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Full length Research paper

Assessing the effects of six organic and inorganic treatments on germination and incremental growth of three tree species

A thesis presented
in partial fulfilment of the requirements for the award of Doctor of Philosophy (PhD) forestry
Department of Forestry Faculty of Life and Earth Sciences,
Bircham International University

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Doctor of Philosophy (PhD) forestry
4th June, 2021

"I do hereby attest that I am the sole author of this thesis and that its contents are only the result of the readings and research I have done''.

BIRCHAM INTERNATIONAL UNIVERSITY

ASSESSING THE EFFECTS OF SIX ORGANIC AND INORGANIC TREATMENTS ON GERMINATION AND INCREMENTAL GROWTH OF THREE TREE SPECIES

APPROVAL

This is to certify that Gbessay Ehlogima Sam Momoh in the Department of Forestry in the Faculty of Life and Earth Sciences of Bircham International University has fulfilled the requirements prescribed by the University for the award of the PhD degree. The thesis titled 'Assessing the effects of six organic and inorganic treatments on germination and incremental growth of three tree species' was carried out under my direct supervision. No part of this thesis has been submitted for the award of any diploma or degree prior to this date.

Professor William Martin
Faculty of Life and Earth Sciences
Date:17th June, 2021

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Dedication

I wish to dedicate this piece of research work to my family especially my wife Mrs. Ann- Marie Sam Momoh and my four kids Ms. Ehloma Kadie Sam, Mr. Ehlogima Joe Sam, Ms. Ehlonyama Lucia Sam and Mr. Ehlomuma Maada Sam

Acknowledgement

This combined social and experimental research initiative would not have yielded any fruit had it not been the relentless efforts of people with passion in the discipline and the perceived results the research will produce. Firstly, I wish to acknowledge my Supervisor Prof. William Martin of Bircham International University for critically evaluating the topic and adjustment of the contents to fit the purpose and aspiration of the theme. Special thanks go to Madam Diana Simpalean for her tireless effort in coordinating and providing timely feedback. Many people turned down the offer to collect research data due to cost implications and what I was willing and able to offer as monthly stipend. Mr. Sallu Barrie, a student availed himself. He supported the research work from seeds collection, nursery preparation and management and daily data collecting. I wish to also acknowledge Mr. Ambrose Bockarie Kanneh for the computer software skills provided.
Posterity will judge me if I fail to mention those who provided financial support directly or indirectly. I will ever remain grateful to Bircham International University for awarding me scholarship and CoViD grant. My aunt, Madam Regina Makieu based in Maryland, United States of America (USA) directly supported me financially. I owe so much to my family for coping with the daily-reduced ration caused by the monthly fees payment and research stress.

Accepted 1st September, 2021.

Abstract

The purpose for this two-track research initiative was to substantiate misconceptions about organic and inorganic manure through perception survey and secondly, to test the effects of the six organic and inorganic treatments on the germination and growth of the three tree species. Growth. Three tree species were identified for this research intervention based on the respective functions of these species in revenue generation, relative growth rate, easy availability, climate change mitigation, sinking of carbon emission, meeting social, furniture and construction needs etc. These species include, Terminalia ivorensis, Gmelina aborea and Theobroma cacao. Terminalia ivorensis, a native species in Sierra Leone is hard to germinate. It is good for timber and many people use it for furniture and construction work. It can cure many ailments and diseases. Gmelina aborea is an alien species, regarded by many to be domineering and evasive. Those interviewed considered it to have the tendency of dominating the entire landscape of Sierra Leone in the next 50 years. It has medicinal values. Theobroma cacao was introduced in the South/East of Sierra Leone as a commercial tree crop. The seeds are sold and exported for the production of cholate. Rural people locally pound it in to powder and use it as substitute for tea or coffee. The leafs, roots, stem and bark also have medicinal values. The combination of three different treatments (ordinary soil, sawdust and fertilizer) resulted in six different treatments which were used to achieve the experimental research initiative. For each treatment, 50 viable seeds of each tree species were nursed at the same time. Thus 900 seeds were nursed (50 seeds x 3 tree species x six treatments). The resultant effect of these three treatments gave rise to the following six organic and inorganic treatments:

i) **ordinary soil alone;**
ii) **organic manure alone;**
iii) **powdery sawdust alone;**
iv) **burnt sawdust mixed with ordinary soil;**
v) **powdery sawdust mixed with ordinary soil and**
vi) **fertilizer mixed with ordinary soil;**

The social survey revealed that people's perception of organic and organic manure has effect on the consumption of products from these treatments. There is the need to address these misconceptions if development in this field is to be enhanced. Germination and incremental growth rate comparison was done at two different levels (within and across species under the six treatments). The research revealed that all the six treatments can support seed germination and expedite seedling growth. Ordinary soil can support plant germination and incremental growth in nurseries if it is fertile. The research proved that powdery sawdust can trigger and expedite seeds germination and incremental seedling growth rate. This was also true for sawdust mixed with other treatments. Yellowish colouration of the leafs were noticed with powdery sawdust alone two weeks after germination but this was not so with sawdust combined with other treatments.

Terminalia ivorensis a native species of Sierra Leone took 27 days to germinate. For burnt sawdust mixed with ordinary soil and organic manure alone, it took 18 days to germinate. For fertilizer mixed with ordinary soil, the seeds germinated within 18 days. However, only few of the seeds germinated. On average, the seeds took 21 days to germinate with a germination rate of 47%. In terms of incremental growth under ordinary soil powdery sawdust and sawdust mixed with ordinary soil. Terminalia ivorensis seedlings under organic manure treatment witnessed the highest increment in height with stem increasing by 7.8mm, the leaf length by 5.1mm and leaf width by 2.3mm within 20 days compared to the rest of the other treatments.

Thus, the daily incremental growth rate calculated for Terminalia ivorensis under this treatment was 0.41mm per day. Gmelina aborea under the five treatment manifested positive results in terms of germination and incremental growth rate except fertilizer. On average, it took 8 days for the seeds to germinate under all the treatments at a germination rate of 53%. For the ordinary soil, burnt sawdust, organic manure mixed with ordinary soil, the seeds took 7 days to germinate but for powdery sawdust and sawdust mixed with ordinary soil, the seeds took 10 days to germinate. The highest increment was recorded under ordinary soil treatment as at 9.8mm stem height, 4.5mm leaf length and 4.3mm leaf width. By using the incremental growth rate formula, Gmelina aborea increased by 1.4mm per day. Theobroma cacao, a commercially valuable tree species seeds nursed witnessed mortality after the first date of nursing. This was attributed to poor pre-germination treatment of the seeds (removed from pods, travel long distance and seed not carefully handled). A fresh seeds was collected from communities near the nursery site. On average, the seeds in the six treatments took 11 days to germinate at 52% germination rate. For the ordinary soil, burnt sawdust, organic manure mixed with ordinary soil and sawdust mixed with ordinary soil, the seeds took 11 days to germinate but for powdery sawdust and inorganic (fertilizer), the seeds took 13 days to germinate. The highest increment in stem height of 31.9mm was recorded under powdery sawdust at 31.9mm. The leaf length and width increased by 16.3mm and 6.7mm respectively. The incremental growth rate was calculate to be 0.31mm per day.

CHAPTER ONE

INTRODUCTION

Background

Every living organism needs nutrients in diverse forms for their growth and other metabolic activities. Human beings depend on plants for nutrients while plants on the other hand have autotrophic mode of nutrition where they prepare their own food and obtain their nutrients via photosynthesis. Land including soil plus the water bodies where farming occurs remains constant while human population continue to increase at exponential growth rate. This increase in human population has exacerbated pressure on the fixed available land, leading to the over cultivation of the same piece of land resulting in the depletion of the soil nutrients that support plant growth and yield. As a result, a cultivated single piece of land is no longer allowed to fallow for even three years due to the high population expansion. Because the soil is no longer fertile enough to provide essential macro and micronutrients to plants in sufficient quantity, another source of nutrition is therefore needed. Shifting cultivation, slash and burn farming practices coupled with long fallow period have been used before the colonial era to replenish the soil with organic substances.

In Sierra Leone, increase in population, large scale agricultural investment and mining has further reduced the size of land that a single household should possess. There has been drastic change in population growth over the last 100 years. The total national population increased from 1,024,278 in 1901 to 4,976,871 in 2004, an increase of 386 percent in 103 years, at an average annual rate of 1.5 percent as reported in the 2004 population census. The disputed 2015 population census even created an exaggerated and alarming population figure of 7,092,113 with population growth rate at 3.2 percent. Analysing the nature of the fixed land and exponential population pressure, I could relate this to my village, Kavuyama in the Yawei Chiefdom, Kailahun district. The population in 1901 was about 50 living in five huts but was able to grow enough food to support its population and reserve some for the next planting season using the shifting cultivation, slash and burn farming practices followed by long fallow period of over 10 years. A single household by then possessed a land space of roughly 500 hectares. The long fallow period and less population pressure paved the way for the cultivated land to regain its lost.

nutrients. With a population of this same village now increased from 50 to over 500 in 2004 occupying 50 houses, the land space possessed by a single household drastically reduced to less 50 hectares or less. The reduction in the fallow period from 10 to 3 years or less implies that the soil is no longer able to regain its nutrients and hence no more productive.

Though slash and burn farming practices and over cultivation of the same piece of land can deplete soil nutrients, the long fallow period was used to support the soil to regain the lost nutrients. This means that rural farmers in Sierra Leone and other African countries

have for long adopted and adapted to organic farming even before the world recently turned its attention to it. To help meet the high demand for food and to increase plant growth and yield, inorganic fertilizer consisting of chemicals are manufactured in factories and introduced in agricultural treatment of plants to support plant growth and yield. However, many rural farmers find it difficult to access, afford and convey fertilizers to their communities and subsequently to their farms. They also lack adequate knowledge and capacity in the application procedures and technologies. Besides, there are series of misconceptions by rural farmers about the application of fertilizer, its influence on plants growth and yield. There are also misconceptions about eating products from fertilizer application, its harmful nature, and the implications of it been mishandled and exposed to children. In addition, the lack of fertilizer, inaccessibility, the high cost, health/environmental hazards, harmful nature and series of misconceptions placed it used in an unacceptable situation by many small-scale farmers. Exposing the potential of less cost-effective organic treatment, which is within the reach of poor rural farmers, its accessibility, environmentally friendly, harmless and easy to apply will motivate rural farmers to go organic. This will help improve the impoverished soil conditions leading to increase in plant growth and yield and subsequently increase the income earning, living conditions and well-being of rural farmers.

The research was conducted using two two-track approach. The first was perception survey using interviews to find out the uses and misconceptions about crops cultivated and yields from inorganic and organic treatments. Views were also collected on the uses and misconceptions about the three tree species. The second approach was through experimental design which investigated the germination of the seeds and incremental growth rate of the seedlings of the three tree species under the six different treatments. Apart from the ordinary soil, organic manure
and powdery sawdust, the other three were combined with ordinary soil. The treatments were randomly combined with the three tree species to ensure that each treatment in each plot fulfil the criteria for randomized plot design. Ordinary soil was used as the control experiment but also used in combination with other treatment except powdery sawdust and organic manure. Terminalia ivorensis was used as the trail species while Gmelina aborea and Theobroma cacao were used as the replicates. This randomized combination of each treatment with each tree species resulted in to 18 plots, which resulted from multiplying 6 treatments with 3 tree species.

Purpose, aim and objectives of the study

The essence of this study was to find out series of misconceptions about organic and inorganic manure and to investigate the effects of six organic and inorganic treatments on the germination and incremental growth rate of the three tree species.

The research therefore investigated the following parameters: misconceptions of organic and inorganic manure, days each seed took to germinate, number of seeds that germinated, percentage germination rate, increment in stem height, leaf length, leaf width and number of leafs that developed during the first and last week of the research. To achieve this, three randomly selected healthy seedlings from each of the 18 plots were identified and marked for periodic date collection on daily for germination parameters and weekly basis for the post germination parameters.

The objectives of this research intervention was to:

Identify some of the misconceptions about organic and inorganic treatments;

Investigate the germination of the 50 seeds nursed in each of the 18 plots on daily basis;

Investigate the increment (stem height, leaf length/width and number of leafs) of three randomly selected healthy three tree species seedlings from each of the 18 subplots,;

Compare the results within and across two levels (species and treatments)

Three tree species and the treatment levels

The three tree species selected for this research and used as control and replicates included:

1. Terminalia ivorensis, an indigenous species commonly known in Sierra Leone as ‘Bargie’
2. Gmelina aborea, an exotic and alien species commonly known in Sierra Leone as ’Yeamanie’ and
3. Theobroma cacao, an alien species known as in Sierra Leone also as ‘cacao’ or coco.

The six organic and inorganic treatments which resulted from the combination of different sources of nutrients included:

a) ordinary soil alone;
b) organic manure alone;
c) powdery sawdust alone;
d) burnt sawdust mixed with ordinary soil;
e) powdery sawdust mixed with ordinary soil and
f) fertilizer mixed with ordinary soil;

To achieve the desired results, the research investigated:

a) the various misconceptions about organic and inorganic treatments.

b) which of the three tree species seeds germinate first, the number of days taken to germinate under each treatment and also counted the total seeds that germinated on that day;

c) the total seeds that germinated under each treatment after the proposed research end period of germination of 30 days beyond this, the seeds were considered as not viable;

d) the germination percentage by species and under the various treatment;

e) the increase in stem height, leaf length and width of three randomly selected healthy seedlings from those that germinated in each of the eighteen plots

f) the total leafs of the three healthy seedlings randomly seedlings from the 18 plots during the first and last week of the research period;

The research in to the various organic treatments could be useful in helping farmers to go organic and use the treatments as substitute to the fallow period. Shifting rural farmers' interest from inorganic to organic treatment due to environmental sustenance, free from chemicals, availability, accessibility and affordability will help enhance productivity and yield. The overall goal was to investigate the pre and post germination growth rate of three tree seedlings using a combination of organic and inorganic treatments.

Misconceptions, assumptions and hypothesis

The research investigated and established fact about the misconception, assumptions and hypothesis strongly held by both literate and illiterate people. These included:

1. Rural farmers hold series of misconceptions about exposure to fertilizer, its application, harmful nature products from fertilizer and the three tree species;
2. Ordinary soil alone can trigger seed germination;
3. Ordinary soil alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
4. Powdery sawdust alone can trigger seed germination;
5. Powdery sawdust alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
6. Powdery sawdust mixed with ordinary soil can trigger seed germination;
7. Powdery sawdust mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
8. Burnt sawdust mixed with ordinary soil can trigger seed germination;
9. Burnt sawdust mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
10. Organic manure from dustbin can trigger seed germination;
11. Organic manure from dustbin can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
12. Fertilizer (urea) mixed with ordinary soil can trigger seed germination and
13. Fertilizer (urea) mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width).

In conclusion, this research journey took six months of monitoring seed germination, periodic measurement of the increment in stem height, leaf length, width and total number of leafs of three healthy tree seedlings in each of the 18 plots. Chapter 1 provided background to the use of organic and inorganic treatments their advantages and disadvantages in nutrient provision. It captured the research aim, objectives and assumptions. Chapter 2 exposed the body of knowledge in published journals reflecting on this same or related field of research with reference to the treatments and the three tree species types. It further disclosed critical knowledge gap in the current literature and tries to gather enough strategies to address them.

Chapter 3 dealt with the approach and methodology that was designed to find answers to the research problem. It focuses on the combination of the treatments with the various three tree species to ensure consistency and fairness with the view to minimize biasness. Some treatment were combined to realize the effect on tree species seeds. This randomized plot design treatments resulted in eighteen plots with 50 seeds nursed in each plot. This resulted in a total of 900 seeds (50 x 18 plots) nursed which were periodically monitored for germination and post germination incremental rate recording for a period of six months. This chapter explained the random selection of healthy three seedlings for periodic growth monitoring per plot. Out of the total seeds that germinated in each plot, only three healthy seedlings were randomly selected for periodic measurement. Chapter 4 disclosed the findings and results of this research. Critical to the findings was the various misconceptions and effect of the treatments in triggering seeds germination and increment in seedling growth under each of the treatments. This chapter

provided new revelations of the incremental growth rate measured under each treatments. Chapter 5 discussed the findings and results and digressed to compare results and findings at treatment and species levels per plot. It tried to relate these findings to previous research efforts in the same or related discipline. Chapter 6 concluded with series of recommendations and suggestions for further research interventions. It provided a body of facts recommended for rural farmers, state and non-state actors to follow and apply in the future to change the existing narratives that will enhance organic farming. For this study, urea fertilizer was the preferred fertilizer used.

CHAPTER TWO

LITERATURE REVIEW

Recent literatures on the proposed topic were hard to find. However, specific recent literatures on related discipline were searched and referenced.

Growth in height and weight is the biological phenomenon of increase in size with time and involves the formation, differentiation and expansion of new

cells, tissues or organs. In any one growing season, different parts of a tree start growing at different times. Different species may also react differently. Plants need nutrients to expedite their germination and incremental growth. Venkata, Rao (2002) discovered that germination success (the presence of germinant) is largely influenced by soil temperature, soil moisture, soil nutrient and substrate type. There are two basic approaches to fertilization as supported by Andrew Carberry in 2020. The first is to provide required nutrients to each crop in a suitable form that plants can use immediately i.e. feed the plant. The second approach is building and maintaining a healthy, biologically active soil with large reservoirs of plant nutrients that will provide a crop with its needs. In 2020, Andrew Carberry further proved that the amount of height growth in any one season depends on hereditary factors, immediate past environmental conditions and present environmental conditions. He highlighted the following factors, which generally have important effects on growth of most plants: silvicultural practices, agronomic treatments, initial spacing, nutrient availability, artificial thinning and pruning, site conditions (including nutrition) and climatic conditions. Increment in plant is determined by the pattern and rate of growth of the tree and varies with: species, internal conditions (genetic and physiological) and external conditions (climatic, edaphic, biotic).

Wikipedia defined fertilizer as any material of natural or synthetic origin that is applied to soil or to plant tissues to supply plant nutrients. Chemical fertilizers are very costly and leads to environmental pollution. Organic compost is cost effective and sustainable. Sawdusts are produced as a small discontinuous chips or small fragments of wood during sawing of logs of timber into marketable sizes. In many parts of the world, sawdust is a common wood industrial waste that is either wasted or used as fuel. Sawdust has low weight, good drainage and is inexpensive. The chips flow from the cutting edges of the saw blade to the floor during sawing operation, hence its name Sawdust has hitherto been classified as a waste and a nuisance to man and its environment, but in recent years, researches have shown that sawdusts can be used in the production of biogas, packaging fillers, as lagging materials etc. In 2020, Manahil Siddiqui assessed the potential of wood sawdust to be used as a viable substrate for soilless garlic production using two experiments where garlic (Allium sativum) was grown in plastic bags containing six different types of sawdust substrates made of Azadirachta indica (neem), Mangifera indica (mango), Morus alba (mulberry), Acacia nilotica (gum arabic), Eucalyptus albens (eucalyptus), Bombax ceiba (cotton tree) and in clay loam soil (control). The research discovered that Acacia nilotica and Morus alba sawdust significantly decreased the leaves number, plant height, leaf area, relative water content, bulb diameter, number of cloves bulb−1, shoot dry weight and bulb dry weight of garlic. FAO 2011, discovered that in summer of 2011, "clean" sawdust was sold at a high-priced market in the United Sates, averaging $50 or more and ranging from $600 to $1,200 per truckload of material. Saw dust has proven to be critical in agricultural interventions. These include mixing saw dust with white paint to make fake snow, used as traction on slippery roads, food for plants except if it is walnut sawdust; make fire starters, fill holes and defects in wood and use it to pack a path. It can also be used to kill weeds, lighten the heft of mixed cement, cleaning floor, bedding for animal, smoking meat smoker or fish, serve as fuel, can be absorbed and used as turpentine and mineral spirits. In addition it can be recycled for other uses, make mulch, protect concrete, bricks molding, broadcasting tiny seeds, amend soil, cover farm walk-way, prevent erosion, growing mushroom, repel slugs, store root parenting organs etc. After being dried, sawdust can be utilized via the gasification, combustion, and pyrolysis processes to generate electricity, heat, and oil. In addition, sawdust has many desirable qualities, making it a popular material for fibre composite manufacturing. Bishwarop Ghosh, in 2018 carried out a study on the use of sawdust in place of sand as a mixture in concreting. He discovered that it is possible to manufacture concrete containing sawdust with similar characteristics to that of natural concrete provided the percentage of sawdust replaced by sand should be within the ratio of 10 to 20.

Treatments

For ease of proper understanding and conceptualization of application of nutrients, I attempted to classify all the various treatments below in to two major classes: Organic and inorganic fertilizer.

Ordinary soil - organic

Soils vary in properties due to geology and climatic situation, over distance and time. It is the biologically active, porous medium in the earth crust and has the principal substrata of life on Earth. It serves as a reservoir of water and nutrients and as a medium for the filtration and breakdown of wastes. In addition, it supports cycling of carbon and other elements through the global ecosystem. The chemical composition of soil include silicon, aluminum, iron, and oxygen, with lesser amounts of calcium, magnesium, sodium, potassium and hydrogen. Other element contained in soil include plant nutrient elements such as phosphorus, nitrogen, sulfur, manganese, boron, zinc, copper, molybdenum, and vanadium. It also contains fluorine, cobalt, and iodine. The organic matter consists chiefly of carbon, hydrogen, and oxygen that plants take from the air and water, as well as small amounts taken from the soil. In terms of percentage, the typical soil consists of approximately 45% mineral, 5% organic matter, 20-30% water, and 20- 30% air.

Soil fertility plays an important role in sustaining crop

productivity in any area, particularly in situations where input of nutrients application differs and the information on the nutritional status can go a long way to develop economically viable alternatives for management of deficient nutrients in the soil. In Sierra Leone, the fist soil survey was done by W.J. Veldkamp in 1979 with support from Food and Agriculture Organization (FAO) and United Nations Development Programmes (UNDP). The current national soil survey started in 2019 and is currently going on. It was also discovered that soils in Sierra Leone have inherently low fertility and do not receive adequate nutrient replenishment. These soils are also acidic. They differ in their physical and chemical characteristics and productivity due to differences in physiography. The pH of top soils in Sierra Leone are mostly likely to be above 7 (alkaline) which decreases with depth to about 4.5 to 5.5. The alkaline topsoil could be explained by the slash and burn activities of local people over hundreds of years depleting the nitrogen by burn. Deficiencies of available major and micronutrients are widespread and information on soil fertility status is lacking. With many farmers typically applying insignificant amounts of fertilizers, coupled with continuous cropping, soil degradation and declining soil fertility continue to pose major threat to sustainable food production by smallholders (MAFFS 2009). Coupled with
other constraints including soil moisture stress, low nutrient capital, erosion risks, low pH with aluminum (Al) toxicity, high phosphorus (P) fixation, low levels of soil organic matter, poor farming methods and a loss of soil biodiversity, food security may not be achieved in the near future unless urgent intervention measures are undertaken (WFP 2009). A student research on soil for Master's degree carried out by Amara Denis and Alie Kamara conducted in three districts in 2004 revealed that most smallholders cannot afford the conventional soil fertility management strategies dominated by high use of inorganic fertilizers and agrochemicals considering their escalating prices. Therefore, many of these farms are dependent on short-term natural fallow to maintain soil fertility. Deficiencies of available major and micronutrients are widespread in soils of Sierra Leone. Most of the soil types are ferralitic in nature and lack important mineral nutrient reserves. Current land and land-use patterns present three basic constraints to achieving growth and reducing poverty namely the nature of the soils and farmers are reluctant to cultivate in more fertile lowlands due to the decline in soil fertility. Sustainable soil fertility management with nitrogen fixing rotations, conservation agriculture/minimum tillage and targeted use of chemical inputs are increasingly expensive. A preliminary findings of the 2020 National Soil Survey, reaffirmed the acidity of the soils of Sierra Leone to be very high.

Powdery Sawdust (organic)

Sawdust is the wood residue created when a log is cut by saw to make lumber. It is a waste from wood and timber industry commonly referred to as "wood flour," which indicates the particles can pass through a 20-mesh gauge screen. Saw dusts are produced as a small discontinuous chips or small fragments of wood during sawing of logs of timber into marketable sizes. The chips flow from the cutting edges of the saw blade to the floor during sawing operation, hence its name Sawdust has hitherto been classified as a waste and a nuisance to man and its environment, but in recent years, researches have shown that sawdusts can be used in the production of biogas, packaging fillers, as lagging materials etc.

As it possesses a firing capacity, it is normally used as a fuel source in thermal processes (biomass). It is also used as insulating material. Green sawdust has relatively limited uses. Green sawdust can be used for domestic heating in special sawdust furnaces, although this is not very common, as well as for smoking meats. A variety of products, including bedding, abrasives, insulation, and packaging, can be produced from sawdust using this process. The main chemical components are carbon (60.8%), hydrogen (5.2%), oxygen (33.8%), and nitrogen (0.9%). It is absorbent, abrasive, bulky and fibrous, nonconductive, and granular. It is often thrown into dustbin and left to rot which takes years.

Chris Smith in 2012 twitted in Linked In Twitter Facebook that sawdust has health risks including nuisance and keeps you from breathing clean fresh air and irritate the eyes. Some of the Symptoms after inhaling sawdust include: irritation in the nose, ears and/or throat, headaches, double vision, consistent coughing or sneezing, rhinorrhea, fever, aches and pains, difficulty breathing, laryngitis, bronchitis, nasopharyngitis etc.

In addition to its agricultural support packages, only few people use sawdust as an organic manure to support plant germination and growth. Sawdust is high in carbon: If you plough sawdust into your soil especially using high sawdust-soil ratio, plant would find difficulty in growing there for a year or more. Pure wood materials like sawdust and wood shavings are very-high in carbon and this carbon will absorb all of the plant-feeding Nitrogen in your soil in the process of decomposing. Though, after it decomposes, the soil would be far rich in soil humus and organic material resulting in to seedlings incremental growth. Sawdust is a 'dry brown' material, but much more highly concentrated form of carbon. It is also proven that sawdust used alone could be useful in triggering seed germination and in enhancing incremental growth. When burnt, it can greatly influence seed germination and seedling increment. It was also noticed that the seedlings started to develop leafs faster but yellowish colouration of leafs were detected. Yellowish colouration of leafs were not detected with the powdery sawdust mixed with ordinary and the burnt sawdust mixed with ordinary soil.

Organic manure (organic)

Gayathri and Anburani in 2008 discovered that organic fertilizer such as farmyard manure increased the productivity by maintaining the soil health with nutrient balance, besides minimizing the pollution hazards as well as fertilizer cost. Due to the high cost of fertilizer, the scarcity or non-availability and it environmental hazards, many farmers prefer to go organic. Manure should not be replaced with fertilizer as constant use of it may lead to infertility of the soil and pollution. Organic manure is highly rich in organic matter and humus. It is a valuable and renewable resource and helps improves soil fertility. It does not cause any pollution or environmental damage. It is the decomposed form of dead plants and animals, which is applied to the soil to increase production. It is a natural form of fertilizer and is cost-effective. Other forms of organic manure include human and animal excreta, livestock dung (rich in nitrogen, phosphorus, and potassium). Tejeda, Yadav, B.K. and C.A. Lourduraj in 2005 revealed that green manure increases the percentage of organic matter in the soil. They also did similar work on farmyard manure and noted that it improves the soil structure and is used as a natural fertilizer in farming. It increases the soil capacity to hold more water and nutrients. It also increases the microbial Fertilizers are specific in nutrients and help in increasing the fertility as well as the productivity of the soil but they are very expensive and not many poor or rural farmers can afford it. It does not help in making the soil porous and increase the water retaining capacity. Treatments of fertilizers to expedite plant growth is very key in large scale commercial agriculture. One threat is that fertilizers are washed along with excess water and are unavailable for absorption by plants which cause water pollution. This in turn kills many aquatic habitats.
Yadav and Lourduraj discovered in 2005 that the continuous and excess use of chemical fertilizers over a longer period of time has resulted in deterioration of soil health and causes less productivity. In 2007, Kumudha, P. and M. Gomathinayagam found out that urea is likewise the most widely used fertilizer worldwide. Urea is the richest source of nitrogen among the common dry fertilizers. FAO reported in 2011 that there would be a steady rise in the world demand for the fertilizer nutrient nitrogen from 105.3 million tons in 2011 to 112.9 million tons in 2015 at the rate of 1.7% per annum.

Tree species

Each year, many countries of the world embarked upon tree planting programmes. Sierra Leone is no exception. With this approach, the number of trees planted is bound to increase each year. In 2020, the government of Sierra Leone committed to the yearly planting of 1 million trees. In addition to new planting, replanting of harvested plantations of non-coppicing species must be carried out on a considerable scale each year. This is exactly happening in Sierra Leone with emergence of Miro Forestry Company and Government private forestry investment and the National Tree Planting initiative funded by the government. The three tree species (Terminalia ivorensis, Gmelina aborea and Theobroma cacao) used in this research are crucial in tree planting , afforestation and reforestation and agroforestry initiatives in Sierra Leone.

Terminalia ivorensis

Terminalia ivorensis is a deciduous tree with heartwood that is yellowish brown to pale pinkish brown. It thrives well in tropical climate and may grow up to 30 meters in height. The wood is easy to saw and work with both hand and machine tools. It contains yellowish tannins, which may cause staining under humid conditions and in contact with iron. It is a useful timber species with a yellow-brown heartwood that is similar to oak and good for timber. In 2009, Orwa et al. disclosed that Terminalia ivorensis is very difficult to germinate. They proposed series of investigations in pre-treatment to find out which of the methods will give quick germination percentage. A series of experiments was performed by giving six pre-treatment to batches of seeds each batch of which has four replicates with about 50 seeds in each replicate. The results of the experiment are not encouraging yet it can be seen that changing water hourly seems to be the best pre-treatment, followed by continually treating with concentrated acid treatment. Partial scarification of the seed coat will also aid

Chemical fertilizer- urea (inorganic)

Fertilizers are made in factories by adding inorganic substances and chemicals that can enhance the soil fertility. Three main nutrients used to replenish the soil are nitrogen (N), phosphorus (P) and potassium (K), commonly known as NPK. Other important nutrients are calcium, magnesium and sulfur. Plants also need small quantities of iron, manganese, zinc, copper, boron and molybdenum, known as trace elements. Rout, G.R., S. Samantary and P. Das in 2000 found out that fertilizers have inorganic substances and high concentration of nutrients because they are human-made and do not provide humus to the soil. They are quickly absorbed by plant.

germination. Pre-treatment can also be by alternate soaking and drying for 1 week. The seed germinates better if it is covered by the soil to exclude light. Germination rate is usually 10 - 50%, but up to 93% has been achieved under experimental temperature fluctuations. Light shade is generally applied during germination, but it should be removed after 1-2 months. Adequate moisture during germination as a prerequisite. Germination usually starts within 2 weeks of sowing and lasts for another 2 – 5. This research discovered that Terminalia ivorensis takes between 20 to 27 days to germinate under the different treatments. The germination rate ranges between 20 to 56% under the six treatments with an average rate of 21%.

Gmelina aborea

Gmelina arborea is a deciduous fast growing tree of verbenaceae family and subclass of Dicotyledonea. It was named in the eighteenth century after a German Botanist J.C Gmelina Moldenke in 2000. The specific name means treelike, from the Latin word 'arbor' (tree) and Gmelina named after the above named German Botanist.

It can grow from 3 - 30 meters tall or beyond. The straight, cylindrical bole is commonly around 50cm in diameter, but specimens up to 140cm have been recorded. Gmelina consists of about 33 species of trees and shrubs. Similar research discovered that Tectonia grandis belong to this same family while Gmelina dalrympleana, Gmelina fasciculiflora Gmelina moluccana all belong to the same species. It was introduced to tropical Africa from South-East Asia as reported by Ogbonnaya *et al*. in 2002. It was introduced in Sierra Leone in the1960s by the colonial masters as a way to rapidly regenerate degraded areas. The tree is harvested from the wild for local use as a food, medicine and source of materials. Dvorak WS in 2004 found that Gmelina aborea has suitable characteristics for agroforestry, with fast growth, ease of establishment, and relative freed from pests outside its natural range without damage. He disclosed that it can be grown as an ornamental and occurs in a variety of forest habitats, including tropical semi-evergreen, sub-montane, very moist teak forests, deciduous, savannah, woodland, montane landscape etc. It can survive in very dry to wet areas in the tropics and subtropics elevations up to 2,100 meters. Its annual daytime temperatures ranging between 22 - 34°c and between 16 - 46°. The seeds germinate within 20 - 50 days under ideal conditions and the average rate for a healthy seed lot is 60%. This research further proved a shorter germination period between 7 to 10 days and germination rate of 65% on average.

Theobroma cacao

Cacao, scientifically known as Theobroma cacao, is a small evergreen tree native to South America. Its seeds are used to make cocoa powder and chocolate. In 2005, Whitefield R noted that cacao economically important as cocoa butter extracted from the seeds is widely used in the confectionery industry. He noted that Theobroma cacao, is taken from the Greek words: theo (god) and broma (drink). The tree grows cacao seedpods that contain the cacao beans used to produce chocolate products. It can grow in size to between 4–8 m with a maximum height of about 7.5 m. The decrease in viability and vigor of the seeds is closely related to the moisture content of the seed. Storage of cocoa seeds at moisture content of 35-38% can suppress the rate of decline of seed. The length of the shelf period affects the viability and vigor of cocoa seeds.

The longer the seed is stored, the lower the viability and the vigor. Justice and Bass in 2002 affirmed that there are several factors that affect the viability of recalcitrant seeds which include moisture content of seeds, humidity, storage space temperature, container, and storage period. The longer the seeds is stored, the faster the decrease in the moisture content thus resulting in death of the seed. Bahri et al. in 2018 applied the maximum growing potential to cacao. To calculate the growing potential, he used the formula (Maximum Growing Potential (%) = total seeds showing symptoms of growing/Σ seeds planted x 100). Nainggolan in 2001 noted that good plant growth can be characterized by high dry weight and is influenced by the rapidity of roots reaching nutrients in the soil thus increasing the number and length of plant roots.

CHAPTER THREE

MATERIALS AND METHODOLOGY

In 2015, Lewis stated that research approaches are plans and procedures that range from steps including making broad assumptions to detailed methods of data collection, analysis, and interpretation. However, Guetterman in 2015, Lewis in 2015 argued that the selection of the specific research approach is based on the nature of the research problem, or the issue that is being addressed by any study, personal experiences of the researchers', and even the audience for which the study is being developed.

Research approaches could be organized in three main categories: quantitative, qualitative and mixed methods. The methodology used in this research employed a mixed methods including both quantitative and qualitative parameters and analysis.

Research always assesses philosophical assumptions which serves as the backbone and nucleus for the investigation.

This study employed two main research approaches, namely social and experimental through a mixed match strategy. The experimental research was conducted in Mokonde village, Njala University, Republic of Sierra Leone during the dry season.

Part 1 – Social Research

Misconceptions about organic and inorganic manure

The social research was conducted using checklist to solicit information from respondents on the various misconceptions held about organic and inorganic treatments, products from each, environmental, social and health related implications. The main variables investigated included: food, products, cultural values, taboos, health and environmental implications of organic and inorganic fertilizer. The checklist design approach was used to investigate the uses of sawdust, misconceptions and myths about the various treatments and taste patterns of people about yields from the organic and inorganic treatments. Twelve groups involved in agriculture from production, processing, transportation and marketing were identified. These groups include; male youths in agriculture, female youths in agriculture, women in agriculture, men in agriculture, farmers (master farmers), loggers in agriculture, miners in agriculture, Community Based Organization (CBO), Non-Governmental Organization (NGO), business groups, Ministry of Agriculture (MAF) and stakeholders (chiefs, leaders and heads). Fifty respondents were randomly selected from each group. In all, 600 respondents (12groups x 50 respondents) were identified and interviewed.The materials used included checklist, pen, paper, computer and other essential logistics.

Part 2 – Experimental research

Nursery layout

After clearing and leveling the site, the nursery with the dimensions of 22ft (7m) x14ft (4.3m) was constructed.

Treatment level approach

The research used six single or combined treatments to achieve the results obtained. Ordinary soil which is the traditional hub for nursing and planting seeds was used as the control experiment. Powdery sawdust free of chemicals were collected from local carpentry shop. They were sun dried for 24 hours in an open space and loaded in polythene bags based on the treatments as specified below:

a) Powdery sawdust alone

The dried powdery sawdust alone was loaded in 50 polythene bags for each tree species totaling 150 polythene bags;

b) Powdery sawdust mixed with ordinary soil

Powdery sawdust was mixed with ordinary soil at a ratio of 50:50 and loaded in 50 bags for each tree species, totaling 150 polythene bags;

c) Burnt sawdust mixed with ordinary soil

To get the burnt sawdust, the dried sawdust was placed in a drum and burnt. It took four days to completely burn a bag of sawdust in to ashes. A total of 10 bags of sawdust were burnt for this research. The sawdust ashes was mixed with ordinary soil at a ratio of 50:50 and loaded in 50 bags for each tree species totaling 150 loaded polythene bags;

d) Ordinary soil alone – this was also used as the dependent or control variable

Ordinary soil was collected from the top soil of fertile area of an agricultural land site notable for rotational potato, cassava and other perennial crop cultivation. This was sheaved and loaded in 50 polythene bags for each tree species, totaling 150 polythene bags;

e) Organic manure alone

Organic manure was collected from a five-year-old dustbin. This too was sheaved to remove the coarse materials, plastic etc. and loaded in 50 polythene bags for each tree

species, totaling 150 polythene bags;

f) Fertilizer (urea) mixed with ordinary soil

This gave enough space for watering, weeding, monitoring and

measuring the various parameters (stem height, leaf length and width and leave count). Randomize Plot Design (RBD was used based on two sources of variations.Since this was done in the dry season, the constructed nursery was fenced with thatch and empty rice bags. Polythene bags were loaded with each treatments. For each species under each treatment, 50 seeds were nursed in 50 poly bags resulting into 300 seeds per species. Since three tree species were involved in this research, the total seeds nursed was 900 (i.e. 50 polythene bags x 6 treatments x 3 tree species).

Growth monitoring

For quantitative or experimental research, two data collection templates were designed. One to record daily observations about seed germination parameters. See Tables 1 and 2. The variable investigated included, information on the germination date, the first seed that germinated under each treatment, total number that germinated and those that did not germinate. The experimental design approach investigated the germination, incremental growth rate of the various species under the different treatments. The experimental research tried to investigate the germination and incremental growth rate of the three tree species under six different treatments. It focused on series of critical assumptions which were investigated. In this experimental research, one independent variable were manipulated and applied to one dependent variable to measure their effect. The effects were recorded starting with daily observation of the timing of germination, total seeds that germinated, germination percentage and total seeds that germinated at the end of the 30 days germination period. The analysis resulted in to concrete recommendations.

Fertilizer (urea) was procured from Freetown since it was difficult to get it in the research area. Ordinary soil was also mixed with fertilizer at a ratio of 50:2.5 and loaded in 50 polythene bags, totaling 150 polythene bags. The loaded polythene bags using this treatment were watered and kept for two weeks before seeds were nursed to reduce the chemical strength of the fertilizer.

Seed level approach

Three tree species commonly used in Sierra Leone were selected for this research based on their proximity, availability and cost-effectiveness in handling them. The seeds were collected from healthy plant and stored in a save place. They were soaked in cold water in a container to determine their viability. All the seeds that floated above water were removed and thrown away. For pre-germination treatment, Terminalia ivorensis was soaked for 24 hours and Gmelina aborea for 5 minutes before they were nursed. Due to high moisture content of Theobroma cacao, it was only washed in cold water and later nursed. Randomly selected fifty (50) viable seeds from each of the three tree species were nursed in each of the six treatments. Thus, 300 seeds of each tree species totaling 900 seeds were nursed, cared for, monitored and periodically measured. It is worth noting that all the seeds were nursed on the same date that is 14th November, 2021.

Research materials

Locally imported as well as natural and artificial materials were used during this research. These were grouped in to three as displayed below:

a) Natural materials used as treatments include:
i. Ordinary soil alone (OS);
ii. Powdery sawdust alone (PS);
iii. Powdery sawdust mixed with ordinary soil (SP);
iv. Burnt powdery sawdust mixed ordinary soil (BS);
v. Organic manure from dustbin alone (OM); and
b) Natural materials used as seed include:
i. Terminalia ivorensis (Ti);
ii. Gmelina aborea (Ga); and
iii. Theobroma cacao (Tc)
c) Artificial materials used include:
i. Fertilizer (urea) mixed with ordinary soil (SF);

A ratio of 50:50 was used for any of the treatments above that required mixture of the dependent or control variable (ordinary soil) with any independent variable. Other materials used included nursery materials, paper, pens, calibrated ruler for measuring stem height, leaf length and width and drum for burning sawdust etc.

Table 1: Data on treatment combination, tree species, symbols and quantity of seeds nursed.

Treatments	Tree species nursed	Symbols	Seeds nursed in polybag
Plot 1			
1.1 Ordinary soil	Terminalia ivorensis	TiOS	50
1.2 Powdery sawdust	Terminalia ivorensis	TiPS	50
1.3 Soil mixed with fertilizer	Terminalia ivorensis	TiSF	50
1.4 Soil mixed with powdery sawdust	Terminalia ivorensis	TiSS	50
1.5 Organic Manure	Terminalia ivorensis	TiOM	50
1.6 Burnt sawdust mixed with ordinary soil	Terminalia ivorensis	TiBS	50
Subtotal			**300**
Plot 2			
2.1 Ordinary soil	Gmelina aborea	GaOS	50
2.2 Powdery sawdust	Gmelina aborea	GaPS	50
2.3 Ordinary Soil mixed with Fertilizer	Gmelina aborea	GaSF	50
2.4 Ordinary soil with powdery Sawdust	Gmerlina aborea	GaSP	50
2.5 Organic Manure	Gmelina aborea	GaOM	50
2.6 Burnt sawdust mixed with ordinary soil	Gmelina aborea	GaBS	50
Subtotal			**300**
Plot 3			50
3.1 Ordinary soil	Theobroma cacao	TcOS	50
3.2 Powdery sawdust	Theobroma cacao	TcPS	50
3.3 Ordinary soil mixed with Fertilizer	Theobroma cacao	TcSF	50
3.4 Ordinary soil mixed with powdery sawdust	Theobroma cacao	TcSS	50
3.5 Organic Manure	Theobroma cacao	TcOM	50
3.6 Burnt sawdust mixed with ordinary soil	Theobroma cacao	TcBS	50
Subtotal			**300**
Total			**900**

At the treatment variation levels, OS refers Ordinary Soil, PS refers to Powdery Sawdust, SF refers to Soil with Fertilizer, SS refers to Soil with powdery Sawdust, BS refers to Burnt Sawdust and OM refers to organic manure.
At the seed variation level, the three different tree species were represented by the symbols as reflected in the table above where Ti refers to Terminalia ivorensis, Ga refers to Gmelina aborea and Tc refers to Theobroma cacao.

Data collection and analysis

Sampling method

It should be noted that there are many kinds of sampling methods that can be used for creating a specific target sample from a population. For the qualitative or checklist designed approach, the study used systematic random sampling to solicit information from different categories of respondents by constant skipping.
The checklist consisted of a mixture of closed and open end questions that look to comprehend the demographic makeup of the respondents, occupation, setting (rural or urban) etc. It was designed to take no longer than twenty minutes. Where respondents were not reached due to their busy schedules, phone or WhatsApp calls were used and this exercise lasted for three weeks.
The population in our primary sampling units are spread out and we cannot sample from every localities. It is therefore necessary to use an adjustment ''design effect'' to any formula in determining the effective sample size.
For this study we used the formula proposed by Mugenda and Mugenda (2003).

$$n = \frac{z^2 p(1-p)}{d^2}$$ Where

n = the desired sample size
z = the z score at the desired confidence level (i.e. z = 1.96)
p = estimated proportion of community with positive impacts on forest management, (p = 10% = 0.1)
d = permissible marginal error (i.e. the level of statistical significance, set at α = 0.05).
Using the values of *z, p* and *d*, the value of *n* was computed as follows:

$$n = \frac{1.96^2 * 0.1(1-0.1)}{0.05^2} = 138 \approx 139(Approximately)$$

Data collection

For the social research, data was collected based upon the sample sizes initially identified from each group. Ten Data Collectors were engaged to interview 600 people from 12 groups in three weeks. Each data Collector was assigned to 60 respondents.
For the experimental research, an effective care and nursery monitoring systems was organized to first monitor and record the early and late germination of the various species under the different treatments. Once the seeds sprout up, the Experimental Data Collector, constantly kept on monitoring germination parameters on a daily basis. Germination rate period for all the seeds nursed was 30 days. If any of the seeds could not germinate within this thirty days, that seed was declared not viable.
After germination, the research team systematically identified three healthy seedlings from each of the species under the different treatments and periodically measure the stem height, leaf height and width using transparent calibrated ruler. Out of the total seeds that germinated, only three healthy seedlings with improved condition of growth were randomly selected and marked with stick for the weekly growth parameter measurement from the 18 plots –that is 6 treatments x 3 seedlings x 3 tree species. In total, 54 seedlings were measured on weekly basis. Measurement was done in millimetre. Two set of data sheets were prepared for this experimental research. One was designed and used to collect direct field data from germination parameters (Table 2) and the other used to record post germination parameters (Table 3). The data were then entered in to the data sheets in MS Excel. The first task of the Experimental Data Collector was to watch on daily basis the germination period of each seeds, record the total seeds that germinated and noted the germination date. After germination of each seeds, three healthy seedlings were identified from each treatments. A total of 54 seedlings (that is 3 health seedlings x 3 tree species x 6 treatments) were identified, marked with broom stick for weekly observation, monitoring and measurement of the various parameters for six months. Measurement of seedlings' stem height, leaf length, width and leaf count commenced just after the germination of each seed. Number of leafs were also counted during the second and last week of the research. To estimate the number of days taken for each seeds under the various treatment to germinate, daily observation of seeds that germinated were noted and number that germinated were also counted. Recording of germination timeline was closed after one month. Estimates of height increment are usually satisfactory if height is measured by height sticks, but may be unsatisfactory if measured by hypsometer. Instruments such as the Haga, Blume Leiss, etc., are much less precise and more subject to bias in use than height sticks! Estimates of diameter increment are much more reliable particularly if the point of measurement on stems is marked permanently.

Data Analysis

data collected was analyzed using Analysis of variance (ANOVA) which is a collection of statistical models and their associated estimation procedures (such as the "variation" among and between groups). This was used to analyze the differences among means and to indicate the statistical differences between the means of three or more independent groups in this case the seeds and the treatments. It was also used to check if the means of two or more groups are significantly different from each other. Lastly, it was used to test the impact of one or more factors by comparing the means of different samples. The groups included the three tree species and the various treatments applied to investigate the duration the seeds in each group took to germinate, the estimation of germination percentage, calculation of stem height of the seedlings, leaf length and width and number of leafs.

A mean weekly rate of height growth (hm) was calculated. It was this value against which the current weekly means were compared. This assumed linearity, although not representative of height growth progression, does not necessarily invalidate its use. Andrew Carberry, MPH (2020) revealed the following methods to measure plant growth rate. The Relative Weekly Growth Percentage can then be expressed as:

$$RWGP = \frac{(H_t - H_{t-1}) - h_m}{h_m} \times 100$$

$$\text{or} = \frac{h_c - h_m}{h_m} \times 100$$

where (Ht - Ht-1) = hc (current weekly height increment), ht and ht-1 represent total seedling height at weeks t and t-1 respectively and hm is the mean weekly height increment calculated as h(m) = H/N f where H(f) the total (assumed) desired final height, and N is the total growing period in weeks. This could be by measuring stem height, leaf length and width, calculation of growth rate with fresh plants and calculation of growth rate with dried plants. For this research, the focus was on measuring and estimating the various parameters (stem height, leaf length/width and number of leafs of each of the selected 54 healthy seedlings but not to calculate the fresh or dry weight of the seedlings.

i)The equation for stem height measurement used was S2-S1/T that is S2 minus S1 divide by T where S1is first measurement, S2 the second measurement, and T equals the number of days between each measurement

ii)To calculate leaf length, the formula used was S2-S1/T that is S2 minus S1 divide by T where S1is first measurement, S2 the second measurement, and T equals the number of days between each measurement

iii)To calculate leaf width the formula used was S2-S1/T that is S2 minus S1 divide by T where S1is first measurement, S2 the second measurement, and T equals the number of days between each measurement

iv)Leaf number growth rate was calculated to determine how many leafs are approximately growing per day. The equation used was L1 minus L2/T where L1 is the first leaf count, L2, is the second leaf count, and T equals the number of days between each.

v)Germination percentage was calculated using the formula - total germinated seeds divide by the total seed nursed multiply by 100;

Underlying misconceptions and assumptions/hypothesis

One key component in defining the approach to research involves philosophical assumptions which contribute to the research goals, objective and approach of planning or proposing to conduct research.

It involves the intersection of philosophy, research designs and specific methods. Some of these assumptions previously mentioned include:

14. Rural farmers have series of misconceptions about exposure to fertilizer, its application, harmful nature and products from fertilizer;
15. Ordinary soil alone can trigger seed germination;
16 .Ordinary soil alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
17. Powdery sawdust alone can trigger seed germination;
18. Powdery sawdust alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
19. Powdery sawdust mixed with ordinary soil can trigger seed germination;
20. Powdery sawdust mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
21. Burnt sawdust mixed with ordinary soil can trigger seed germination;
22. Burnt sawdust mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
23. Organic manure from dustbin can trigger seed germination;
24. Organic manure from dustbin can expedite seedling incremental growth rate (increase in stem height, leaf length and width);
25. Fertilizer (urea) mixed with ordinary soil can trigger seed germination and
26. Fertilizer (urea) mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width).

The research hypothesis included the following:

a) Many people prefer crops grown from organic manure than those grown from inorganic fertilizer;

b) People have very little knowledge about the agricultural usefulness of sawdust as an organic nutrient for soil productivity, germination and plant growth,

c) Sawdust is a smelly trash and should be thrown away into the wild;

d) Organic manures are mixed with human waste which is not good for human consumption;

e) Sawdust if appropriately applied can expedite plant growth more than inorganic fertilizer;

f) Application of sawdust is environmentally friendly than fertilizer;

g) Taste of products from ordinary soil is palatable than those from inorganic fertilizer;

h) Inorganic fertilizer when applied to plants stays with it and when consumed results in to series of stomach health related infections – cancer, ulcer, stomach pains etc.

i) Germination period is shorter in soils treated with sawdust than soils treated with inorganic fertilizers.

Table 2: Data collection sheet on seed germination parameters

						1st reading		2nd reading		3rd reading	
Plot no.	**No**	**Treatments**	**Tree species**	**Total seeds nursed**	**Nursing date**	**Germination date**	**Total germinated seeds**	**Germination date**	**Total germinated seeds**	**Germination date**	**Total germinated seeds**
1	1	Ordinary soil	Terminalia ivorensis	50							
1	2	Powdery sawdust	Terminalia ivorensis	50							
1	3	Ordinary Soil mixed with fertilizer	Terminalia ivorensis	50							
1	4	Ordinary Soil mixed with powdery sawdust	Terminalia ivorensis	50							
1	5	Organic Manure	Terminalia ivorensis	50							
1	6	Burnt sawdust Mixed with ordinary soil	Terminalia ivorensis	50							
		Subtotal		300							
2		**Plot 2**									
2	1	Ordinary soil	Gmelina aborea	50							
2	2	Powdery sawdust	Gmelina aborea	50							
2	3	Ordinary Soil mixed with fertilizer	Gmelina aborea	50							
2	4	Ordinary Soil mixed with powdery sawdust	Gmelina aborea	50							
2	5	Organic Manure	Gmelina aborea	50							
	6	Burnt sawdust mixed with ordinary soil	Gmelina aborea	50							
		Subtotal		**300**							
3		**Plot 3**									
3	1	Ordinary soil	Theobroma cacao	50							
3	2	Powdery sawdust	Theobroma cacao	50							
3	3	Ordinary Soil mixed with fertilizer	Theobroma cacao	50							
3	4	Ordinary Soil mixed with powdery sawdust	Theobroma cacao	50							
2	5	Organic Manure	Gmelina aborea	50							
	6	Burnt sawdust mixed with ordinary soil	Gmelina aborea	50							
		Subtotal		300							

3		**Plot 3**									
3	1	Ordinary soil	Theobroma cacao	50							
3	2	Powdery sawdust	Theobroma cacao	50							
3	3	Ordinary Soil mixed with fertilizer	Theobroma cacao	50							
3	4	Ordinary Soil mixed with powdery sawdust	Theobroma cacao	50							
3	5	Organic Manure	Theobroma cacao	50							
3	6	Burnt sawdust mixed with ordinary soil	Theobroma cacao	50							
		Subtotal		300							
		Total		900							

Table 3: Data collection sheet on post-germination parameters

Plot no.	No	Treatment Type	Tree species	Symbol	Weekly recording (every Saturday at 8:00AM)– measure height in millimetre of 3 randomly selected seedlings in each treatment after germination using transparent calibrated ruler.											
					Variable measured											
					1st reading			**2nd reading**			**3rd reading**			**4th reading**		
					Stem	**Leaf**		**Stem**	**Leaf**		**Stem**	**Leaf**		**Stem**	**Leaf**	
					Height	height	width	height	Height	Width	Height	Height	width	Height	height	width
1	1a	Ordinary soil	Terminalia ivorensis	TiOSP1												
	1b	Ordinary soil	Terminalia ivorensis	TiOSP1												
	1c	Ordinary soil	Terminalia ivorensis	TiOSP1												
1	2a	Powdery sawdust	Terminalia ivorensis	TiPSP1												
	2b	Powdery sawdust	Terminalia ivorensis	TiPSP1												
	2c	Powdery sawdust	Terminalia ivorensis	TiPSP1												
1	3a	Ordinary Soil mixed with fertilizer	Terminalia ivorensis	TiSFP1												
	3b	Ordinary Soil mixed with fertilizer	Terminalia ivorensis	TiSFP1												

1	4a	Ordinary Soil mixed with powdery sawdust	Terminalia ivorensis	TiSSP1													
	4b	Ordinary Soil mixed with powdery sawdust	Terminalia ivorensis	TiSSP1													
	4c	Ordinary Soil mixed with powdery sawdust	Terminalia ivorensis	TiSSP1													
1	5a	Organic Manure	Terminalia ivorensis	TiOMP1													
	5b	Organic Manure	Terminalia ivorensis	TiOMP1													
	5c	Organic Manure	Terminalia ivorensis	TiOMP1													
1	6a	Burnt sawdust mixed	Terminalia ivorensis	TiBSP1													
		with ordinary soil															
	6b	Burnt sawdust mixed with ordinary soil	Terminalia ivorensis	TiBSP1													
	6c	Burnt sawdust mixed with ordinary soil	Terminalia ivorensis	TiBSP1													
2	1a	Ordinary soil	Gmelina aborea	GaOSP 2													
	1b	Ordinary soil	Gmelina aborea	GaOSP 2													
	1c	Ordinary soil	Gmelina aborea	GaOSP 2													
2	2a	Powdery sawdust	Gmelina aborea	GaPSP 2													
	2b	Powdery sawdust	Gmelina aborea	GaPSP 2													
	2c	Powdery sawdust	Gmelina aborea	GaPSP 2													
2	3a	Ordinary Soil mixed with fertilizer	Gmelina aborea	GaSFP2													
	3b	Ordinary Soil mixed with fertilizer	Gmelina aborea	GaSFP2													
	3c	Ordinary Soil mixed with fertilizer	Gmelina aborea	GaSFP2													
2	4a	Ordinary Soil mixed with powdery sawdust	Gmelina aborea	GaSSP 2													

	4b	Ordinary Soil mixed with powdery sawdust	Gmelina aborea	GaSSP2													
	4c	Ordinary Soil mixed with powdery sawdust	Gmelina aborea	GaSSP2													
2	5a	Organic Manure	Gmelina aborea	GaOMP2													
	5b	Organic Manure	Gmelina aborea	GaOMP2													
	5c	Organic Manure	Gmelina aborea	GaOMP2													
2	6a	Burnt sawdust mixed with ordinary soil	Gmelina aborea	GaBSP2													
	6b	Burnt sawdust mixed with ordinary soil	Gmelina aborea	GaBSP2													
	6c	Burnt sawdust	Gmelina aborea	GaBSP2													
		mixed with ordinary soil															
3	1a	Ordinary soil	Theobroma cacao	TcOSP3													
	1b	Ordinary soil	Theobroma cacao	TcOSP3													
	1c	Ordinary soil	Theobroma cacao	TcOSP3													
3	2a	Powdery sawdust	Theobroma cacao	TcPSP3													
	2b	Powdery sawdust	Theobroma cacao	TcPSP3													
	2c	Powdery sawdust	Theobroma cacao	TcPSP3													
3	3a	Ordinary Soil mixed with fertilizer	Theobroma cacao	TcSFP3													
	3b	Ordinary Soil mixed with fertilizer	Theobroma cacao	TcSFP3													
	3c	Ordinary Soil mixed with fertilizer	Theobroma cacao	TcSFP3													
3	4a	Ordinary Soil mixed with powdery sawdust	Theobroma cacao	TcSSP3													
	4b	Ordinary Soil mixed with powdery sawdust	Theobroma cacao	TcSSP3													
	4c	Ordinary Soil mixed with powdery sawdust	Theobroma cacao	TcSSP3													
3	5a	Organic Manure	Theobroma cacao	TcOMP3													
	5b	Organic Manure	Theobroma cacao	TcOMP3													
	5c	Organic Manure	Theobroma cacao	TcOMP3													

3	6a	Burnt sawdust mixed with ordinary soil	Theobroma cacao	TcBSP3													

	6b	Burnt sawdust mixed with ordinary soil	Theobroma cacao	TcBSP3													
	6c	Burnt sawdust mixed with ordinary soil	Theobroma cacao	TcBSP3													

CHAPTER FOUR

RESULTS

Two-rack approach was employed to carry out the study classified under social and experimental research. The results presented and analyzed here are therefore based upon this two-track approach. In the first instance, the first set of results presented were based upon social research which investigated the various misconceptions about organic and inorganic manure from 600 respondents belonging to 12 groups involved in agriculture from production to consumption. These misconceptions were weighed against the various assumptions identified.

Secondly, the other set of results were presented and analyzed based upon scientific and experimental designed approach. The data presented here captured information on some growth parameters such as germination timing, germination percentage rate, number of seeds that did or did not germinate, total number of leafs counted, incremental growth in stem height, leaf length and width. These variables were measured every week and recorded in a datasheet.

The presentation and analysis are therefore organized under Part 1 – Social Research which focused on data from the perception survey followed by critical analysis and interpretation. Part 2, which is Experimental research focused on experiment conducted on three tree species under six treatments targeting the growth monitoring parameters mentioned above.

Part 1 – Social Research

Data from perception survey

The data displayed below indicated the perceptions of respondents on organic and inorganic (fertilizer) treatments. Each table or figure is followed by analysis of the information solicited, presented and critically analyzed. The analysis also captured some critical data collected during the survey. For the perception survey, 600 respondents were selected from 12 groups. For each group 50 respondents were randomly selected and interviewed. To get the percentage for the variables in the graphs, one should multiply the values by 2. Tables 4 to 6 and Figures 1 and 2 below provided data on people's views, concepts and misconceptions about the yield from organic and inorganic manure and their application.

Interest over yield from organic/inorganic manure

Table 4: Responses on food and yields from organic and inorganic manure.

Categories of Respondents	Total interviewed	Number		Percentage	
		Organic	Inorganic	Organic	Inorganic
Youths - males in agric	50	44	6	7.3	1.2
Youths - females in agric	50	43	7	7.2	1.4
Women in agric	50	40	10	6.7	1.9
Men in agric	50	42	8	7.0	1.6
CBOs in agric	50	48	2	8.0	0.4
NGOs in agric	50	47	3	7.8	0.6
MAF	50	48	2	8.0	0.4
Stakeholders in agric	50	45	5	7.5	1.0
Farmers	50	47	3	7.8	0.6
Loggers in agric	50	35	15	5.8	2.9
Miners in agric	50	37	13	6.2	2.5
Business people in agric	50	38	12	6.3	2.3
Total	**600**	514	86	85.7	14.3

Table 4 provides detailed information people's likes or dislikes about organic and inorganic including products derived from them. About 514 respondents representing 85.7% of the 600 interviewed indicated that they prefered products from organic manure while 86 respondents representing 14.3% indicated inorganic products. This therefore means that majority of those interviewed prefer products from organic manure.

At individual group level, we noticed that the following groups indicated high interest in organic manure out of the 50 respondents interviewed from each of thse groups as stipulated here: MAF - 48, CBOs - 48, NGOs – 47 and Farmers (Master Farmers) – 47. On the other hand, those who prefered inorganic manure included

Loggers in Agriculture with 15 people and Miners in Agrculture with 13 out of 50 interviewed from each of these groups.

Agricultural usefulness of organic manure

Table 5: Knowledge about agricultural usefulness of organic manure (sawdust) in agriculture

Categories of Respondents	Total interviewed	Knowledge about agricultural usefulness of organic manure (sawdust) in agriculture			Percentage		
		Useful	Not useful	Don't know	Useful	Not useful	Don't know
Youths - males in agric	50	2	11	37	0.3	8.8	23.7
Youths - females in agric	50	1	13	36	0.2	10.4	23.1
Women in agric	50	4	12	34	0.7	9.6	21.8
Men in agric	50	5	15	30	0.8	12.0	19.2
CBOs in agric	50	15	17	18	2.5	13.6	11.5
NGOs in agric	50	17	18	15	2.8	14.4	9.6
MAF	50	19	10	21	3.2	8.0	13.5
Stakeholders in agric	50	11	10	29	1.8	8.0	18.6
Farmers	50	17	15	18	2.8	12.0	11.5
Loggers in agric	50	13	10	27	2.2	8.0	17.3
Miners in agric	50	10	14	26	1.7	11.2	16.7
Business people in agric	50	11	11	28	1.8	8.8	17.9
	600	**125**	**156**	**319**	**20.8**	**26.0**	**53.2**

Table 5 focuses on the usefulness of sawdust (organic manure) as either useful or not useful to plants. Out of the 600 people interviewed, 125 representing 20.8% indicated that sawdust an organic nutrient is useful in agriculture, 156 representing 26% confirmed that it is not useful and has never been introduced in agriculture while 319 representing 53.2% revealed that they don't know the usefulness of sawdust in agriculture. At group level, a significant number of the male youths in agriculture that is 23.7% indicated that they don't know the usefulness of sawdust in agriculture followed by the female youth in agriculture with 23.1% and women in agriculture with 21.8% for the 'don't know' responses. One could link this to wide knowledge gap, lack of awareness and education.

Environmental/health risks associate with inorganic manure use

Table 6: Responses on environmental and health risks of inorganic manure (fertilizer) use

Categories of Respondents	Total interviewed	Environmental hazards of inorganic fertilizer			Percentage		
		Hazardous	Not hazardous	Don't know	Hazardous	Not hazardous	Don't know
Youths - males in agric	50	40	4	6	6.7	0.7	1.0
Youths - females in agric	50	37	7	6	6.2	1.2	1.0
Women in agric	50	35	8	7	5.8	1.3	1.2
Men in agric	50	38	7	5	6.3	1.2	0.8
CBOs in agric	50	45	3	2	7.5	0.5	0.3
NGOs in agric	50	47	2	1	7.8	0.3	0.2
MAF	50	48	2	0	8.0	0.3	0.0
Stakeholders in Agric	50	37	5	8	6.2	0.8	1.3
Farmers	50	35	9	6	5.8	1.5	1.0
Loggers in agric	50	33	9	8	5.5	1.5	1.3
Miners in agric	50	30	11	9	5.0	1.8	1.5
Business people in Agric	50	33	9	8	5.5	1.5	1.3
Total	**600**	**458**	**76**	**66**	**76.3**	**12.7**	**11.0**

Table 6 above reveals the environmental and health implications associated with inorganic manure application to crops. Responses were analyzed under hazardous, not hazardous or don't know. Out of 600 respondents interviewed, 458 representing 76.3% indicated that inorganic manure is hazardous to the environment and has series of health related implications on humans as well as flora and fauna, 76 respondents that is 12.3% indicated that it is not hazardous while 66 representing 11% disclosed that they don't know if it is hazardous or not. At group level, it was observed that majority of the respondents from MAF and NGOs disclosed that inorganic manure is hazardous to humanity, the environment and other lving things.

Availability of organic and inorganic manure

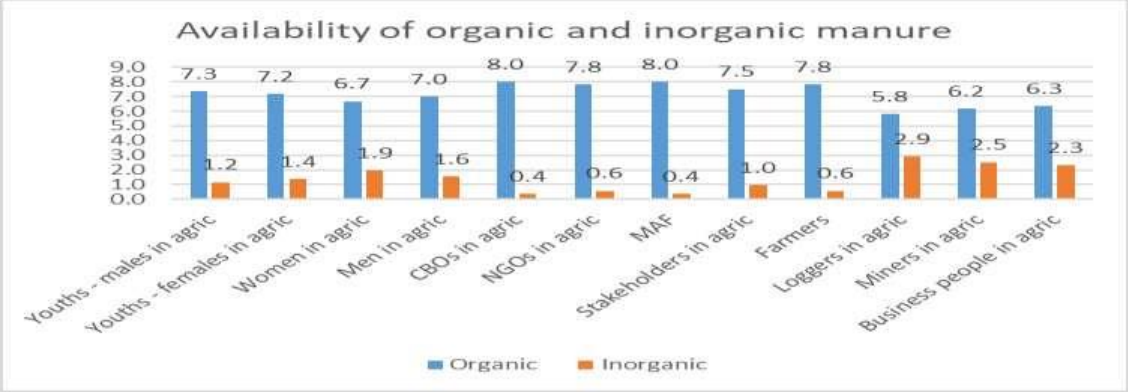

Figure 1: Availability of organic and inorganic manure in percentages

By addiing all the responses in favour of organic manure as reflected in Figure 1 above it came out clear that majority of the respondents admitted that organic manure is available. Out of the 600 respondents interviewed, 514 representing 85.7% interviewed indicated that organic manure is available while 86 respodents representing 14.3% revealed that organic manure is not available. Conversly, the responses could also be interpreted for inorgnic manure where 86 respondents representing 14.3% stated that inorganic manure is available. This implies that 514 respondents representing 85.7% disclosed that it is not available.

At group level, we observed that majority of the 50 people interviewed from each of these groups (MAF and CBOs) indicated that organic manure is available. Only few people from Logers in Agriculture indicated that organic manure is not available.

Cost of inorganic manure (fertilizer)

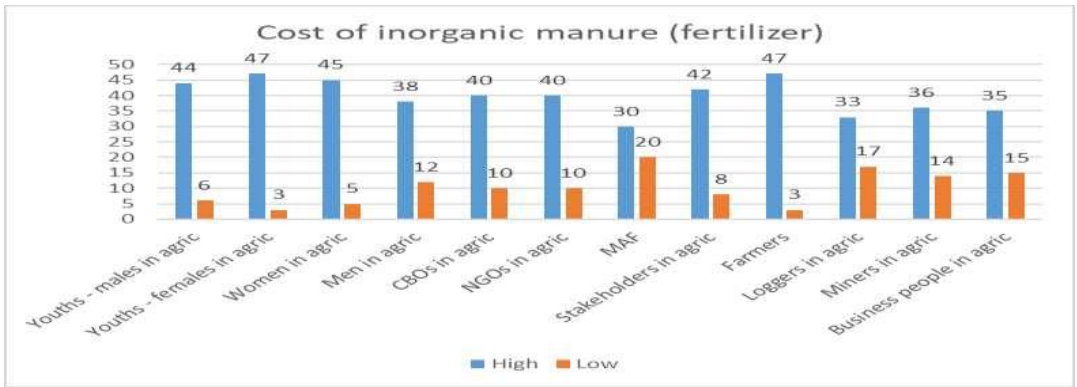

Figure 2: Cost of inorganic manure (fertilizer)

Figure 2 provides information about the cost implications associated with inorganic manure. About 447 respondents representing 79.5% of those interviewed admitted that inorganic manure is very expensive while 123 respondents representing 20.5% revealed that the cost is low. At group level, all the groups confirmed that the cost of inorganic manure is high. However, few groups such as MAF, NGOs, CBOs, loggers, miners and business people in agriculture admitted that it is high but with a lower number.

Part 2 – Experimental Research

Tables 7 to 10 and Figures 3 to 9 present data on growth monitoring parameters of the three tree species in the nursery.

Data from treatment effects on germination and post germination monitoring

Data from treatment effects on germination monitoring parameters

Table 7: Data on total seeds nursed, total germinated seeds, date of germination and germination rate and duration,

Tree species	Treatment	Tree species and treatment Code	Nursed date	Re-nursed date	Total seeds nursed	Date of germination	Total no. of seeds that germinated 11/12/2020	Days taken to germinate	Total seeds that germinate d after 30 days	% germination rate at the end of the germination period -30 days	Total seeds that did not germinated at the end of the germination period - 30 days
Terminalia ivorensis	Ordinary soil	TiOSP1	14/11/2020		50	11/12/2020	3	27	24	48.0	26
Terminalia ivorensis	Powdery sawdust	TiPSP1	14/11/2020		50	11/12/2020	4	27	20	40.0	23
Terminalia ivorensis	Sawdust mixed with ordinary soil	TiOSP1	14/11/2020		50	11/12/2020	3	27	25	50.0	25
Terminalia ivorensis	Burnt sawdust mixed With ordinary soil	TiOSP1	14/11/2020		50	4/12/2020	8	18	27	54.0	
Terminalia ivorensis	Organic manure from dustbin	TiOSP1	14/11/2020		50	4/12/2020	2	18	28	56.0	22
Terminalia ivorensis	Fertilizer (urea) mixed with ordinary soil	TiOSP1	14/11/2020		50	4/12/2020	4	18	10	20.0	40
Total					**300**		**24**		**134**	**44.7**	**166**
Gmelina aborea	Ordinary soil	AcOSP1	14/11/2020		50	22/11/2020	1	7	25	50.0	25
Gmelina aborea	Powdery sawdust	AcPSP1	14/11/2020		50	24/11/2020	2	10	23	46.0	27
Gmelina aborea	Sawdust mixed with ordinary soil	AcSSP1	14/11/2020		50	24/11/2020	4	10	33	66.0	17

Gmelina aborea	Burnt sawdust mixed with ordinary soil	AcBSP1	14/11/2020		50	22/11/2020	5	7	36	72.0	16
Gmelina aborea	Organic manure from dustbin	AcOMP1	14/11/2020		50	22/11/2020	1	7	30	60.0	20
Gmelina aborea	Fertilizer (urea) mixed with ordinary soil	AcSFP1	14/11/2020		50	22/11/2020	1	7	13	26.0	37
Total					**300**		**14**		**160**	**53.3**	**140**
Theobroma cacao	Ordinary soil	AeOSP1	14/11/2020	14/12/2020	50	25/12/2020	5	11	28	56.0	22
Theobroma cacao	Powdery sawdust	AePSP1	14/11/2020	14/12/2020	50	25/12/2020	11	13	24	48.0	26
Theobroma cacao	Sawdust mixed with ordinary soil	AeSSP1	14/11/2020	14/12/2020	50	25/12/2020	2	11	30	60.0	20
Theobroma cacao	Burnt sawdust mixed with ordinary soil	AeBSP1	14/11/2020	14/12/2020	50	25/12/2020	1	11	32	64.0	18
Theobroma cacao	Organic manure from dustbin	AeOMP1	14/11/2020	14/12/2020	50	25/12/2020	1	11	27	54.0	23
Theobroma cacao	Fertilizer (urea) mixed With ordinary soil	AeSFP1	14/11/2020	14/12/2020	50	25/12/2020	11	13	15	30.0	35
Total					**300**		**31**		**156**	**52.0**	**144**

Table 7 above presents results on nursing and germination dates, total seeds that
germinated or did not germinate, duration (days) taken to germinate, percentage rate of germination resulting from the effect of the six different treatments. All of the seeds were nursed on the same day - 11th November, 2020. However, due to some limiting factors, Theobroma cacao seeds nursed together with the others on the same day did not germinate. These limiting factors included long travel with seeds and exposure of seeds to intense sunlight. It was therefore re-nursed on the 14th December 2020. Gmelina aborea was the first to sprout when to Terminalia ivorensis.
The first germination was noticed for Gmelina aborea on the 22nd November 2020 under burnt sawdust mixed with ordinary soil. A total of 5 seeds were observed to have sprouted under this treatment. The days taken for these seeds to germinate was 7 days. Gmelina aborea nursed under two other treatments – organic manure and fertilizer mixed with ordinary soil also took 7 days to germinate. The rest of the other treatments for Gmelina aborea took 10 days to germinate. On average, out of the 300 seeds nursed, only 160 seeds germinated representing 53.3%. However, 140 did not germinate representing 46.7% at the end of the germination period of 30 days.
For Terminalia ivorensis, the first seeds that sprouted were observed on the 4th December, 2020 under the following treatments burnt sawdust mixed with ordinary soil with 8 germinated seeds, and 2 seeds from organic manure and 4 seeds from seedlings under fertilizer mixed with ordinary soil. The seeds under these three treatments took 18 days to germinate after nursing. For the other treatments, the seeds took 27 days to germinate. On average, out of the 300 seeds nursed, only 134 seeds germinated representing 44.4% and 166 which represents 55.6% of those that did not germinate at the end of the germination period. Though, Theobroma cacao did not germinate during the first nursing on the 11th November, 2020, yet still it manifested remarkable germination and post germination incremental growth under all the treatments after it was re-nursed on the 14th December, 2020. On the 25th December, 2020, many of the seeds under the six treatments germinated within 11 days. On the 25th December, 2020 11 Theobroma cacao seeds germinated. Out of the 300 seeds nursed, 156 seeds on average germinated representing 52% while 144 representing 48% did not germinate at the end of the germination period.
At treatment and species level comparison, Gmelina aborea recorded the highest germination percentage at 72% under burnt sawdust mixed with ordinary soil, followed by 66% under sawdust mixed with ordinary soil. Theobroma cacao recorded 64% germination rate under burnt sawdust mixed with ordinary soil. Terminalia ivorensis under organic manure also recorded germination rate at 54%. For the three tree species, fertilizer mixed with ordinary soil recorded the lowest germination percentage for Terminalia ivorensis with 20% followed by Gmelina aborea with 26% and Theobroma cacao with 30%.

Data from treatment effects on post germination monitoring parameters A Stem height increment

Stem height increment was estimated using the formula previously provided in the methodology.

Table 8: Average stem height increment under the six treatments

Tree species	Treatments effect measured in mm					
	ordinary soil	Powdery sawdust	Sawdust mixed with ordinary soil	Burnt sawdust mixed with ordinary soil;	Organic manure from dustbin	Fertilizer (urea) mixed with ordinary soil
Terminalia ivorensis	0.2	0.2	0.2	0.3	0.2	0.1
Gmelina aborea	0.2	0.3	0.3	0.3	0.3	0.1
Theobroma cacao	0.3	0.3	0.3	0.3	0.3	0.2

Table 8 provides results from the weekly seedling stem incremental monitoring over a period of 120 days for Terminalia ivorensis, Gmelina aborea and Theobroma cacao. Growth formula was used to calculate stem increment by subtracting the first reading from the last reading for each of the selected healthy seedlings. The total for each seedling under each treatment was divided by the number of days (120) and the summary presented as shown in table 8 above. From the result, Gmelina aborea exhibited a high response rate in stem height increment with an average daily rate of 0.3 mm for all the treatments except ordinary soil with 0.2mm and fertilizer mixed with ordinary soil with 0.1mm. For Terminalia ivorensis, the highest daily stem height

increment was 0.3mm under burnt sawdust mixed with ordinary soil. Theobroma cacao, exhibited a uniform daily stem height increment of 0.3 under the six treatments except fertilizer mixed with ordinary soil, which recorded an increment of 0.2mm.

B Progressive average weekly stem height increment by treatment

The progressive weekly stem increment of the three tree species was compared at the six treatment level as shown in figures 3 to 9. Gmelina aborea increased more than the other species under the six treatments.

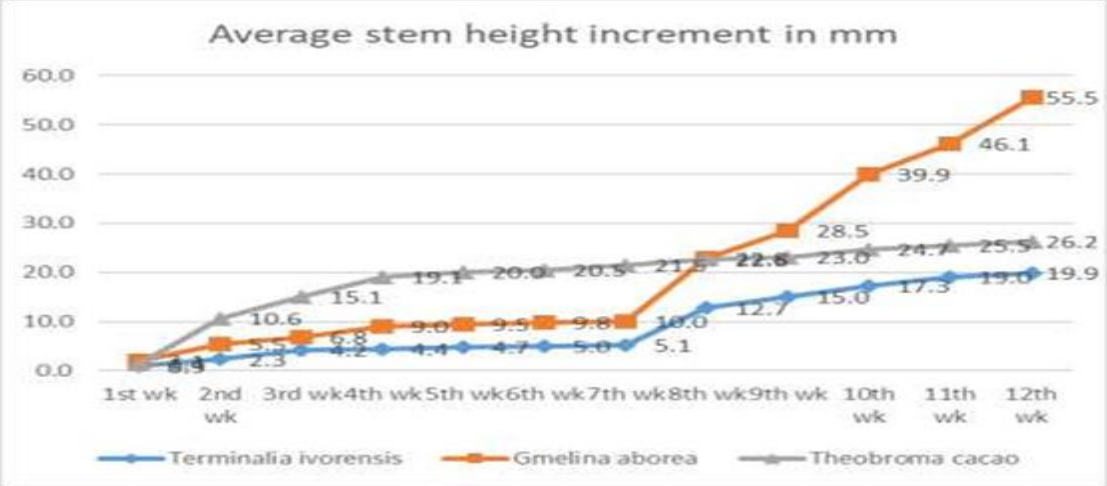

Figure 3: Progressive average weekly stem height increment under Ordinary soil

Figure 3 presents data on weekly progressive increment in stem height of the three tree species under ordinary soil. Gmelina aborea exhibited rapid stem height increment from 2.1 in the first week to 55.5mm, Theobroma cacao from 1.4 to 26.2mm and Terminalia ivorensis from 0.9 to 19.9mm. Gmelina aborea due to it exotic nature increased rapidly under ordinary soil compared to the others. Theobroma cacao stem height increased more than the other two species from the first to the 7th week.

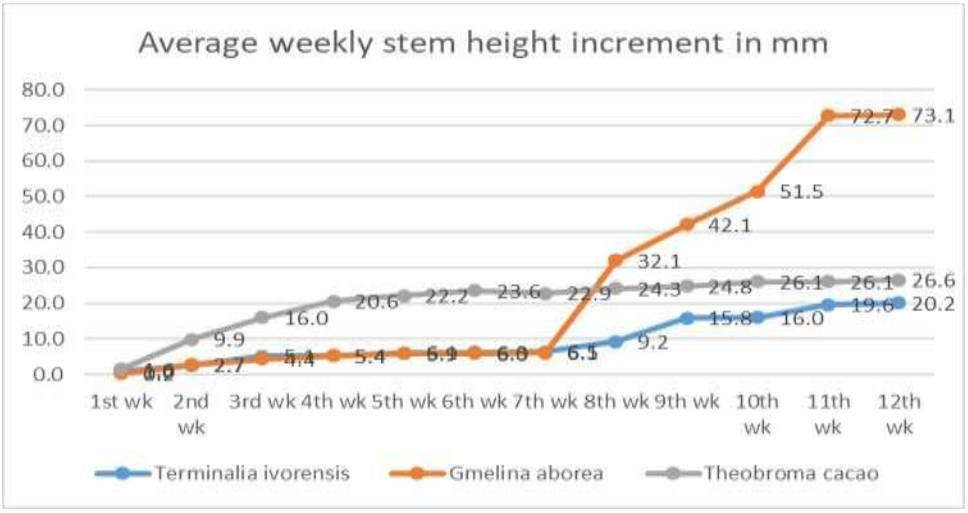

Figure 4: Progressive average weekly stem height increment under Powdery sawdust

The response of the three tree species under powdery sawdust was remarkable with Gmelina aborea as presented in table 4 where stem increased from 0.2 to 73.1mm, followed by Theobroma cacao from 1.6 to 26.6mm and Terminalia ivorensis from 1.0 to 20.2mm on progressive weekly basis. In the first 7th week, Theobroma cacao stem increment was high but was later overtaken by Gmelina aborea.

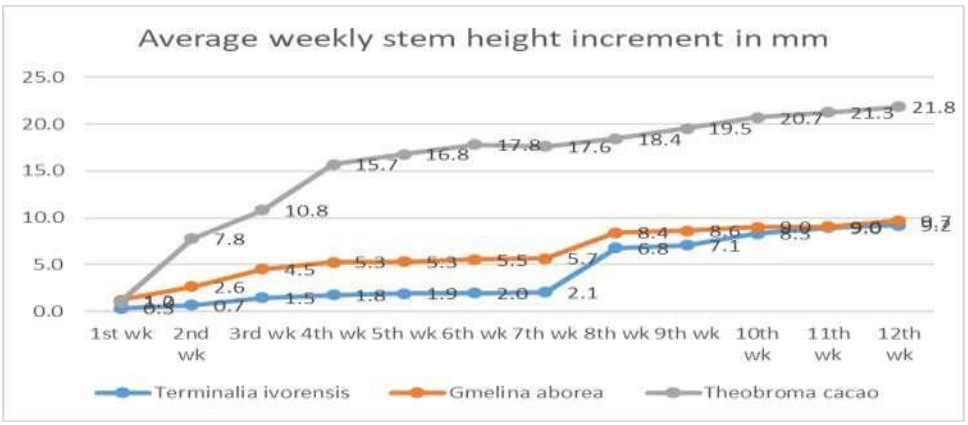

Figure 5: Progressive average weekly stem height increment under fertilizer mixed with ordinary soil

Under this treatment as depicted in figure 5 above, we observed a remarkable stem height increment of Theobroma cacao from 1.0 to 21.8mm with Terminalia ivorensis increasing from 0.3 to 9.2mm on weekly basis. Gmelina aborea shows drastic decrease in stem increment under this treatment from 1.2 to 9.7mm compared to all the other treatments.

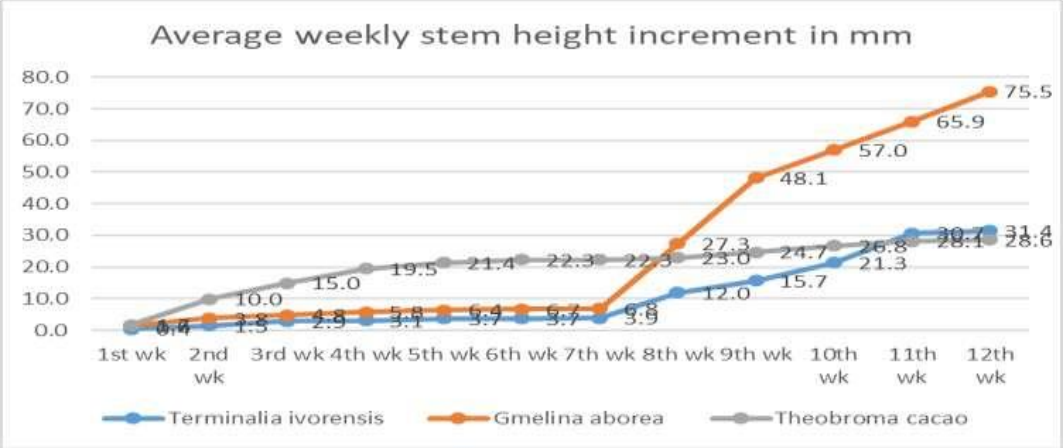

Figure 6: Progressive average weekly stem height increment under sawdust mixed with ordinary soil

Figure 6, provides data on Gmelina aborea stem height increment from 1.5 to 75.5mm in the first and 12th week followed by Theobroma cacao with 1.7 to 28.6.4mm and Terminalia ivorensis from 1.5 to 31.4mm under sawdust mixed with ordinary soil. Gmelina aborea recorded the highest increment of 75.5mm and Theobroma, the lowest increment.

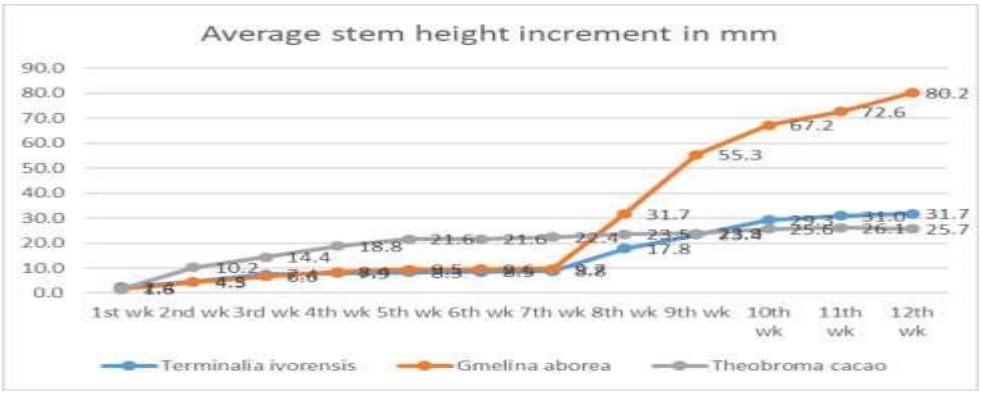

Figure 7: Progressive average weekly stem height increment under organic manure

Under organic manure treatment as presented in figure 7 above, we observed an increase in stem height from 1.6 to 80.2mm for Gmelina aborea.

Terminalia ivorensis stem height increased from 2.4 to 33.7 mm while Theobroma cacao increased from 1.6 to 25.7mm.

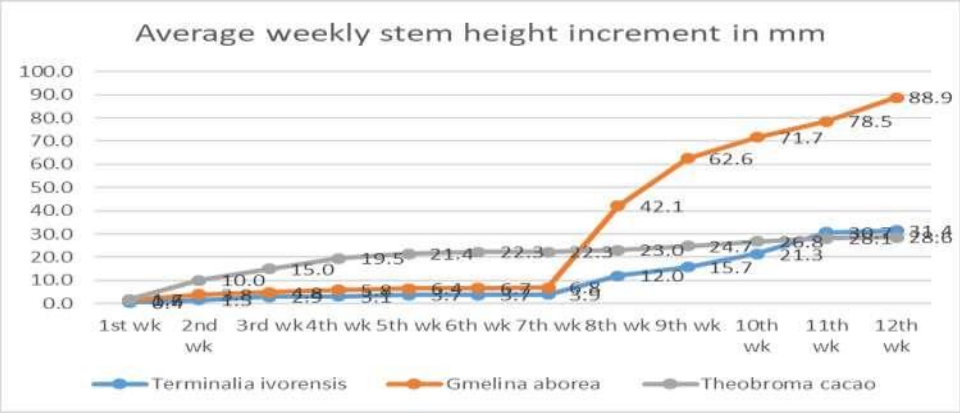

Figure 8: Progressive average weekly stem height increment under Burnt sawdust mixed with ordinary soil

Figure 8 reveals the highest increment for Gmelina aborea under the six treatments with stem height increment of 88.9mm. Theobroma cacao stem height increased to 28.6mm and Terminalia ivorensis from 0.9 to 31.4mm.

Leaf length increment

Table 9: Average leaf length increment in mm

Tree species	**Treatments effect measured in mm**					
	ordinary soil	Powdery sawdust	Sawdust mixed with ordinary soil	Burnt sawdust mixed with ordinary soil	Organic manure from dustbin	Fertilizer (urea) mixed with ordinary soil
Terminalia ivorensis	0.1	0.1	0.1	0.2	0.2	0
Gmelina aborea	0.2	0.2	0.2	0.2	0.1	0
Theobroma cacao	0.1	0.1	0.1	0.1	0.1	0.1

Table 9 above presents data on the leaf length that were measured and recorded every week. After careful calculation, Terminalia ivorensis had an increase in leaf length of 0.2mm under burnt sawdust mixed with ordinary soil and organic manure. For the species, fertilizer treatment mixed with ordinary soil shows on average a zero increment. This could be due to the impact of fertilizer effect on seedling growth. Similar result was observed for Gmelina aborea. The leafs also increased in length by 0.2mm on average. Average daily leaf length increased in Theobroma cacao on daily average rate of 0.1mm for all the treatments.

Leaf width increment

Table 10: Average daily leaf width increment in mm

Tree species	**Treatments effect measured in mm**					
	ordinary soil	Powdery sawdust	Sawdust mixed with ordinary soil	Burnt sawdust mixed with ordinary soil	Organic manure from dustbin	Fertilizer (urea) mixed with ordinary soil
Terminalia ivorensis	0	0	0	0.1	0.1	0
Gmelina aborea	0.2	0.2	0.2	0.2	0.1	0
Theobroma cacao	0.1	0.1	0.1	0.1	0.1	0.1

Table 10 provides data on the daily average leaf width measured weekly and calculated. The highest daily increment was observed with Gmelina aborea with an increment of 0.2mm under the treatments except organic manure and fertilizer mixed with ordinary soil. Terminalia ivorensis did not show any significant increment in width under ordinary soil, powdery soil and sawdust mixed with ordinary soil. Theobroma cacao still exhibit uniform leaf width increment of 0.1mm for all the six treatments as depicted in table 10.

Total number of leafs during the first and last week

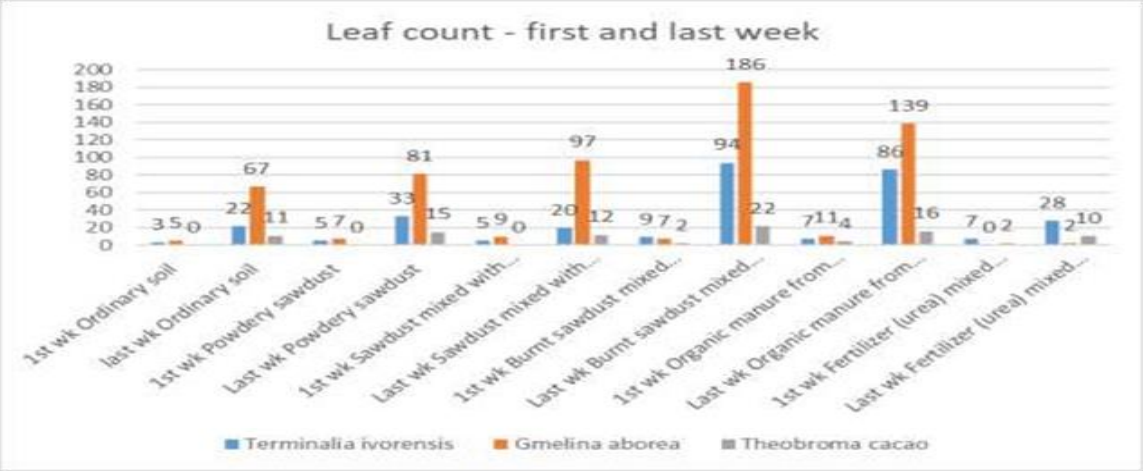

Figure 9: Total leaf counted in the first and last week of research period

Figure 9 presents data on the total leafs counted in the first week and those counted in the last week for each species under each treatment. The tree species that developed more leafs than the other was Gmelina aborea with a total leaf of 186 under burnt sawdust mixed with ordinary soil treatment. It was observed that this particular plot was raided by sheep which resulted in trigeing more new leaf formation. Organic manure also reached a total leaf count for Gmelina aborea to be 139 leafs. For Terminalia ivorensis, the highest leaf count was 94 and the least was 7. Theobroma cacao normally do not produce leafs until after two weeks of germination hence the lowest leaf count on the first week was zero and the highest was recorded to be 33 under powdery sawdust alone.

Research hypothesis and limitations

The experimental research investigated the following hypothesis and proved them
to be true hence they were accepted. These are:

1. Sawdust if appropriately applied can expedite plant growth more than inorganic fertilizer (tables 8 to 10 and figures 1 to 9);
2. Ordinary soil alone can trigger seed germination (table 7);
3. Ordinary soil alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width) (tables 8 to 10 and figure 3);
4. Powdery sawdust alone can trigger seed germination (table 7);
5. Powdery sawdust alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width) (tables 8 to 10 and figure 4);
6. Powdery sawdust mixed with ordinary soil can trigger seed germination (table 7);
7. Powdery sawdust mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width) (tables 8 to 10 and figure 6);
8. Burnt sawdust mixed with ordinary soil can trigger seed germination (table 7);
9. Burnt sawdust mixed with ordinary soil can e
10. Organic manure from dustbin can trigger seed germination (table 7)';
11. Organic manure from dustbin can expedite seedling incremental growth rate (increase in stem height, leaf length and width) (tables 7 to 10 and figure 7); and
12. Fertilizer (urea) mixed with ordinary soil can trigger seed germination (table 7).

The following hypothesis were found to be false and were therefore rejected with modification. These are:

1. Fertilizer (urea) mixed with ordinary soil can expedite seedling incremental growth rate (increase in stem height, leaf length and width) tables 8 to 10 and figure 5).
2. Germination period is shorter in soils treated with sawdust than soils treated with inorganic fertilizers (tables 7).

Limitations

This study like many others is not without challenges and limitations which affected or influenced to some extent the results in one way or the other. Some of these limitations included:

1. Initial plan to test the effects of the six treatments on vegetable crops and tree species. At the start of the study, two categories of species were initially identified and set up– vegetable and tree species. With the wide spread nature of the variable and parameters and too many data to have been analyzed, it was reduced to only tree species. This however affected initial focus and concentration with cost implications.
2. Finance also affected the duration of the research. The study could have moved from nursery stage to the field level investigation but this could have lasted for many years with series of cost implication especially when the study was fully funded by me alone;
3. Too many paramters were investigated which resulted in the collection of too many data. However, the series of research data from the various paramters could be used to develop different research papers.
4. Intense and prolong dry season limited the study. To water the seeds and seedlings was the greatets challenge the study encountered. The Experimental Data Collector had to procure water from distance locations;
5. Crop raiding by goats. Goats loved Gmelina aborea so they rushed in and ate all the leafs in one plot when they detected a hole in the fence.

CHAPTER 5

DISCUSSIONS

Part 1 – Social Research

Misconceptions about organic and inorganic treatments from perception survey

The results of the research justify what have been circulating and strongly held by different literate and illiterate people about organic and inorganic manure. All of the misconceptions were proven to be true and strongly held by majority of the people in Sierra Leone. For instance, one senior lecturer at the Njala University where I set up the experimental research had this to say about sawdust (organic manure) in his attempt to persuade me to change my topic. 'Sawdust is smelly and bulky; so many farmers wouldn't even have time to carry it, let alone use it in their farms'.

Interest over yield from organic and inorganic manure

The research proved that majority of Sierra Leoneans like organic food products. This was noted by 514 respondents representing 85.7% of the 600 who indicated that they prefered products from organic manure while 86 respondents representing 14.3% indicated inorganic products.

In rural communities in Sierra Leone, majority of the farmers do not use inorganic manure for agricultural activities. This is because the interest is not there and people's mentality about inorganic food has been difficult to change. Many people hardly eat inorganic food due to believe that the chemicals will remain within the plant even after harvesting. The implication for most people is that this eventually transfer in to the systems of those eat inorganic food including animals as well. The worst side of it is the total absence of inorganic manure (fertilizer) in rural communities and the cost implications. Organic farming has been going on for years supplemented by long fallow period to allow replenishment of nutrients lost. Most people therefore are now looking for alternative means through the use of organic manure application which is costless and available in most communities. As a result most farmers in rural communities have now redirected their attention to organic farming. Many international and national organizations have thrown their weight behind organic farming. Many farmers here considered the recent campaign on organic farming as not new but the world confirming and emphasizing what they have been doing and are still doing. The introduction of inorganic farming is to maximize food production with the view to meet the food needs of this rapid growing population. Some farmers however apply fertilizer to their crops when they want to maximize production and make huge profit. It was noticed however, most of them only sell but they don't eat the product from fertilizer. During the interview, it was confirmed that organic farming is the preferred choice of majority of those interviewed and by extension majority of Sierra Leoneans (table 4). The knowledge about organic farming is now gaining momentum in the country with majority searching for organic food in the market. People's taste pattern in the cities has now changed to products or yield from rural communities due to organic nature of their products. This has thus led to an increase in the prices of organic products. It should be noted that organic farming has been the only farming approach practiced by farmers in Sierra Leone before fertilizer (inorganic)manure) entered the race. Organic certification is gradually gaining grounds in the country with some national and international institutional campaigning for it locally and nationally.

In urban settings, many people are now going in for farm yield from rural communities due to their organicity. It should ne noted that organic farming has been the only farming approach practiced by farmers in Sierra Leone before fertilizer (inorganic)manure) entered the race. Samantary and P. Das in 2000 found

out that fertilizers have inorganic substances and high concentration of nutrients because they are human-made and do not provide humus to the soil.
It should be noted that organic farming has been the only farming approach practiced by farmers in Sierra Leone before fertilizer (inorganic)manure) entered the race. Organic certification is gradually gaining grounds in the country with some national and international organizations campaigning for it locally and nationally.

Agricultural usefulness of sawdust (organic manure)

The research revealed that sawdust (organic manure) is very useful in agriculture. However, there is a huge knowledge gap about its usefulness with majority (53.2%) admitting that they don't know it usefulness and 21% indicated that it is useful. By implication, it shows that 79.2% of those interviewed admitted that sawdust (organic manure) is either not useful or they do not know it's usefulness in agriculture. Ram in 2010 discovered some agricultural uses of sawdust including useful in killing weeds, cleaning floor, bedding for animal, smoking of meat or fish, useful for mulching, broadcasting tiny seeds, amending soil, preventing erosion, growing mushroom, etc. However, very little is known about its useful as nutrients for plants growth. These and many more justify the relevance of sawdust in plant growth. In terms of stem height increment, leaf length and width, all the sawdust treatments revealed some remarkable result. More leafs were also recorded under the various sawdust treatment combinations.

Environmental and health risks associated with organic and inorganic application

The study discovered that inorganic manure is harmful to the environment and living things with 76.3% of the respondents affirming this (table 6). Some of the respondents revealed that their greatest challenge with inorganic manure application include lack of knowledge on how and when to apply it, what quantity to apply and at what time and how often to apply it. One interesting confirmation was that there is very little environmental and health risks associated with organic manure. Majority admitted that it is not harmful to any living thing or the environment. Yadav and Lourduraj discovered in 2005 that the continuous and excess use of chemical fertilizers over a longer period of time has resulted in deterioration of soil health and causes less productivity. Only few of the seeds nursed under this treatment survived. Those interviewed complained of the health related injuries, rashes and eye defect farmers faced when applying fertilizer. Some also complained about the odour from the chemical they inhale which to them may have caused some unknown ailment or sicknesses. The experimental research proved this assumption with massive mortality of seeds and seedling recorded under fertilizer treatment Farmers are now conscious of the relevance and usefulness of organic manure. With reference to this knowledge gap on the usefulness of sawdust (organic manure), there is the need to demonstrate its usefulness through the establishment of experimental plots and farmer field school where the two applications - the ordinary soil and sawdust will be tested on different crops. By so doing rural farmers will observe for themselves how the different crop perform under these two treatments. This experimental research proved the usefulness of sawdust. It expedited the germination of three tree species seeds that were nursed under all the six treatments though with varying degree. This was noticed with high percentage rate of germination of the various treatments with sawdust alone or combined with other treatments. For example, Gmelina aborea recorded the highest germination percentage at 72% under burnt sawdust mixed with ordinary soil, followed by 66% under sawdust mixed with ordinary soil. Theobroma cacao recorded 64% germination rate under burnt sawdust mixed with ordinary soil. Terminalia ivorensis under organic manure also recorded germination rate at 54%. Amongst all the six treatments, the first germination was recorded for Gmelina aborea under burnt sawdust mixed with ordinary soil. A total of 5 seeds were observed to have sprouted under this treatment. combination. Ffertilizer mixed with ordinary soil recorded the lowest germination percentage for Terminalia ivorensis with 20% followed by Gmelina aborea with 26% and Theobroma cacao with 30%. If fertilizer destroys the very crop it is meant to support it to grow, it therefore means that it has the tendency to damage those who eat the products from it as well.

Availability of organic and inorganic manure

It was discovered that organic manure is available at all time but this was not so with inorganic manure (figure 1).
The study found this misconception to be true about the availability of organic manure everywhere. On the other front, inorganic manure is not available in many rural communities. Distance to access it is another challenge faced by farmers. The unavailability of fertilizer (inorganic) is felt more in rural communities than in the cities due to their locations, inaccessibility, transportation and absence of financial power base in rural communities. This should be a concern to the government, development practitioners and the international communities who wants to maximize food production to meet the growing population. Sawdust is found in carpentry shops where they are eventually thrown in to the dustbin as waste. Gradually, vegetable growers have started to realize the importance of sawdust as an important weed killer and nutrient for plant growth.

Cost of organic or inorganic manure

With reference to the cost implications for both organic and inorganic manure, majority disclosed that organic manure cost nothing at all while inorganic manure is very expensive and majority cannot afford it (table 4). In 2014, Amara Denis and Alie Kamara in a soil research conducted in three districts revealed that most smallholder farmers meet with the conventional soil fertility management strategies dominated by high use of inorganic fertilizers and agrochemicals considering their escalating prices. Since sawdust as an organic manure is found in dustbin and many carpentry shops, it is regarded as valueless and costless. Setting up organic compost cost little or nothing compared to buying inorganic manure.

From the findings above, it was indeed discovered that 'Rural farmers have series of misconceptions about exposure to fertilizer, its application, harmful nature and products from fertilizer'. It was discovered that:

1. Many people prefer crops grown from organic manure than those grown from inorganic fertilizer – true;
2. People have very little knowledge about the agricultural usefulness of sawdust as an organic nutrient for to soil productivity, germination and plant growth– true;
3. Sawdust is a trash and should be thrown away into the wild– not true;
4. Organic manures are mixed with human waste which is not good for human consumption – not true; and
5. Application of sawdust is environmentally friendly than fertilizer true.

Based upon the justification and research confirmation of these misconceptions, many people are yet to be convinced to use inorganic manure or eat product from it.

Part 2 – Experimental Research

Treatment effects on germination and post germination parameters

Treatment effects on seed germination

The time between seed nursing/sowing and seedling establishment is considered to be the crucial period of any plant. Wheeler et al. in 2011 and Johnson and Yeakley in 2016 discovered that germination success (the presence of germinant) is largely influenced by soil temperature, soil moisture, soil nutrient and substrate type). For this study, the treatment effect influenced to some degree the period of germination of the seeds and total seeds that germinated during the germination period of 30 days. One remarkable observation was that some of the seeds nursed under each treatment germinated. For example out of the 300 Gmelina aborea seeds nursed, 160 seeds germinated representing 53.3%. with 140 that did not germinate representing 46.7%. For Terminalia ivorensis, 134 seeds germinated representing 44.4% while 166 (55.6%) did not germinate. For Theobroma cacao, out of the 300 seeds nursed, 156 seeds germinated representing 52% while 144(48%) did not germinate. This shows that all the treatments had some direct or indirect effect on seed germination, number of seeds that germinated and germination period. However, variations were noticed on the days each seed took to germinate and number that germinated. At treatment level comparison, the highest total germinated seeds was recorded under Burnt sawdust mixed with Ordinary soil followed by Sawdust mixed with Ordinary soil for the three tree species. This indicates that sawdust is a good nutrient for seed germination. Mixing sawdust be it powdery or burnt with the ordinary soil is a good combination for seed germination. With the exception of fertilizer mixed with Ordinary soil which had less than 20 germinated seeds, it was observed that the three tree species under the other five treatments had over 20 seeds that germinated in each plot. This shows that fertilizer is not good in triggering seed germination. In fact, the highest seed mortality was observed under this treatment. This therefore justifies the miscomputations held by people that fertilizer is harmful to plants, humans, the environment and other living organisms. However, if one is to apply fertilizer to expedite germination, it should be done three weeks before nursing the seeds. This will allow the chemical composition to subside.

Terminalia ivorensis

Terminalia ivorensis, an indigenous tree species in Sierra Leone is indeed difficult to germinate under normal circumstances and most people have had no time to nurse them in their nurseries due to it long dormancy to sprout.

The seed of Terminalia ivorensis has been very difficult to germinate. As a result, a series of investigations in pre-treatment were commissioned by World Agroforestry Organization to test pre-germination of Terminalia ivorensis to know which of the methods will give quick germination percentage. A series of experiments was performed by giving six pre-treatment to batches of seeds each batch of which has four replicates with about 50 seeds in each replicate. The results of the experiment are not encouraging yet it can be seen that changing water hourly seems to be the best pre-treatment, followed by continually treating with concentrated acid. It can be generally inferred that the standard practice of soaking is not necessarily the best pre- treatment. See http://www.aluka.org.

For this research using the six treatments, this species took the longest duration to germinate - 27 days for all other treatments except for burnt sawdust mixed with ordinary soil, organic manure and fertilizer mixed with Ordinary soil which recorded 18 days for the seeds to sprout. This is another research opportunity that could

be explored in the future.
Considering total seeds that germinated under each treatments, it was recorded that 24 seeds germinated under Ordinary soil, 20 seeds under Powdery sawdust, 25 under Sawdust mixed with ordinary soil, 27 under Burnt sawdust, 28 under Organic manure and 10 under Fertilizer mixed with ordinary soil

Gmelina aborea

Due to its rapid growth rate, *G. arborea* is a tree which has been widely used in reforestation programs in tropical and subtropical regions of the world and as a source of commercial timber and cellulose (Dvorak, 2004; Rojas-Rodríguez et al., 2004; Silva et al., 2005; USDA-ARS, 2016). This species produces large numbers of fertile fruits that are easily dispersed by birds and bats, spreading seedlings quite far from the parent tree (Orwa et al., 2009). In this way, *G. arborea* has escaped from plantations and entered wild habitats where it is now replacing native trees and becoming invasive (IUCN, 2013). Currently, it is listed as invasive in Costa Rica, the Dominican Republic, Ghana, Australia and the Cook Islands (Chacón and Saborío, 2012; Mir, 2012; IUCN, 2013; PIER, 2016; Weeds of Australia, 2016). It is also separately reported as invasive in Malawi, Tanzania and Zambia.
In Sierra Leone this species is gradually taken over the vast of the landscape of the country and many considered it now as an invasive species.
Seed - pre-treatment is not necessary, though for quick germination, the seeds should be soaked for 48 hours in warm water.
Gmelina aborea, an alien and exotic species took the shortest duration of 7 days to germinate under ordinary soil, burnt sawdust mixed with ordinary soil, organic manure and fertilizer mixed with ordinary soil treatments. The number of seeds that germinated under the six treatment for this species included 25 seeds for Ordinary soil, 23 for Powdery sawdust, 33 for Sawdust mixed with ordinary soil, 36 for Burnt sawdust mixed with ordinary soil, 30 for Organic manure and 13 for Fertilizer mixed with ordinary soil.
Gmelina aborea germination response rate was very high with 53.3% germination percentage. At treatment level, it was observed that the highest germination percentage was 72 for Burnt sawdust mixed with Ordinary soil followed by 66 for sawdust mixed with ordinary soil. Thus, this signifies the relevance of sawdust in serving as seed germination. The least germination percentage of 26 was recorded under the fertilizer mixed with ordinary soil. This implies that fertilizer (urea) is not ideal for the germination of seeds. The highest seed germination mortality rate was recorded for Terminalia ivorensis with 40% followed by Gmelina aborea with 37% under fertilizer mixed with ordinary soil.

Theobroma cacao

Cacao (Theobroma cacao L.) is a tropical woody species which belongs to the family Malvaceae. It is a valuable commercial tree crop grown mainly in the South and Eastern regions of Sierra Leone. It is one of the export commodities in Sierra Leone. This study discovered that this particular seed responded well under all the six treatments. This was manifested by the number of seeds that germinated with 28 seeds that germinated under Ordinary soil, 24 under Powdery sawdust, 30 under Sawdust mixed with ordinary soil, 32 under Burnt sawdust, 27 under Organic manure and 15 under fertilizer mixed with ordinary soil.
Even where many of the seeds nursed from the two tree species died and some experienced stunted growth, under fertilizer mixed with ordinary soil treatment, Theobroma cacao grew in height, size and number of leafs. However, due to it tenderness, the seeds require careful handling. Traveling with the seeds from a long distance from the East to the South affected their germination when they were first nursed together with the other two tree species seeds. Justice and Bass in 2002 affirmed that there are several factors that affect the viability of recalcitrant seeds which include moisture content of seeds, humidity, storage space temperature, container, and storage period. To overcome, this challenge, the seeds were then sourced from within the locality and did exceedingly well when they were nursed. Though re-nursed one month after the others have sprouted, it grew rapidly and overtook Terminalia ivorensis except Gmelina aborea. It took 11 days for Theobroma cacao seeds to germinate under ordinary soil, burnt sawdust mixed with ordinary soil, sawdust mixed with ordinary soil and fertilizer mixed with ordinary soil. Series of experiment conducted by Famuwagun, I.B., and Agele S.O. between 2004 and 2018 discovered that the use of manure mixed with sawdust and loamy soil aided excellent seed germination, seedling vigor and root development.

Treatment effect on post germination monitoring parameters

Stem height increment

The study shows the effects of these treatments on stem height, which resulted in a significant difference ($P \geq 0.05$). At the end of the experiment which was120 days, all the various treatments significantly influenced stem height increment. Mattson in 1997 disclosed two categories of seedling quality assessment: morphological and physiological. Morphological quality is based on the physical attributes of the seedling, whereas physiological quality is based on the seedling's internal functions. The study recorded the highest stem height increment for Gmelina aborea under burnt sawdust mixed with ordinary soil reaching a record height of 88.9mm, followed by organic manure with

80.2mm. This shows that sawdusts are critical nutrients in stem height increment. I have noted this to be like 'dog eat dog' simply put a tree eating another tree but the dead one. The response of the three tree species' seedlings under fertilizer mixed with ordinary soil was unique. Comparatively, Gmelina aborea stem height increased drastically under the five treatments more than the other two tree species. On the other front, Theobroma cacao increased rapidly more than the other two tree species under fertilizer mixed with ordinary soil. This could be attributed to the reduced chemical power concentration after six weeks of continuous watering twice a day in the nursery.

Leaf Length increment

The study shows the effects of the treatments on leaf length which resulted in a significant difference (P≥ 0.05). In comparison, a significant variation existed in average leaf length for Gmelina aborea and Terminalia ivorensis except Theobroma cacao which maintained uniform leaf length (table 9. Terminalia ivorensis had an increase in leaf length of 0.2mm under burnt sawdust mixed with ordinary soil and organic manure which did not vary significantly from normal average leaf length for most tree species. For Gmelina aborea and Terminalia ivorensis, fertilizer mixed with ordinary soil showed on average a zero leaf length increment. This however, is not indicating that the leafs did not increase in length. However, when computed against the mean variation, the leafs of these two tree species had a zero leaf length. One could relate this to chemical concentration of fertilizer which affected the stem growth. This consequently affected the leaf development and growth as well. By computing against the mean variation, Theobroma cacao average leaf length increased by 0.1mm under all the treatments.

Leaf width increment

The study shows the effects of these treatments on leaf width with a significant difference (P≥ 0.05). In comparison, Gmelina aborea leafs increased by 0.2mm for all the treatments except organic manure and fertilizer mixed with ordinary soil. By computing the leaf length and leaf width, these two tree species had the largest Leaf Area Development. (LAD) compared to Terminalia ivorensis which did not show any significant increase in LAD under ordinary soil, powdery soil and sawdust mixed with ordinary soil. For Theobroma cacao, no significant difference was observed but the species maintained a uniform leaf width increment of 0.1mm for all the six treatments. In similar research conducted by Famuwagun, I.B. and Agele, S.O. between 2004 and 2018, it was observed that no significant mean difference was recorded among the treatment combinations for Theobroma cacao.

Total leaf in the first and last week of the research period

Significant differences (P≥ 0.05) were recorded during the last week for all the tree species after nursing under all the treatments except ordinary soil and fertilizer mixed with ordinary soil (figure 9). The research proved beyond reasonable doubt that Gmelina aborea is indeed an exotic species with fast growing attributes in height, leaf length, width and number of leafs. The tree species with more leafs than the other is Gmelina aborea with a total leaf of 186 under burnt sawdust mixed with ordinary soil treatment. It could be deduced from the research that the soils in Sierra Leone are poor in nuttrients and that fertilizer application can not increase soil humus. The research however, revealed some of the disadvantges associated with the use of chemical fertilizer. The fast decompostion of sawdust in the polythene bags and the availability of a concentrated nutrient only for the seedlings also played critical role. Once the sawdust get desomposed faster in the polythene bags, the seedlings were able to utilize it easily compared to when it is undecomposed. The second treatment with a good number of leafs was organic manure which had a good concentrate of orgaic nutrients vital for plant growth including leaf development.

Research hypothesis

The experimental research investigated the following hypothesis and proved many to be true. These include:

1. Sawdust if appropriately decomposed and applied better, it can expedite plant growth more than inorganic fertilizer. Sawdust was discovered to be a good nutrient for both seeds germination and seedling growth. It was observed that most of the seeds nursed under the various sawdust combination impacted seeds germination and seedling growth compared to inorganic manure where high seed and seedling mortalities were recorded.
2. Ordinary soil alone can trigger seed germination. Most farmers in Sierra Leone used ordinary soil to nurse and plant seeds. Though the acidity of the soils in Sierra Leone is high, the research proved that ordinary soil is still useful in expediting seed germination.
3. Ordinary soil alone can expedite seedling incremental growth rate (increase in stem height, leaf length and width). It was observed also that the stems of the seedlings increased in height, leaf length and width.
4. Powdery sawdust alone can trigger seed germination. It was realized powdery sawdust greatly influenced seeds germination. The study discovered that powdery sawdust alone resulted in high germination percentage and hence recommended for rural farmers to use in their farms especially when it is free.
5 Powdery sawdust mixed with ordinary soil

can expedite seedling incremental growth rate.
The research also revealed increased stem height increment, leaf length/width increment for all the seedlings that germinated. Farmers can use powdery sawdust alone to nurse their seeds provided the moisture content is reduced and decomposition is expedited.
5 Burnt sawdust mixed with ordinary soil can trigger seed germination. This combination proved to be the most effective in triggering seeds germination.
7. Burnt sawdust mixed with ordinary soil

Burnt sawdust did not only expedite seed germination but also increase stem height, leaf length and width and the leafs appeared very fresh.
8. Organic manure from dustbin can trigger seed germination and is widely used by some farmers. The investigation revealed it to be an important ingredient for seed germination.
9. Organic manure from dustbin can expedite seedling incremental growth rate. Remarkable height increment for both stem ad leafs were noticed under this treatment.
10. Fertilizer (urea) mixed with ordinary soil can trigger seed germination. The treatment proved the shorted number of days seeds took to germinate especially for Terminalia ivorensis which is difficult to germinate.
The following hypothesis were found to be false in some instances and true in the other. These are:
1.Fertilizer (urea) mixed with ordinary soil can expedite seedling incremental growth rate
This treatment affected the incremental growth of some seedlings except Theobroma cacao. Gmelina aborea grew rapidly under all the six treatments except under fertilizer mixed with ordinary soil; and
2.Germination period is shorter in soils treated with sawdust than soils treated with inorganic fertilizers. This means inorganic manure are not good nutrient that will trigger seed germination.
This hypothesis was true with burnt sawdust mixed with ordinary soil where a short germination period occurred under burnt sawdust mixed with ordinary soil, organic manure and fertilizer mixed with ordinary soil. Here 8 seeds took just 18 days to germinate while seeds under the other treatments took 27 days (table 7). Some Gmelina aborea seeds took 7 days to sprout under ordinary soil with 1 germinated seed, burnt sawdust mixed with ordinary soil with 5 germinated seeds, organic manure with 1 germinated seed and fertilizer mixed with ordinary soil also with 1 germinated seed.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study investigated farmers' perceptions about organic and inorganic manure application and products derived from its use. This was done through social research. It also investigated six organic and inorganic treatment effects on growth parameters of three tree species seeds and seedlings through experimental design approach. The three tree species used for this experimental research included Terminalia ivorensis, Gmelina aborea and Theobroma cacao.
Using combination of treatments, six organic and inorganic manure treatments derived and used to test their effects on seedling incremental growth rate. (control), powdery sawdust alone, sawdust mixed with ordinary soil, burnt sawdust mixed with ordinary soil, organic manure and fertilizer mixed with ordinary soil.
Daily observation of seeds nursed lasted for 30 days where germination period, total seeds that germinated or did not germinate were observed and recorded on daily basis. Weekly observation focused on growth monitoring of germinated seeds where recording of stem height, leaf length, and width and total number of leafs of the three randomly selected healthy seedlings under the six treatments for each tree species lasted for six months.
The study found out that all of the misconceptions about organic and inorganic manure and products derived from their use were true. It furthered tested the hypothesis and discovered most of them to be true except two. Those found to be true were therefore accepted and the two that were investigated to be false were rejected with modification.

Misconceptions about organic and inorganic manure

This study was motivated by the idea that farmers' perceptions on organic and inorganic manure is a driving factor critical in agricultural interventions which may result in the adoption or non- adoption of innovations. The important value that this study adds, therefore, is in terms of integrating farmers' perspectives to the adoption of knowledge and practice that support organic farming. A partial review of the available literature shows that there is considerable knowledge gap on organic and inorganic manure application and acceptance of products from inorganic manure.
The following were the key findings from the perception survey:

Interest over yield from organic and inorganic manure

It came out very strongly that many people dislike products from inorganic manure. From the one-on-one discussions with the respondents, many people in rural communities now attributes or link some emerging health related complications such as chest pain, chest burn, stomach ulcer, liver complications etc. to inorganic food.

Agricultural usefulness of sawdust (organic manure)

The survey revealed that sawdust is still considered by many as not relevant in agricultural intervention and that many people including the educated elites do not know its usefulness. However, this misconception was proved wrong during the perception survey and confirmed from the combined sawdust treatments effects, which influenced seed germination and growth of seedlings. It should be noted therefore that there is a huge knowledge gap on agricultural usefulness of organic manure (sawdust) even amongst the educate folks. Comments of sawdust 'as a smelly and bulky thing' from a senior lecturer at the Njala University justifies this knowledge gap. Sensitization is therefore needed in this discipline so that farmers will start adopt the use of sawdust in their farming activities.

Environmental and health risks associated with organic and inorganic application

The survey confirmed that organic manure has little or no environmental and health related issues or complications compared to inorganic manure. During the interviews, stories were revealed of people and children unknowingly using inorganic manure especially urea as domestic consumable salt. This often results in deaths and other health complications. Other stories were revealed of people using it to poison others.

Availability of organic and inorganic manure

Organic manure is available in almost every locality but this is not so with inorganic manure. Many people especially from the rural communities justified that they hardly see inorganic manure (fertilizer) and even where it is available, it is either in small quantity or meant for those highly placed in the society or with the financial strength. Urban markets were reported as the only places where fertilizer is always available.

Cost of organic or inorganic manure.

The study proved beyond doubt that inorganic manure (fertilizer) is very much expensive in this country. Many people revealed that 1kg of fertilizer currently costs Le20, 000.
This cost has increased four times over the last two years when it was sold for Le5, 000 per kilogram. Majority of those interviewed complained that they hardly see fertilizer in the market.

Treatment effects on germination and post germination parameters

Treatment effects on seed germination parameters

Treatment effects on germination period

The study discovered that all the six treatments had effect on germination period. Germination period for this study was regarded as the number of days seeds took to germinate from the day of nursing. The shortest period seeds took to germinate under each treatment were noted as follows:
a)7 days for Gmelina aborea under ordinary soil, burnt sawdust mixed with ordinary soil, organic manure and fertilizer mixed with ordinary soil. For this species the normal germination period is 10 days on average;
b)11 days for Theobroma cacao under ordinary soil, burnt sawdust mixed with ordinary soil, sawdust mixed with ordinary soil and fertilizer mixed with ordinary soil. The normal period Theobroma cacao seeds take to germinate is 14 days on average;
c)18 days for Terminalia ivorensis under burnt sawdust mixed with ordinary soil, sawdust mixed with ordinary soil and fertilizer mixed with ordinary soil. The normal germination period is 24 days for this species on average;

Treatment effects on total germinated seeds and germination percentage

The study further investigated and discovered also that the six treatments influenced the total number of seeds that germinated within the research period. Ordinary soil mixed with either sawdust or burnt sawdust and powdery sawdust alone influenced total seeds that germinated as reflected below:
a) 36 (72%) and 33(66%) - Gmelina aborea seeds germinated under burnt sawdust mixed with ordinary soil and sawdust mixed with ordinary soil respectively;
b) 32(64%) and 30(60%) - Theobroma cacao seeds germinated under burnt sawdust mixed with ordinary soil and sawdust mixed with ordinary soil respectively;
c) 28(56%) and 33(54%) Terminalia aborea seeds germinated under organic manure and burnt sawdust mixed with ordinary respectively;
The treatment with the high number of germinated seeds was recorded under burnt sawdust mixed with ordinary soil with 36(72%)of the seeds germinated out of the 50 seeds nursed. The highest seed mortality was recorded under fertilizer mixed with ordinary soil with 40 (80%)out of 50 Terminalia ivorensis seeds died. For fertilizer treatment few seeds germinated. Amongst the tree species, Gmelina aborea recorded the highest germination percentage.

Treatment effects on post germination parameters

Treatment effect on stem height

The six treatments also influenced the average daily stem height increment with the highest record of 0.3mm with 0.1 deviating above the normal.

a) 0.3mm for Terminalia ivorensis under

burnt sawdust mixed with ordinary soil;
b) 0.3mm for Gmelina aborea for all the treatments except ordinary soil and fertilizer mixed with ordinary soil; and
c) 0.3mm Theobroma cacao for all the treatments except for fertilizer mixed with ordinary soil with a record of 0.2mm.
The least stem height increment was recorded under fertilizer mixed with ordinary soil with 0.1mm thus indicating 0.1mm deviation below the normal.

Treatment effect on leaf length

The effect of the six treatments were also recorded in terms of the response of increment in leaf length. All the leafs increased in length under the six treatments except fertilizer mixed with ordinary soil where 0mm increment was recorded for Terminalia ivorensis and Gmelina aborea. However, the normal leaf length increment of 0.2mm was recorded for all the treatments and the three tree species with exception for Theobroma cacao which recorded 0.1mm leaf length increment. Gmelina aborea recorded leaf length increment of 0.2mm for all the treatments except fertilizer mixed with ordinary soil where 0mm and 0.1mm for organic manure.
The leaf length comparison at treatment level per tree species recorded rapid increment for Gmelina aborea for all the treatments except fertilizer mixed with ordinary soil where Theobroma cacao took the lead (figure 5).

Treatment effect on leaf width

Increment in leaf width was also influenced by the six treatments except for Terminalia ivorensis and Gmelina aborea under fertilizer mixed with ordinary soil where 0mm width was recorded. Gmelina aborea recorded the highest leaf width increment of 0.2mm under all the six treatments except for organic manure with 0.1mm and fertilizer mixed with ordinary soil with 0mm..

Treatment effect on number of leafs

The total number of leafs were equally influenced by the six treatments. Leafs increased in number progressively under all the treatments from the first to the last week of the reseearch. The highest total number of leafs were recorded by Gmelina aborea under 186 leafs under burnt sawdust mixed with ordinary soil and the least by Terminalia ivorensis with 22 leafs under burnst sawdust mixed with ordinary soil. It could be noted that Theobroma cacao do not develop leafs within the first two weeks after germination.

Hypothesis

The study significantly influenced the effect of these treatments on the various germination and post germination parameters. The hypothesis previously presented prior to the study were tested against the results. The study discovered and proved the following hypothesis to be true and hence should be accepted:
1.Sawdust if appropriately applied can expedite plant growth more than inorganic fertilizer;
2. Ordinary soil alone can trigger seed germination;
3. Ordinary soil alone can expedite seedling incremental growth rate;
4. Powdery sawdust alone can trigger seed germination;
5. Powdery sawdust alone can expedite seedling incremental growth rate;
6. Powdery sawdust mixed with ordinary soil can trigger seed germination;
7. Powdery sawdust mixed with ordinary soil can expedite seedling incremental growth rate;
8. Burnt sawdust mixed with ordinary soil can trigger seed germination;
9. Burnt sawdust mixed with ordinary soil can expedite seedling incremental growth rate;
10. Organic manure from dustbin can trigger seed germination;
11. Organic manure from dustbin can expedite seedling incremental growth rate;
12. Fertilizer (urea) mixed with ordinary soil can trigger seed germination.
The study however, proved the following hypothesis to be insignificant in influencing the various parameters and were therefore rejected.
1.Fertilizer (urea) mixed with ordinary soil can expedite seedling incremental growth rate. This treatment recorded the highest seed mortality rate hence this hypothesis should be rejected;
2. Germination period is shorter in soils treated with sawdust than soils treated with inorganic fertilizers. For instance, the reserved discovered 18 days germination period for Terminalia ivorensis. On this premise, the study proved this hypothesis not true. It was therefore considered insignificant and hence rejected.

Recommendations

Organic manure is a natural form of fertilizer which is cost-effective and environmentally friendly. It is the decomposed form of dead plants and animals, which is applied to the soil to increase growth and production. Sawdust for instance is an example of organic manure. It contains lots of carbon, which makes it a “brown” (carbon-rich) compost material. Grass clippings, on the other hand, contain lots of nitrogen, which makes them a “green” (nitrogen- rich) compost material. Inorganic manure exclusively now referred to as fertilizers, are chemicals produced by controlled chemical processes.
In conclusion it was evident that organic manure, burnt sawdust mixed with ordinary soil, sawdust mixed with ordinary soil greatly influenced germination period, total

seeds that germinated, increment in stem height, leaf length, leaf width, total number of leafs more than fertilizer mixed with ordinary soil, powdery sawdust ordinary soil. This means that sawdust is a good nutrient in influencing germination and post germination parameters.

The wide knowledge gap about organic and inorganic manure's usefulness, environmental impact, availability and cost should be a concern to all. The study was tailored to factor people's perceptions about organic and inorganic manure. The results from the experimental research was aligned with these perceptions to justify some assumptions and hypothesis. In the same direction, the sharp variation in germination period, total germinated seeds, seed mortality, stem height, leaf length/width, total number of leafs among the three tree species indicated the effects the various treatments had on these parameters.

The following recommendations are therefore advanced for future research in the same field:

a) Sensitize and educate the populace especially rural communities about the agricultural usefulness of organic manure especially sawdust;

b) Undertake similar research work to discover the unknown, prove or disprove an existing knowledge or add knowledge to existing one;

c) Farmers to make use of organic manure for better growth as they are cost effective, less toxic and environment friendly, cheaper and can be readily sourced within most localities;

d) Do not use too much water when seeds are nursed in sawdust alone;

e) Frequently aerate sawdust. Once water is applied to sawdust alone in a polythene bags, the dust will become compact and tight the seedlings;

f) It is very common to see yellow colouration of the leafs due to iron content. When this is detected, apply water intermittently, aerate frequently and mix the top with the bottom;

g) Humanity should go organic to reduce health risks associated with inorganic manure.;

h) Undertake similar research with focus on one tree species and few parameters;

i) Extend the study beyond nursery stage to the field for some years;

j) Where inorganic manures are just a necessity especially in large scale agriculture, it is advisable to use the right proportion and ratio following standard guidelines;

k) If you wish to apply fertilizer (urea) to your nursery seeds, nurse your seeds one month after applying fertilizer especially for seeds with tender coat. Early application will result in seed mortality and stunted growth.

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Appendix – List of photos – progress in growth of seedlings

A. Photos of 3 tree species seedlings increment under the six treatments in the first two weeks in the nursery

1. Terminalia ivorensis – 6 treatments

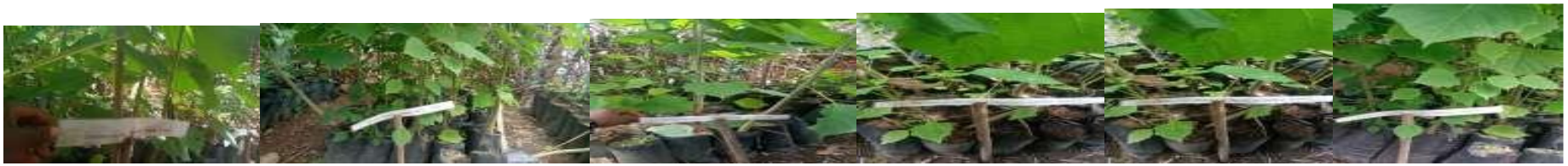
2. Gmelina aborea – 6 treatments

3. Theobroma cacao – 6 treatments

A. Photos of 3 tree species seedlings increment under the six treatments in the last week in the nursery

1. Terminalia ivorensis – 6 treatments

2. Gmelina aborea – 6 treatments



3. Theobroma cacao – 6 treatments