EFFECT OF JACK BEAN (*Canavalia enformis*) GREEN MANURE ON MAIZE GROWTH AND YIELD

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DEDICATION

I dedicate this work to my beloved parents, the late John Goro Hitler and Mrs. Goro Margaret for their inspiration in my life; for all the support and sacrifices they made that allowed me to achieve what I am today. I wish to remember in a special way to dedicate this work to my fiancé Mulumba Herbert Kanaabi, the entire family for their endurance during my absence while at campus and during the research study that enabled I complete the research and the course well.

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ACRONYMS AND ABREVIATION

ANOVA: Analysis of Variance

BNF: Biological Nitrogen Fixation

C.V%: Stratum standard errors and coefficient of variation

CTRL: Control plots

ESE: Treatment effects

EVF: Equator valley Farm

Fpr: Significant Level

JBI: Jack Bean manure imported

JBW: Jack Bean Manure from within

LSD: Least Significant difference of means

NPK: Nitrogen Phosphorous and potassium

RCBD: Randomized Complete Block Design

SED: Standard errors of difference of means

ABSTRACT

This study was conducted to evaluate the effect of jack bean green manure on the growth and yield of maize. The experiments were set up in two locations using a Randomized Complete Block Design (RCBD) with four treatments: control (CTRL), jack bean green manure grown at the experimental site (JBW), jack bean green manure grown elsewhere and imported to the experimental site (JBI) and NPK fertilizer used as a check. These treatments were replicated three times on plots that measured 5m by 5m. Data was collected on the soil fertility status of the experimental sites, maize plant height at four and eight weeks after germination, fresh plant biomass at tussling stage , root length at tasseling stage, and total dry biomass, cob weight and grain weight at harvest. This data was analyzed using SPSS and Genstat (12^{th} edition). The results show that soils at both sites were low in organic matter, Nitrogen, available phosphorous, cation exchange capacity. Jack bean green manure application significantly increased their contents in the soil. Maize plant height, fresh biomass, root length, total dry matter, cob weight and grain weight were all significantly improved by jack bean green manure application and more especially the JBW. From the results above, it is concluded that jack bean green manure can be used to enhance maize production. Based on the above conclusion, it is recommended that extension workers and NGOs should promote jack bean as a better alternative to use of inorganic fertilizers in the production of maize.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter contains the back ground which highlights the information on; the maize production trend, maize production constraints in Uganda, fertilizer use in Uganda, effects of fertilizer application on crop yield and maize production situations in Equator Valley Farm and Kalagala.

1.1 Background

1.1.1 The Maize production trend

According to Research Program on Agriculture for Nutrition and Health, maize is among the most widely- grown cereal crops around the world in both tropical and temperate climates ("Maize; Mostly grown cereal in the world.pdf," n.d.). The top six producers of maize in the world are the United States, china, Brazil Argentina, India and Mexico. United states is the largest maize producer in the world producing 42 % (785 million tons,) of maize and covering more than 90 Million acres of land planted with maize each season (Abbassian, n.d.). According to United Nations Economic Commissions for Africa, maize is the major cereal crop grown in Africa ("Maize_ the major cereal crop grown in Africa..pdf," n.d.). Africa produces 6.5% and the largest African maize producer is Nigeria with nearly 8 million tons, followed by South Africa. Uganda is the eighth largest producer of maize in Africa and third in East Africa with production area of 1.15 million hectares and production of 2.7 million metric tonnes. According to Caitlin Aylward *et al*, Maize yield in Uganda increased by 1000 Kg per hectare between 1993 and 2013 ("EPAR_UW_310_National-Level_Maize Yield Trends_5.31.16.pdf," n.d.). According to Uganda bureau of statistics, eastern Uganda lead in maize production with 2.9 Mt/Ha followed by western region with 2.6 Mt/Ha and the Northern region with 1.2 Mt/Ha, while Iganga District being lead with 303,000 Mt from an area of 49,000 Ha followed by Mubende with 171,000 Mt from an area of 41,000 Ha and then Soroti district third with a total of 138,000 Mt from an area of 15,000 Ha. Kampala and Katakwi districts is ranked the least producers of maize with the total output of 776 Mt, 255Mt respectively ("03_2018UCACrop. UBOS_Maize production trend in uganda.pdf," n.d.).

1.1.2 Maize production constraints in Uganda

Despite the large proportion of land suitable for Maize production and efforts being made by many development Agencies/ companies such as AFGRI and World food Program, Maize and most staple crops production in Uganda have been low due to low use of improved technologies, soil degradation and inappropriate post-harvest handling. It has been estimated that 4 to 12% of gross domestic product is lost from environmental degradation, 85% of this is from soil erosion, nutrient loss and changes in cropping pattern. Production statistics from the Food and Agricultural Organization of United Nations (FAO) show that while Uganda's maize output has more than doubled from 0.6 to 1.26 million tonnes over the last 2 decades (1990&2007), yield declined from about 1.8 tonnes per hectare in 2004 and leveled off the yield obtained in 1990. Comparing farmer average yield with researcher managed yield (7 tonnes per acre) however, it is clear that there still remains a huge gap between actual and potential maize yield in Uganda (Sadras, 2015). According to the World Bank report 2011, on farm farmers maize yield is far much lower than on research station yield of 1676 and 5000kg/hectare respectively ("Agriculture for inclusive growth in Uganda_ The World Bank report 2011.pdf," n.d.). In addition to the above mentioned factors, the current low maize production in Uganda is attributed to poor post-harvest handling (Agona et al., n.d.), inadequate access to credit and farm inputs, inadequate access to extension services, low labour productivity, land fragmentation, price fluctuation, poor marketing systems and inefficient value addition.

1.1.3 The levels of fertilizer use in Uganda

Despite the increased rate of soil infertility in Sub Saharan Africa and Uganda in particular, fertilizer use in most farms has been low. According to Zoé Druilhe and Jesús Barreiro-Hurlé 2012, only 3% (7kg/ ha) of global fertilizer is used in Sub Saharan Africa and the low level of fertilizer use is attributed to failure in inputs market, poor price incentive, seasonal and variable production, lack of credit, lack of knowledge and high transport, distribution and storage costs ("Druilhe and Barreiro-Hurlé - Fertilizer subsidies in sub-Saharan Africa.pdf," n.d.). According to Mbowa et all 2015, use of fertilizer in Uganda is very low at about 1 kg of nutrient per hectare per year , compared to Kenya at 32 Kg/ha; Rwanda at 29 kg/ha; and Tanzania at 6kg/ha. (Mbowa et al, 2015). According to report by food and agricultural organization, only less than 10% of farmers in Uganda use inorganic fertilizer (an average of 1kg/ ha), this is due to lack of affordability and ignorance about its importance. According to Uganda National Fertilizer Policy 2016, only 1-1.5 kilogram per hectare per year of fertilizer is used in Uganda ("uga172925-Uganda national fertilizer policy 2016.pdf," n.d.).

1.1.4 The effects of fertilizer application in crop production

Fertilizer application has significant effects on crop production worldwide. Estimates show that chemical fertilizer can increase agricultural production by 50%. According to Kareem et al 2017, fertilizer application facilitates and improve maize growth and yield (Kareem et al., 2017). On the other hand, other scholars say, 50% of applied chemical fertilizer can be recovered in the plant system through nutrient mining and leading to unavailability in the soil. Organic materials holds great promise due to their local availability as source of multiple nutrients and ability to improve soil characteristics (palm et al, 2001) and their long term effects on crop yield. Green manure can provide the same amount of food as chemical fertilizers but with less fossil fuel left in the soil. Use of chemical fertilizer alone does not sustain crop productivity under continuous cropping system, where as its integration with organic fertilizers improves the soil physical properties builds up soil fertility and increase crop yields (Yaduvanshi, 2003).

1.1.6 Maize growth requirements

Just like any other broad leaf crop, Maize requires reliable soil nutrient availability. According to Mbowa et all 2015, fertilizer application should be done at the right time when the different nutrients are needed and using the right methods (Mbowa et al., 2015). Maize nitrogen requirement is greatest during flowering, but carry over in to harvest is detrimental. Phosphorus is needed all season long but the ability of roots to extract it is reduced in humid soil conditions. Potassium activates enzymes required for growth which helps prevent disease and control insects and also maintain stalk strength and stand ability. Phosphorus, calcium and magnesium stays where they are placed until that soil zone is disturbed, nitrogen boron and sulphur are vulnerable to leaching from the root zones prior to plant uptake (Balirwa, n.d.).

1.1.6 The Low Maize yield in Equator Valley Farm and Karagara

Despite the big size of arable land in SSA and Uganda in particular, maize yield has been low due to declining soil fertility; low optimal amounts soil nutrients in the soil and insufficient use of fertilizers resulting in severe plant nutrient depletion of soils (Mumtaz et al., 2014) .Maize yield in both low and high input farms in Nkozi have been stagnating or declining. Report from surrounding farmer' revealed decline from an average of 700kgs per acre to 350kgs and 1500kgs to 1000kgs per acre between 2009 and 2018 for low and high input farms respectively. The declining yield of maize in Nkozi encouraged few farmers to adopt fertilizer use. Many NGOs introduced farmers to NPK and had trials. Most trails performed very well but few farms had control sides with higher yields than treatment sides. The problem could have been poor method of application or untimely application. According to NOGAMU, 2010, Mucuna (velvet) beans green manure increased cotton yields by 15.3% in few selected farms in Gulu district (Paicho, Ognako, Lalogi and Lakwana sub counties). However information obtained through preparatory interviews with farmers in Nkozi revealed that, most farmers knows Jack bean as wild bean without any use attached to it, its use in soil nutrient replenishment has not been explored, and no assessment to determine its effect in comparison with any chemical fertilizer like NPK or UREA or DAP has been done.

1.2. Problem statement

Karagara and Equator Valley Farms are characterized by moderate rainfall pattern, acidic soils, soil erosion, land fragmentation, monoculture, subsistence farming, sandy clay soils and moderate population pattern. Major crops grown in the area include all types of legumes, cereals, Maize and Banana ("A_look_at_the_Uganda_Martyrs_University.pdf," n.d.). Despite the efforts being made by the Farm Manager of Uganda Martyrs University and the NGOs from within to promote the production of Maize in the area, yield of Maize in both high and low input farms have been stagnating or declining and so, few farmers in the area adopted the use of NPK while majority of them believe that chemical fertilizers are costly and destroys soil. There has been no knowledge of how jack bean could be used as a strategy to achieving soil fertility and improving crop yield, therefore the study aimed at assessing the effect of Jack Bean green manure on growth and yield of Maize, and the results acted as a guide for them to make better decision in choosing the best soil nutrient improvement strategy that suits their locality.

1.3 Objectives of the study

1.3.1 General objective

To determine the effect of Jack Bean *(Canavalia ensiformis)* green manure on growth and yield of Maize

1.3.2 Specific objectives

- To determine the effect of Jack Bean green manure on plant height, root length and fresh biomass at tasseling stage of maize
- To determine the effect of Jack Bean green manure on Maize yield (total dry biomass yield, cob weight, and grain weight)
- To assess the merits and demerits associated with jack bean green manure in Maize Production

1.4 Research hypothesis

a) Application of Jack Bean green manure can have effect on maize performance

b) Application of Jack bean green manure cannot have effect on Maize yield

c) Application of Jack Bean green manure can have economic advantages in maize production

1.5. Scope of study

1.5.1 Geographical scope

The assessment of the effect of Jack Bean green manure on growth and yield of Maize was conducted in Karagara and Equator Valley Farms, Mpigi district, about 2.km off Kayabwe-Masaka road. The Place is bordered by from the south by Kayabwe, from the north by Butamba, from the east by Lukonge and Kasuubo and from the west by Ketosis.

1.5.2 Time scope

The study was conducted from January2018 to 2019 beginning with concept development, proposal defense, proposal writing, input sourcing and experimental lay out where the performances of Maize in regard to different treatments (NPK and Jack bean derived green manure) were compared.

1.5.3 Content scope

The study assessed the effects of Jack bean green manure on pant height, fresh biomass, root length, total dry biomass, cob weight and grain weight and the benefit-cost analysis of using Jack bean green manure in maize production.

1.6. Significance of the study

Many farmers in Nkozi have limited knowledge on fertilizer use and their effects on growth characteristics and yield of maize. The study was important because it acted as a reference point for them to discover how Maize performs with application of jack Bean green manure and the advantages and the disadvantages associated jack bean green manure application in maize production. This made them to appreciate the technology since the research produced relevant information for use by them and other stakeholders, especially those interested in increasing maize yield using different soil nutrient replenishment strategies.

1.7. Justification of the study

Soil nutrient depletion is very rampant in most farms in Uganda today, this can lead to low crop production and introduction of pests and diseases which would result to increased cost of pesticides hence can increase the production cost where by farmers would end up getting losses, for example, witch weed is a common pest (parasitic weed) that introduces itself on less fertile land. Land in Nkozi is getting more fragmented each day with too much of monoculture being practiced. Yields of Maize and other crops have been dropping at an increasing rate, and thus the need to assess the different soil fertility replenishment strategies in the area is a great deal

1.8 Definition of key terms

Variables

Variable is a measurable characteristic that varies. It may change from group to group, person to person, or even within one person over time.

(http://chemistry.about.com/od/sciencefairprojects/a/What-Is-A-Variable-In-Science.htm)

Dependent variables

Dependent Variable is the variable that is not manipulated and it is observed or measured for variation as a presumed result of the variation in the Independent Variable.

(http://www2.uncp.edu/home/collierw/ivdv.htm)

Independent variables

The Independent Variable is the variable that is controlled and manipulated by the experimenter (http://chemistry.about.com/od/sciencefairprojects/a/What-Is-A-Variable-In-Science.htm)

Morphological characteristics

These are the observable features that plants possess in the course of its growth stages in response to treatment given, for example leaf area, plants height, weight, and numbers of branches. (http://en.wikipedia.org/wiki/Plant_morphology)

Soil productivity

Soil productivity is the long term capacity/ability of the soil to supply the plant nutrients required by the crop plants in available and balanced forms to allow agricultural healthy and sustainable production (http://agriinfo.in/?page=topic&superid=1&topicid=355)

Replicates

Replication is the repetition of an experimental condition or observation in the same or similar conditions so that the variability associated with the phenomenon can be estimated. (http://www.statistics.com/glossary&term_id=832)

Intervening/ extraneous variables

Refer to abstract processes that are not directly observable but that link the independent and dependent variable. They are those factors in the research environment which may have an effect on the dependent variable(s). (http://chemistry.about.com/od/sciencefairprojects/a/What-Is-A-Variable-In-Science.htm)

Maize height

Maize height is the total length of cotton plant from the base to the tip. The height of Maize plant determines the number leaves

Leaf area index

Leaf area index is the ratio of the leaf surface area to that ground area occupied by the plant size. The leaf area determines the rate of photosynthesis by the plant and thus has effects on the performance of the plant.

Maize yield

Maize yield is total weight of total dry matter of maize.

Pests

Pests are organisms that cause economic injury to crops by feeding and releasing toxic substances on them.

Diseases

Disease means deviation from normal condition and they may come as a result of infection by pathogens or due to nutrient deficiency.

Rainfall

Is the total amount of natural down pour received in an area within a specific period of time.

Fertilizer

It is inorganic or organic food for plants that is applied to the soil.

Fertilizer concentration

Fertilizer concentration means the dose or quantity of fertilizer applied to the soil.

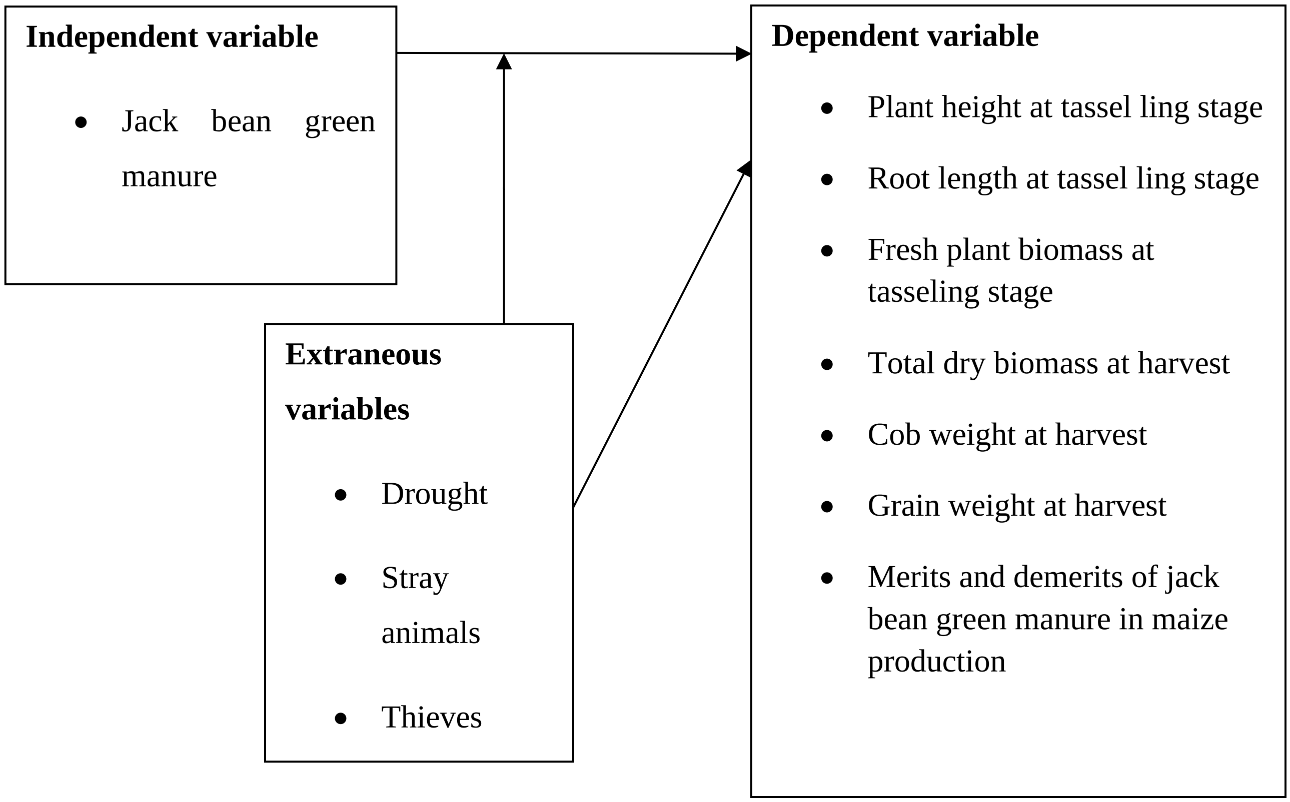
Moisture content

Is the amount of water contained in an object in relation to its dry matter?

1.9 Conceptual frame work

Growth and yield of Maize are attributed to a number of factors such as rainfall, soil fertility, management, pest and diseases. Soil infertility is the major contributing factor in Maize production and so fertilizer application being recognized as key strategy to soil fertility improvement and yield increase is very important. The study focused on assessing the effect of jack bean green manure on growth and yield of Maize. It thus factored in dependent, independent and extraneous variables. The dependent variables were; yield/ yield contributing characters (plant height, fresh biomass, root length, total dry matter, cob weight and grain weight) and the merits and demerits associated with jack bean green manure in maize production. The independent variable was jack bean green manure and the extraneous variable were drought, theft and stray animals

Figure 1 Conceptual framework



CHAPTER TWO

LITERATURE REVEIEW

2.0 Introduction

This chapter contains theatrical reviews and information related to the effects of fertilizers on performance of Maize. In particular, it contains information about the effects of green manure on growth parameters and yield of Maize, and the advantages and disadvantages associated with Jack bean green manure application in maize production

2.1 The theoretical review

This section include the information on the origin of maize, global maize production statistics, maize production situations in soil nutrient replenishment strategies, limiting factors to fertilizer use, maize production constraints in Uganda, maize growth requirements, levels of fertilizer use in crop production in Uganda and the effects of fertilizer application in crop production

2.1.1 The global Maize production

According to Abbassian, united states is the leading maize producer of maize the world with more than 90 Million acres of its land planted with maize each season and producing 42% of maize globally (Abbassian, n.d.). Maize is a major crop grown in Africa(“VIB_MaizeIn Africa_EN_2017.pdf,” n.d.). According to… more than half of crop land is Africa is under maize production where it produces 6.5% of maize. Africa generally accounts for between 1.5-3.5% of global exports of maize; by comparison, the value of the continent’s exports of maize flour represented 20.1% of worldwide exports in 2013, and the value of the continent’s maize flour exports increased by close to 400% in the period from 2004 to 2013(“Daly-et-al-2017-Maize-paper-1.pdf,” n.d.). The largest African maize producer is Nigeria with nearly 8 million tons, followed by South Africa. Uganda is the eighth largest producer of maize in Africa and third in East Africa. The production area for maize is 1.15 million hectares with a production of 2.7 million metri**c** tonnes. According to Daly 2017, South Africa was the second largest global exporter of maize flour in 2013, while EAC countries Uganda, Tanzania and Rwanda all had a significant market share within Africa. Much of the maize flour emanates from more advanced processing nations to countries that do not have mills("Daly-et-al-2017-Maize-paper-1.pdf," n.d.). Compared to other continents, maize production in Africa is low and majority of African countries produce less than 1 tonne of maize per hectare ("VIB_MaizeInAfrica_EN_2017.pdf," n.d.). The maize production constraints in Africa is attributed to soil fertility loss, inadequate access to fertilizers, improved seeds, crop protection inputs and extension services (Justin, 2015).

2.1.2 Maize production in Uganda

Maize is a major food crop in Uganda produced by almost all households who have at least farm land no matter the size. Maize in Uganda is consumed when roasted or eaten as posho. Maize has also been used as a very key input in making livestock feeds. The Uganda Bureau of Statistics reported that formal maize exports accounted for 1.9% of the country's total exports in 2014, which ranked 13th of all goods, but well behind the top tier of coffee (18.1%), petroleum (6.4%), fish and fish products (6%), animal/vegetable fats and oils (4.5%), and iron and steel (4.1% ("UBOS _2015.pdf," n.d.). Despite the large proportion of land suitable for Maize production and efforts being made by many development Agencies/ companies such as AFGRI and World food Program, Maize and most staple crops production in Uganda have been low majorly due to low use of improved technologies and soil degradation. It has been estimated that 4 to 12% of gross domestic product is lost from environmental degradation, 85% of this is from soil erosion, nutrient loss and changes in cropping pattern. Production statistics from the Food and Agricultural Organization of United Nations (FAO) show that while Uganda's maize output has more than doubled from 0.6 to 1.26 million tonnes over the last 2 decades (1990&2007), yield declined from about 1.8 tonnes per hectare in 2004 and leveled, off to 1990 yield of 1.5 t ha. Comparing farmer average yield (1.5 t ha1) with researcher managed yield (7 t ha) however, it is clear that there still remains a huge gap between actual and potential maize yield in Uganda. In addition to the above mentioned factors, the current low maize production in Uganda is specifically attributed to poor post-harvest handling, inadequate access to credit and farm inputs, inadequate access to extension services, low labour productivity, land fragmentation, price fluctuation, poor marketing systems and inefficient value addition. The seed industry in Uganda is largely undeveloped, with farmers relying almost entirely on their own low-yielding seed supplies and the Government of Uganda recognizes that both the public and private sectors have critical roles to play in the development of the seed industry("Weak seed industry_ Menyha Emmanuel.pdf," n.d.).

2.1.3 Soil nutrient replenishment strategies

Soil nutrients are termed as the essential elements required for plants growth and maturity (McGrath et al., 2014). Soils are considered fertile only if they are alive. Ecologically, soils perform a number of functions such as production, transformation, habitat, degradation, self-regulating, filtering, buffering and storage functions ("The Basics of Soil Fertility. Shaping our relationship to the soil," 2016). Earthworms and insect larvae burrow through the uppermost soil layers in search of dead plant material, their passages aerate the earth and the pores and passages are able to absorb water like a sponge. Springtails, mites and millipedes degrade plant litter. Microorganisms turn residue from animals and plants into valuable organic matter, whereas bacteria convert organic residues into their chemical constituents, and predatory mites, centipedes, beetles, fungi and bacteria regulate organisms before they can become harmful. It is therefore important to restore soil nutrients as soil nutrients can be lost through many ways such as soil erosion, monoculture, nutrient import, soil reclamation and leaching to mention but a few. Soil fertility replenishment can be achieved through the use of inorganic fertilizers, organic fertilizers or their combination. A number of strategies such as green manuring, compost manure, farm yard manure, liquid manure, nitrogen fixing legumes, fallowing and mineral fertilizers are sources of soil nutrients. The potential benefit of green manures and inorganic fertilizers in cereal production on contrasting soils in eastern and Northern and other parts of Uganda can be achieved through the use of both inorganic fertilizers and Biological Nitrogen Fixation (BNF).

2.1.4 Limiting factors to fertilizer use

Despite the increased rate of soil infertility in Sub Saharan Africa and Uganda in particular, fertilizer use in most farms has been low. According to Zoé Druilhe and Jesús Barreiro-Hurlé 2012, only 3% (7kg/ ha) of global fertilizer is used in Sub Saharan Africa and the low level of fertilizer use is attributed to failure in inputs market, poor price incentive, seasonal and variable production, lack of credit, lack of knowledge and high transport, distribution and storage costs ("Druilhe and Barreiro-Hurlé - Fertilizer subsidies in sub-Saharan Africa.pdf," n.d.). According to Mbowa et all 2015, use of fertilizer in Uganda is very low (at about 1 kg of nutrient per hectare per year) , compared to Kenya (32 Kg/ha); Rwanda (29 kg/ha); and Tanzania (6kg/ha.(Mbowa et al., 2015). According to report by food and agricultural organization, only less than 10% of farmers in Uganda use inorganic fertilizer (an average of 1kg/ ha), this is due to lack of affordability and ignorance about its importance. According to Uganda National Fertilizer Policy 2016, only 1-1.5 kilogram per hectare per year of fertilizer is used in Uganda ("uga172925- Uganda national fertilizer policy 2016.pdf," n.d.). According to Uganda National Fertilize Policy 2016, only less than 10% of farmers in Uganda apply inorganic fertilizer (an average of 1kg/ ha), this is due to lack of affordability, ignorance about their importance and skills in using them. In some instances Smallholder farmers applies little fertilizer due to inefficiencies across the fertilizer value chain meaning that fertilizer is not available in outlets close to the farmer at the time when needed, procurement cost, and the high opportunity cost for the money spent on fertilizer is not available for other urgent needs. However existing recommendations do not allow farmers to maximize net returns on their investment("ISFM-MANUAL_Uganda.pdf," n.d.).On the other hand, constraints limiting the use of organic materials include labor for collecting and applying the materials as in the case of biomass transfer (Ruhigwa et al. 1995), limited quantities and variation in quality of organic materials (Palm et al. 1997), and the demand for crop residues as fuel and fodder (Palm 1995). In the case of green manure or in-situ biomass production, farmers have to sacrifice land by keeping it out of food production (Giller et al. 1997), which they cannot afford especially in areas with high population density(Selvi and Kalpana, 2009). Organic materials are not only frequently in limited supply, where they are used alone, the quantities may not provide the productivity boost needed by the smallholder farmers. Hence a judicious combination of available organic materials with inorganic fertilizers may be an appropriate option(Selvi and Kalpana, 2009).

2.1.5 Maize production constraints in Uganda.

Despite the large proportion of land suitable for Maize production and efforts being made by many development Agencies/ companies such as AFGRI, World food Program, Maize and most staple crops production in Uganda have been low majorly due to low use of improved technologies , soil degradation and inappropriate post-harvest handling. It has been estimated that 4 to 12% of gross domestic product is lost from environmental degradation, 85% of this is from soil erosion, nutrient loss and changes in cropping pattern. Production statistics from the

Food and Agricultural Organization of United Nations (FAO) show that while Uganda's maize output has more than doubled from 0.6 to 1.26 million tonnes over the last 2 decades (1990 & 007), yield declined from about 1.8 tonnes per hectare (t ha1) in 2004 and leveled off to 1990 yield of 1.5 t ha. Comparing farmer average yield (1.5 t ha1) with researcher managed yield (7 t ha1) however, it is clear that there still remains a huge gap between actual and potential maize yield in Uganda. In addition to the above mentioned factors, the current low maize production in Uganda is attributed to poor post-harvest handling, inadequate access to credit and farm inputs, inadequate access to extension services, low labour productivity, land fragmentation, price fluctuation, poor marketing systems and inefficient value addition.

2.1.6 Maize growth requirement

Just like any other broad leaf crop, Maize requires reliable soil nutrient availability. According to Mbowa et all 2015, fertilizer application should be done at the right time when the different nutrients are needed and using the right methods (Mbowa et al., 2015). Maize nitrogen requirement is greatest during flowering, but carry over in to harvest is detrimental. Phosphorus is needed all season long but the ability of roots to extract it is reduced in humid soil conditions. Potassium activates enzymes required for growth which helps prevent disease and control insects and also maintain stalk strength and stand ability. Phosphorus, calcium and magnesium stays where they are placed until that soil zone is disturbed, nitrogen boron and sulphur are vulnerable to leaching from the root zones prior to plant uptake (Balirwa, n.d.). Nitrogen fertilizer can be broadly classified in to four groups depending in chemical form in which the nitrogen is present in them; ammonium, combined ammonium and nitrate, nitrates and amide fertilizers. Other forms of NPK fertilizers include powdered mixed, granular compound and bulk blend.

2.1.7 The effect of fertilizer use in crop production

Fertilizer application has been recognized as a key strategy to achieving soil fertility and improving crop yield worldwide especially when done in an integrated manner (integrated soil fertility management). Mineral fertilizer provides large amount of nutrients such Nitrogen, phosphorus and potassium etc. and so do manures (soil fertility mgt in ug). Meanwhile estimates show that chemical fertilizer can increase agricultural production by 50% (FAO, 1989), on the other hand, other scholars says 50% of applied chemical fertilizer can be recovered in the plant system through nutrient mining and leading to unavailability in the soil. Organic materials holds great promise due to their local availability as source of multiple nutrients and ability to improve soil characteristics (palm et al, 2001) and their long term effects on crop yield. Green manure can provide the same amount of food as chemical fertilizers but with less fossil fuel left in the soil. Growing legumes like Jack bean, Mucuna, lablab, canavalia, etc., then incorporating them into the soil when they are still green improve good amount of soil nutrients. Use of chemical fertilizer alone does not sustain crop productivity under continuous cropping system, where as its integration with organic fertilizers improves the soil physical properties (Benbi et al,. 1998) builds up soil fertility and increase crop yields (Yaduvanshi, 2003).

The morphological characteristics of crops thus depend on the availability of major nutrients in the soil. The soil chemical, physical and biological properties and adds very good quality organic matter as well as N to the soil though the constraints with them is that they are bulky as the nutrients are not concentrated, sometimes their production competes with food production, have limited supply and where they are used alone, the quantities may not provide the productivity boost needed by the smallholder farmers. Studies have shown that combined use of mineral and organic fertilizers is more effective at maintaining high yields and soil fertility status in the long-term than either application of mineral or organic fertilizers alone. Mineral fertilizers release nutrients quickly, thus benefit a growing crop within a relatively short period while organic fertilizers release nutrients more slowly, thus meeting the nutrient requirements of the crop at a later stage of growth. The morphological characteristics of cotton thus depend on the availability of major nutrients in the soil.

2.2 The effect of Jack Bean green manure on growth (height, fresh biomass and root length) of maize

2.2.1 The relevance of use of organic manure

Organic fertilizers are natural fertilizers derived from animal matter, animal excreta (manure), human excreta and vegetable matter human excreta. Forms of organic matter include; compost manure, farm yard manure, green manure, animal liquid tea, plant tea. According to Tejada 2008 and Sinha 2009, usages of inappropriate technologies have to deterioration of soil quality leading to soil organic matter losses and structure degradation, affecting water, air and nutrients flows, and consequently plant growth (Tejada *et al.*, 2008 and Sinha *et al.*, 2009). For this reason, the application of organic matter including green manure to the soils has become a common environmentally important agricultural practice for soil quality restoration, maintaining soil organic matter, reclaiming degraded soils and supplying the plant nutrients (Sinha *et al.*, 2009; Kumar, 2010, (Kumar et al., 2014a). According to Rajeev Pratap Singh, not all types of organic materials are safe for humans and environment due to reported adverse effects of some of them on the environment and human health ("Organic Fertilizer-Type Production and Enivronmental Impact.pdf," n.d.).

2.2.2 The relevance of use of green manure in soil nutrient replenishment

According to CM Cherr et al 2006, green manure is a crop primarily used as soil amendments and nutrient source for subsequent crops (Cherr et al., 2006). Such approaches are complex since they depends on interaction between the green manure, the environment and management. Green manure is applied globally due to their known potential of improving soil fertility and soil structure. According to Rolland Bunch, green manuring is the practice of enriching the soil by turning under fresh plant material either *in situ* or brought from a distance as a widely used practice in organic farming to maintain soil organic matter (Bunch and Canadian Foodgrains Bank, 2012). According to Barthes 2004, green manure application is beneficial in maintaining soil fertility, protecting the soil against erosion, control of weeds such as imperata cylindrical, nut grass and pajablanca due to their aalelopathic activity (Barthès et al., 2004). According to Kumar et al, 2014, plants such as grain legume (pigeon pea, green gram, soybean or ground nut), perennial woody multipurpose legumes trees such as Leucaena leucocephala (Subabul), Gliricidiasepium (Gliricidia or Mata Ratón), Cassia siamea (Kassod tree) or non-grain legumes like sunn hemp (Crotalaria sp), dhaincha (Sesbania spp),Centosemia, Stylosanthes, Desmodium , Sunn hemp (Crotalaria juncea L.), dhaincha (Sesbania aculeata L.), berseem (Trifolium alexandrinum) and mungbean (Vigna radiata) are most commonly grown green manure crops (Kumar et al., 2014b). According to Kayeke, a field experiment was done to determine the effects of green manure (C.ochroleuca, M. invisa and C. obtusifolia) and inorganic fertilizer on striga weed management. The results show decrease in striga weed seed germination, plant heiht, shoots and capsules per plant (Kayeke et al., n.d.).

2.2.3 The effects of green manure on crop performance

According to Rolland Bunch, green manure is a very cost effective soil nutrient supplement that improves crop performance by adding organic matter and recycling nutrients in the soil and preventing nutrients from being washed out of the soil (Bunch and Canadian Foodgrains Bank, 2012). The nutrients are taken up by the green manure and held inside the plant and then when decomposed, can be utilized by crop plants. Legumes and other nitrogen fixing plants which take nitrogen from the air to the soil are particularly beneficial. In order to realize their benefits appropriately, green manure (preferably leguminous ones), should be sown at the beginning of the rainy season and should be incorporated preferably at flowering stage and completely decomposed before sowing the next crop. The benefits of green manuring in crop production are generally interpreted as their capacity to produce or provide nitrogen as substitute for fertilizers. According to Bhuiyan, leguminous green manure have relatively more N, low C-N ratio and behave almost like chemical nitrogenous fertilizers (Bhuiyan and Zaman, 1996), this helps to increase crop yields keeping the use of chemical fertilizers at low level. According to Kumar et al al 2014, higher availability of phosphorus from rock phosphate has been reported in rice due to green manuring (Kumar et al., 2014a).Kumar recommends grain legume such as green gram, soybean or groundnus, and perennial woody multipurpose legume trees such as Leauceniia leucocepphala (Sababul), Gliciricidiasepuim (Gliricidia or Mata Raton), Cassia seimea (Kassod tree) or non legumes like Sunn hemp (Crotalaria sp), Dhiancha (Sesbania sp), Centosemia, Stylosanthes and desmoddiu for use and suggests that green manure should be planted at the beginning of rainy season and should be incorporated preferably at flowering stage and completely should be decomposed completely before sowing the next food crop. According to Selvi and Kalpana, 2009, green manure crops during decomposition release nutrients and recycles nitrogen, phosphorus and potassium in integrated plant nutrients system (Selvi and Kalpana,2009 and Sinha *et al.,* 2009). According to Kumar et al., 2014, green manures improve soil structure, letting more air into the soil and improving drainage and helps sandy soils hold more water and not drain so quickly (Kumar et al., 2014b). The regular use of green manuring results in a high organic matter reserve which enhances both soil chemical and physical properties when compared to control fields. According to Egodawatta *et al* usages of green manures between crop sequences enhances the effectiveness of nutrient recycling, since a regular pruning strategy increases the soil organic matter and other nutrients and improves on soil qualities of cultivated lands and therefore lead to higher crop yields (Egodawatta *et al*., 2011). According to Schumann *et al* green manure help to stop the soil being carried away by wind and rain and facilitates roots penetration in the soil and hold it in place and helps reclaim land from effects of monoculture such as hard pans, decreased water holding capacity, surface compaction, runoff, (Schumann *et al.*, 2000). Acoording to Blackshaw *et al.,* 2001, green manure has the ability to suppress weeds (Blackshaw *et al.,* 2001) and enriches diversity of the rotation and reduces the opportunities for weeds to become adapted to a particular cropping pattern (Kumar et al., 2014b). Accoding to Boydston and Hang some green manures also secrete specific chemicals into the soil (both during their life and after incorporation) that inhibit weed seed germination, this 'allelopathic effect' is demonstrated by many clovers but also non-legumes including rye (Boydston and Hang, 1995). Bare soil can become quickly overgrown with weeds which can be difficult to remove, therefore green manures cover the ground well and stop weeds growing beneath them, by competing for nutrients, space and light(Kumar et al., 2014b).

According to Eriksen , 2005, the application of green manures to soil is considered as a good management practice in any agricultural production system because it stimulates soil microbial growth and activity, with subsequent mineralization of plant nutrients (Eriksen, 2005), and therefore increase soil fertility and quality (Doran *et al.*, 1988). (Kumar et al., 2014a). According to Chaiwong et al, benefits to rice yields from green leaf manuring with effectively nodulated S. rostrata were observed at the International Institute of Tropical Agriculture in NWaaria when the legume was intercropped with rice (Mulongoy I '6)o S. rostrata. The closer spacing produced higher legume yields. The legume provided a total of 3-4 Mg/ha dry matter (120140 kg/ha N), which was distributed to the soil surface around the rice plants(Chaiwong et al., 2012).

2.2.4 Potentials of green manure on crop performance

According to a research done in Brazil on one of farmers field by the University of Exeter, United kingdom in 1990, Mucuna beans can produce up to 35 tons of organic matter per hectare and is able to fix about 150kgs of nitrogen per acre therefore capable of increasing crop yields (Poku et al., 2014). In 1999, a research done in Brazil also showed yield increase in different crops as follows; soy beans 83%, wheat 82% and maize 47%. Another research done in

Guatemala on yield response to Mucuna bean used as green manure showed double increase in maize yields from 500kgs/ hectare to 2000kgs/ hectare.

Another research done by the national organic Agricultural movement of Uganda (NOGAMU) in Omoro district to assess the effect of Mucuna green manure on the performance of maize in Lakwana sub county in Omoro District revealed significant differences in terms of the chemical soil properties in which plots denoted with Mucuna had relatively better soil properties in terms of Nitrogen and organic matter and to some extent improved cation exchange capacity, rapid /early reproductive growth of plants as compared to plots donated as control and better yield that outweighed control sides by 15.3% (NOGAMU report 2010).

According to Adediran *etal*., 2004 and (Shave et al., 2012) Mucuna biomass when incorporated into the soil, in combination with application of minimal dose of other fertilizers can lead to higher effects on crop performance than when Mucuna is solely incorporated into the soil Adediran *etal*., 2004 and Shave et al., 2012) (Adediran *etal*., 2004 and Shave et al., 2012) and therefore suggested that Mucuna and other fertilizer application could complement each other in improving soil fertility and increasing crop yields. According to Shave et al., 2012, Mureithi *et al*., 2000 and Avav *et al*., 2008, intercropping of *Mucuna* also helps in suppressing weeds (Mureithi *et al*., 2000; Avav *et al*., 2008 (Shave et al., 2012).

2.2.5 The effects of different rates of fertilizers on crop performance

Crops perform differently with the different rates of fertilizers application. This was evident by many studies whose results showed positive effects on either morphological characteristics or yields of crops. According to El Hage, 2012, a field experiment was laid out to assess the yield Performance of cotton under ten fertilizer (NPK) treatments during 1997, 1998 and 1999 crop seasons, averagely, highest seed cotton yield of 2434 kg haG1 was obtained when the crop was fertilized with 75, 50 and 50 kg haG1 of N, P and K respectively followed by 100 nitrogen, 50 phosphorus and 50 potash kg haG1 where seed cotton yield of 2403 kg haG1 was obtained, the lowest yield of 1053 kg haG1 was produced from the control plot where no chemical fertilization was applied and the results revealed that balance use of nutrient elements are essential for harvesting better yields (El Hage, 2012).

According to School of Agriculture Science & Biotechnology, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin (UniSZA, that conducted a study in 2014 to April, 2015 to assess the effects of different application rates of NPK (150 kg ha-1, 170 kg ha-1, 190 kg ha-1 and 210 kg ha-1) on growth, yield and quality of okra, the results obtained show NPK at the rates of 190 kg ha-1 and 210 kg ha-1 with highest growth and yield performance, followed by application of 170 kg ha-1 and 150 kg NPK/ha-1 in decreasing manner and no application of NPK showed the lowest growth and yield response. (School of Agriculture Science & Biotechnology, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200 Besut, Terengganu, Malaysia et al., 2017).

2.3 Effect of Jack bean green manure on crop yield

2.3.1 The effects of different rates of fertilizers on crop yield

Different rates of fertilizers also either affect the performances of crops negatively or positively. Excessive nitrogen especially in humid condition can lead to delay in crop maturity, defoliation excessive vegetative growth leading to shading of lower fruiting positions contributing to boll shed, boll rot, delayed opening and immature fiber, and thus severely decreases yield and quality. According to Faculty of Agriculture, Omdurman Islamic University, Sudan a field experiment was conducted for two consecutive seasons in 2004/2005 and 2005/2006 at the demonstration to investigate the effect of different nitrogen sources on growth, yield and quality of fodder maize (*Zea mays* L.). The nitrogen sources were urea, nitrophoska (NPK), ammonium sulphate nitrate (ASN) and ammonium sulphate (AS). Number of days to 50% tasseling, forage yield, crude protein and crude fiber were also investigated in this study. The results revealed that nitrogen sources significantly affected growth parameters at all sampling occasions during the two seasons. Remarkable results noticed that nitrogen sources ASN followed by NPK and the AS, as compared with urea performed better. The results showed that, the number of the days for 50% tasseling, fresh forage yield and dry forage yield were significantly affected by nitrogen sources during two seasons. Moreover, dry and fresh forage yield, increased progressively by ASN and NPK as compared with other nitrogen sources. The data revealed that, the crude protein and crude fiber were significantly affected by nitrogen sources in both seasons. The urea gave the lowest crude protein compared with the other nitrogen sources. On the other hand, the lowest crude fiber content was recorded when plant was treated with (ASN) fertilizer, while the highest crude fiber content was recorded only under the control.

According to School of Agriculture Science & Biotechnology, Faculty of Bioresources and Food Industry, Universiti Sulta, a field experiment was carried out to examine the effect of the combination of varying levels of neem (100%, 75% and 50% concentration), cypermethrin (350 ml and 250 ml), poultry manure (6000 kg and 8000 kg) and NPK fertilizer (112 kg and 83 kg) on the growth, yield and yield component of okra. The results show significant effects of combined application of 100% neem, 350 ml/ha cypermethrin, 8000 kg/ha poultry manure and 112 kg/ha NPK fertilizer reduced pest population compared to the control plot. The combination of 50% neem, 350 ml/ha cypermethrin, 6000 kg/ha poultry manure and 112 Kg/ha NPK fertilizer produced the best yield in the numbers and weight of okra fruits. It was concluded that the Combined application of pesticides and fertilizer resulted in the control of pest population and significantly P= 0.05 increased the soil fertility and yield of okra planted on Oxic Paleustalf (School of Agriculture Science & Biotechnology, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200 Besut, Terengganu, Malaysia et al., 2017).

A study conducted in Murang'a County Kandara Sub-County in Kenya to determine the effects of applying different nutrients on growth and yield of maize showed that control, PK and NK treatment had significant result ($p<0.05$) for leaf number and bio-volume during the 2 cropping seasons mean while NK and PK showed significant differences ($p<0.05$) for grains and stover yield during the two cropping seasons and therefore concluded that absence of N and P nutrients significantly affects maize leaf number and bio-volume and eventually influenced the grain yield.(maize research in Kenya). According to the department of entomology Bangladesh Agricultural University An assessment was done at three cotton research farms located in Jagadishpur, Jessore, Sadarpur, Dinajpur and Gazipur between 2012- 2013 to determine the effect of poultry manure combined with NPK fertilizers on cotton yield and yield contributing characters was conducted The main effects of NPK and location effects were found significant for vegetative branch, fruiting branch, plant height at harvest, boll number and seed cotton yield.

While the application of poultry manure contributed to significant yield and yield contributing characters. But the yield of cotton decreased with increase in poultry manure

2.3.2 Comparison between green manure and other nutrient sources on crop yield

Organic materials holds great promise due to their local availability as sources of multiple nutrient sources and ability to improve soil characteristics (Kumar et al., 2014b). (palm et al., 2001) and therefore have long term effects on crop yield. According to Chaiwong et al., 2012, green manure can provide the same amount of soil nutrients as inorganic fertilizers but with less fossil fuel(Chaiwong et al., 2012). While Benbi et al., 1998 confirmed that the integration of organic and inorganic fertilizers improves soil physical properties. (Benbi et al., 1998), builds up soil fertility and increase crops yield (Yaduvanshi. 2003) and enhance balanced soil nutrients that can facilitate high yield in cotton production and thus can boost agricultural productivity and reduce environmental degradation (Smaling et al., 2006). However, other scholars believe that 50% of applied chemical fertilizers can be recovered in the plant systems through nutrient mining hence leading to their unavailability in the soil and also contains ruminants of fossil fuels (Thilakarathna and Raizada, 2015). Therefore, their usage alone does not sustain productivity under continuous cropping system. Whereas experience from many parts of the world confirms that derived Mucuna green manure is beneficial in maintaining soil fertility, protecting the soil against erosion, control of weeds such as Imperata cylindrical, nut grass and pajablanca (Barthès et al., 2004). (Arun K Shama) due to its allopathic activity (Glismen 1981) and these makes it a sustainable nutrient replenishment measure.

Many Researchers have shown that neither mineral fertilizers nor organic manures are a panacea for soil fertility management in Nigeria. This has led to the innovation of organ mineral fertilizer which combines the attribute of both mineral and organic fertilizers. Field experiments were conducted in 2011 and 2012 to compare the effect of industrial manufactured organic (OG) fertilizer and organomineral fertilizer (OMF) at the rate of 0, 2.5 and 10t/ha; and NPK 15:15:15 fertilizer (NPK) at the rate of 300kg/ha on soil chemical properties, nutrient uptake, growth and yield of maize in Ondo, Southwestern Nigeria. Compared with control, OG, OMF and NPK fertilizers significantly increased plant N,P, K, Ca, Cu, Fe, Zn and Mn. Also compared with control, Organic fertilizer (OM), Organomineral fertilizer (OMF) and NPK 15:15:15 fertilizer at all rates significantly increased maize plant height, number of leaves, leaf area, Stover yield, root dry matter and grain yield. The percent increases in cumulative grain yield were 5t/ha OMF (68.31), 2.5t/ha OMF (60.21), 10t/ha OMF (38.72), 10t/ha OG (49.65) 300kg/ha NPK (12.13), 5t/ha OG (9.51), 2.5t/ha OG (5.63) compared with control. Organic and organomineral fertilizers at low level of application could be used to increase plant nutrients as well as maize production in south western Nigeria(“organic npk.docx,” n.d.). Field experiments were conducted during the 2010 and 2011 growing seasons at the University of Education, Winneba, Mampong-Ashanti campus, located in the forest-savanna transitional zone of Ghana to evaluate the effect of munca green manure, NPK, and chicken manure on performance of carrot showed that the application of *Mucuna pruriens* green manure, chicken manure or their integrated combinations used as amendments increase soil organic matter content as well as increase in soil nutrients such as P and K, total N and ECEC and therefore promoted plant growth and improved yield of carrot compared to no form of amendment. With the yield components, the sole *Mucuna pruriens* green manure and chicken manure performed better in terms of carrot root length and root girth (diameter) in 2010 season, while the combination of chicken manure and *Mucuna pruriens* recorded the highest root length in 2011 season. In respect of the improvement in soil physical and chemical conditions, plant growth and yield of the crop, the study therefore recommended for further or extensive evaluation on farmers’ fields for possible adoption (Poku et al., 2014).

Just like the benefits provided by the above literatures, jack bean green manure is capable of increasing maize and other crops yield due to its capacity to recycle nutrients, improve soil chemical and physical properties , protect soil from erosional factors, weed management by suppressing weeds and pest and diseases management by creating unfavorable conditions for pests (“jack bean green manure benefits.pdf,” n.d.) Just like my experiment that had plots with jack bean green manure application have less weeds, and better yields and yield contributing parameters

2.4 The merits and demerits associated with using jack bean green manure in maize production

Soil fertility replenishment can be achieved through a number of strategies including the use of inorganic fertilizers, organic fertilizers or their combination though the sustainability aspects in terms of economic, environmental, ecological and financial benefits matters the more. According to Cherr et al, green manure approaches may improve economic viability while reducing the environmental impacts of agriculture(Cherr et al., 2006). The potential benefit of green manures and inorganic fertilizers in cereal production on contrasting soils in Uganda can be achieved through the use of both inorganic fertilizers and Biological Nitrogen Fixation (BNF). Unfortunately, social and economic factors do not favour the use of inorganic fertilizers by the smallholder farmers. In sub–Saharan Africa, inorganic fertilizers cost two to six times as much as those in Europe (Bumb and Baanante 1996; Sanchez 2002) mainly due to transport costs, and other charges (Vlek 1990)(El Hage, 2012). In addition, the profitability of fertilizer use is highly variable and dependent on agro-climatic and economic conditions at local and regional levels (Vlek 1990). Most farmers do not have access to credit, and the returns to fertilizers are low and variable (Badiane and Delgado 1995; Heisley and Mwangi 1996). Inorganic fertilizers are mainly used on cash crops such as tobacco, tea, and sugarcane, which can be marketed on a profitable basis (Vlek 1990). In addition, farmers are not aware of the forms of fertilizers, methods of their use and the potential benefits accruing from their use (Bekunda et al. 1997).

According to Barthes et al, green manure is thus a viable low cost technology for enhancing agricultural productivity as its well known in weed suppression(Barthès et al., 2004). It also enhances the availability of nitrogen and other nutrients such as potassium and phosphorus (Barthès et al., 2004). Most types of green manure species can also fix nitrogen with help of nitrogen fixing bacteria and therefore can increase soil nitrogen levels by approximately 459kg per acre. (Cherr et al., 2006). Mucuna beans, Lablab, beans, alfafa, soybeans and peas among others are known for improving soil fertility and soil physical properties (Brar et al., 2015).

According to Ladha et al 1992, Whitbread et al 2000, Ray and Gupta 2001, Aulakh et al., 2001, Ladha et al., 2000, Puget and Drinkwater 2001), jack been green manure just like any other green manure performs all the above functions such as sol nutrient recycling, weed management, pest control, soil structure improvement, crop yield improvement and therefore, achieving higher economic, environmental and ecological gains (“jack bean green manure benefits.pdf,” n.d.). According to Kayeke, green manure can help in weed management and therefore reduce on the use of herbicides (Kayeke et al., n.d.). By providing affordable nutrient supplement, reduction of cost on herbicides and yield improvement, jack bean green manure is considered economical soil nutrient replenishment strategy except the time value of land and labour intensity that makes it somehow costly as noticed my research

CHAPTER THREE

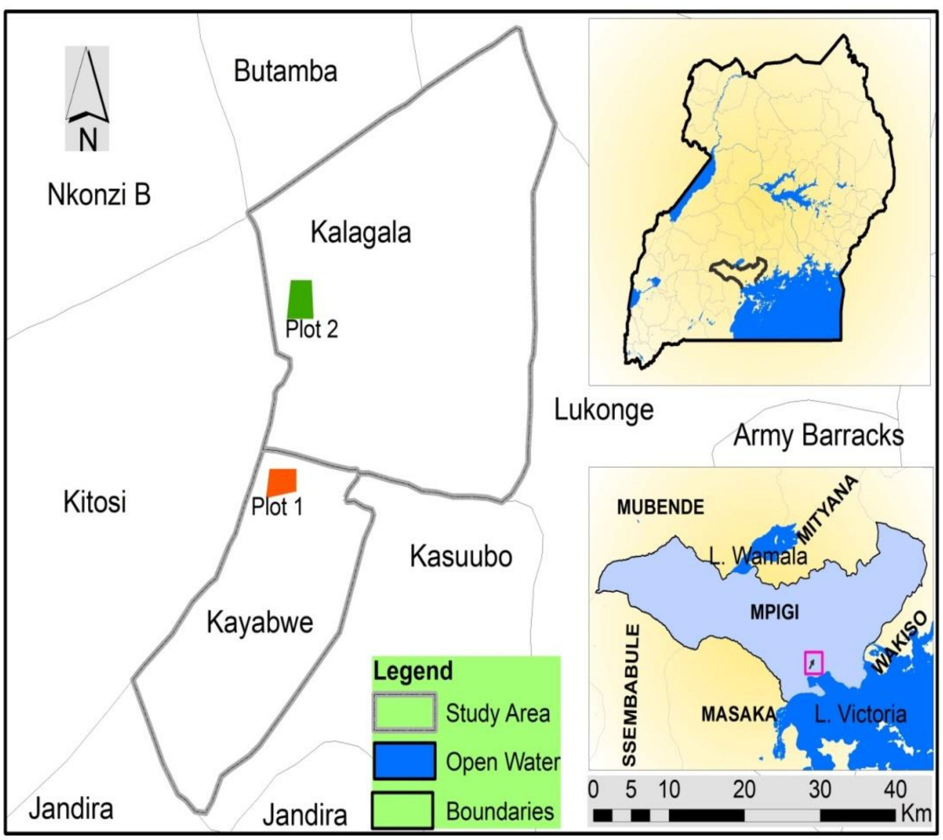
MATERIALS AND METHODS

3.0 Introduction

This chapter contains the methods and materials that were used ; and this include; the research design, study area characteristics, experimental lay out, study population, sampling procedures, data collection methods and instruments, quality control methods, data management and processing, data analysis and hypothesis testing, , ethical considerations and limitation of the study.

3.1 Study area characteristics (soil, Temperature, Rainfall and location)

Figure 2 Map of Uganda and Magnified study area (UBOS 2017)



The study was conducted in Mpigi district, Nkozi Sub County, Karagara and Equator Valley farm, located about 2.5 and 5 kilometers from Kayabwe Masaka highway respectively. The places are bordered from the north by Butamba from the south by Kayabwe, from the east by Lukonge and from the west by Kitosi. The study area is located at 32º East and almost at the equator. The study area receives moderate rainfall and temperature. Major crops grown include maize, banana, cassava, groundnuts and sweet potatoes(“A_look_at_the_Uganda_Martyrs_University.pdf,” n.d.).

3 .2 Research Design and treatments

The study used randomized complete block design (RCBD) with four treatments: Control (CTRL), jack bean planted and incorporated on the same land (JBW), Jack bean grown elsewhere and brought (imported) to the experimental sites (JBI) and NPK fertilizer used for comparison purpose. These treatments were replicated three times. Both fields measured 27*21m (567 m2) and were divided in to 12 plots

3.3 Experimental set up

The study was conducted in two locations, Equator Valley Farm (experiment one) and Kalagala (Experiment two).

3.3.1 Soil sampling

Baseline sampling was done at both sites in October 2018 before planting Jack Bean to establish the soil fertility status of the two sites, and another sampling was in march 2019 (two weeks after incorporating Jack bean green manure at the time of planting maize). The samples were properly labeled, air dried to and later taken to the Soil, Plant and Water analytical Laboratory-Makerere University for physical and chemical analysis

3.3.2 Field establishment and management

The lands at both sites were prepared using hand hoes. The experimental sites were demarcated into twelve 5*5m plots (four treatments times’ three replicates). Jack Bean was planted in three of the twelve plots in mid-November 2018 and left to grow until mid-march when it was cut/ chopped in to small pieces, quantified and 35kg of fresh biomass was incorporated in each plot.

The imported Jack bean biomass was equally cut, quantified (35kg) and incorporated in another three plots. Planting of maize at spacing of 75*30cm took place two weeks after incorporating the jack bean biomass. Basal application of NPK was done at the rate of one bottle top per hole as used by farmers and then covered with soil before placing the maize seeds. All other agronomic practices factors including weeding, pest spraying and irrigation were done as recommended.

3.4 Study materials

The study used the following materials;

- Maize seed; The experiment used Longe V Maize variety which was got from Equator seeds company Limited while the jack bean seed was got from one of the shops in Containers village in Kampala
- Jack Bean seeds and NPK sources of nutrients
- Planting string
- Tape measure for taking measurements
- Hoes, pangas and axes for land preparation
- Sealed paper for plants identification
- Weighing scale
- bags for harvesting and storing Maize
- Papers and pens for recording data
- Computer for analyzing and storing data

3.5 Study population

Each study site had twelve 5*5m plots, and each plot had 96 plants at a spacing of 75cm by 30cm

3.7 Sampling procedures

3.7.1 Sample size

For both experiments, 5 per plot were sampled for height, 5 per plot for root length and fresh biomass and 5 plants for total dry matter, cob weight and grain weight. All the sampled plants were tagged for easy identification during data collection.

3.7.2 Sampling techniques

The study used systematic sampling in which the sampling was done at interval of 19 plants for the first variable (plant height). The interval reduced as the population also kept reducing since other variable (root length, and fresh biomass) led to elimination of the sampled plants after recording the data. In other words, the total population was divided by the sample size in order to get the interval of sampling

3.8 Data collection and instruments

Data collection sheet had provision for collecting data for all the variables. Data were collected on Plant height beginning from week two up to week eight from planting, root length and fresh biomass at tasselling stage, total dry matter, cob weight and grain weight at harvest. Fresh biomass weight, total dry matter weight, cob weight and grain weight were measured by use of a digital weighing scale to determine their weights, whereas root for length and plant height, linear measurements were taken using metallic tape measure. For the third objective (merits and demerits of jack been green manure in maize production), the inputs, weeding and labour costs were recorded and also field observations especially on weed infestation rate was also done.

3.9 Quality control methods

All the plots were visibly labeled and all the sampled plants in each plot were tagged. Data for experiment were separated from the data for experiment two to avoid mix up of information

3.9 Data management and processing

Data were collected in raw form, filed and entered in a designed excel sheet. Root length data were reduced to a unified data set by measuring five roots and getting their averages in order to make it match the data arrangement for other variables in order to form uniform data set arrangement for analysis

3.10 Data analysis

Genstat was used to determine the ESE, SED, CV%, LSD and Fpr. SPSS was used to determine the correlation between variables and excel was used to make the graphical presentations of the data. The correlation analysis and ANOVA (collection of statistical model) produced results from which the hypothesis was tested

3.10 Hypothesis testing

The statistical results were used to test the null hypothesis (application of Jack bean green manure cannot have effect on Maize yield) in which confidence level of 95% (that is p value = 0.05 and below represented significant results) was taken

3.11 Quality control

3.11.1 Reliability

The study made sure that the assessment tool produced stable and constant result;

- Uniform data collection tool across all treatments.
- Data collection on parameters took place in all plots at the same time.
- Replicates in blocks were labeled.
- Sampled plants were marked with marker pens and tagged using sealed papers which had their respective numbers (1-5) per plot in order to do observation on the required plants consistently.

3.11.2 Validity

- For repeated data collection (on height), recording were done on the same plants sampled except for dry matter biomass, root length, fresh biomass, cob weight and grain weight whose data were taken once
- Two weeks after planting maize, the data collection commenced and data were compiled filed and entered as soon as possible to minimize risk associated with data loss later stage. Observations from the same sampled plants were done for plant height.
- Calibrated and digital weighing scale was used to weigh the fresh and dry biomass, total dry matter of Maize and all weights less than 1kg were taken care of easily.

3.12 Ethical consideration

The study was carried out while taking human dignity and promoted self-respect.

3.12.1 Honesty and integrity

Data were collected entered and kept the way it was got from the field without manipulation even one unexpected results were seen, for example I expected root length to be longer in plots the had NPK and jack but, but the reverse was true during data collection

3.12.2 Informed consent

Permission to carry out the study was got from the host (faculty of Agriculture Uganda Martyrs University) before carrying out the experiment

3.12.3 Plagiarism

The study never copied peoples work but made appropriate citations where necessary.

3.12.3 Environmental safety

Considering the perspective of both economic and ecological benefits to farmers/host, both fertilizers and pesticides was judiciously used, appropriate rates and this minimized negative effects of their usage on the soil and human health. The empty bottles of pesticides were disposed appropriately.

3.13 Limitations of the study and how to overcome them

The following were some of the limitations that were experienced during the study

- Inadequate finance to facilitate the research processes, though used my personal finance or borrowed money to bridge the gap, the research was abit costly in terms of input acquisition, transport cost, accommodation and payment of research assistants especially during field establishment an data collection
- Weather changes especially drought affected the plants growth, the first planted Jack Bean failed to germinate and even after second planting, I had to buy water and do simple irrigation
- Stray animal within EVF also affected the maize
- Pest infestation (Army worm) was also experienced at early stage after emergence of the maize plants
- Change in work place also affected some of the research variables , this required me to train and recruit research assistant though it was be quiet expensive

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter contains the results of the study following the objectives as stipulated in chapter one.

4.1 Results presentation

This section contains the soil analysis results and results of other findings which are in line with the specific objectives of the study.

4.1.1 Soil analysis results

A number of soil properties were analysed including soil pH, total nitrogen, available phosphorus; organic matter, exchangeable cation, (Potassium (K), sodium (Na), Calcium (Ca), Magnesium (Mg), soil texture and Cation exchange capacity (CEC) and the results are shown in the table below

Table 1 Soil analysis results for soil samples taken from the two experimental sites (Equator Valley Farm and Kalagala Farm)

Equator Valley Farm

Date of sampling	**Treatments**	**pH**	**O.M**	**N**	**Av.P**	**K**	**Na**	**Ca**	**Mg**	**Textural %ages**			**CEC**
			%ages		**mg/kg**	**Cmoles/kg**				**sand**	**Clay**	**silt**	**Cmoles/kg**
20. 10.2018	Start of study	6.13	1.42	0.08	14.40	0.42	0.253	7.54	1.23	64	30	6	7.89
30.3.2019	CTRL,	5.64	1.06	0.06	18.94	0.42	0.28	6.67	1.20	70	24	6	7.12
30.3.2019	JBI	6.12	1.95	0.11	27.30	0.63	0.322	7.44	0.98	56	32	12	8.41
30.3.2019	JBW	6.29	2.66	0.1	31.38	0.71	0.391	7.76	1.24	64	30	6	9.65

Kalagala Farm

0	Start of study	6.07	1.49	0.09	4.43	0.62	0.37	7.43	1.03	46	46	8	8.44
30.3.2019	CTRL,	5.46	1.77	0.10	5.04	0.28	0.23	6.65	1.02	50	44	6	6.94
30.3.2019	JBI,	5.47	2.13	0.12	5.31	0.39	0.276	6.55	0.89	44	44	12	7.56
30.3.2019	JBW,	5.74	3.30	0.19	5.01	0.42	0.253	7.04	1.05	46	44	10	7.19

As seen in the above table the pH increased from 6.13 from the start of the study to 6.29 in JBW, and from 6.07 to 5.74, organic matter increased from 1.42 to 2.66 in JBW plot, and from 1.49 to 3.30 in JBW plot , nitrogen increased from 0.08 to 1.5 and from 0.09 to 0.19 in JBW plot, Available phosphorous (Avp) increased from 14.40 to 31.8 and from 4.43 to 5.01 in JBW and cation exchange capacity increased from 7.89 to 9.6 and 8.44 to 7.19 in JBW for experiments one and two respectively. Therefore the above statistics confirm that application of jack bean green manure improves on the physical and chemical properties of the soil more especially when planted and incorporated in the same piece of land. The study results on soil physical and chemical properties improvements were confirmed by Meena in his study in 2018 whose research results found out that green manure adds organic acids, adds around 50-60KG Nitrogen per hectare, reduces the leaching losses of Nitrogen and increases soil organic matter (Meena et al., 2018).

4.2 The effect of Jack Bean green Manure on growth (height, fresh biomass and root length) of Maize

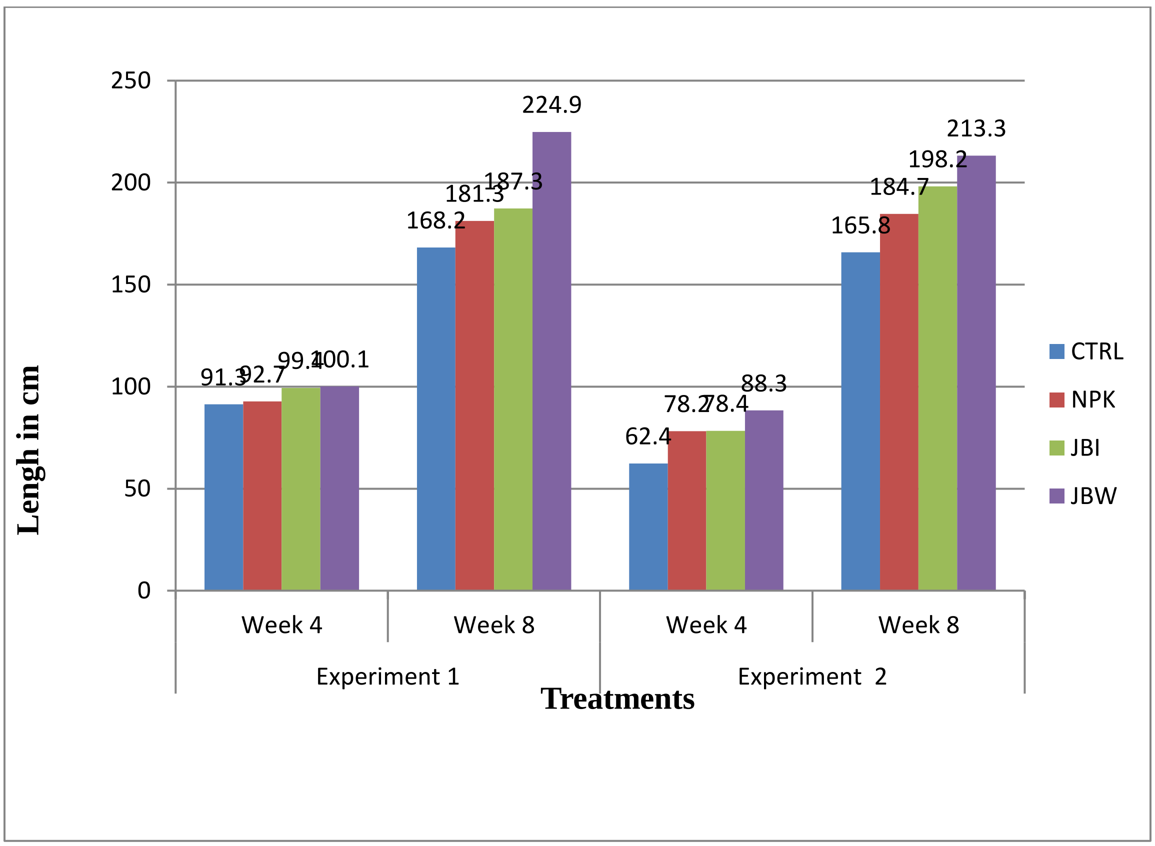
This was the first objective of the study and the results are presented in the table below.

Table 2 Mean plant height (in cm) for experiments one and two at 4 and 8 week after planting

Treatments	**Experiment 1**		**Experiment 2**	
	Week 4	Week 8	Week 4	Week 8
CTRL	91.3	168.2	62.4	165.8
NPK	92.7	181.3	78.2	184.7
JBI	99.4	187.3	78.4	198.2
JBW	100.1	224.9	88.3	213.3
ESE	42.25	7.8	3.55	5.93
SED	6.01	11.3	5.02	8.39
LSD	12.05	22.11	10.06	16.83
c.v%	1.9	1.7	1.2	1.9
Fpr	0.010	<0.001	<0.001	<0.001

For both experiments one and two, Maize mean Plant height show highly significant results for both 4th and 8th weeks as indicated by the fpr (test value) of P≤0.001, LSD (Leas Significant Difference), SED (standard errors difference of means), ESE (treatment effects) and CV% (stratum standard errors and coefficient of variation). Quantitative results show highest mean Plant height of 224.9 cm in JBW plot, followed by plots with JBI with 187.3cm, then NPK with 181.3cm and finally plots with no treatment with 168.2. Similarly experiment two registered highest mean plant height in JBW registered of 213.3cm, followed by plots with JBI of 198.2, and then NPK with 184.7 and finally plots with no treatment with 165.8. This could have been due to the effect of fertilizer nutrients on plants when different fertilizers were applied to maize. The above findings are supported by Zafar (1996) who also reported significant effect of NPK sources on plant height (Mumtaz et al., 2014). Increase in plant height with increase in nitrogen rate was also observed by Ashfaq, Khan *et al* and Maqsood *et al.*

Figure 3 Plant height (in cm) for experiments one and two at week 4 and 8



Source: primary data

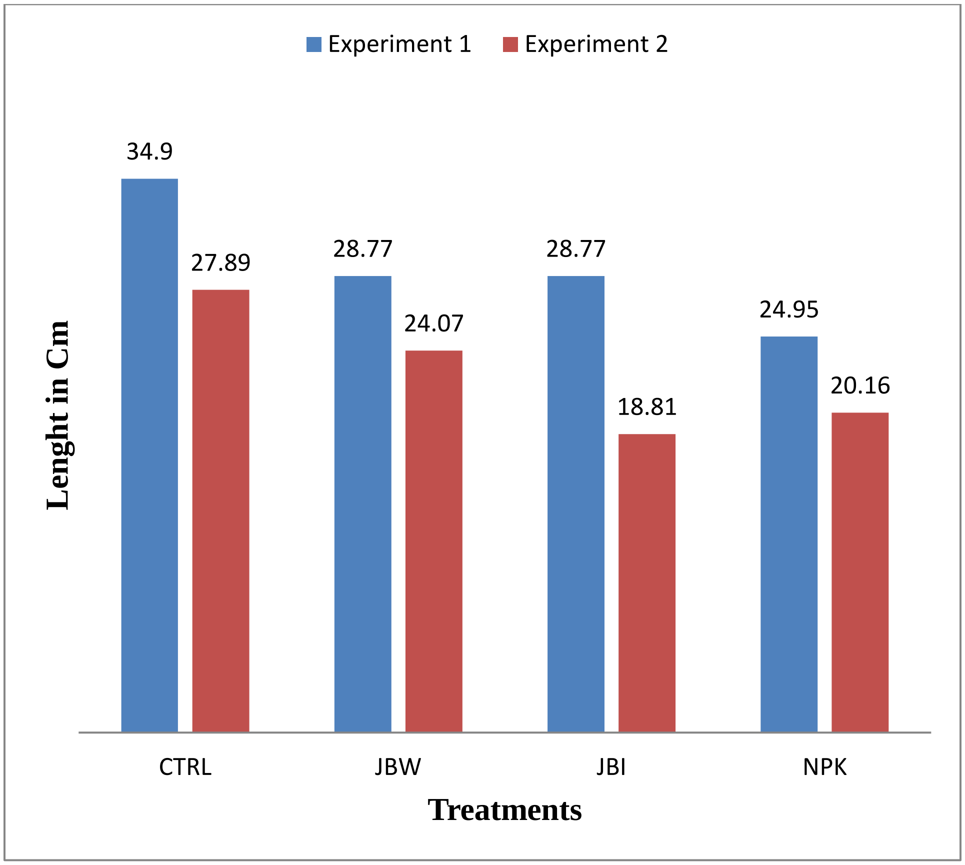
Table 3: Mean fresh biomass (in kg) at tassel ling stage

Treatments	Experiment 1	Experiment 2
NPK	2.57	1.87
JBW	2.17	1.42
JBI	1.70	1.44
CTRL	1.53	1.29
ESE	0.12	0.09
SED	0.02	0.12
LSD	0.41	0.25
c.v%	4.3	9.5
Fpr	<0.001	<0.001

Source: primary data

As seen in the 3 table above, both experiments one and two show highly significant results for Maize mean Plant fresh biomass as indicated by the fpr value of P≤0.001, Leas Significant Difference, SED, ESE and Cv%. Quantitatively, NPK plot had highest fresh biomass of 2.573kg followed by JBW with 2.173gk, then JBI with 1.707kg and Control with 1.533kg for experiment one, while for experiment two, JBW had the highest kilogram of mean fresh biomass of 1.8kg, followed by NPK with 1.449kg then JBI with 01.42kg and Control with 1.299kg. The assumption is that NPK have the capacity to promote high vegetative growth than other treatments may be due to its very high ability to dissolve in the soil faster than the rate at which the jack bean manure could decompose and avail plant nutrients. This result is supported by Salahin Nazmus who found out that Sesbanian aculeate species green manure can produce good amount of fresh biomass, aids nutrient recycling and improves on crop yield (Salahin et al., n.d.).

Figure 4 Root length (in cm) at tasselling



Source: primary data

As seen in the table 7 above, Control plot with longest mean root length of 34.9cm followed by JBW &JBI with the same length of 28.77cm and NPK 24.95cm for experiment one, similarly experiment two had longest mean root length in Control plot with 27.89cm, followed by JBW with 24.07cm then NPK with 20.16 and lastly JBI with 18.81. During data collection in both experimental sites, plots that had no fertilizer application at all had fewer and longer roots, the assumption here is that longer and fewer roots signifies nutrient in availability close to the rooting zones so plants try to extent their roots to get nutrients and moisture from farther distance, whereas Plots that had NPK and Jack bean had more and moderate roots.

4.3 The effect of Jack bean green Manure on Maize yield (total dry biomass, cob weight and grain weight)

This was the second objective of the research study; the results of yields are discussed and presented and in Tables and or figures below;

Table 3 Mean total dry biomass (in kg) at tasselling

Treatments	**Experiment 1**	**Experiment 2**
CTRL	0.385	0.35
NPK	0.5	0.54
JBI	0.59	0.60
JBW	0.659	0.78
ESE	0.03	0.34
SED	0.04	0.04
LSD	0.10	0.10
Cv%	3.5	11.5
Fpr	<0.001	<0.001

Source: primary data

As seen in table 3 above, total dry matter for both experiments had highly significant results as indicated by the fpr value of P≤0.001, Leas Significant Difference, SED, ESE and Cv%. Quantitatively, experiment one had highest total dry matter in JBW plot of 0.659kg, followed by JBI with 0.59kg, then NPK with 0.5kgand lowest in control plot (CTRL) with 0.38kg. Similarly, experiment two had highest total dry matter in JBW plot of 0.777, followed by JBI with 0.609, then NPK 0.545 with and lowest in control plot (CTRL) with 0.351.

Table 4 Mean cob weigh (in kg) at harvest

Treatments	**Experiment 1**	**Experiment 2**
CTRL	0.17	0.18
NPK	0.23	0.23
JBI	0.32	0.26
JBW	0.32	0.31
ESE	0.05	0.17
SED	0.04	0.24
LSD	0.03	0.49
Cv%	3.4	39.8
Fpr	<0.001	0.029

Source: Primary data

As seen in the table above, experiment one had more and the same cob weight for JBW and JBI of 0.32kg, followed by NPK with 0.23kg and least in control plot with 0.17kg. Meanwhile for experiment two, cob weight was highest in JBW with 0.31, followed by JBI with 0.26, then NPK with 0.23 and lastly control plot with 0.18. In terms of levels of significance, the results for experiment two had highly significant results as indicated by the fpr values, LSD, ESE and SED in table 4 above.

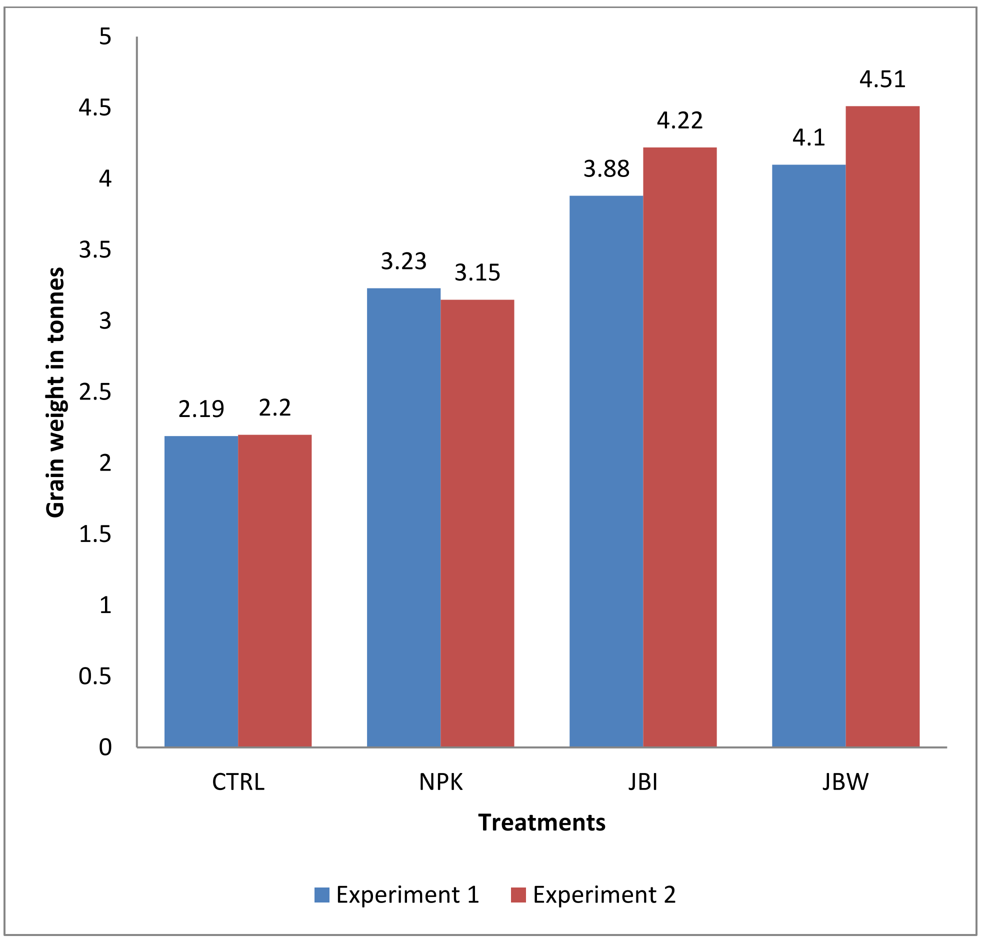
Table 5 Mean grain yield (tonnes) at harvest

Treatments	Experiment 1	Experiment 2
CTRL	2.19	2.20
NPK	3.23	3.15
JBI	3.88	4.22
JBW	4.10	4.51
ESE	0.29	0.26
SED	0.42	0.36
LSD	0.84	0.73
Cv%	9.9	9.9
Fpr	<0.001	<0.001

Source: primary data

The above table show very high significant results of fpr value of <0.001 for grain weight for both experiments. In terms of figure, experiment one had more grain weight of 4.10ha-1 in JBW plot of, followed by plot with JBI with3.88 and then NPK with 3.23 and lastly 2.19in control plot; meanwhile experiment two had JBW with highest grain weight of 4.51 ha, followed by NPK with 4.22, then JBI with 3.15 t ha-1 and lastly 2.20 in control plots. The above yield differences could have been realized because of the effects of the fertilizers applied as green manure and NPK. Increase in morphological characteristics of maize increased yields, larger leaf area for example encourages photosynthesis and enables plants to produce enough food for its maintenance and development. The higher the leaf area, the more the rate of photosynthesis and the healthier the plants (Mumtaz et al., 2014).

Figure 5 Maize grain weight yield (in tonnes) for both experiments 1 and 2



Source: primary data

The Analysis of variance tables 6 and 7 below summarizes the yield significance results previously discussed above and the d.f, s.s , ms, v.r and Fpr all show highly significant results for maize grain weight for both experiments one and two.

Table 6 **Analysis of variance for grain weight for experiment 1**

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK_N0 stratum	2	4.423	2.211	1.65	
TREATMENT	3	32.861	10.954	8.17	<.001

Table 7 Analysis of variance for grain weight for experiment 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	4.855	2.428	2.39	
TREATMENT	3	50.160	16.720	16.48	<.001

The table 8 below show very strong relationship between root length and fresh biomass of P value of 0.003, height and total dry matter of 0.001, height and cob weight of 0.001, grain weight and cob weight of 0.000, total dry matter and cob weigh 0.000, height and cob weight of 0.01 and grain weight and cob weight of 0.000

Table 8 Correlation descriptive statistics of variables: experiment one

Variables	1	2	3	4	5	6
1. Root length	–					
2. Height	-.102	–				
3. Total dry matter	-.221	.424**	–			
4. Fresh biomass	-.379**	-.006	.184	–		
5. Grain weigh	- .175	.335**	.242	.054	–	
6. Cob weight	-.174	-.406**	.625**	.055	.468**	–

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 9 Correlation descriptive statistics of variables: Experiment 2

Variables	1	2	3	4	5	6
1. Height	–					
2. Root length	-.053	–				
3. Fresh biomass	.167	-.334**	–			
4. Total dry biomass	.408**	-.174	.231	–		
5. Cob weight	.049	-.315*	.439|**	.215	–	
6. Grain weight	362**	-.338*	.288**	.396**	.303*	–

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The above table 9 show very strong significant relationship between grain weight and height of P value of 0.005, 0.001 between height and total dry matter, 0.002 between total dry matter and grain weight and 0.000 between fresh biomass and cob weight

Increase in morphological characteristics of maize increased yields, larger leaf area for example encourages photosynthesis and enables plants to produce enough food for its maintenance and development. The higher the leaf area, the more the rate of photosynthesis and the healthier the plants and the same applies to other maize growth characteristics except root length which may signify something else. From the above discussion, it is clearly seen that that Jack Bean green manure performed better than NPK control in terms of yield. This could have been attributed to the fact that Jack Bean green manure application has multiple benefits that enables it support crop performance, such as enhancing water infiltration, softening the soil, adding soil nutrients ,suppressing and smoothening the weeds vigorously and very effectively, it known for fixing over 100kgs of Nitrogen/ha for successive crops. An analytical results of a research done by NOGAMU in 2010 in Gulu indicated that most of the soils had slightly lower levels of available phosphorous (<15 ppm). However, they noticed that sites with Mucuna labels had higher Phosphorus levels compared to the Control labeled sites. However, more efforts to enhance P availability are critical, for increased root growth, and high nutrient uptake and crop outlook.

4.4 The merits and demerits associated with Jack Bean green application in Maize Production

Soil fertility replenishment can be achieved through many strategies such as use of organic fertilizers, Biological Nitrogen Fixation (BNF), inorganic fertilizers or their combination, but the sustainability in terms of the benefits derived such as economic, ecological, environmental and financial benefits are what matters. The potential benefit of green manures in cereal production on contrasting soils in Uganda can be achieved alongside Biological Nitrogen Fixation (BNF). Social and economic factors do not favor the use of inorganic fertilizers by the smallholder farmers. Whereas organic fertilizers such as green manure has many benefits as far as soil nutrient replenishment, environmental concern, economic and ecological benefits are concerned

4.4.1 The merits of Jack bean manure green manure application in maize production.

In terms of cost of inputs (purchase of seed) Jack bean green manure was far much cost effective than NPK. For the purpose of this experiment, NPK was bought at 4000 ugx per kilogram meanwhile Jack bean seed was bought at 2000, so in terms of cost, NPK was more costly than Jack Bean. Besides, jack bean seed can be produced by farmers and replanted, but

NPK is applied once. That means each time of application a farmer has to buy new fertilizer and therefore becomes expensive and not sustainable ("socio economics of green manure on crop yield.pdf," n.d.). Additionally the cost of transporting inorganic fertilizer makes inorganic fertilizers costly than green manure which is planted and incorporated on the same piece of land unless when it is being taken to another pace like JBI in my experiment. To a local farmer, it is easier to find jack bean seed than NPK. In some village places, some farmers are still ignorant about the existence of inorganic fertilizers. Plots that had Jack bean manure (JBW) had almost no or fewer weeds than Jack bean imported (JBI), NPK and control plots. The weeds got suppressed by the jack bean plant since the ground totally got covered by the plant. This would reduce the cost of weeding, but since weed management was one of the extraneous variable, weed management was equally done and at the same time. But ideally, this would reduce on herbicide use. Since this was an experiment, Jack bean and NPK had single treatment, but ideally NPK requires top dressing for better yield. This means that a farmer needs to by the same quantity of Nitrogen fertilizer preferably CAN or UREA twice in order to realize better yield. Never the less with the single treatment, Jack bean plots performed better than NPK and control in terms of yield. Plots that had jack bean from within Jack bean derived green manure better yield compared to NPK and control as supported by Fabunmi, T.O.1 and Agbonlahor, M. U("socio economics of green manure on crop yield.pdf," n.d.). The assumption is that, green manure constitute balance nutrient, contains good amount of organic matter, improves soil texture and structure and can last for longer time in the soil than NPK, secondly, jack bean plant fixes nitrogen due to its special root nodules. Through addition of good amount of organic matter and nitrogen fixation, green manure aided appropriate nutrient recycling in the soil. Jack bean green manure provided good ground cover that protects the soil from being washed by erosional factors. As seen from the soil analysis report, Jack bean manure improved on soil structure and texture and therefore improved on soil water infiltration and conserved soil moisture and provided reliable nutrient sources for the maize. From ecological, biological and environmental point of view, jack bean green manure promotes biological soil preparation, provides habitat for natural enemies and creates unfavorable conditions for pests that do not like cold environment, thus help in pest and disease control

4.4.2 The demerits of jack been manure use in maize product

In terms of labour cost lack green manure in maize production is labour intensive in terms of additional costs on planting and incorporation. For uniformity, the jack bean biomass had to be quantified before incorporation for the purpose of this research and thus had additional cost, but a local farmer can broadcast and cover jack bean seed during first ploughing without incurring additional cost and incorporation can be done during second ploughing without any additional cost as well. In terms of time value of land Jack bean was planted and left to grow until it reached flowering stage, in case of land shortage, this would not be economical, but never the less since it's a drought tolerant plant, Jack bean can be planted during off season targeting incorporation at the onset of the rain. The research had jack bean planted in November and got incorporated in March and left to decompose for two weeks before planting.

4.4.3 Conclusion

Green manure is a viable low cost technology for enhancing agricultural productivity as its well known in weed suppression (Barthès et al., 2004). It also enhances the availability of nitrogen and other nutrients such as potassium and phosphorus (Barthès et al., 2004). Most types of green manure species can also fix nitrogen with help of nitrogen fixing bacteria and therefore can increase soil nitrogen levels by approximately 459kg per acre. (Cherr et al., 2006). Mucuna beans, Lablab, beans, alfafa, soybeans and peas among others are known for improving soil fertility and soil physical properties (Brar et al., 2015).Ladha et al 1992, Whitbread *et al* 2000, Ray and Gupta 2001, Aulakh *et al*., 2001, Ladha *et al*., 2000, Puget and Drinkwater 2001). From the above result, Jack Bean green manure performed better than NPK in terms of growth and yield of maize although both had significant results. This could be attributed to the fact that Jack Bean derived green manure application has multiple benefits that enables it support crop performance, such as enhancing water infiltration, softening the soil, adding soil nutrients ,suppressing and smoothening the weeds vigorously and very effectively, it known for fixing over 100kgs of Nitrogen/ha for successive crops.

4.6 Hypothesis testing

SPSS and Genstat were used to produce analysis of variance, correlation which were used to determine the significant levels of the effects of the different treatments on performance of Maize. The ANOVA results had highly significant values for all the variables for both experiments except for root length for experiment two, height at week four for experiment one and cob weight for experiment two. The statistical results generally confirmed that the application of Jack bean derived green manure in Maize production is significantly different, thus accepting the null hypothesis as stated in 1.4 chapters 1. However, for plant height at week four for experiment one and cob weight for experiment two, the application of jack bean green manure and NPK accepted the alternative hypothesis

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter provides the summary of the findings, discussions of the findings based on the findings presented in chapter four, conclusions and recommendations

5.1 Summary

This study was done in Mpigi,- Nkozi (Equator Valley farm and Karagara) Uganda Martyrs University farm. The objectives of the study was to; determine the effectiveness of Jack bean green manure on growth and yield of Maize, and to assess the advantages and disadvantages of jack bean green manure in maize production

5.1.1 The effect of Jack bean green manure on plant height, root length, fresh biomass, total dry biomass, cob weight and grain weight

The study show best results for plant height and cob length in JBW plots, followed by JBI , then NPK and lastly control for both seasons, meanwhile root length for both seasons was longest and fewer in control plot in both seasons, moderate in JBW and JBI and shorter in NPK plots

5.1.2 The effects of Jack bean green manure maize yield

Grain weight, fresh biomass and total dry matter show best results in JBW plot , followed by JBI, and then NPK and lastly control in both seasons, except first season NPK had more fresh biomass

5.1.3 The merits and demerits of Jack bean green manure in maize production

The study results show that jack bean green manure is more economical than NPK in terms of cost of buying inputs, cost of transport, access, weed management, retention in the soil, environmental effects on other creatures and the yield outcome. But in terms of time value of land, and labour cost, NPK become economical than green manure

5.2 Conclusion

5.2.1 The effect of Jack bean green manure on plant height, root length, fresh biomass, total dry biomass, cob weight and grain weight

The study results conclude that jack bean green manure can facilitate the development of better plant height and cob length more especially when the jack bean is planted and incorporated on the same piece of land. Meanwhile root length was longer in length and fewer in numbers in control plots

5.2.2 The effects of Jack bean green manure maize yield

The study conclude that jack bean green manure can increase maize grain weight, fresh biomass and total dry matter had best results in JBW plot , followed by JBI, and then NPK and lastly control in both seasons, except first season NPK had more fresh biomass

5.2.3 The merits and demerits of Jack bean green manure in maize production

The study conclude that jack bean green manure is so advantageous in maize production due to its ability to supply soil nutrients, protect the soil from erosion, promote microbial activities, suppress weeds, improve on soil moisture retention and increase maize yield. In terms of cost of buying inputs, cost of transport, access, weed management, retention in the soil, environmental effects on other creatures and the yield outcome, Jack bean green manure is more economical than NPK. But in terms of time value of land, and labour cost, NPK become economical than jack bean green manure

5.2.4 General conclusion

From the above discussion, the results showed that jack Bean green manure performed better than NPK and control in terms of growth and yield of maize. This could have been attributed to the fact that jack bean green manure application has multiple benefits that enables it support crop performance, such as enhancing water infiltration, softening the soil, adding soil nutrients ,suppressing and smoothening the weeds vigorously and very effectively, it known for fixing over 100kgs of Nitrogen/ha for successive crops. The results show that soils at both sites were low in organic matter, Nitrogen, available phosphorous, cation exchange capacity. Jack bean green manure application significantly increased their contents in the soil. Maize plant height, fresh biomass, root length, total dry matter, cob weight and grain weight were all significantly improved by jack bean green manure application and more especially the JBW. From the results above, it is concluded that jack bean green manure can be used to enhance maize production. In terms of costs, access, yield and environmental concern, Jack bean manure was more cost effective than NPK and control except labour cost and time value of land that had negative side of it.

5.3 Recommendations

The study came out with specific and general objectives below;

5.3.1 The effect of Jack bean green manure on plant height, root length, fresh biomass, total dry biomass, cob weight and grain weight

The study recommends that, jack bean green manure should be incorporated properly and left to decompose only for two weeks before planting the intended crop in order for the plants to be able to utilize the nutrients that can be supplied by it. Over time after decomposition may lead to nutrient loss through leaching and other factors therefore the plants would not be able to get the nutrients. At the time of decomposition of jack bean green manure and planting/ growth of maize, the soil moisture should be ideal enough to make the nutrients readily available for the plant. In case of drought occurrence, there is need to irrigate plants to ensure healthy and vigorous growth.

5.3.2 The effects of Jack bean green manure maize yield

For better maize yield to be obtained, it is recommended that jack been green manure obtains reasonable quantity of biomass before incorporation preferably towards flowering/ podding stage in order for it to supply enough nutrients required for maize plant growth, development and maturity. All the recommended agronomic practices such as proper seed selection, proper land preparation, timely planting, timely weed control, pest and diseases especially army worm control and timely harvesting and post-harvest handing should be taken care of. As witnessed from my study, maize can easily be stolen especially towards maturity, this calls for routine monitoring and security, otherwise a farmer may end up getting losses through theft.

5.3.3 The merits and demerits of Jack bean green manure in maize production

As seen in the discussion above, jack bean green manure in maize production is disadvantageous in terms of time value of land and labour cost. For it to have more economic benefits, It is therefore recommended, jack bean can be planted off cropping season as it can withstand drought as long it germinates so that at the onset of the rain, it is ready to be incorporated. And to address the labour cost incurred in incorporating the biomass, farmers would use ox plough for incorporation at second ploughing time. For farmers with larger farm land, they can produce jack bean seeds for the next cropping season themselves instead of buying the seed every time they need to use the biomass.

5.3.4 General recommendation

The study recommends that Agricultural extension workers and NGOs promote the use of jack bean manure as an alternative nutrient source to inorganic fertilizers. For effectiveness in morphological data collection, machines such as drone and other GIS gadgets should be used especially for determining the leaf area index.

5.4. Suggestions for further study.

Since the study only did independent analysis on the treatments, there is need to assess the effects of the combination of Jack bean green manure with other nutrient sources for top dressing such as CAN or urea. A similar experiment can be carried out in different agro ecological zones to find out whether the results would be similar or different. Some other type of legume should be tested alongside Jack bean to determine the best legume that can be worked with easily in soil nutrient replenishment. Further study should be done to compare the consumer preferences towards maize grown with NPK compared to maize grown with green manure.

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APPENDICES

Appendix 1 Picture taken during jack bean plant growth prior to incorporation

Appendix 2 Picture taken during jack bean fresh biomass quantification

Appendix 3 Picture taken during jack bean green manure incorporation

Appendix 4 Picture take during field weeding 2 weeks after planting

Appendix 5 Plant height data collection at week 4

Appendix 6 Pictures of root samples taken from plots that had different variables as identified below the pictures

Sampled root from JBI plot.

Sampled roots from NPK plot

Sampled root from JBW plot

Sampled root from Control plot

Appendix 7 Analysis of variance for grain weight for experiment1

Variate: GW

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK_N0 stratum	2	4.423	2.211	1.65	
BLOCK_N0.*Units* stratum					
TREATMENT	3	32.861	10.954	8.17	<.001
Residual	54	72.359	1.340		
Total	59	109.643			

Appendix 8 Analysis of variance for grain weight for experiment 2

Variate: GW

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	2	4.855	2.428	2.39	
BLOCK.*Units* stratum					
TREATMENT	3	50.160	16.720	16.48	<.001
Residual	54	54.772	1.014		
Total	59	109.787			

Appendix 9 Correlation results between variables: experiment one

		RL	H	TDM	FBM	GW	CW
RL	Pearson Correlation	1	-.102	-.221	-.379**	-.175	-.174
	Sig. (2-tailed)		.438	.092	.003	.181	.184
	N	60	60	59	60	60	60
H	Pearson Correlation	-.102	1	.424**	-.006	.335**	.406**
	Sig. (2-tailed)	.438		.001	.963	.009	.001
	N	60	60	59	60	60	60
G	Pearson Correlation	-.080	.051	.313*	.166	-.015	.068
	Sig. (2-tailed)	.541	.697	.016	.205	.911	.604
	N	60	60	59	60	60	60
TDM	Pearson Correlation	-.221	.424**	1	.184	.242	.625**
	Sig. (2-tailed)	.092	.001		.162	.065	.000
	N	59	59	59	59	59	59
FBM	Pearson Correlation	-.379**	-.006	.184	1	.054	.055
	Sig. (2-tailed)	.003	.963	.162		.683	.675
	N	60	60	59	60	60	60
GW	Pearson Correlation	-.175	.335**	.242	.054	1	.468**
	Sig. (2-tailed)	.181	.009	.065	.683		.000
	N	60	60	59	60	60	60
CW	Pearson Correlation	-.174	.406**	.625**	.055	.468**	1
	Sig. (2-tailed)	.184	.001	.000	.675	.000	
	N	60	60	59	60	60	60

		RL	H	TDM	FBM	GW	CW
RL	Pearson Correlation	1	-.102	-.221	-.379**	-.175	-.174
	Sig. (2-tailed)		.438	.092	.003	.181	.184
	N	60	60	59	60	60	60
H	Pearson Correlation	-.102	1	.424**	-.006	.335**	.406**
	Sig. (2-tailed)	.438		.001	.963	.009	.001
	N	60	60	59	60	60	60
G	Pearson Correlation	-.080	.051	.313*	.166	-.015	.068
	Sig. (2-tailed)	.541	.697	.016	.205	.911	.604
	N	60	60	59	60	60	60
TDM	Pearson Correlation	-.221	.424**	1	.184	.242	.625**
	Sig. (2-tailed)	.092	.001		.162	.065	.000
	N	59	59	59	59	59	59
FBM	Pearson Correlation	-.379**	-.006	.184	1	.054	.055
	Sig. (2-tailed)	.003	.963	.162		.683	.675
	N	60	60	59	60	60	60
GW	Pearson Correlation	-.175	.335**	.242	.054	1	.468**
	Sig. (2-tailed)	.181	.009	.065	.683		.000
	N	60	60	59	60	60	60
CW	Pearson Correlation	-.174	.406**	.625**	.055	.468**	1
	Sig. (2-tailed)	.184	.001	.000	.675	.000	
	N	60	60	59	60	60	60

		RL	H	TDM	FBM	GW	CW
RL	Pearson Correlation	1	-.102	-.221	-.379**	-.175	-.174
	Sig. (2-tailed)		.438	.092	.003	.181	.184
	N	60	60	59	60	60	60
H	Pearson Correlation	-.102	1	.424**	-.006	.335**	.406**
	Sig. (2-tailed)	.438		.001	.963	.009	.001
	N	60	60	59	60	60	60
G	Pearson Correlation	-.080	.051	.313*	.166	-.015	.068
	Sig. (2-tailed)	.541	.697	.016	.205	.911	.604
	N	60	60	59	60	60	60
TDM	Pearson Correlation	-.221	.424**	1	.184	.242	.625**
	Sig. (2-tailed)	.092	.001		.162	.065	.000
	N	59	59	59	59	59	59
FBM	Pearson Correlation	-.379**	-.006	.184	1	.054	.055
	Sig. (2-tailed)	.003	.963	.162		.683	.675
	N	60	60	59	60	60	60
GW	Pearson Correlation	-.175	.335**	.242	.054	1	.468**
	Sig. (2-tailed)	.181	.009	.065	.683		.000
	N	60	60	59	60	60	60
CW	Pearson Correlation	-.174	.406**	.625**	.055	.468**	1
	Sig. (2-tailed)	.184	.001	.000	.675	.000	
	N	60	60	59	60	60	60

Appendix 10 Correlations between variables: Experiment 2

		H	RL	FBM	TDM	CW	GW
H	Pearson Correlation	1	-.053	.167	.408**	.049	.362**
	Sig. (2-tailed)		.688	.201	.001	.710	.005
	N	60	60	60	60	60	60
RL	Pearson Correlation	-.053	1	-.334**	-.174	-.315*	-.338**
	Sig. (2-tailed)	.688		.009	.185	.014	.008
	N	60	60	60	60	60	60
FBM	Pearson Correlation	.167	-.334**	1	.231	.439**	.288*
	Sig. (2-tailed)	.201	.009		.076	.000	.026
	N	60	60	60	60	60	60
TDM	Pearson Correlation	.408**	-.174	.231	1	.215	.396**
	Sig. (2-tailed)	.001	.185	.076		.100	.002
	N	60	60	60	60	60	60
CW	Pearson Correlation	.049	-.315*	.439**	.215	1	.303*
	Sig. (2-tailed)	.710	.014	.000	.100		.019
	N	60	60	60	60	60	60
GW	Pearson Correlation	.362**	-.338**	.288*	.396**	.303*	1
	Sig. (2-tailed)	.005	.008	.026	.002	.019	
	N	60	60	60	60	60	60

		H	RL	FBM	TDM	CW	GW
H	Pearson Correlation	1	-.053	.167	.408**	.049	.362**
	Sig. (2-tailed)		.688	.201	.001	.710	.005
	N	60	60	60	60	60	60
RL	Pearson Correlation	-.053	1	-.334**	-.174	-.315*	-.338**
	Sig. (2-tailed)	.688		.009	.185	.014	.008
	N	60	60	60	60	60	60
FBM	Pearson Correlation	.167	-.334**	1	.231	.439**	.288*
	Sig. (2-tailed)	.201	.009		.076	.000	.026
	N	60	60	60	60	60	60
TDM	Pearson Correlation	.408**	-.174	.231	1	.215	.396**
	Sig. (2-tailed)	.001	.185	.076		.100	.002
	N	60	60	60	60	60	60
CW	Pearson Correlation	.049	-.315*	.439**	.215	1	.303*
	Sig. (2-tailed)	.710	.014	.000	.100		.019
	N	60	60	60	60	60	60
GW	Pearson Correlation	.362**	-.338**	.288*	.396**	.303*	1
	Sig. (2-tailed)	.005	.008	.026	.002	.019	
	N	60	60	60	60	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

		H	RL	FBM	TDM	CW	GW
H	Pearson Correlation	1	-.053	.167	.408**	.049	.362**
	Sig. (2-tailed)		.688	.201	.001	.710	.005
	N	60	60	60	60	60	60
RL	Pearson Correlation	-.053	1	-.334**	-.174	-.315*	-.338**
	Sig. (2-tailed)	.688		.009	.185	.014	.008
	N	60	60	60	60	60	60
FBM	Pearson Correlation	.167	-.334**	1	.231	.439**	.288*
	Sig. (2-tailed)	.201	.009		.076	.000	.026
	N	60	60	60	60	60	60
TDM	Pearson Correlation	.408**	-.174	.231	1	.215	.396**
	Sig. (2-tailed)	.001	.185	.076		.100	.002
	N	60	60	60	60	60	60
CW	Pearson Correlation	.049	-.315*	.439**	.215	1	.303*
	Sig. (2-tailed)	.710	.014	.000	.100		.019
	N	60	60	60	60	60	60
GW	Pearson Correlation	.362**	-.338**	.288*	.396**	.303*	1
	Sig. (2-tailed)	.005	.008	.026	.002	.019	
	N	60	60	60	60	60	60

*. Correlation is significant at the 0.05 level (2-tailed).