Journal of Research in Ecology

An International Scientific Research Journal

ISSN No: Print: 2319 –1546; Online: 2319– 1554

Short Communication

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

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ABSTRACT:

The objective of this study was to determine and compare the residual effects of *Tithonia diversifolia* and bat guano on corn cultivation. The experiments were carried out in a completely randomized simple block design with three treatments *viz* : T_0 - the treatment without residual effects of manure, T_1 - treatment with residual effects of *Tithonia diversifolia* and T_2 - treatment with residual effects of bat guano. At the end of this study, T_2 gave the yield of 2.87 t/ha and 3.16 t/ha in maize monoculture and maize-cowpea combination respectively, which was significantly higher than that achieved with T_1 (2.27 t/ha and 2.55 t/ha respectively) and control (1.41 t/ha and 1.63 t/ha respectively). Thus, it was confirmed that bat guano had greater residual effects on the cultivation of corn than those of *T. diversifolia* and the latter being effective more than the control. Both organic manures with their residual effects not only increased the yield of maize cultivation, but they also increased soil fertility.

Keywords:

Tithonia diversifolia, Maize cultivation, Ngandajika.

Article Citation:
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Journal of Research in Ecology (2020) 8(2): 2754-2761

Dates:
Received: 10 July 2020 **Accepted:** 18 Sep 2020 **Published:** 26 Oct 2020

Web Address:
http://ecologyresearch.info/documents/EC0713.pdf

Journal of Research in Ecology

INTRODUCTION

The DRC (Democratic Republic of the Congo) is facing significant demographic growth with forecasts of the doubling of the population by 2050 (Agrimonde, 2009). This growth will be mainly urban and will be accompanied by increasing food needs. In order to meet the food production need of this ever-growing human population, it is necessary to ensure the long-term ability of the soil to produce crops while preserving the environment (Fabrégat, 2019; Hartemink, 2007).

It is in this perspective that the emphasis must be placed on the cultivation practices in agricultural soil heritage conservation, which focuses on restoring and maintaining Soil Organic Matter (SOM) (Lobell *et al.*, 2011; Muna-Mucheru *et al.*, 2007; Ybesere and Elemo, 2000). In this regard, organic manures play an important role in restoring and maintaining organic matter in the soil, which may contribute not only to increasing its capacities for the production of foodstuffs, but also to safeguard the soil fauna and flora biodiversity of that particular environment (Kiema *et al.*, 2008; Anonymous, 2008; Dillon and Hardaker, 1993).

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

Their residual effects would naturally increase the growth and yield of the maize crop and help to maintain or increase soil fertility for subsequent agricultural production. To achieve this goal, the completely randomized single block design was adopted.

It is with this objective that this study was carried out. The objectives include determination of the residual effects of manuring *Tithonia diversifolia* and bat-guano on corn cultivation in the Ngandajika region and comparing the residual effects of bat guano with those of *Tithonia diversifolia* on the maize crop. The organic manures were found to increase the growth and yield of the crops on previous researcher *viz*: *Tithonia diversifolia* and bat guano.

MATERIAL AND METHODS

Study area

The site of the INERA / Ngandajika Station served as an experimental setting for the study under review. 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 "South and 23° 56' 33.5" East, at 793 m average altitude (Anonymous, 2003). It is an agricultural area par excellence for the provinces of Kasai Oriental and Lomami.

Soils of Ngandajika

The soils of Ngandajika are formed by a sandy covering on a clay sediment which often rests at a shallow depth, on an old lateritic slab. The small clay fraction does not seem to consist entirely of kaolinite. These soils contain 21 to 23% of 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 shallow water table.

Climate of Ngandajika

The climate of Ngandajika territory is tropical, AW_4, according to the Köppen classification. It is characterized by the alternation of two climatic seasons, the rainy and the dry. The first is subdivided into two, a large said 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 ma-

nifests itself in certain seasons in the region.

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

Relief and vegetation of Ngandajika

The relief of Ngandajika is dominated by plains and plateaus. The climate gives this region a good agricultural potential. The typical vegetation of Ngandajika is the wooded grassy Savanna (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 cylindrica* on heavy soils and Hyparrhenya dissoluta, *Digitaria brazzol, Triumfetta* sp*, Eriosema griseum and Mimosa pudica* sporadically and some species of the leguminous family like *Mucuna* sp and *Stylosanthes* sp were found in the shallows of the light soils. Like other wooded Savannas, there are forest galleries along rivers and streams

Biological material

The biological material used in this test consisted of maize seeds (*Zea mays*) of variety QPM3 from INERA/Ngandajika. The QPM variety arises from the conversion of normal tropical and subtropical maize varieties to OPAQUE-2 which was discovered in the United States (Krivanek *et al.,* 2007; Bressani, 1991). Researchers developed a maize breed with a normal appearance and a high content of lysine and tryptophan (70-100%) (Vivek *et al.,* 2008). No fertilizer was used, since the objective of the test was to evaluate the residual effects of *Tithonia diversifolia* and bat-guano applied as organic manure on the maize crop.

Experimental setup

The experimental set-up was a simple and completely randomized block design. It was made up of 3 blocks separated by 1.5 m frame one another. Each block comprised of two parts, the first with the continuous corn and second on which the corn was in association with cowpea containing three separate plots of 0.5 m with three replicas. Their area was 12 m^2 or 4 m by 3 m.

- T_0 : Treatment without residual effects of the manure

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

S. No	Types of RE	Monoculture of maize				Corn and cowpea association			
		TL	DC	HP	SF	TL	DC	HP	SF
1	RE Titho	78.3[a]	1.47[b]	1.26[a]	280.6[a]	79.0[a]	1.75[a]	1.27[a]	254.2[b]
2	RE Bat	81.0[a]	1.88[a]	1.35[a]	287.7[a]	85.47[a]	1.85[a]	1.20[a]	324.5[a]
3	Witness	74.6[a]	1.35[b]	1.21[a]	237.3[b]	75.86[a]	1.47[b]	1.15[a]	245.8[b]
4	Avg para	77.96	1.56	1.27	268.5	80.11	1.7	1.21	274.8
5	Dec.	NS	S	NS	S	NS	S	NS	S
6	CV (%)	10.08	12.62	5.92	17.45	10.08	12.62	5.92	17.45

Note: RE Titho - Residual effect on *Tithonia diversifolia*; RE Bat - Residual effect on bat guano; Avg para - Average on the parameter; TL - Emergence rate (%); DC - Diameter at crown (cm); HP - Height of plants (m); SF - Leaf area (cm^2); Decision - Decision; CV (%) - Coefficient of Variation; S - Significant and NS - Non Significant.

- T_1 : Treatment with residual effects of *Tithonia diversifolia*
- T_2 : Treatment with residual effects of bat-guano

The experimental ground had an area of 312 m^2 or 24 m X 13 ms.

Plowing was carried out with the plow coupled to the tractor on January 28, 2013. Harrowing and crumbling were carried out manually on February 03, 2013. While the delimitation of the land was carried out on February 4, 2013. Sowing and sowing void relining took place on February 06 and 13, 2013 respectively. In order to assess the residual effects of organic manuring of bat guano and *Tithonia diversifolia*, the following measurements on the growth parameters were taken. They were the emergence rate, crown diameter, 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 tonnes or megagrams per hectare.

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 analysis of variance (ANOVA) using the Statistix 8.0 software. The test of Least Significant Difference (LSD) was then used to compare means at the 5% probability threshold.

RESULTS AND DISCUSSION

Residual effects of organic manures on the cultivation of maize in monoculture and in association with cowpea.

Residual effect on the emergence rate

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

Residual effect on the diameter at the neck

There is a significant difference between the residual effects of manure in maize monoculture and in maize-cowpea combination for crown diameter. The residual effect on bat guano is significantly greater than

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

S. No	Types of RE	Monoculture of maize				Corn and cowpea association			
		NEP	NGE	P1000	RDT	NEP	NGE	P1000	RDT
1	RE Tith	1.10^{at}	334.63^{b}	170.10^{b}	2.27^{b}	1.20^{at}	355.68^{b}	204.96^{at}	2.55^{b}
2	RE Bat	1.10^{at}	354.57^{at}	193.26^{at}	2.87^{at}	1.14^{at}	396.56^{at}	205.71^{at}	3.16^{at}
3	Witness	1.00^{at}	326.40^{b}	147.36^{vs}	1.41^{vs}	1.08^{at}	290.98^{vs}	144.36^{b}	1.63^{vs}
4	Avg para	1.06	338.53	170.24	2.18	1.14	347.74	185.01	2.45
5	Dec.	NS	S	S	S	NS	S	S	S
6	CV (%)	9.46	14.03	10.68	28.46	9.46	14.03	10.68	28.46

Note: RE Tith - Residual effect on *Tithonia diversifolia*; RE Bat - Residual effect on bat guano; NEP - Number of ears per plant; NGE - Number of seeds per ear; P1000 - Thousand grain weight; RDT - Yield (in ton / hectare); Avg par - Average per parameter; Dec - Decision; Control - Control; CV (%) - Coefficient of Variation; S - Significant and NS - Non Significant.

that on *Tithonia diversifolia* and the control. It is 1.88 cm for bat guano and 1.47 cm for Td, 1.35 cm for the control. In maize-cowpea combination, the residual effect on bat guano (1.85 cm) is significantly the same as on Td (1.75 cm) and the latter, 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 well 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.

Residual effect on the height of plants

There is no significant difference between the residual effects of different manures in monoculture as in a maize-cowpea combination.

Residual effect on the leaf surface

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 the leaf surface, i.e. 280.60 cm^2 with Td and 287.70 cm^2 with bat guano. These averages were significantly greater than that recorded with the control (237.30 cm^2. In the corn-cowpea combination, the difference between the residual effects of manure was also significant. The residual effect on bat guano 324.50 cm^2 was significantly greater than those obtained on Td 254.20 cm^2 and the control 245.80 cm^2. The fact that bat guano enriches and loosens the soil better than Td and the control would explain these results.

Residual effect on the number of ears per plant

There is no significant difference between the treatments in maize monoculture as in maize-cowpea combination. The residual effect of manure is not expressed in relation to this parameter.

Residual effect of the manures on the number of seeds per ear

In monoculture, the residual effect on bat guano gave the number of seeds per ear as (354.57) which was significantly greater than *Tithonia diversifolia* (334.63) and the control (326.40), with the two treatments having significantly the same value for this parameter. In a maize-cowpea combination, the residual effect observed on manuring bat guano (396.56) was significantly greater than that observed on Td (355.68) and this was significantly higher than the control.

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

Residual effect on the weight of a thousand grains

In monoculture, the residual effect on bat guano (193.26 g) was significantly greater than Td (170.10 g) and the control (147.36 g). These results were justified by the same explanations as those mentioned for the previous parameter.

In a maize-cowpea combination, the residual effect on bat guano was evaluated at an average value of 205.71 g, being significantly the same as on Td (204.96 g). Their residual effect was significantly greater than that recorded on the control (144.63 g). Failure to provide organic manure on the farm results in a decrease in fertility, which is expressed by the decrease in the average values of certain parameters.

Residual effect on the yield

In monoculture and in maize-cowpea combination with respect to yield, the residual effect on bat guano showed the mean values of 2.87 t/ha and 3.16 t/ha respectively, which was significantly greater than on Td with 2, 27 t/ha and 2.55 t/ha, respectively and the control (1.41 t/ha and 1.63 t/ha) respectively.

These results could be explained by the fact that not only is bat guano richer in nutrients, it also leaves 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 breaks down and does not leave stable humus, leaving its richness in carbohydrates and nitrogen.

CONCLUSION

The objective of this study was to determine the residual effects of organic manures of *Tithonia diversifolia* and bat guano on maize cultivation, in addition to comparing them with each other.

The results recorded in this study clearly indicate that bat guano has overall greater residual effects than those of *Tithonia diversifolia* on the maize crop. Whether it is the average values of growth parameters or the production parameters these two organic materials have greater residual effects than the control or the non-use of organic manures which only impoverishes the soil as long as what it loses over the growing seasons is not restored to it.

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

The two organic materials *viz*: bat guano and *Tithonia diversifolia* thus constitute a solution to the problem of soil fertility in the Ngandajika region where the goat manure used is 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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