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THEME

EFFECTS OF TWO BIOLOGICAL FERTILISERS A AND B ON GROWTH AND LEAF PRODUCTION OF *MORINGA OLEIFERA LAM.* AND *ADANSONIA DIGITATA L.*

- **FERTILISANT A: liquid fertiliser containing microorganisms useful to the soil and plants**
- **FERTILISANT B: Compost made from chicken droppings and wood shavings**

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In front of the Jury composed of :

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DEDICATION

I dedicate this memoir to my family

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ACRONYMS AND ABBREVIATIONS

BDOT	Land use database
BUNASOL	Bureau National des Sol
DG	Chief Executive Officer
CSA	Committee on World Food Security
FAO	Food and Agriculture Organization of the United Nations
IFV	Institut Français de la Vigne et du Vin
INGRIDD	Institut de Gestion des Risques Miniers et du Développement Durable (Institute for Mining Risk Management and Sustainable Development)
IRA	: Acute respiratory infection
MAHRH	Ministry of Agriculture, Hydraulics and Halieutic Resources
MATDSI	Ministry of Territorial Administration, Decentralisation and Security Interior
MECV	Ministry for the Environment and the Living Environment
MEDD	Ministry for the Environment and Sustainable Development
NTFPS	: Promotion of non-timber forest products
GDP	Gross Domestic Product
RN3	Route Nationale N°3
SNAT	National Spatial Planning Scheme

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SUMMARY

The general objective of the study is to help increase the growth and foliar production of *Moringa oleifera Lam. and Adansonia digitata L.* plants using two biological fertilisers. The specific aim is to assess the effects of the two fertilisers A and B on the growth of *Moringa oleifera Lam.* and *Adansonia digitata L.* plants *and to* assess their effects on the foliar production of *Moringa oleifera Lam.* and *Adansonia digitata L.* plants. The plant material consisted mainly of moringa and baobab seeds and fertilisers A and B. Three treatments were evaluated: T0: no fertilisation (control); T1: treatment with liquid biological fertiliser; T3: treatment with hen droppings compost. A block design with three replications was used. The growth and leaf production parameters of the two species were assessed. Analysis of variances and comparison of means showed that the manure-based fertiliser had a positive impact on the growth and leaf production of both species. As for the liquid biological fertiliser, it can be used, on the one hand for the production of moringa seedlings only and on the other hand for the amendment of the two species at the leafing stage in order to obtain fresh leaves in quantity.

Key words: organic fertiliser, growth stimulator, foliar production

ABSTRACT

The general objective of the study is to contribute to improvement of leaf production and the growth of the plants of *Moringa oleifera Lam. and Adansonia digitata L.* through two biological fertilizers. Specifically it is to know the effects of fertilizers A and B on *Moringa oleifera Lam.* and *Adansonia digitata L.* growth, and identify the effects of the two fertilizers on leaf production on *Moringa oleifera Lam.* and *Adansonia digitata L.* The plant material consisted of seeds of moringa and baobab and the fertilizers A and B. Three treatements were evaluted ; T0 : without fertiliser ; T1 : treatement based on liquid biological fertilizer ; T3 : treatement based on chicken droppings compost. A three-rep block device was used. The growth and leaf production parameters of the two species were evaluated. The analysis of variance and the comparaison the means showed that the chicken droppings compost recorded the best performance in term of growth and leaf production for the two species of plant. For liquid fertilizer, it can be used for on the one hand, the production of moringa plants, on the other hand for amendment at the leaf stage for both species in ordre to obtain fresh leaves in quantity.

Key words : biological fertilizer, growth stimulator de croissance, leaf production

INTRODUCTION

Food insecurity and climate change are now, more than ever, the two major global challenges facing humanity. Climate change is one of the greatest threats to food security (CSA, 2012). Climatic hazards, coupled with harmful human actions, have led to accelerated degradation of natural resources, including forest resources. Soils are becoming unproductive and rural populations increasingly poor (MEDD, 2010). This phenomenon is severely affecting the whole world, particularly sub-Saharan Africa, including Burkina Faso.

As a country with a predominantly agricultural economy, Burkina Faso has for some years been devoting its efforts to combating hunger through the development of a number of strategies, including the promotion of Non-Timber Forest Products (NTFPs). NTFPs are a means of subsistence and a source of additional income. They generate jobs and help to improve the health of the population, especially in rural areas. Their contribution to GDP averages around 10% according to official FAO figures (FAO, 2013).

Efforts are therefore being made to produce, promote and add value to NTFPs in terms of processing and marketing. The need for NTFPs continues to grow. There is strong demand from processing companies, mainly wholesalers, and households for their food requirements (MECV, 2010). The need to produce in quality and quantity while preserving the resources that provide NTFPs is imperative. This is why, since 2011, the Ministry in charge of the environment has been promoting this technology through what it calls a "nutrient garden" for the intensive production of baobab and moringa leaves. Poor soils and scarce rainfall are compromising the production and use of these NTFPs, which occupy a prime position in Burkina Faso's growing sectors. These NTFPs include the leaves of *Adansonia digitata* (baobab) and *Moringa oleifera* (moringa), which are highly prized by local people for their nutritional value and richness. *Moringa oleifera* (moringa) is undoubtedly one of the most useful tropical trees. The production of fresh or dried *Moringa* leaves is a highly profitable activity for farmers. *Moringa* leaf powder has become a highly prized raw material for companies making infant formula or food supplements. Baobab leaves are used to make sauces, both fresh and dried. *Adansonia digitata* is the first species preferred by producers in the northern region.

and Sahel regions of Burkina Faso. In these regions, during the period of availability, sauces are generally made from baobab leaves. *Adansonia digitata* products, mainly leaves and fruit, are sought after on the national and sub-regional markets and provide income for the economic agents involved (MAHRH, 2008). However, natural production is no longer sufficient to meet consumption and marketing demand. This situation has led to the intensive production of *moringa* and baobab for market gardening under the name of nutrient gardens. This activity depends on the availability of permanent water points for watering the beds and providing fertilisers (Kudaogo. 2019). Unfortunately, we are now witnessing a proliferation of chemical products in agricultural production. These products not only have a negative impact on the health of producers and consumers, but also disrupt the ecological balance. This is why the Ministry of the Environment, through its Directorate General for the Green Economy and Climate Change, is promoting agroecological techniques and products. Nutrigreen, a project that promotes green production and consumption, has made this its hobbyhorse, particularly the promotion of production using green fertilisers. There are several types, including A and B fertilisers, available to producers. To ensure that they are used efficiently and effectively, the technical supervisors are asking themselves the following questions: can the use of these fertilisers contribute to good baobab and moringa growth? Can it provide good yields in terms of leaf production from baobab and moringa plants? These are some of the concerns and questions we are legitimately entitled to ask ourselves. The answers to these questions could not only revolutionise agricultural production, but especially market gardening, and thus solve the problem of malnutrition. They could also provide a springboard for organic production, especially in countries affected by the effects of climate change, with its corollaries of drought and chronic famine. This is the rationale behind the present study on the "**effects of two biological fertilisers A and B on the growth and leaf production of *Moringa oleifera Lam.* and *Adansonia digitata L.***". Its general objective is to: help increase the growth and foliar production of *Moringa oleifera Lam. and Adansonia digitata L.* plants using two biological fertilisers.

Specifically, it involves:

- to know the effects of the two fertilisers A and B on the growth of *Moringa oleifera Lam.* and *Adansonia digitata L.*.

- to determine the effects of the two fertilisers A and B on the foliar production of *Moringa oleifera Lam.* and *Adansonia digitata L.* plants.

To achieve the objectives, the following assumptions have been made:

- There is a difference in the impact of the two fertilisers on plant growth;
- there is a difference in the impact of the two fertilisers on plant foliar production.

This report is divided into three chapters: the first chapter summarises the bibliography, the second describes the equipment used and the methodology adopted to conduct the study, and finally the third chapter presents the results obtained, followed by a discussion.

CHAPTER I: LITERATURE REVIEW

1.1. *Moringa oleifera*

1.1.1 Origin of the species

Moringa oleifera Lam. is a species native to the Agra and Oudh regions of India.

It was first cultivated in the north-east of India, south of the Himalayan mountain range, but is now grown in all tropical and sub-tropical regions of the world (Rajangam et *al,* 2001). It was introduced to East Africa at the beginning of the twentieth century through trade and maritime exchanges during this period (Foidl et *al,* 2001). According to the same author, this species can be found on three continents and in more than fifty tropical and subtropical countries (Africa, Saudi Arabia, South-East Asia, the Pacific Islands and South America). In these countries, it is used as a medicinal and food plant.

1.1.2. Biology of the species

1.1.2.1. Stem

According to **(**Rajangam et *al,* 2001**)**, *Moringa oleifera is* a shrub-like plant that can reach heights of 4 to 5 metres. The diameter of the trunk varies between 20 and 40 cm according to **(**Foidl et *al,* 2001**)**. The trunk is generally straight, but is sometimes very shallow. It generally branches when it reaches a height of 1.5 to 2 metres. The branches grow in a disorganised manner and the canopy is umbrella-shaped.

Figure 1: *Moringa oleifera* stem

1.1.2.2. Racine

Its root system is tubular in structure, consisting of a central pivot that can penetrate the soil to a depth of 1.30 m, making it resistant to drought. Secondary roots then branch out laterally from this to form a dense hair (Rosa, 1993).

Figure 2: *Moringa oleifera* root

1.1.2.3. Leaves

The leaves are alternate, tripinnate at the base and bipinnate at the top. They are 20 to 70 cm long with a long petiole and 8 to 10 pairs of pinnae, each composed of two pairs of opposite leaflets, plus a terminal one; the leaflets are oval and 1 to 2 cm long (Morton, 1991).

Figure 3: *Moringa oleifera* leaves

1.1.2.4. Flowers

The flowers are 2.5 cm wide and grow in axillary, drooping panicles 10 to 25 cm long. They are fragrant, white or creamy in colour, with yellow dots at the base. The five sepals are symmetrical and lanceolate. The five petals are thin and spatulate, symmetrical with the exception of the lower petal, and surround five stamens (Foidl et al, 2002).

Figure 4: *Moringa oleifera* flower

1.1.2.5. Fruit

The fruits are elongated pods with three valves, dehiscent and 20 to 60 cm long. The pods are located at the top of the branches and each contains between 12 and 35 seeds (Foidl et *al, 2002).*

Figure 5: *Moringa oleifera* fruit

1.1.2.6. Seed

The seeds are rounded and winged, with a semi-permeable brown shell. The average weight of a seed is 0.3g, 25% of which is accounted for by the shell. Annual production per tree is 15,000 to 25,000 seeds (Makkar and Becker, 1997).

Figure 6: *Moringa oleifera* seeds

1.1.3. Physiology or ecology

1.1.3.1. Adaptation of the species

Requiring little water, it is particularly suited to dry regions, as it can be grown using rainwater without expensive irrigation techniques. Its tuberous root allows it to go without water for several months. In waterlogged clay soils, its tuberous roots tend to rot.

It tolerates a wide range of soil conditions, but prefers neutral to slightly acidic (pH 6.3 to 7.0), sandy or loamy, well-drained soil. Moringa is a plant that likes sun and warmth, and does not tolerate frost or hoarfrost. It can be propagated by sowing or cuttings. It can be grown extensively for seed production (seed or oil production) or intensively irrigated for leaf production (highly nutritious) with a harvest every 6 weeks. It is a very fast-growing tree: up to 1 metre per month.

The following table shows the parameters that favour good growth for this species.

Table I: Main ecological requirements of *Moringa oleifera*

Parameters	**Value**
Climate	Tropical or subtropical
Altitude	0-2000 m
Temperature	25-35°C
Rainfall	250 mm-2000 mm Irrigation required for leaf production if rainfall < 800 mm
Type of soil	Silty, sandy or sandy loam
Soil pH	Slightly acidic to slightly alkaline (pH: 5 to 9)

Source: (De Saint Sauveur and Broin, 2010).

Moringa oleifera thrives in arid and semi-arid environments, but can also be found in very arid areas such as the Sahara and can adapt to different types of soil (Benkaddour, 2016).

1.1.3.2. Type of soil in the regions where it grows

Moringa oleifera is grown in a pantropical distribution. It is an invasive plant in Cuba. Being a plant of tropical or sub-tropical climate the moringa needs a lot of sun and heat. It needs the best exposure to the sun. However, a half-shaded spot will do just fine. It grows relatively well on slopes, but is more widespread in pasture areas and river basins. It grows rapidly, up to 6 or 7 metres in a year, even in areas receiving less than 400 mm of annual rainfall. *Moringa oleifera does* not like heavy soil. It does not like its roots to get wet, so the soil must be well drained. It tolerates silty, sandy or sandy-loam soils. If possible, avoid termite-infested soils. Sterilised soil where the layer has been burnt of organic matter such as crop tops on the seedbed will help prevent the development of pathogenic fungi.

1.1.4. Specific diversity of the moringa genus

Moringa belongs to the Moringaceae family, of which 14 species are known. Nine are African, two Malagasy, two Indian and one Saudi Arabian. The most common species are: *Moringa oleifera, M. stenopetala, M. conxanensis, M. Drouhardii,*
Mr Longituba and *Mr Peregrina. "Moringa*" comes from *muringa* in Malayalam, an Indian language. Most languages use a phonetic derivative of this word to designate the plant *Moringa oleifera* is a tree known by a variety of names. In French-speaking Africa, the most common name is nébéday, a name probably derived from the English *"never die",* in reference to its ability to resist drought, to propagate rapidly from seedlings or cuttings and to regenerate even after very severe felling (Fuglie, 2001). In India, it is called Dumstick after the rod-like shape of the fruit (Pousset, 1999).

In Burkina Faso, the name varies from one ethnic group to another, reflecting the tree's miraculous nutritional qualities:

- in "mooré" (*Arzan Tiiga*).
- in "dioula" (*ArdjilUi Yiri*).
- in "fulfuldé" (*Leggal Aljenna*).

1.1.5. Virtues of moringa

All the organs of a Moringa plant have virtues. In short, the species is used in food and human and animal medicine.

1.1.5.1. Importance of food

The leaves, fruit, young stems, roots and flowers are edible and consumed throughout the world. The leaves can be eaten fresh or powdered (Broin, 2006). They can even be combined with spices such as chilli. They can also be prepared in soup or salad (Foidl et *al,* 2001). The young green pods can be boiled and eaten like beans. The dried seeds can be ground into powder and used to season sauces, while the powdered roots of young plants can be used to season dishes (Foidl et *al,* 2001). According to the same author, the flowers can also be used as an ingredient in a salad.

1.1.5.2. Therapeutic properties

The leaves, fruit, seeds, roots, bark and flowers each have specific medicinal properties. Although as yet little verified by science, the various parts of moringa are used to treat anaemia, loss of appetite, gastric pain, stomach ulcers, diarrhoea, dysentery, colic, and to regulate diabetes and blood pressure (Pousset, 1999). According to De Saint Sauveur and Broin (2006), moringa leaves are now used in certain programmes to combat malnutrition, particularly in Senegal, India, Benin and Zimbabwe (Mansaly, 2001). The same author confirmed a marked improvement in the health of children suffering from Acute Respiratory Infections (ARI), measles, malaria or diarrhoea and put on a diet of *M. oleifera* in Senegal.

1.2. *Adansonia digitata* L.

1.2.1. Origin of the species

The history of the African baobab is well documented by Baum (1995). Linnaeus gave the binomial *Adansonia digitata* the generic name in honour of Michel Adanson, who was the first botanist to describe the African baobab in the eighteenth century (Adanson, 1771). Different local names are used for the baobab in Burkina Faso and Africa. These names vary depending on the socio-linguistic group and the cultural significance attributed to the species.

1.2.2. Biology of the species

1.2.2.1. Stem

The baobab's trunk is crowned by a large number of branches, remarkable for their size, and even more so for their length, which ranges from 15.25m to 18.3m. The branch that starts at the centre rises vertically, while those on the sides barely rise at an angle of thirty degrees. Most of them even follow a horizontal direction, so that their own weight often causes their tips to drag to the ground. Viewed from a distance, this arrangement of branches gives the tree the appearance of a fairly regular hemispherical mass, 18.3 m to 21.35 m high. Its cylindrical trunk, often swollen at the base, can reach 10 m in diameter (A. G. Diop et al, 2006).

Figure 7: Foot of *Adansonia digitata*

1.2.2.2. Racine

The baobab tree has an extensive lateral root system extending up to 50 metres from the trunk, often terminating in a tuber. But the trees' main roots are relatively shallow and rarely extend further. As a result, baobab trees are very sensitive to strong storm and thunderstorm winds, which can uproot them.

Figure 8: *Adansonia digitata* root

1.2.2.3. Leaves

Baobab leaves are (2 to 7) cm × (5 to 16) cm] and alternate, digitate and deciduous in the dry season (Assogbadjo 2005). These leaves measure 20 cm in diameter, are petiolate (8 to 16 cm) and acuminate at the apex. However, a single leaf may have between five and nine leaflets. The leaf blade, with a whole or denticulated margin, is usually glabrous and shiny on the upper side and slightly pubescent on the underside. The leaves, which are deciduous in the dry season, are alternate, compound digitate, with 5 - 9 leaflets.

Figure 9: Leaves of *Adansonia digitata*

1.2.2.4. Flowers

According to A.G. Diouf (2006), baobab flowers are white, large (10-20 cm long) and hang from a stalk up to 1 m long. They are solitary or in pairs, hermaphrodite, and consist of numerous white stamens with an ovary of 5 to 10 cells. Flowering takes place before the rainy season. Pollination is mainly carried out by bats, in particular *Rousettus aegyptiacus.*

Figure 10: *Adansonia digitata* flower

1.2.2.5. Fruit

The shape of baobab fruits varies according to morphological type. The inside of the capsule is divided lengthways into fibrous partitions. The fruits are woody, varying in shape and length. They contain seeds with a very hard tegument, also of variable shape and colour, embedded in a floury pulp intermingled with reddish fibres (Assogbadjo 2005).

Figure 10: Capsules of *Adansonia digitata*

Figure 11: Baobab capsule and contents

1.2.3. Physiology or ecology of the species

1.2.3.1. Adaptation of the species

The baobab occurs naturally in the Sahelian, Sudano-Sahelian, Sudanian, Sudano-Guinean and Guinean zones, where average annual rainfall is 300, 700, 800, 1100 and 1200 mm respectively. In these zones, the average temperature varies from 24 (or sometimes lower) to 31°C and air humidity from 18 to 99% (Sow Alioun, 2018). The baobab can withstand temperatures of up to 42°C and is sensitive to frost, which is limited to areas where this phenomenon occurs no more than one day a year (A. G. Diop et al 2006). The baobab can grow on a wide range of soils, from thick-textured, permeable soils to clay soils. The tetraploid species *A. digitata* prefers altitudes below 800 m, unlike its diploid ancestor *A. kilima*, which was limited to altitudes of between 650 and 1,500 m (Sow Alioun, 2018).

1.2.4. Type of soil in the regions where it grows

Adansonia digitata is indigenous to the Sahelian steppes and Sudan-Sahelian savannahs. This species of baobab can be found in most of the semi-arid and sub-humid regions south of the Sahara and is often found close to dwellings. The baobab has a very wide distribution area. In the west, it extends from Cape Verde to the coastal plains of Ghana, Benin and Togo. It has been introduced into wetlands such as Gabon and the Democratic Republic of Congo (Sow Alioun, 2018). In the north, it is limited by the Sahara. In Eritrea and Somalia, the tree is typical of the plains, while in Sudan it grows in the Nuba mountains and up to 1,500 m altitude in Ethiopia. In Kenya and further south towards Mozambique, the populations of *A. digitata* are coastal or scattered in low-lying areas and savannah. In Angola and Namibia it tends to be found in wooded areas (Diop *et al*; 2005).

1.2.5. Specific diversity of the genus Adansonia

The genus *A dansonia* belongs to the Malvaceae family and comprises eight species. Six species are endemic to Madagascar: *A. grandidieri* Baill*, A. madagascarensis* Baill*, A. perrieri* Capuron*, A. rubrostipa Jum. & H. Perrier, A. suarezensis H. Perrier* and *A. za* Baill. The species A. *gibbosa (A. Cunn.) Guymer* ex

D. Baum is confined to the north-west of Australia (Kim-berley district and the Victoria and Fitz-maurice rivers region). Finally, *A. digitata* L., which is found on the African continent, is the most widespread and best described species. The various baobab species have been characterised by a number of features (A.G. Diop et al; 2006).

1.2.6. Virtues of the species

1.2.6.1. Food use

- ✓ **Leaves**

The leaves of the African baobab can be used fresh to make sauces. Sun-dried and ground, they can also be sieved to obtain a green powder used to season sauces. The leaves can also be used directly as a vegetable.

It accompanies millet, maize or sorghum paste. Nutritionally, the lipid and protein values of the leaf are low, at 0.41% and 14.12% respectively. However, they are rich in vitamins (A and C) and minerals, particularly iron, magnesium and zinc (Sow alioun et al, 2018).

- ✓ **Pulp**

The pulp contained in the capsule is obtained after crushing and sieving. It is used in a variety of preparations. One example is the drink made from a mixture of baobab pulp and cereal flour. Baobab pulp is also increasingly valued and sold in public places in Africa.

- ✓ **Seed**

Baobab seeds are used to produce a protein concentrate used to season sauces in rural areas. As baobab seeds are very rich in lipids (28%), protein (34%), minerals and vitamins, their by-products are potential sources of nutrients that can help to ensure people's nutritional security and, above all, their health.

of children in at-risk environments (Sow alioun et al, 2018).

1.2.6.2. Therapeutic use

The baobab is a tree with multiple therapeutic uses. Every part of the tree (roots, pulp, bark, leaves, flowers, seeds, etc.), alone or in association with other plant species, is of definite use to people in many areas. In pharmacopoeia, the organs and parts of the baobab are used to treat at least 19 different illnesses and conditions. The pulp is by far the organ of the baobab that contributes most to medicinal use, and is used to treat a number of ailments, the most important of which are anaemia, malaria and diarrhoea. The bark helps to heal wounds, while the kernel extracted from the seeds is used to soothe hiccups. The leaves are used to treat haemorrhoids, while the root is used to treat epilepsy.

All of these recognised uses of the different organs of the species are obviously due to the richness of its different organs in nutritive components and active substances. Alkaloids, flavonoids, sterols, coumarins and saponoids have been found in the various organs of this species. These are nitrogenous, basic organic substances with physiological properties that support the nervous system and spinal cord (alkaloids). They are venous tonics with antispasmodic, antiulcer and anti-inflammatory properties (flavonoids). As polyphenolic substances, they combine with skin proteins to make the leather rot-proof (tannins). The presence of adansonine ($C48H36O33$) in the bark justifies its use against malaria and other fevers (Sidibé & Williams, 2002). The very high iron content in both leaves and seeds, around 29.3% of the dry matter, justifies its use in the treatment of anaemia, iron having the property of fixing haemoglobin.

1.3. Fertilisers in general

Generally speaking, fertilisers are substances (usually mixtures of mineral elements) designed to provide plants with additional nutrients in order to improve their growth and increase crop yield and quality (Zodomé, 2012). All fertilisers contain one or more of the following nutrients:

- ✓ Nitrogen (N) ;
- ✓ phosphorus (P) ;
- ✓ potassium (K).

Fertilisers are generally classified into two main types according to their proportions of nutrients and their nature: organic fertilisers and chemical fertilisers.

I.3.1. Organic fertiliser

Also known as biological fertilisers, organic fertilisers come from living organisms (animals or plants). Specifically, they result from the mixing of animal or plant debris containing nitrogen, phosphorus and potash, but in sometimes smaller proportions than in a mineral fertiliser. There are various types of organic fertiliser:

- ✓ animal waste compost ;
- ✓ compost from plant waste ;
- ✓ compost of plant debris plus animal waste;
- ✓ liquid fertilisers containing live micro-organisms ;
- ✓ fertiliser made from sewage sludge (Aurélie, 2014)

1.3.2. Chemical fertilisers

Chemical fertilisers are exclusively synthetic. Mineral fertilisers are solids, fluids or gases containing a simple fertiliser or composed of major nutrients (N, P, K) in inorganic form. The name of mineral fertilisers is standardised by reference to their three main components: NPK. Nitrogen (N); phosphorus (P); potassium (K).

These fertilisers are manufactured by the chemical industry and are of three types:

- ✓ mineral nitrogen fertilisers: these are made up o f nitric acid and ammonia. Nitrogen is supplied in the form of nitrate NO3, NH4 ;
- ✓ Phosphate fertilisers: composed of phosphate and sulphuric acid. Phosphate is expressed as P2O5, but is supplied in the form of calcium phosphate;
- ✓ Potassium fertilisers: composed of potassium sulphate. Potassium is in the form of K2O, but is carried by potassium chloride, nitrate and sulphate. Phosphate and potassium fertilisers are produced by extracting minerals in the form of processed saline or sedimentary rock (Benamara and Djotni, 2018).

CHAPTER II: SITE, EQUIPMENT AND METHODOLOGY

2.1. Site presentation

Our study was carried out at the Oubritenga Provincial Environment Directorate in Ziniaré. The town of Ziniaré, capital of the Oubritenga province and the Central Plateau region, is located in central Burkina Faso. It lies between 12°35' north latitude and 1°18' west longitude. It lies in the Nakanbé river basin, between the forks formed by this river and its tributary, the Massili. Crossed by the RN3, Ziniaré, the chief town of the Commune, is located 35 km from the capital Ouagadougou. The Commune comprises five (05) sectors and fifty-three (53) villages. It covers an area of 526 km^2 , or 18.51% of the total area of the province of Oubritenga.

With reference to Law N°030-99/AN establishing the administrative boundaries of the communes in Burkina Faso, it is limited :

- to the north by the communes of Zitenga and Korsimoro ;
- to the west by the communes of Dapelogo and Loumbila ;
- in the south by the communes of Nagréongo and Saaba ;
- and to the east by the commune of Absouya (MATDSI, 2016).

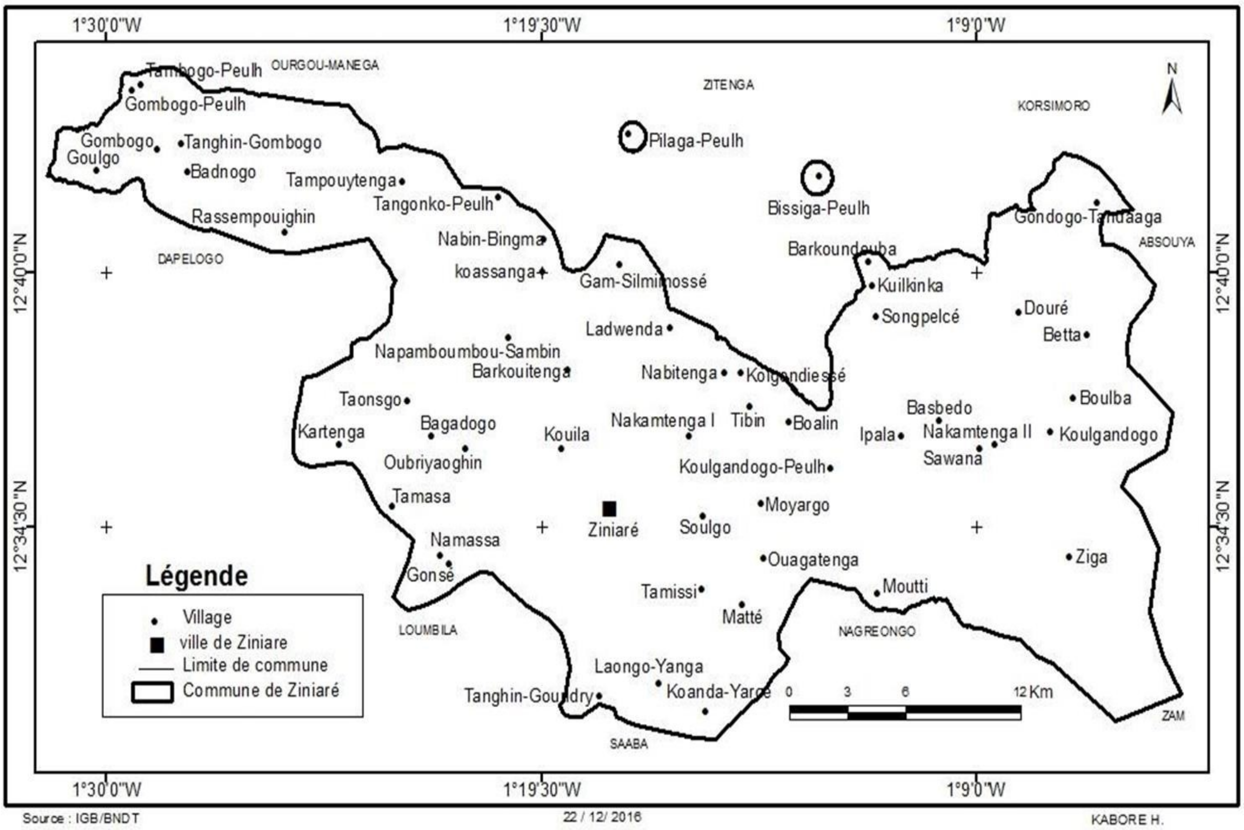

Figure 12: Map of the commune of Ziniaré (MATDSI, 2016)

2.2. Hardware

2.2.1. Technical equipment

The following equipment was required to carry out the study:

- a digital camera to capture the images;
- Plastic pots 20cm in diameter and 20cm high for potting the substrate;
- watering cans ;
- an electronic calliper for neck diameter measurements;
- a measuring tape to measure height or length;
- an electronic weighing scale;
- shovels, picks, rakes, wheelbarrows, machetes, for the development of the experimental site;
- fencing, fixing posts, turnbuckles and wires to protect the experimental site;
- a solar dryer for drying vegetative organs

2.2.2. Plant material

The plant material consists mainly of moringa and baobab seeds for production;

2.3. Methodology

2.3.1. Fertiliser preparation

2.3.1.1. Manufacturing process for fertiliser B based on hen droppings

Fertiliser B: hen droppings compost is obtained by composting wood shavings with hen droppings. To do this, the wood shavings are mixed with the droppings in equal quantities. The mixture obtained must then be packed in bags and regularly sprinkled with a sufficient quantity of water. The fertiliser is obtained after the mixture has decomposed.

Figure 13: Compost made from hen droppings

2.3.2. Fertiliser A manufacturing process, liquid fertiliser

Fertilizer A is made by mixing the ingredients in the following proportions:

- one kilogram of fresh cow dung;
- one kilogram of cowpea flour ;
- a handful of sugar ;
- 0.5 kilograms of *Kaya senegalensis* or *Azadirachta indica* leaves;
- a litre of beef urine;
- nine litres of water ;

This product, which contains micro-organisms useful to plants, is obtained on the tenth day after its manufacture following fermentation.

2.3.3. Device used

The experimental set-up used was block design and consisted of a total of three hundred and sixty pots of seedlings divided equally between the two species, *Adansonia digitata* and *Moringa oleifera,* in three blocks. Each block is made up of six lots. The batch groups together all the plants of the same treatment, of the same species in the same block. It is consisting of 20 plant pots. The two types of treatment were liquid fertiliser and hen droppings-based compost. Apart from the treatments based on these two organic fertilisers, we note the simple soil used as for the control batches. The type of block system was as follows:

Figure 14: Presentation of the experimental set-up

2.3.4. Conduct of the trial

2.3.4.1. Potting operations

Perforated pots were used for potting. These pots were filled with a base substrate consisting of topsoil taken from the experimental site within the Oubritenga Provincial Environment Directorate. This soil was mixed with sand (three measures of soil for one measure of sand). The soil and sand mixture obtained was divided into three according to the three following treatment contents:

- pots containing only a mixture of soil and sand (without fertiliser): control pots (weight of pot + contents = 8.5 kg);
- pots in which the soil-sand mixture is amended with compost made from hen droppings +Wooden pot (weight of pot + contents = 8.2 kg) ;
- pots in which the soil-sand mixture is amended with liquid fertiliser (pot mass + its contents = 8.33 kg).

2.3.4.2. Seed pre-treatment

Moringa seeds were pre-treated by soaking in water for 24 hours before sowing. As for the baobab seeds, they were scalded and then soaked in tap water for 24 hours before being sown.

2.3.4.3. Sowing seeds

The seeds will be sown directly two per pot. The pots should be 30 cm high and 20 cm in diameter. They should be watered regularly with approximately 2 litres of water per pot, morning and evening. One litre of liquid fertiliser is applied to the pots every fourteen days.

Figure 15: Seeding the pots

2.3.4.4. Plant care and maintenance

Watering, amendment of the pots treated with fertiliser A using the product (1 litre/pot), weeding and hoeing made up the bulk of the upkeep.

2.3.4.5. Data capture

The growth and leaf production parameters measured concerned :

- the diameter at the collar of the plants using an electronic caliper (in mm);
- the number of leaves per plant ;
- mass of fresh and dried leaf (obtained by weighing) ;
- the length of the aerial part of the plants by measurement ;

Measurements of growth parameters, number of leaves per plant and leaf mass were taken every fourteen (14) days. Monitoring lasted ninety (90) days. Data was collected using specially designed forms. At the end of the 90 days, ten (10) seedlings were excavated in each treatment in order to evaluate some morpho-metric parameters of certain organs of the two species (Table II).

Table II: Data taken and their abbreviations

Parameters measured	Abbreviations
Total Root Length	LTR
Length of the Tuberised Part of the Root	LPTR
Diameter at mid-length of the Tuberised Part of the Root	DPTR
Fresh weight of the aerial part of the seedling	PFPA
Fresh weight of the underground part of the seedling	PFPS

CHAPTER III: RESULTS AND DISCUSSION

3.1. Results on growth parameters

The results are based on a comparison of the data collected on the plants treated with the two fertilisers with the data collected on the control plants (not treated with fertiliser).

3.1.1. Effect of fertilisers on baobab growth

3.1.1.1. Effect of treatments on baobab diameter growth

From the first moments of the trial, neither fertiliser had a significant difference on the growth in thickness of the moringa plants. From the fifty-sixth day onwards, the two fertilisers showed a significant difference in the growth in diameter of the baobab plants. As for their effects, one was positive and the other negative. The following table gives the various summary results for baobab.

Table III: Summary of average diameters by baobab treatment

	after 14 days	28th day	Day 42	Day 56	60th day	Day 74
Manure	2.699 a	3.328 a	4.992 b	7.458 b	9.736 b	11.051 b
Indicator	2.596 a	2.980 a	4,586 ab	5,268 ab	7,530 ab	7.210 a
Liquid	2.432 a	2.899 a	3.726 a	5.158 a	6.406 a	7.055 a
Pr > F	0,487	0,189	0,054	0,025	0,005	0,001
Significant	No	No	No	Yes	Yes	Yes

From day 14 to day 42, there was no significant difference between the two treatments in terms of their effect on diameter growth (Figure 17). But from day fifty-six and beyond there was a significant difference. The hen droppings treatment had a positive effect, while the liquid fertiliser treatment had a negative effect.

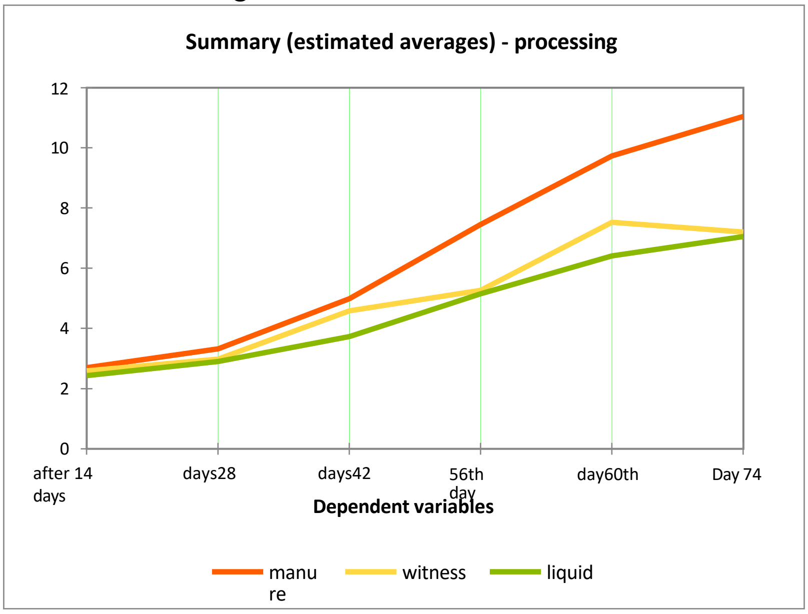

Figure 16: Summary of average diameters by baobab treatment

With the exception of periods when there was no significant difference between the two treatments, the hen droppings treatment performed better than the liquid fertiliser treatment.

3.1.1.2. Lengths, diameters, fresh weight of roots, and fresh weight of stems at harvest baobab

Considering the following parameters: length, diameter, root mass in the fresh state, and fresh weight of stems at harvest, all two treatments had a significant difference (Table IV). As for their effects on these parameters, the manure-based fertiliser had a positive impact on all the growth parameters considered. The liquid fertiliser treatment only had a positive effect on root diameter and root weight.

Table IV: Summary of average lengths, diameters, fresh weights of roots and stems at harvest by moringa treatment.

	root length	Root diameter	root_weight	stem_weight
Manure	14.167 b	14.751 b	16.678 b	30.683 b
Liquid	11.783 a	10,697 ab	8.744 a	6.280 a
Indicator	14.092 b	10.657 a	9.173 a	3.699 a
Pr > F	0,004	0,027	0,015	0,000
Significant	Yes	Yes	Yes	Yes

- **Root length**

There was a significant difference between the two treatments in terms of their effect on root length. Specifically, the effect of the manure-based treatment was positive, while that of the liquid fertiliser was negative.

- **Root diameter**

The two fertilisers had a significant difference in terms of impact on root diameter. The manure-based fertiliser performed better than the liquid fertiliser-based treatment.

- **Fresh root weight**

All treatments showed a significant difference in the effect on root weight. Specifically, the effect of the manure-based treatment was positive, while that of the liquid fertiliser was negative.

-Fresh stem weight

In terms of this parameter, the two organic fertilisers showed a significant difference. Both had a positive effect. However, the hen droppings performed better than the liquid fertiliser.

The graph below shows these results.

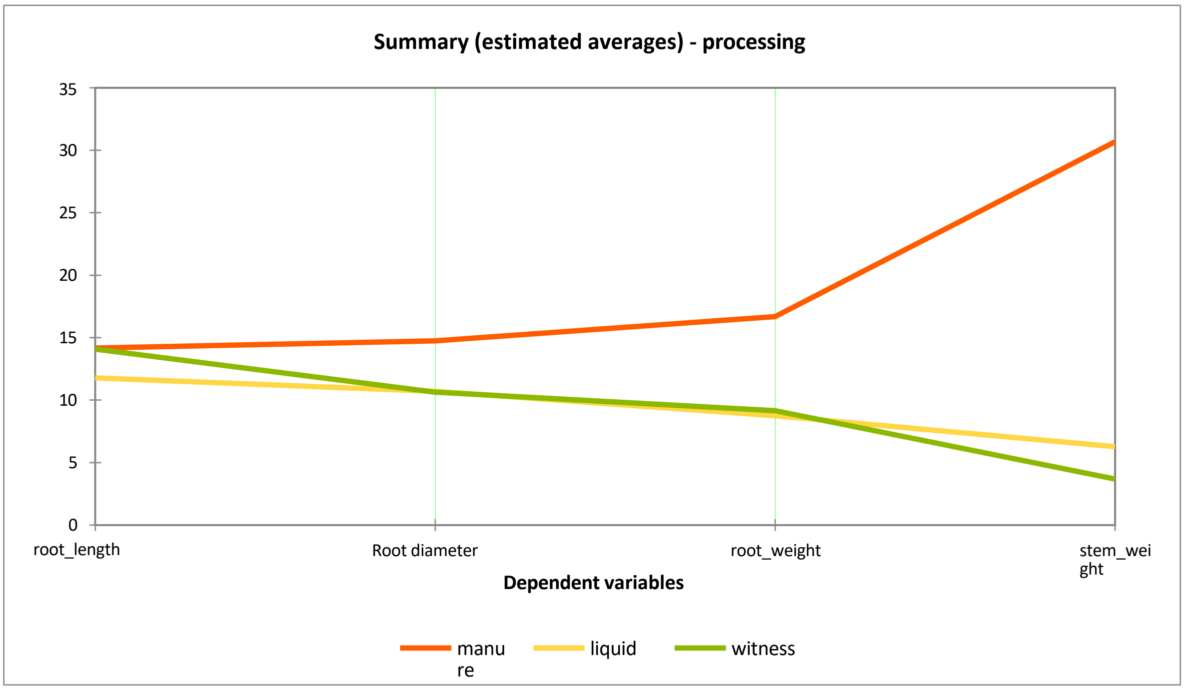

Figure 17: Summary of average length, diameter, fresh weight of roots and stems at harvest by baobab treatment.

For all the parameters considered, treatment with hen droppings proved more suitable.

3.1.2. Effect of fertilisers on moringa growth

3.1.2.1. Effect of fertilisers on the height of moringa plants

From the beginning to the end of the study, both fertilisers had a significant difference and a positive effect on the height growth of moringa plants (Table V). The impact of the two products on the height growth of moringa plants was as follows: **Table V**: Summary of plant averages by moringa treatment

Summary (estimated averages) - processing :						
	after 14 days	28th day	Day 42	Day 56	60th day	Day 74
Manure	9.424 b	15.435 b	32.184 b	52.938 b	68.400 b	82.834 b
Liquid	7.546 a	10.503 a	13.179 a	19.607 a	22.107 a	26.679 a
Indicator	7.426 a	10.264 a	12.116 a	17.074 a	19.158 a	23.674 a
Pr > F	0,007	0,000	0,000	0,000	0,000	0,000
Significant	Yes	Yes	Yes	Yes	Yes	Yes

Throughout the trial period, the two treatments showed a significant difference in length growth (Figure 19). However, the hen droppings treatment had a greater positive effect than the liquid fertiliser treatment.

The following graph shows the impact of each treatment on plant length growth:

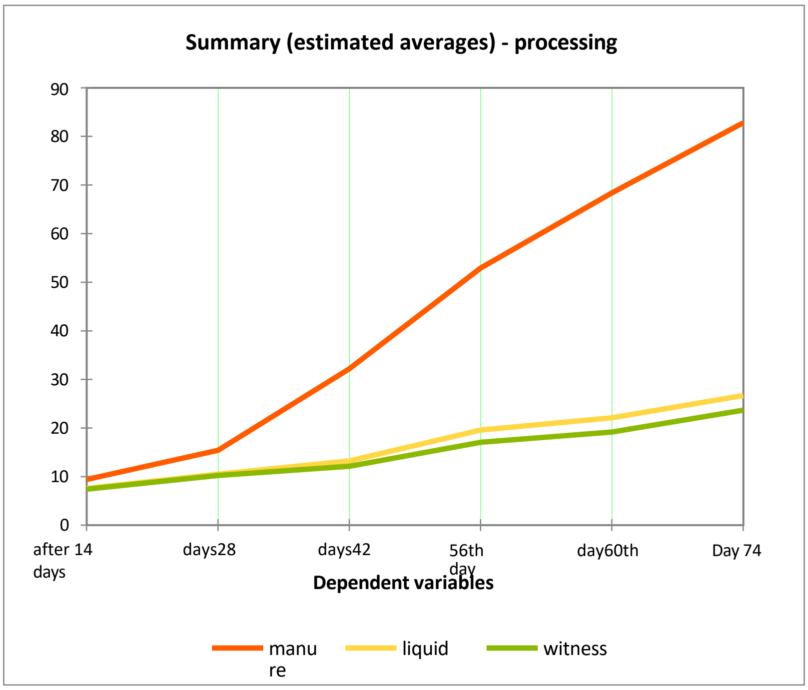

Figure 18: Summary of average plant heights by moringa treatment

There was a big difference between these two fertilisers in terms of their effect on height growth. Although both fertilisers had a significant difference and a positive effect, the hen droppings-based fertiliser was better and increased over time.

3.1.2.2. Effect of treatments on Moringa diameter growth

Both fertilisers had a positive impact in terms of their effects on the thickness growth of Moringa plants. However, their performance is assessed on a period-by-period basis. The following table shows the effect of each product depending on the period.

Table VI: Summary of average diameters per moringa treatment

	after 14 days	28th day	Day 42	Day 56	60th day	Day 74
Manure	1,801 ab	3.576 b	7.153 b	9.742 b	12.511 b	13.784 b
Liquid	2.070 b	2.589 a	3.674 a	4.574 a	5.441 a	6.024 a
Timer	1.506 a	2.358 a	3.270 a	3.903 a	4.745 a	5.146 a
Pr > F	0,010	0,000	0,000	0,000	0,000	0,000
Significant	Yes	Yes	Yes	Yes	Yes	Yes

Both treatments showed a significant difference and a positive effect on diameter growth (Figure 20). With the exception of the fourteenth day, when the liquid fertiliser treatment had a greater effect on diameter growth than the hen droppings treatment, the hen droppings treatment had a greater impact throughout the rest of the trial.

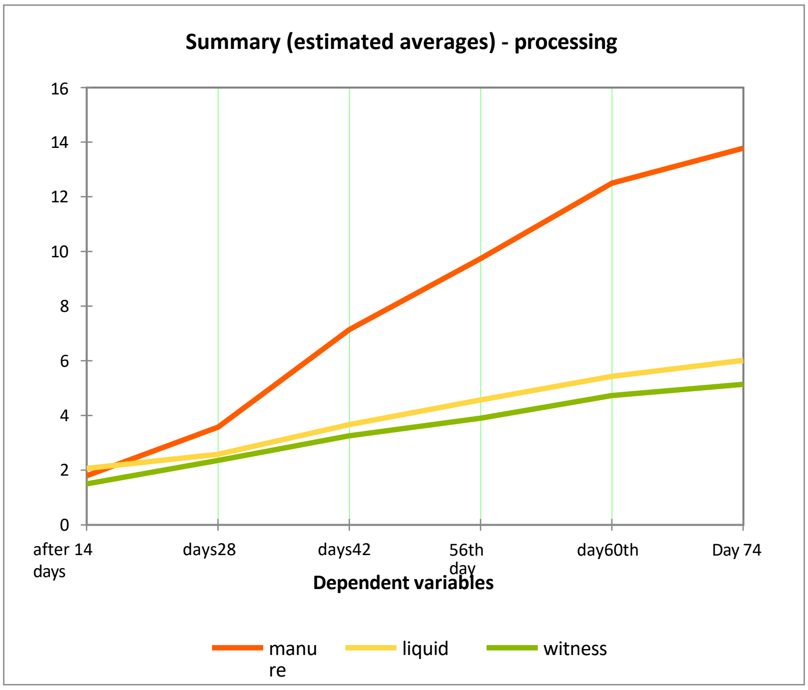

Figure 19: Summary of average stem diameters by moringa treatment

Overall, the manure-based fertiliser had a more positive and increasing impact on moringa diameter growth.

3.1.2.3. Effect of treatment on moringa length, diameter, root fresh weight and stem fresh weight at harvest

There is a variation in length, diameter, fresh root weight and stem weight at harvest according to the two fertilisers and according to the periods (Table VII).

Table VII: Summary of average lengths, diameters, fresh weights of roots and stems at harvest of moringa plants by treatment

	root_length	Root diameter	root_weight	stem_weight
Manure	13.673 b	14.057 a	24.368 b	25.424 b
Liquid	10,542 ab	11.783 a	7.380 a	3.041 a
Indicator	9.653 a	11.242 a	6.653 a	3.548 a
Pr > F	0,021	0,176	0,000	0,000
Significant	Yes	No	Yes	Yes

- **Root length**

There was a significant difference between the two treatments in terms of their effect on root length. Specifically, the effect of the manure-based treatment was more positive than that of the liquid fertiliser.

- **Root diameter**

There was no significant difference between the two treatments in terms of their effect on root diameter.

- **Fresh root weight**

There was a significant difference between the two treatments in terms of their effect on root weight. Specifically, the effect of the manure-based treatment was positive, while that of the liquid fertiliser was negative.

- **Fresh stem weight**

There was a significant difference between the two treatments in terms of their impact on stem weight. However, the manure-based treatment performed better than the liquid fertiliser-based treatment (Figure 21).

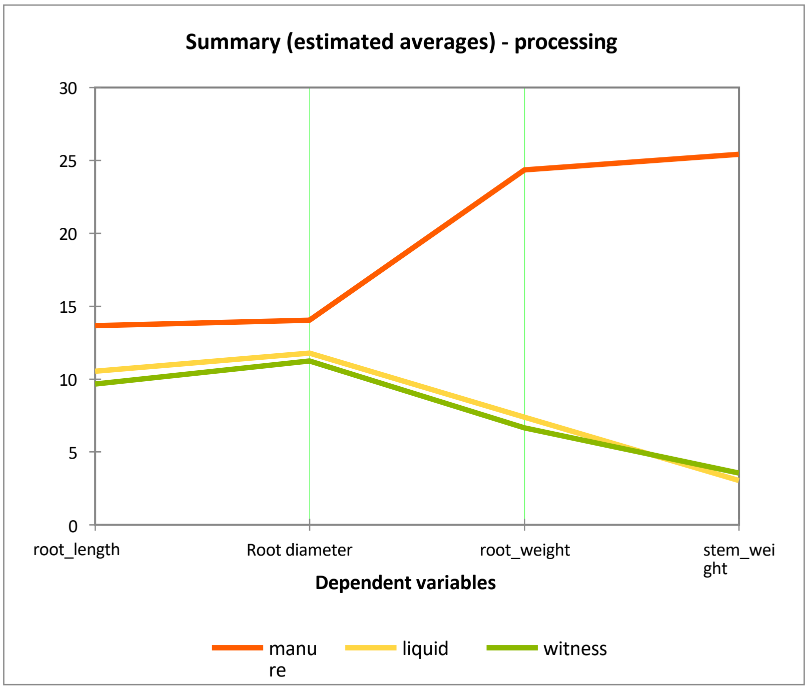

Figure 20: Summary of average length, diameter, fresh weight of roots and stems at harvest by moringa treatment.

Neither fertiliser had a positive effect on root diameter. By comparing their impact, we can conclude that the manure-based fertiliser has a greater effect on root diameter growth than the liquid fertiliser.

3.2. Results on leaf production parameters

3.2.1. Effect of treatments on baobab leaf production

3.2.1.1. Effect of treatments on the number of baobab leaves

There was no great variation in the number of leaves for the two treatments before the twenty-eighth day (Table VIII). It was after this period that the variation was remarkable.

Table VIII: Summary of average number of leaves per Baobab treatment

	after 14 days	28th day	Day 42	Day 56	60th day	Day 74
Manure	4.609 a	8.826 a	14.739 b	19.565 b	23.565 b	26.739 b
Indicator	3.857 a	8.857 a	12,286 ab	15,286 ab	16.714 a	17.857 a
Liquid	6.357 a	7.857 a	10.214 a	14.143 a	15.286 a	16.214 a
Pr > F	0,087	0,620	0,024	0,003	0,000	0,000
Significant	No	No	Yes	Yes	Yes	Yes

Before 42 days, there was no significant difference between the two treatments in the number of leaves, but after this period, there was. However, after this period, there was a significant difference: the hen droppings treatment had a positive effect, while the liquid treatment had a negative effect (Figure 22).

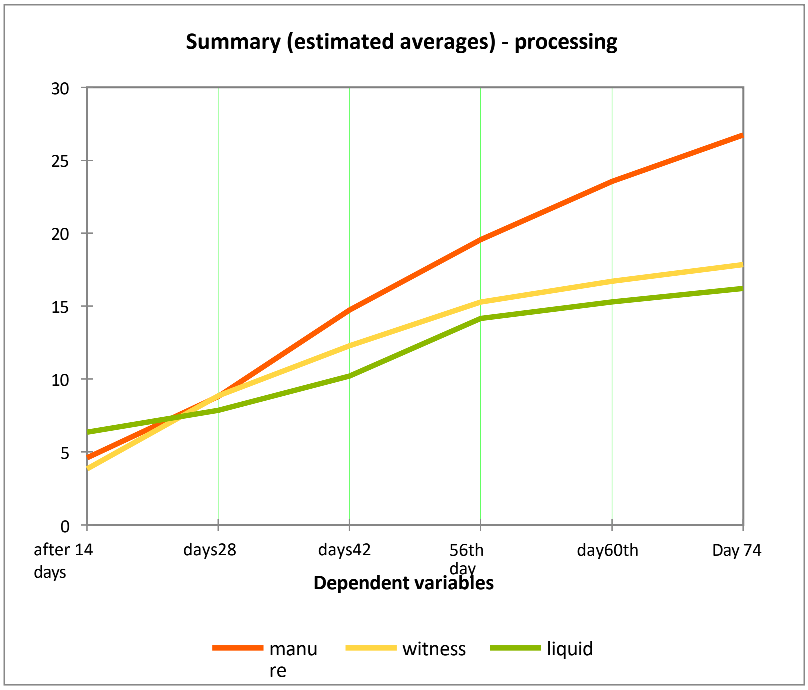

Figure 21: Summary of average number of leaves per baobab treatment

Manure compost has a greater effect on leaf multiplication, while liquid fertiliser has a much reduced effect on leaf production.

3.2.1.2. Effect of products on baobab branching

There was no great variation in the number of branches for the two treatments before the twenty-eighth day. It is after this period that the variation is remarkable (see Table).

Table IX: Summary of the average number of branches per baobab treatment

	after 14 days	28th day	Day 42	Day 56	60th day
Manure	0.043 a	0.174 a	0.348 b	0.652 b	0.696 b
Liquid	0.000 a	0.000 a	0.000 a	0.000 a	0.000 a
Pr > F	0,397	0,154	0,033	0,017	0,011
Significant	No	No	Yes	Yes	Yes

From day 14 to day 28, there was no significant difference between the hen droppings and liquid fertiliser treatments in terms of their effect on baobab branching (Figure 23). However, the difference was significant from a treatment duration of 48 days and more. The droppings treatment had a greater positive effect on baobab branching than the liquid fertiliser treatment.

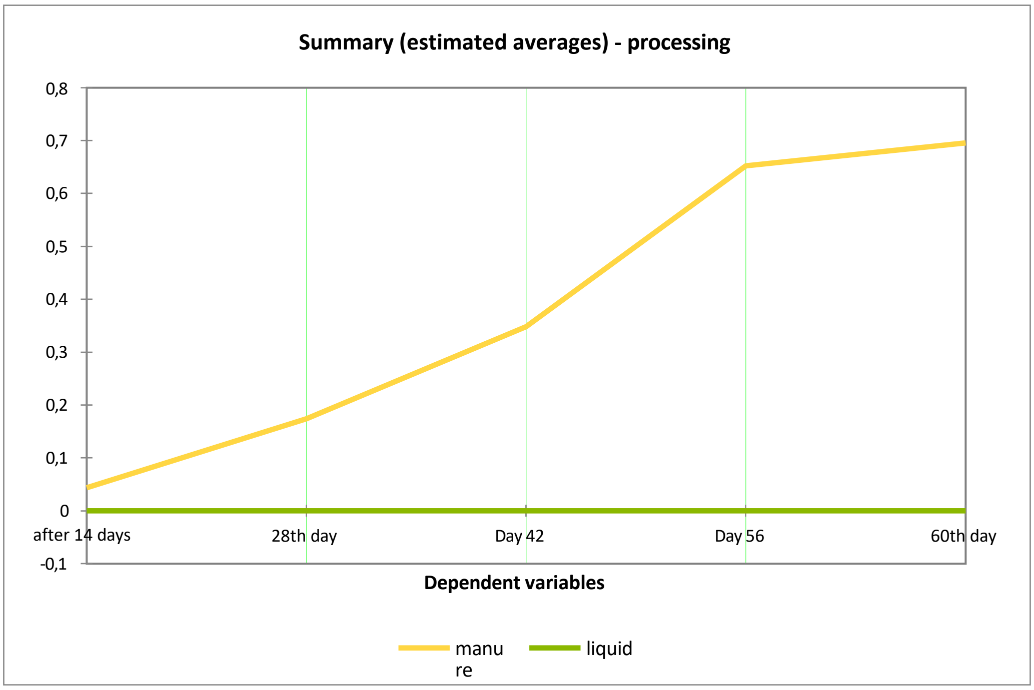

Figure 22: Summary of the average number of branches per baobab treatment

Dung compost encourages more branching, while liquid fertiliser has very little effect on baobab branching.

3.2.1.3. Effect of treatments on the quantity of leaves per baobab harvest

The results presented in the following table showed that both organic fertilisers had a positive effect on leaf mass. However, hen droppings had a greater stimulating effect on leaf production.

Table X: Summary of leaf mass averages by baobab treatment

	45th day	Day 60	Day 75
manure	75.188 b	56.435 b	59.585 b
liquid	16.527 a	10.663 a	12.398 a
witness	11.953 a	8.085 a	8.907 a
Pr > F	0,019	0,013	0,012
Significant	Yes	Yes	Yes

Throughout the trial period, the two treatments showed a significant difference in the quantity of leaves per harvest (graph 24). However, the hen droppings treatment performed better than the liquid organic fertiliser.

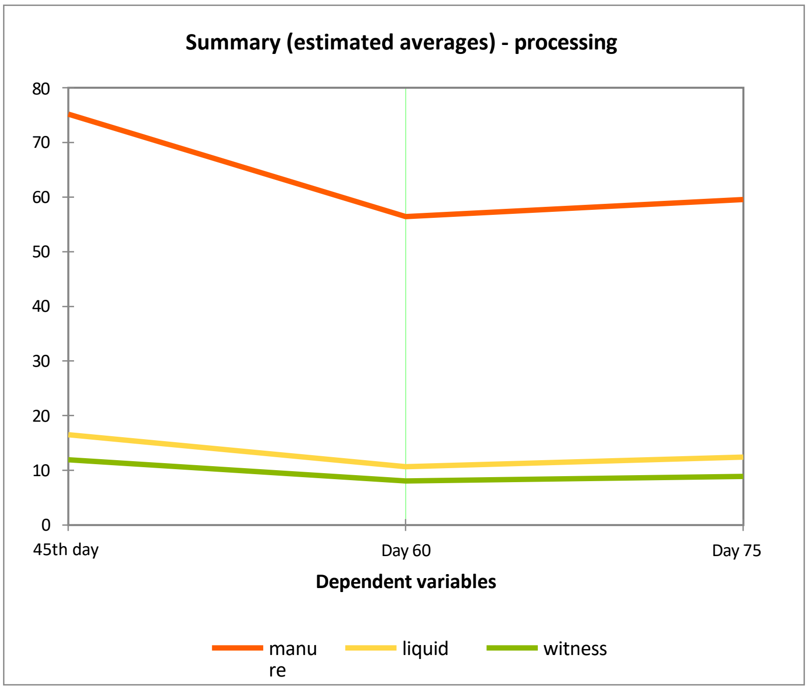

Figure 23: Summary of average leaf mass by baobab treatment

Considering their effects on leaf mass, there was a big difference between the two fertilisers. Although all the fertilisers had a positive effect, the hen droppings-based fertiliser proved better.

3.2.1.4. Proportion of reduction in mass of baobab leaves during drying

The average quantities of leaves and dried leaves and the proportions are shown in the table below:

Table XI: Proportion of leaf reduction during drying on baobab trees

Treatments	Type of sheet	Average per harvest period		
		45e days	Day 60	Day 75
Manure	Fresh	15,84	11,95	12,44
	Dried	3,94	2,91	3,11
	Proportion of reduction(in %)	24,92	24,4	25,02
Liquid	Fresh	4,28	2,76	3,17
	Dried	1,67	1,24	1,39
	Proportion of reduction(in %)	39,14	45,07	44,03

The above results show that when the leaves are dried, there is a greater reduction in mass for the treatment based on liquid fertiliser than for that based on hen droppings.

3.2.2. Effect of treatments on moringa leaf production

3.2.2.1. Effect of treatments on the number of moringa leaves

The number of leaves varies according to the type of treatment and the period. The following table shows the results obtained.

Table XII: Summary of average number of leaves per moringa treatment

	after 14 days	28th day	Day 42	Day 56	60th day	Day 74
manure	5.968 a	8.677 b	11.710 b	13.129 c	14.935 c	17.452 c
liquid	5.261 a	6.913 a	8.261 a	10.652 b	11.478 b	12.348 b
witness	6.053 a	7.053 a	7.105 a	8.000 a	8.474 a	9.789 a
Pr > F	0,111	0,000	0,000	0,000	0,000	0,000
Significant	No	Yes	Yes	Yes	Yes	Yes

With the exception of day 14, when there was no significant difference between the two treatments in the number of moringa leaves, there was a significant difference from day 28e onwards (Figure 25). The manure treatment had a greater positive effect on the number of leaves than the liquid treatment.

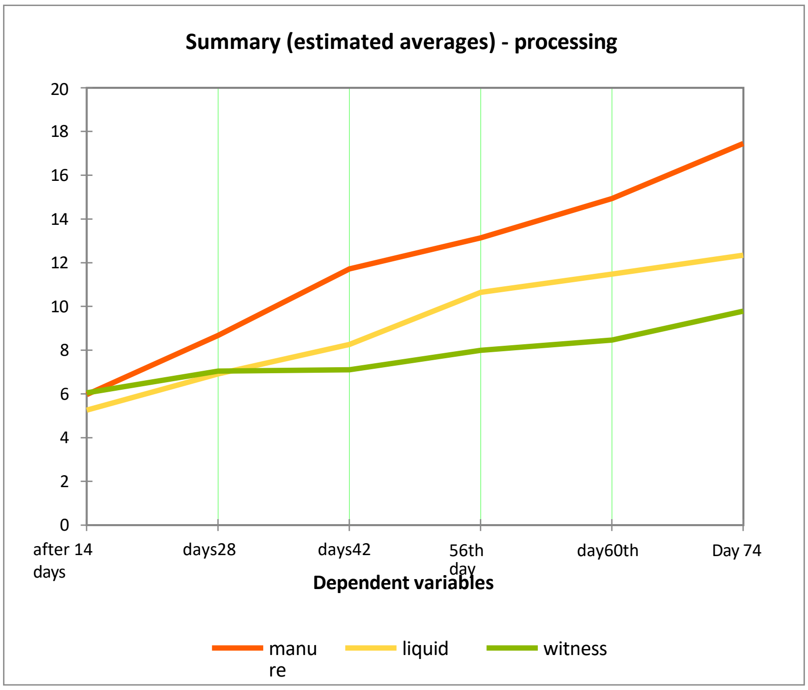

Figure 24: Summary of average number of leaves per moringa treatment

In general, both fertilisers had a positive effect on leaf production. However, at the start of the experiment, both fertilisers were ineffective for Moringa leaf production. Subsequently, the droppings-based fertiliser showed very positive results.

3.2.2.2. Effect of treatments on moringa branching

The following table shows a period of no action by the two fertilisers (from the start to day 42e) and a period of action on moringa branching. Both had a positive effect throughout the rest of the period.

Table XIII: Summary of the average number of branches per moringa treatment

	after 14 days	28th day	Day 42	Day 56	60th day	Day 74
Manure	0.000 a	0.053 a	0.053 a	0.474 b	0.474 b	0.789 b
Liquid	0.000 a	0.000 a	0.000 a	0.167 ab	0.167 ab	0.333 ab
Indicator	0.000 a	0.000 a	0.000 a	0.000 a	0.000 a	0.000 a
Pr > F	0,439	0,439	0,439	0,004	0,004	0,009
Significant	No	No	No	Yes	Yes	Yes

From day 14 to day 42e , there was no significant difference between the two treatments in terms of their effect on moringa branching (Figure 26). However, there was a significant difference from 56 days onwards. The manure treatment had a greater positive effect on moringa branching than the liquid fertiliser treatment.

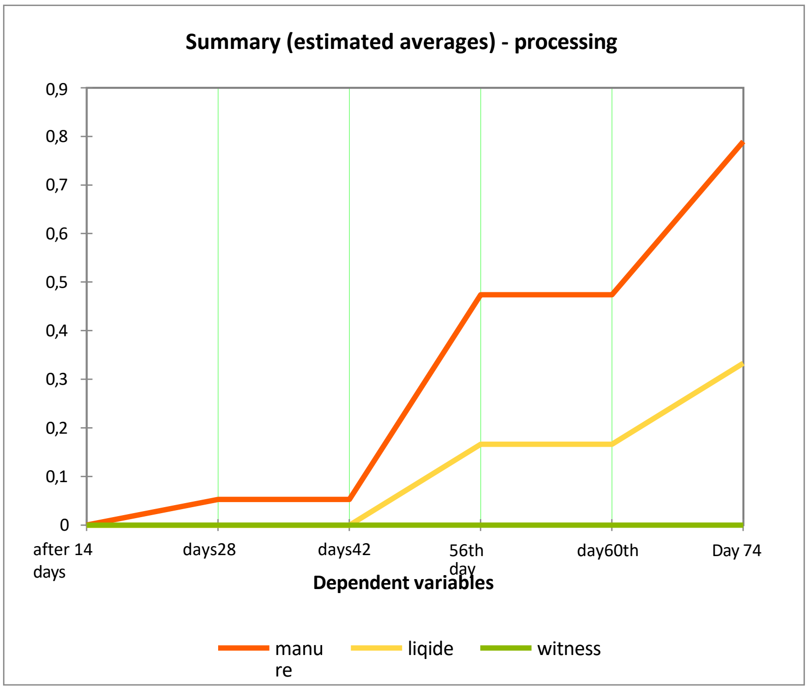

Figure 25: Summary of the average number of branches per Moringa treatment

There is a similarity between the two fertilisers in terms of their effect on moringa branching. The similarity lies in the fact that the two fertilisers did not have a positive effect during the same periods. The two fertilisers also had a concomitant impact on moringa branching during the same period. The manure-based fertiliser performed better.

3.2.2.3. Effect of treatments on the quantity of moringa leaves

Both organic fertilisers had a positive effect on leaf mass but at different levels (Table XIV).

Table XIV: Summary of average leaf mass per moringa treatment

	45th day	Day 60	Day 75
manure	75.188 b	56.435 b	59.585 b
liquid	16.527 a	10.663 a	12.398 a
witness	11.953 a	8.085 a	8.907 a
Pr > F	0,019	0,013	0,012
Significant	Yes	Yes	Yes

Throughout the trial period, the two treatments showed a significant difference in the quantity of leaves per harvest, with a positive effect (Graph 27). However, the hen droppings treatment was better than the liquid fertiliser treatment.

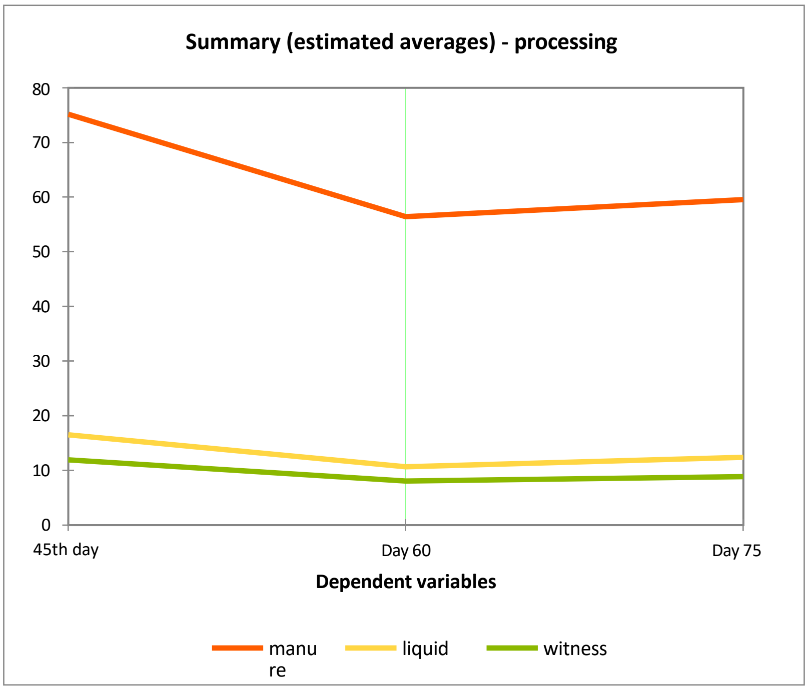

Figure 26: Summary of average leaf weights per moringa treatment

Both organic fertilisers have a positive impact on Moringa leaf mass, but the manure-based treatment is more effective.

3.2.2.4. Proportion of reduction in the mass of moringa leaves during drying

The average quantities and proportions are shown in the table below:

Table XV: Proportion reduction in leaf mass during drying

Treatments	Type of sheet	Average per harvest period		
		45e days	Day 60	Day 75
Manure	Fresh	17,18	13,17	17,93
	Dryer	5,06	3,09	4,88
	Proportion of reduction(in %)	29,47	23,49	27,2
Liquid	Fresh	2,30	2,23	2,8
	Dryer	1,25	1,11	1,39
	Proportion of reduction(in %)	54,18	49,99	49,93

Considering the above results, we can conclude that when the leaves are dried, there is more reduction in mass for the liquid fertiliser treatment than for the hen droppings treatment.

IV. Discussion

The baobab plants treated with hen droppings grew well, while those treated with liquid organic fertiliser did not. Chicken droppings-based compost is therefore a growth stimulant and can be used as a basic fertiliser for the production and growth of *Adansonia digitata L.*. This result is in line with those of Azangue et al (2019) relating to compost production trials using hen droppings on *B. ruziziensis.* According to the results of this study, manure-based compost ensures good plant growth. As for the liquid fertiliser, the baobab plants subjected to its treatment did not show good growth, so this fertiliser cannot be used as a base fertiliser for baobab production. Kotaix et al (2019) confirmed these results: comparative trials of a similar liquid organic fertiliser and a mineral fertiliser showed that the inorganic fertiliser provided better growth than the liquid organic fertiliser.

The results showed that all the moringa plants treated with the two organic fertilisers grew well. So both fertilisers are growth stimulators for the *Moringa oleifera Lam.* species. However, the hen-dung-based fertiliser provided superior growth to the liquid organic fertiliser. Compost based on hen droppings is said to contain all the elements required for the growth of the species. As a result, this fertiliser can be used in moringa production and growth. As far as liquid organic fertiliser is concerned, although it is not as effective as hen-dung compost, it can also be used as a basic fertiliser for amendment at the leafing stage. These results are supported by Coulibaly et al (2016) who showed that Vermicompost, a similar liquid fertiliser, promotes leaf growth of *Lagenaria siceraria*.

As for the effects of the two biological fertilisers on leaf production, the results were similar for both species (*Adansonia digitata* and *Moringa oleifera)*. Plants treated with hen droppings produced more foliage, in terms of both the number and mass of leaves and the number of branches. As for the liquid fertiliser, its impact on leaf production in the two species was not so remarkable. During the plant's development cycle, the liquid biological fertiliser can then be used as an amendment product at the foliage stage in order to obtain a large quantity of fresh leaves. However, the study revealed a significant reduction in mass when the leaves of plants subjected to its treatment were dried. So if you need of a large quantity of dried leaves, it is advisable to limit or even refrain from amending with this product at the leafing stage.

CONCLUSION

This study showed that the hen droppings-based fertiliser is not only a good growth stimulator for both species, but also ensures better leaf production. Liquid organic fertiliser is not a growth stimulant for *Adansonia digitata*. However, it can promote good foliage, provided that the quantity used for the amendment is relatively greater than that used in the trial. On the other hand, it has a positive impact on the growth of *Moringa oleifera*. To sum up, the study shows that the manure-based fertiliser stimulates the growth and leaf production of both species. As for the liquid fertiliser, it can be used both for the production of Moringa seedlings and as an amendment at the foliage stage for both species, in order to obtain large quantities of fresh leaves. This study has enabled us to understand the effects of the two fertilisers on the production of the two species in order to guide growers. However, the following questions need to be considered if these fertilisers are to be used effectively: What quantities of these biological fertilisers will be suitable for plant development? What are the nutritional values of the leaves for each of the two treatments? Can the liquid biological fertiliser be used to treat plant diseases? These questions could be the subject of another study.

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