Assessment of residual effects of organic manures (Tithonia diversifolia and bat-guano) on maize cultivation in the Ngandajika region in central DR Congo

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Abstract: It has been clearly established that organic matter provides crops with not only nutrients, although in a lower proportion compared to mineral fertilizers, it releases them slowly and gradually. In addition, it also improves the other characteristics of the soil and thus further conditions the fertility of the soil. Consequently, the study of organic manure should not only be limited to the analysis of its effects on the development and yield of crops, it should also extend to the examination of its impact on the maintenance or increasing soil fertility.

Keywords: Residual effects, bat-guano, Tithonia diversifolia, corn cultivation, Ngandajika

1. Introduction

The DRC, like some countries in the world, is faced with significant demographic growth with forecasts of a doubling of the population by 2050 (Agrimonde, 2009). This growth will be essentially urban and will be accompanied by growing food needs. Thus, to meet the food production needs of this perpetually growing human population, it is necessary to sustainably ensure the ability of the soil to produce crops while preserving the environment (Frabrégat, 2019; Hartemink, 2007).

It is in this perspective that emphasis should be placed on cultural practices in soil conservation agriculture. Which focuses on restoring and maintaining soil organic matter (SOM) (Lobell et al, 2011, Muna-Mucheru et al, 2007; Uyo Ybesere and Elemo, 2000).

In this regard, organic manures play an important role in restoring and maintaining organic matter in the soil, which can contribute not only to increasing its capacity for the production of foodstuffs, but also to safeguarding the fauna and flora biodiversity of the environment (Kiema et al, 2008; Anonymous, 2007; Dillon and Hardaker , 1993).

It therefore appears clearly that organic matter not only makes nutrients available to crops, although in a slow and progressive manner and in smaller proportions than mineral fertilizers. But it also conditions more soil fertility (Mafongoya and al, 2007; Okalebo et al, 2007). Consequently, the study of organic manure should not be limited solely to the analysis of its effects on the development of the crop and particularly on its yield. It must also extend to the examination of the maintenance or increase of the fertility of the soil where it is applied (Nkongolo et al, 2018).

It is with this objective that this study was conducted, its objective was to: 1) Determine the residual effects of *Tithonia manures diversifolia* and bat-guano on maize cultivation in the Ngandajika region. The two organic manures having increased the development and yield of the maize crop. 2) Compare the residual effects of bat guano to those of *Tithonia diversifolia* on corn cultivation.

Their residual effects would naturally increase the development and yield of the maize crop and help maintain or increase soil fertility for subsequent agricultural production. This study aims to: 1) determine the residual effects of *Tithonia diversifolia* and bat guano on maize cultivation.

2) Compare the residual effects of *Tithonia diversifolia* to those of bat guano on the cultivation of maize.

2. Literature

2.1. Material

2.1.1. Study environment

The site of the INERA/ Ngandajika Station served as an experimental setting for the study under examination. This station is located 7 km from the city of Ngandajika , in the territory bearing the same name, whose geographical coordinates are 6° 43' 326" of latitude South and 23° 56' 33.5" of longitude East, at 793 m average altitude (Anonymous, 2003). It is an agricultural area par excellence for the provinces of Kasai Oriental and Lomami.

2.1.2. Soils of Ngandajika

The soils of Ngandajika are formed by a sandy cover on a clayey sediment which often rests at shallow depth, on an old lateritic slab. The insignificant clay fraction does not seem to consist solely of kaolinite. These soils contain 21 to 23% fine elements (Culot and Laudelout, 1959). They are generally deep with a profile that describes the presence of all horizons and their subdivisions, with the exception of certain places where there may be a superficial water table.

2.1.3. Ngandajika Climate

The climate of the territory of Ngandajika is of the tropical type, AW_4, according to the Köppen classification . It is characterized by the alternation of two climatic seasons, the rainy and the dry. The 1st ^{is} divided into two, a large so-called season A, going from August 15 to December 31 and a small so-called season B which goes from January 15 to May 15, these data are becoming theoretical with the phenomenon of climate change which manifests itself in certain seasons in the region.

As for the dry season, it is also divided into two, it goes from December 31 to January 15, it is the small dry season, and from May 15 to August 15 it is the big dry season. The average annual rainfall, recorded in the period from 1980 to 2014, is 1216.14 mm at the INERA/NGANDAJIKA Research Station, and that of the temperatures is 24.25°C. April is the hottest month with an average maximum of 28.4°C and the coldest is July with an average low of 20.1°C (Crabbe and Totiwe, 1979). The duration of insolation is 2400 hours (Janssens, 1998).

2.1.4. Relief and vegetation of Ngandajika

The relief of Ngandajika is dominated by plains and plateaus. Like the climate, it gives this region good agricultural potential. The typical vegetation of Ngandajika is wooded grassland (Rishirumhirwa et al., 1989: Anonymous, 1998). It is dominated by poaceae which cover more than 70% of the area per m^2 . The dominant species are *Imperata cylindrical* on heavy soils and *Hyparrhenya dissolved, Digitaria Brazil, Triumfetta musteru, Eriosema griseu, Mimosa pudica* sporadically some species of the legume family like *Mucuna Sp, Stylosanthes Sp ,* found in lowlands on light soils. Like other wooded savannahs, there are gallery forests along rivers and streams

2.1.5. Biological material

The biological material used in this trial consisted of maize seeds (*Zea mays*) of the QPM3 variety from INERA/ Ngandajika . The QPM variety comes from the conversion of normal tropical and subtropical maize varieties to OPAQUE-2 which was discovered in the United States (Krivanek et al, 2007; Vietmeyer , 2000; Bressani , 1998). It is the result of research that has enabled the development of maize with a normal appearance and a high content of lysine and tryptophan (70100%) (Vivek et al, 2008). It has been popularized in the DRC since 2012.

2.1.6. Fertilizing material

No fertilizer was used; the aim of the trial was to assess the residual effects of Tithonia diversifolia and bat-guano applied as organic manures to the maize crop in a previous trial.

2.1.7. Restoration of soil fertility in tropical regions

3. Methodology

3.1. Experimental apparatus

The experimental device is in completely randomized simple blocks. It consists of 3 blocks separated by 1.5m; one of the other. Each block has two parts, the 1st with maize monoculture and the 2nd on which maize is associated with cowpea containing 3 plots separated by 0.5m; one from the other corresponding to the three treatments. Their area is 12m ^{2} or 4m by 3m. T $_0$: Treatment without residual effects of manures

T $_1$: Treatment with residual effects of *Tithonia diversifolia*
T $_2$: Treatment with residual effects of bat-guano
The experimental land had an area of 312m ^{2} (24m X 13m).

3.2. Technical itinerary

Plowing was carried out with the plow hitched to the tractor on January 28, 2013. Harrowing and crumbling were carried out manually on February 3, 2013. While the demarcation of the land was carried out on February 4, 2013. Sowing and tillage relining of voids took place respectively on February 6 and 13, 2013.

1) **Comments**
In order to assess the residual effects of organic manures of bat guano and *Tithonia diversifolia,* the following growth parameter measurements were taken. These are emergence rate, collar diameter, and plant height and leaf area. With regard to the production parameters, the following measurements were taken: The number of ears per plant, the number of seeds per ear, the weight of a thousand grains and the yield in tons or megrams per hectare.

2) **Statistical analyzes**
In order to assess the residual effects of organic manures of bat guano and *Tithonia diversifolia* on the maize crop, the data collected were subjected to the analysis of variance (ANOVA) using the Statistix 8.0 software, the Least Significant test Difference (LSD) was then used to compare means at the probability threshold of 5%

4. Results

Residual effects of organic manures on the cultivation of maize in monoculture and in association with cowpea are presented in tables 1 and 2

Table 1. Growth parameters on residual effects of bat guano and *Tithonia diversifolia* in maize monoculture and in association with cowpea

ER-types	Corn monoculture				Combination maize with cowpea			
	TL	DC	HP	SF	TL	DC	HP	SF
ER Titho	78.3y	1.47b	1.26a	280.6a	79.0y	1.75a	1.27a	254.2b
ER Bat	81.0y	1,88a	1,35a	287,7a	85,47a	1,85a	1,20a	324,5a
tem .	74,6a	1,35b	1,21a	237,3b	75,86a	1,47b	1,15a	245,8b
Moy.para .	77,96	1,56	1,27	268.5	80,11	1,7	1,21	274,8
Dec.	NS	S	NS	S	NS	S	NS	S
CV .(%)	10.08	12.62	5.92	17.45	10.08	12.62	5.92	17.45

Legend: ERTitho = Residual effect on *Tithonia diversifolia*
ERBat = Residual effect on bat guano

Avg para= Average on the parameter
TL= emergence rate (%), DC= Collar diameter (cm), HP= Plant height (m), SF= Leaf area (cm ²), Dec.= Decision, CV .(%)= Coefficient of variation

1) **Residual effect on emergence rate**

There is no significant difference between the residual effects of treatments for the emergence rate in maize monoculture or in maize-cowpea association. In monoculture: Bat guano has the residual effect of (81%), *Tithonia diversifolia* (Td .) (78.3%) and the control (74.6%). In maize-cowpea association, bat guano and Td . have the residual effects of 85.47% and 79.0% respectively while the control has 75.86%. These results could be explained by the fact that this parameter is more linked to the variety (its potential) than to the state of the soil (fertility) which was not fully expressed in this case.

2) **Residual effect on neck diameter**

There is a significant difference between the residual effects of manures in maize monoculture and in maize-cowpea association for collar diameter. The residual effect on bat guano is significantly greater than that on *Tithonia diversifolia* and the witness is 1.88 cm for the bat guano and 1.47 cm for the Td ., 1.35 cm for the witness. In maize-cowpea association, the residual effect on bat guano (1.85cm) is significantly the same as on Td . (1.75 cm) and this one, significantly larger than the control (1.47 cm).

These results would be justified by the fact that bat guano, rich in nutrients and other fertilizing characteristics, loosens and enriches the soil better than Td . which is also a good fertilizer and their residual effect is greater than that of the control. These averages reflect both the potential of the variety and the state of soil fertility.

3) **Residual effect on plant height**

There is no significant difference between the residual effects of different manures in monoculture or in maize-cowpea association. These effects are not expressed for this parameter; they evolve while decreasing and are not reflected for certain parameters.

4) **Residual effect on leaf area**

In monoculture: There is a significant difference between the residual effects of different treatments. The residual effects of two organic manures have significantly the same average value on leaf area, ie (280.60cm ²) with Td . and (287.70 cm ²) with bat guano. These averages are significantly greater than that recorded with the control (237.30 cm ²). In combination with corn and cowpea , the difference between the residual effects of manure is also significant. The residual effect on bat guano (324.50 cm ²) is significantly greater than those obtained on Td . (254.20 cm ²) and the control (245.80 cm ²) which have it significantly the same. The fact that bat guano enriches and loosens the soil better than Td . and the witness would explain those results.

Table 2. Production parameters on residual effects of bat guano and *Tithonia diversifolia* in maize monoculture and in association with cowpea

ER-types	Corn monoculture				Combination maize with cowpea			
	CIP	NGE	P1000	RTD	CIP	NGE	P1000	RTD
ERTith	1.10a	334.63b	170.10b	2.27b	1.20a	355.68b	204.96a	2.55b
ER Bat	1,10 a	354,57 a	193,26 a	2,87 a	1,14 a	396,56 a	205,71 a	3,16 a
Tém.	1,00 a	326,40 b	147,36 c	1,41 c	1,08 a	290,98 c	144,36 b	1,63 c

Moy.para.	1,06	338,53	170,24	2,18	1,14	347,74	185,01	2,45
Déc.	NS	S	S	S	NS	S	S	S
CV .(%)	9.46	14.03	10.68	28.46	9.46	14.03	10.68	28.46

Legend: ERTith = Residual effect on *Tithonia diversifolia*
ERBat = Residual effect on bat guano
NEP=Number of ears per plant
NGE=Number of grains per cob
P1000= Thousand grain weight
RDT= Yield (in tons or Megrams/hectare)
Avg.para = Average by parameter, Dec.=Decision, Tem .= Witness,CV .(%)= Coefficient of variation

1) **Residual effect on the number of ears per plant**
There is no significant difference between treatments in maize monoculture and in maize-cowpea association. The residual effect of manure is not expressed in relation to this parameter.

2) **Residual effect of manures on the number of grains per cob**
In monoculture, the residual effect on bat guano gives the number of grains per ear of (354.57) significantly greater than *Tithonia diversifolia* (334.63) and the control (326.40), the two treatments having significantly the same value of this parameter.

In maize-cowpea association, the residual effect observed on bat guano manure (396.56) is significantly greater than that observed on Td. (355.68) and this is significantly higher than on the control.

The bat guano being richer in several fertilizing characteristics than the Td ., enriches and loosens the soil more than the latter although the latter also displays performance in the development or improvement of the fertility of the soil compared to many of other organic materials. Their residual effects are part of this logic.

3) **Residual effect of Bat guano and *Tithonia manures diversifolia* on the weight of a thousand grains**
In monoculture, the residual effect on bat guano of (193.26 g) is significantly greater than on Td. (170.10g). And the residual effect on this one is significantly greater than on the control (147.36).

These results are justified by the same explanations as those mentioned for the previous parameter.In maize-cowpea association, the residual effect on bat guano is evaluated at an average value of 205.71 g, significantly the same as on Td. (204.96 g). Their residual effect then being significantly greater than that recorded on the control (144.63 g).

The non-supply of organic manures in the farm results in the decline in fertility, which is expressed with the decrease in the average values of certain parameters.

4) **Residual effect of manures of bat guano and *Tithonia diversifolia* on the yield of maize cultivation in monoculture and maize-cowpea association**
In monoculture as in maize-cowpea association in relation to the yield, the residual effect on bat guano displays respectively the mean values of 2.87 T/ha and 3.16 T/ha, significantly greater than on Td . with 2.27 T/ha and 2.55 T/ha, which are also statistically greater than those recorded on the control (1.41 T/ha and 1.63 T/ha).

These results could be explained by the fact that not only is bat guano richer in nutrients, it also leaves, when decomposing, a stable humus which allows the loosening of the soil. This gives it an advantage over

Td . which is also rich in nutrients, but decomposes and does not leave stable humus, given its richness in carbohydrates and nitrogen.

At the end of this test, the results below were recorded, the treatment T_2 gives the yield of 2.87T/ha and 3.16T/ha respectively in maize monoculture and in maize-cowpea association, which are significantly higher than that achieved with T_1 (2.27T/ha and 2.55T /ha and this one more than the control (1.41T/ha and 1.63T/ha)

Thus, we can therefore retain that bat guano has effects residuals on the maize crop greater than those of *Tithonia diversifolia* and this one more than on the witness. The two organic manures with their residual effects not only increase the yield of the maize crop, they also increase the fertility of the soil.

5. Methods

6. Results and discussions

7. Closing

This study aimed to determine the residual effects of organic manures of *Tithonia diversifolia* and bat guano on growing corn, further compare them with each other.

The results recorded in this study clearly indicate that bat guano has globally greater residual effects than those of *Tithonia. Diversifolia* on corn cultivation. Whether it is the average values of growth parameters as for production parameters. These two organic materials thus have greater residual effects than the control or the non-use of organic manures which only impoverishes the soil as long as we do not restore to it what it loses over the growing seasons.

This research highlights the beneficial effect of the use of organic manures in the agricultural exploitation of soils. Not only do they increase or increase the yield (production) of crops, they also have an impact on the state of the fertility of the soils that they maintain or improve. They play an important role in the restoration of soil organic matter, likely to contribute to increasing its capacity for the production of foodstuffs and safeguarding the fauna and flora biodiversity of the environment (Mulaji , 2011; Ibrahim et al, 2009).

Both organic bat guano and *Tithonia diversifolia* thus constitute a solution to the problem of soil fertility in the Ngandajika region where the goat manure used proves to be ineffective in restoring soil fertility (Muyayabantu , 2013).

The use of these two organic materials in this region also offers the advantage of practicing intensive agriculture with the possibility of exploiting the same fields and thus putting an end to shifting agriculture which is involved in deforestation. To which is attributed the phenomenon of global warming observed in most parts of the world

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