a complex dynamic [14].

3.1 PH

Soil pH in the top 20cm of the soil profile registered a slight acidification without registering a significant difference between treatments (Figure 1). The initial pH was 8.37 while at the end of the experiment, it varied between 7.70 and 7.80 depending on the treatment applied. The decrease of soil pH may have been due to nitrification of NH4 + [15].

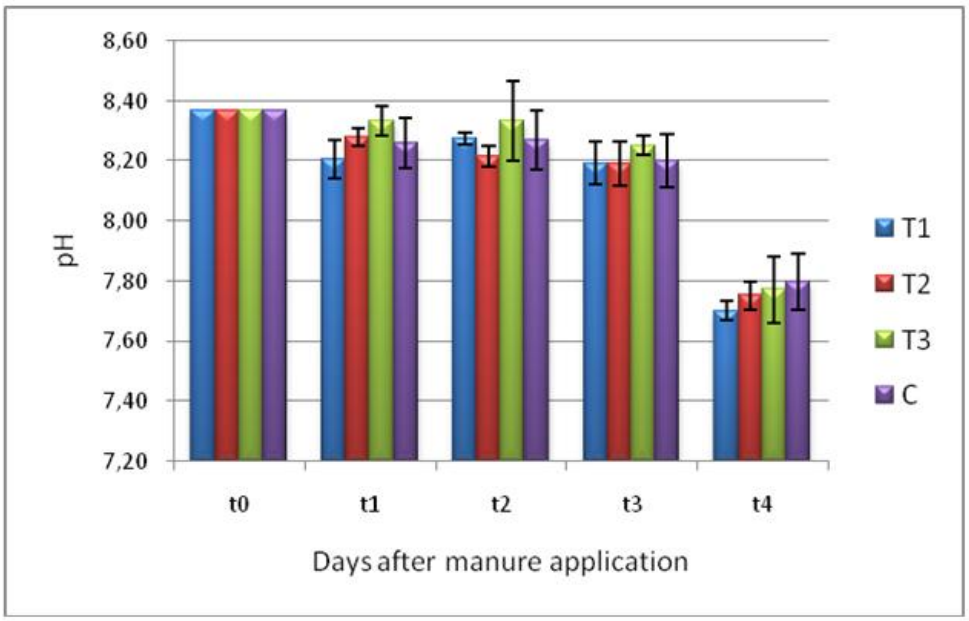

Fig. 1. Effect of chicken manure treatments on soil pH at depth of 0-20 cm.

t0: 1st, t1: 20th, t2: 47th, t3: 82th, t4: 143th days.

3.2 ELECTRICAL CONDUCTIVITY (EC)

The EC is significantly affected by manure application (Figure 2). This effect can be explained by the contribution of manure salts which led to the rise of the EC. This elevation also indicates the accumulation of salts in the soil surface [8].

In contrast with soil pH, soil EC values at 0-20 cm depth were significantly higher after spreading the manure. It could be concluded that EC increased while soil pH decreased [8].

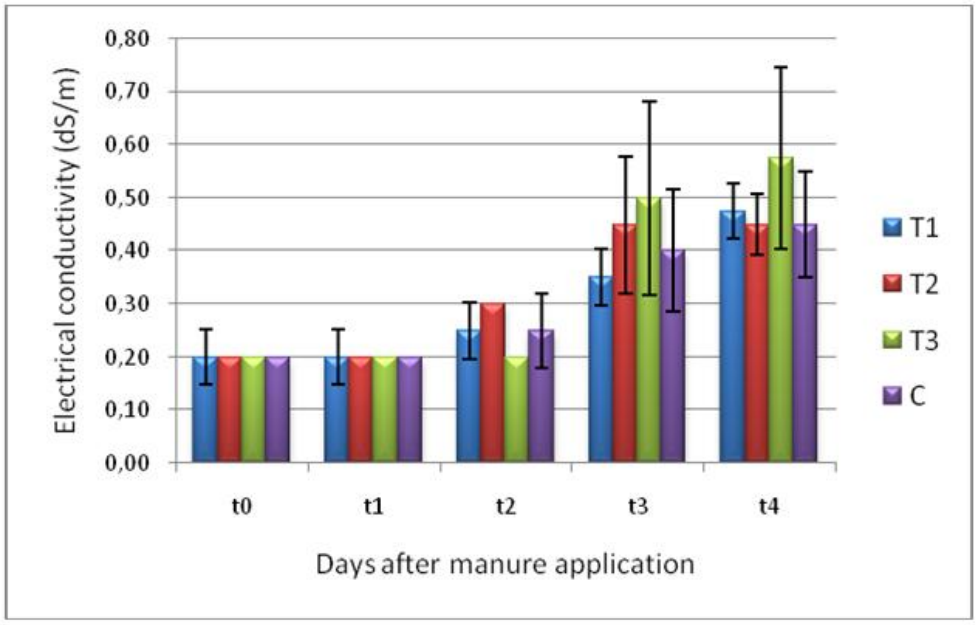

Fig. 2. Effect of chicken manure treatments on soil Electrical conductivity at depth of 0-20 cm

3.3 ORGANIC MATTER

Raw manure amendment was significantly affected the content of soil organic matter (SOM). These contents ranged from 4.60%, 5.65%, 5.57% and 5.66% for C, T1, T2 and T3 respectively. Soil organic matter concentration was higher in the manured plots than other treatments (Figure 3).

Soils that received farmyard manure application or straw had statistically higher amounts of SOM compared with the unfertilized soil [15]. The spreading of manure on agricultural soils improves soil properties such as content of organic matter [2]; [16]; [17]. Several authors showed the presence of a correlation between the amount of organic amendment applied annually and increasing the organic matter content in the soil [18].

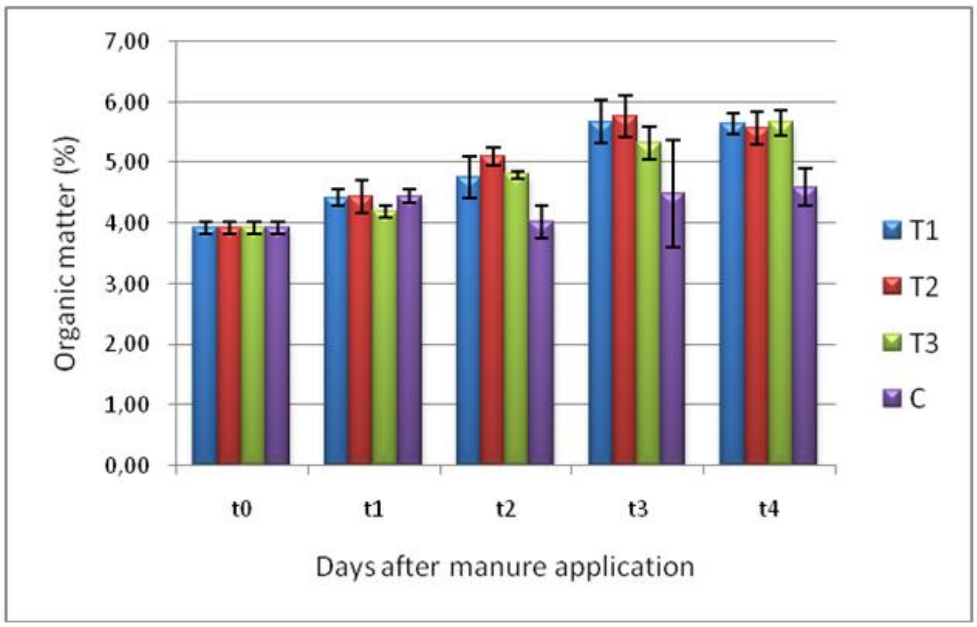

Fig. 3. Effect of chicken manure treatments on soil organic matter content at depth of 0-20 cm

3.4 TOTAL NITROGEN

Soils amended with poultry manure show a higher level of nitrogen than unamended soil [19]. The content of total nitrogen varies between 0.20% and 0.23% in control and T3 respectively (Figure 4). This slight increase was shown by reference [5] which confirmed that the application of farmyard manure at the rate of 40t/ha did significantly increase the content of total nitrogen.

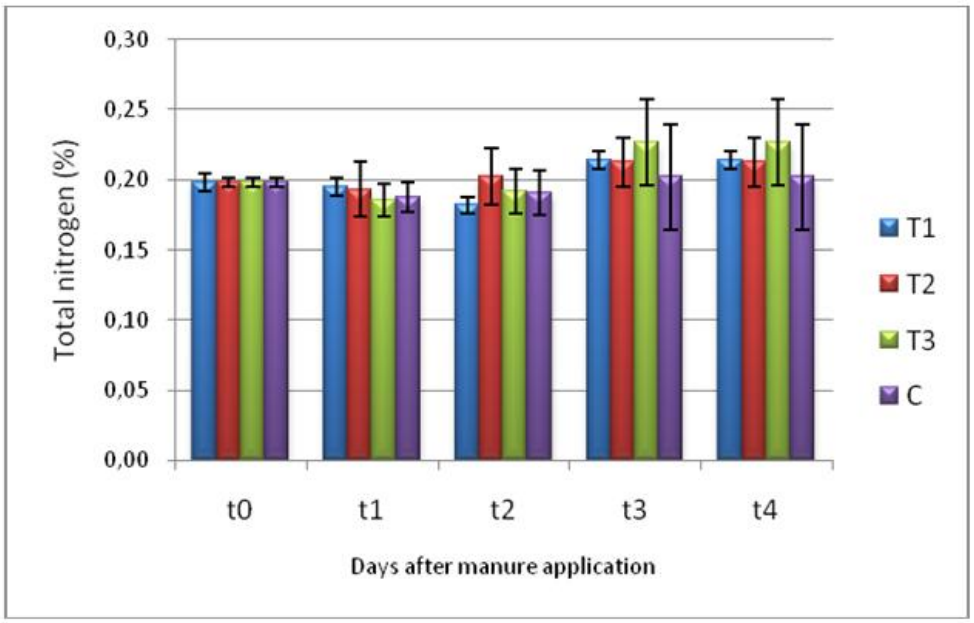

Fig. 4. Effect of chicken manure treatments on soil total nitrogen content at depth of 0-20 cm

3.5 NITRATES (NO3-)

After 5 months of manure application, the nitrates (NO3-) content in the top 20 cm of elementary plots was significantly higher in plots amended at 10 and 15 ton per hectare than those unmanured or manured at 5 ton per hectare (Figure 5). According to reference [19], soil treated with poultry manure registered a higher nitrogen mineralization and nitrification which implies production of mineral nitrogen such as nitrates.

The accumulation of nitrates in the topsoil is significantly different between amended and control plots. These levels have increased by 40% between control and T3, they have spent from 49 to 69 ppm. This indicates that the soils had high potential for nitrification [8].

Other studies have shown that between 15 and 74% organic nitrogen content, in poultry manure, was mineralized between 42 and 120 days after application [4], [20].

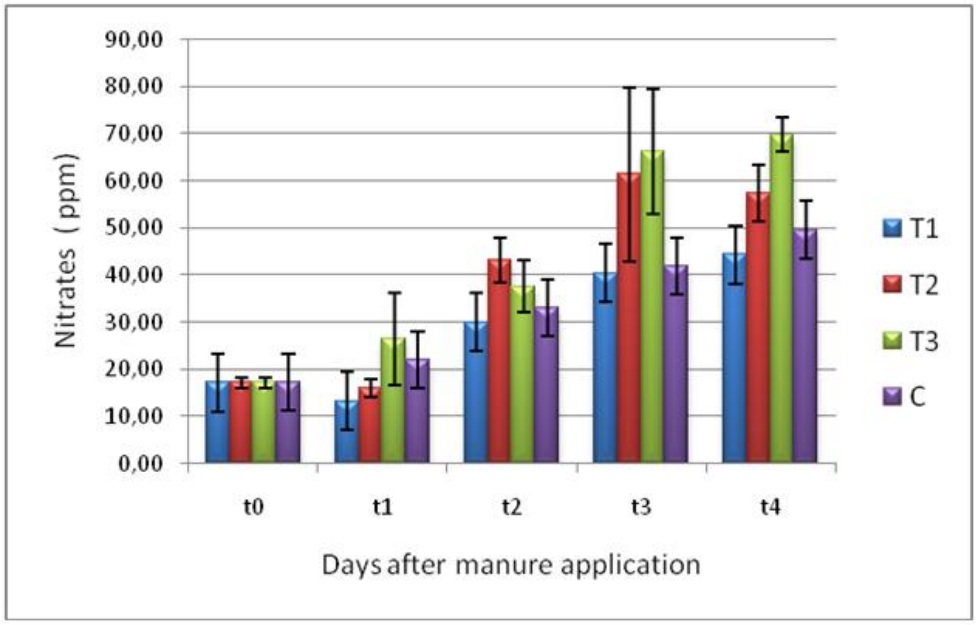

Fig. 5. Effect of chicken manure treatments on soil nitrates content at depth of 0-20 cm

3.6 PHOSPHORUS (P)

Soil available phosphorus (0-20 cm) in amended plots (T2 and T3) was significantly higher than in plots (C and T1). The phosphorus level in the soil has increased from 18 ppm to 36 ppm between control (C) and T2 (Figure 6).

According to reference [21], the application of manure to the soil increases significantly the levels of phosphorus content. Other authors confirm that 15-17% of the phosphorus content is released after 60 days of application [4], [22].

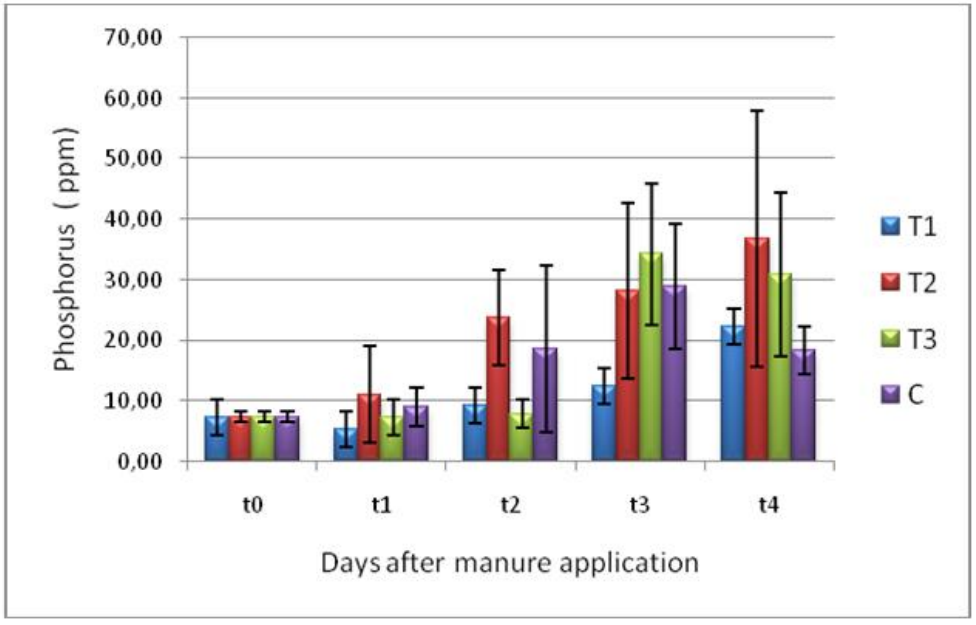

Fig. 6. Effect of chicken manure treatments on soil phosphorus content at depth of 0-20 cm

3.7 POTASSIUM (K)

Soil available K increased with spreading of poultry manure. It should be noted that the levels of K in the control treatment (C) and treatment (T3) have increased from 277 to 350 ppm respectively (Figure 7). The substantial accumulation of potassium in the soil of experiment results from inputs of potassium manures [8].

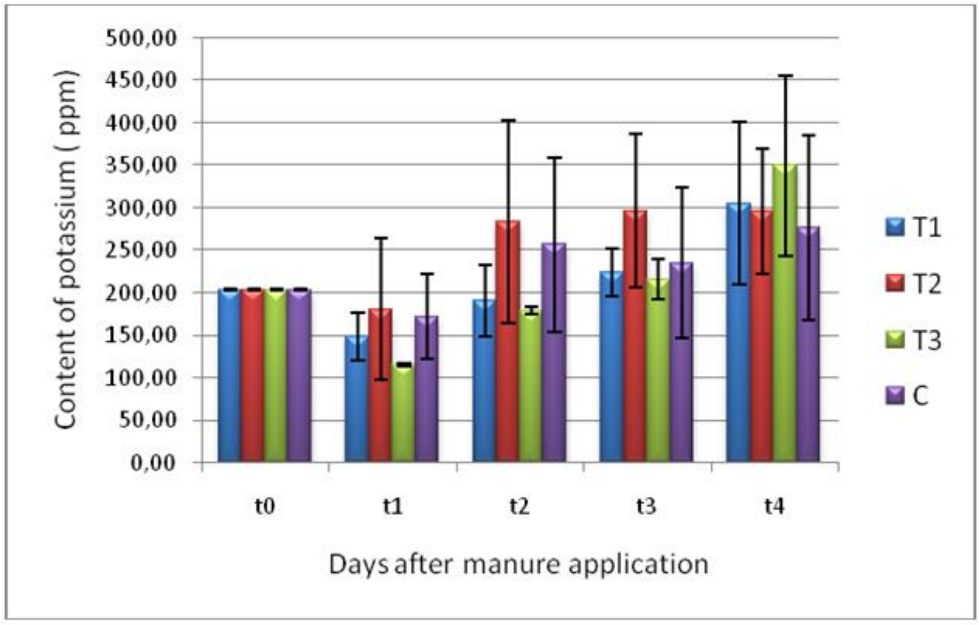

Fig. 7. Effect of chicken manure treatments on soil potassium content at depth of 0-20 cm

3.8 CORN SILAGE PRODUCTION

Maize (Zea mays L.) is one of the most common crops in the world [23]. Application of chicken manure had a significant impact on the production of corn silage. In T3 plots, the production reached 17.8 t/ha while the other treatments recorded productions ranging between 10.7 and 13.4 t/ha (Figure 8).

Among different manures, use of poultry manure (PM) as soil amendment for agricultural crops provides appreciable quantities of all important plant nutrients [24]. The positive yield response to broiler litter is in part due to high N and P contents in this manure. Maize aboveground biomass (AGB) dry weight was significantly greater in fertilized soils with broiler litter than in the control soils [4].

The application of 225 kg N ha−1 resulted in the highest amount of aboveground biomass for silage in arid and semi-arid areas [4]. Silage maize was harvested at physiological maturity in this trial, after which dry matter no longer accumulated and grain humidity changed from 45-50% to 15-25% [23].

Manures are Typically Applied to soil at rates designed to supply a crop's nitrogen requirement. It was mentioned that the increase in corn biomass was associated with increased levels of nitrogen. This latter element is known to be readily available for plant uptake in Poultry manure [25], [26], [27].

Among organic manures, the application of poultry manure can particularly increase the growth and production of maize [26]. The application of manures is a desirable practice for improving plant growth in arid conditions and semi-arid. Application of organic manures result of several environmental benefits such as restoration and maintenance of soil organic matter and increase crop yields [4], [28].

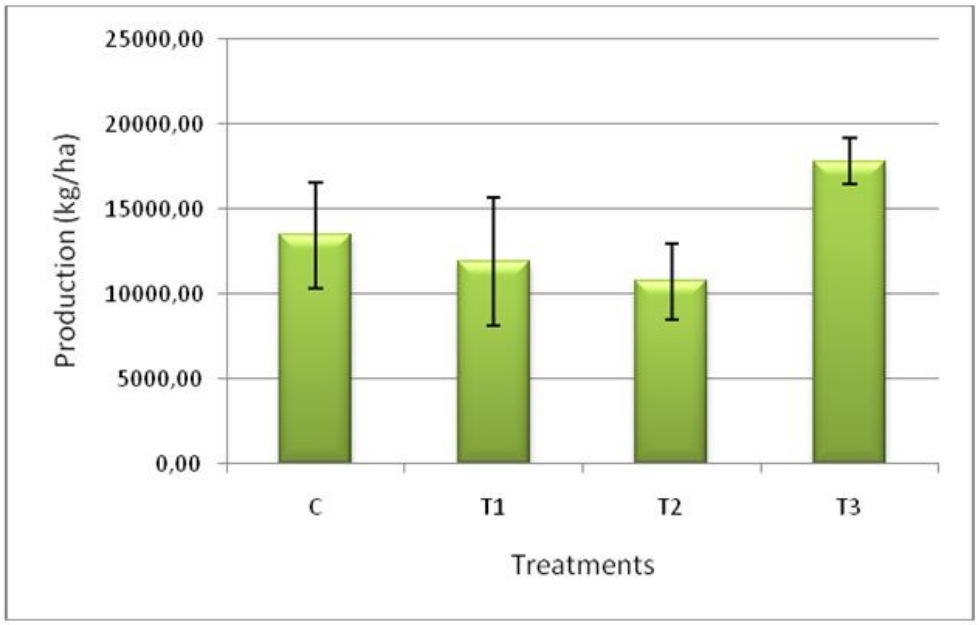

Fig. 8. Total aboveground biomass production of silage maize

4 CONCLUSION

Animal manures have traditionally been applied to soil to maintain levels of soil organic matter, reclaim degraded soils and supply plant nutrients to agricultural soils [29], [30]. Application of organic materials in crop production has been strongly encouraged in many places as a replacement for part or all of the mineral fertilizer [31].

The application of organic manures could be an effective alternative to maintain an adequate input of organic matter [28], [21]). Which improve soil properties, fertility and resistance to water and wind erosion [32], [33].

Chicken manure is a rich source of organic matter and provides large quantities of important nutrients for plant growth. Use of broiler litter resulted in the greatest increased maize and corn yield [4], [34].

The application of organic fertilizers is indeed a desirable practice for ecological restoration of degraded cropland soils and alleviating the constraints to sustainable cropping systems in arid and semi-arid environments [28].

The broiler litter is characterized by good quality carbon and a good amount of nitrogen [4]. The spreading of chicken manure improves several properties of soil such as organic matter, pH, content of nitrogen and other nutrients, and improves agricultural yields compared to the unamended soil.

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