ASSESSING THE EFFECTS OF NPK FERTILIZER AND COW DUNG ON YIELD AND YIELD COMPONENTS OF COMMON BEANS (*Phaseolus vulgaris*)

BY

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DECLARATION

I, NALUZZE EVE, honestly declare that the submitted information in this report is my research and has never been presented to any institution of learning for an award of degree.

Signature.................................... Date..13th../..April....../..2022..

NALUZZE EVE

APPROVAL

I have supervised and checked this report and it meets the required standards.

Supervisor's Signature ....

Date 23.02.2022 ....

DR. NYOMBI KENNETH

DEDICATION

I dedicate this report to the Almighty God who has given me the gift of life and the grace to reach this far in my endeavors and to my dear parents Mr. Kiggundu Steven and Ms. Nakabuye Juliet who have been a strong pillar in my life through their unending financial and emotional support toward my success. I also dedicate this report to Mr. Mugerwa Francis who has guided me through my studies up to where I am.

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LIST OF ACRONYMS

Re	-	Revised
Adv	-	Advanced
N P K	-	Nitrogen Potassium and Phosphorus.
Anova	-	Analysis of variance
Km	-	kilometers
Mm	-	Millimeters
UBOS	-	Uganda Bureau of Statistics
stDev	-	Standard deviation
T	-	Treatment

ABSTRACT

Agriculture is the economic growth engine for most developing countries like Uganda. However, increasing population has created scarcity for land for settlement and farming to support the ever-increasing population. Depletion of soil fertility is the main problem in sustaining agricultural production and productivity in many low-income countries like Uganda. The application of organic or inorganic fertilizers alone has both positive and negative effects on plant growth, nutrient availability and the soil. Organic fertilizers improve physical and biological activities of soil but they are comparatively low in nutrient content and hence large quantities are required for plant growth. An experiment, laid out in a Completely Randomized Block Design (CRBD) with three replicates and seven treatments was carried out to assess the effects of NPK fertilizer and manure on the yield and yield components of the common bean. The buckets used had a capacity of 5kg of soil. The treatments were as follows; T1-control (just soil), T2-0.204g of NPK - 25Kg of N/ha, T3-0.408g of NPK - 50 kg of N/ha, T4-0.612g of NPK - 75kg of N/ha, T5- 0.204g of NPK +1.74g of manure, T6 - 0.204g of NPK+3.48g of manure (25kg of N/ha and 50kg of N/ha) and T7 - 0.816gof NPK 100kg of N/ha). NPK 17:17:17 was used to compare the organic and inorganic fertilizers at the same nitrogen level. Data were subjected to analysis of variance (ANOVA) at 95% confidence level. Results showed no significant difference in the growth parameters (P>0.05) with exceptions occurring in weeks 7 of leaves and height.

CHAPTER ONE

INTRODUCTION

1.1 Back ground

Common beans (*Phaseolus vulgaris*) are a staple food and cash crop in East Africa especially within Uganda and Rwanda (John & Moses, 2013)where it constitutes a major component of food security. The common bean is member of a legume family and its taxonomic hierarchy is order Fables family Fabaceae, genus Phaseolus, species Phaseolus vulgaris. It is the most important grain legume in Uganda (Beebe et al., 2014) and is produced primarily by smallholder farmers (Ugen et al., 2002). The common bean grows well in subtropical to temperate climate because such areas receive moderate rainfall accompanied with defined wet and dry seasons throughout the year. This is so because excessive temperatures cause flowers to fall and low temperatures delay pod formation hence empty pods. Common beans are produced by most farming households under dry land conditions with less external production input resulting into less external production input resulting into low productivity (UBoS, 2014).

Beans are grown on every continent except Antarctica. Worldwide, 27 million tonnes of dried beans and 24 million tonnes of green beans were produced in 2016 and Myanmar being the largest producer of dried beans while China produced 79% of world's total green beans. Uganda produces 370,000 metric tonnes of beans annually. The economic yield of a bean is a culmination of many processes that take place in the plant during its growing period until it reaches physiological maturity. Among the processes are photosynthesis, respiration, xylem transportation of nutrients and water, mobilization and partitioning of photosynthates and assimilates and source sink relationships among others. Economic yield is the function of many components in common beans such as number of pods in each plant, number of seeds in each pod, weight of 100 seeds and plant height and the contributions of these yield components defer greatly depending on the bean genotypes, environment and management practices.

Despite beans being one of the most important legume crops, agro ecological constraints, cultivation in marginal and sub marginal land, un predictable and poorly distributed rainfall, low soil fertility and seasonal constraints, low productivity, susceptibility to pests and diseases, flower shading, lack of adaptive high yielding varieties have been reported to inhibit production of beans in some areas. The practice of shifting cultivation to improve soil fertility and enhance production can no longer be sustained due to rapid increase in population. Therefore, it's necessary to devise an improved way by which the soil fertility can be improved and sustained within the possible shortest time to ensure continual productivity. The use of cover crops such as beans have been known to improve the physical, chemical and biological properties of soil. NPK a mineral fertilizer produced artificially consisting of equal proportions of nitrogen, phosphorus and potassium which are primary macro minerals essential for optimum growth and development of plants is also used to enhance the productivity of the soil. Cow dung which is organic manure composed of a mixture of fecal waste and urine from cows can also be added to the soil to enhance the biological, physical and nutrient status of the soil.

Changes in the land use associated with deforestation and in appropriate land use management had a negative impact on approximately 2 billion hectares of agricultural land hence need to improve the soil with organic and inorganic manure to bring increased productivity. Some other researchers reported that land degradation result in productive decline of soil and can be attributed to changes in the physical, chemical and biological attributes from some ideal state brought about by natural or anthropogenic influences.

1.2 Problem statement

Over the years, farmers have been growing common beans on subsistence level where most production is for home consumption and only a little surplus for commercial use. Due to small plots of land owned by these farmers amidst the increasing population, there has been less consideration of practicing conservational and environmentally friendly farming practices like shifting cultivation among others. Continuous cultivation without replenishments has consequently resulted into soil exhaustion which has greatly reduced the yield and yield components of common beans.

Due to low productivity of common beans as a result of soil exhaustion, some farmers resorted to use of inorganic fertilizers like NPK which increased their yield and yield components though it has been associated with some problems. NPK is expensive to purchase hence not affordable by most Ugandan farmers because majority are poor in addition to its being inaccessible in rural areas.

Farmers have resorted to use of organic manures such as cow dung with associated increment in yield and yield components yet locally available and accessible. However, it was also associated with some challenges which included slow release of nutrients, incubation from pests and diseases, burning effect on bean roots among others. Therefore, there is a need to integrate both organic and inorganic fertilizers to address the associated problems of only using either organic or inorganic fertilizers as a way of making an improvement in soil fertility.

1.3 Objectives of the study

1.3.1 General objective

To assess the effects of NPK, cow dung and their combination on yield and yield components of common beans in order to improve food security and income of smallholder farmers.

1.3.2 Specific objectives

i. To compare the effects of NPK and cow dung on growth parameters i.e. plant height number of leaves at flowering, number of pods and number of seeds per pod.
ii. To compare the number of root nodules produced at flowering for plants subjected to different levels of NPK fertilizer and manure.

1.4 Hypotheses

H_{O1}; There is no significant difference in growth parameters of beans subjected to different levels of NPK and cow dung.

H_{O2}; There is no significant difference in number of root nodules produced by bean plants subjected to different levels of NPK and cow dung.

1.5 Significance of the study

The study will promote food security and increase incomes of farmers since it is associated with ensuring continuous supply of nutrients to the plants hence associated with maximization of production on relatively small pieces of land which improves livelihoods of farmers.

Combined fertilizer application is an intensive farming method associated with great production on small piece of land which minimizes degradation.

The extension personnel being intermediates between research and farmers will easily use this study as a demonstration to improve productivity in collaboration with farming communities, helping them to help themselves become self-reliant and independent ensuring sustainable production and general rural development.

CHAPTER TWO

LITERATURE REVIEW

2.1 Global common bean production

The global bean harvest was 18 million tons primarily in Latin America and Africa (FAO, 2009). Support for research and breeding on common bean languishes at US$5–10 million per year globally, an amount dispersed among national programs, universities and a few international crop improvement centers (Cavalieri et al., 2011).

The Eastern, Central, and Southern Africa are the main common bean-growing regions on the continent (Jansa et al., 2011). Africa is probably the second largest producer of common beans after Latin America with nearly 5 million ha yielding almost 3 million tons of seeds annually (FAO, 2008). Although, statistics indicate higher production of dry beans in Asia than in Africa, bean production in Asia is dominated by other botanical species than *Phaseolus vulgaris L*. (Singh, 1999b). The average annual yields of common bean seeds in Africa vary between 167 kg ha^{-1} in Eritrea and over 1,000 kg ha^{-1} in Madagascar and South Africa (FAO, 2008).

2.2 Nutritional importance of common beans

The importance of common bean *(Phaseolus vulgaris L.*) as a subsistence and cash crop is well established with more than 300 million people relying on the crop for protein, micronutrients and calories and 1 million farmers using beans as an important source of income. Beans are a primary source of dietary protein for 70 million people in sub-Saharan Africa (Cavalieri et al., 2011). It is an important source of calories, proteins, dietary fibers, minerals, and vitamins for millions of people in both developing and developed countries worldwide where it complements cereals and other carbohydrate-rich foods in providing near-perfect nutrition to people of all ages (Beebe et al., 2011). According to (Beebe et al., 2011), a regular intake of beans helps lower cholesterol and cancer risks.

2.3 Common bean production in Uganda

Common bean (*Phaseolus vulgaris L.*) is the most important grain legume in Uganda (Beebe et al., 2014) and is produced primarily by smallholder farmers (Ugen et al., 2002). More recent countrywide per capita bean consumption in Uganda averages about 11 to 16 kg person^{-1} year^{-1} (Broughton et al., 2003). Although the per capita consumption has decreased, the total demand is still increasing due to population growth. Bean yields and soil quality have declined in Uganda over the past two decades (Bekunda et al., 2005), partly due to increased cropping intensity and lack of longer-term bush fallow (Chianu et al., 2012). Beans managed under conventional systems are only producing 500 to 800 kg ha^{-1}, on average, despite having a potential yield of up to 2500 kg ha^{-1}(Broughton et al., 2003). Bean production in Uganda is low due to numerous constraints including poor agronomic practices, soil infertility, lack of seed from improved cultivars, moisture stress, weed competition, and damage caused by pests and diseases (Sinclair & Vadez, 2012). Many farmers are currently looking for improved management systems to increase bean yields. However, there has been little research conducted on management systems that alleviate the aforementioned constraints. Agronomic practices that maximize bean production are not commonly used in Uganda even though some agronomic practices such as planting in rows and more frequent weeding can be implemented with minimal or no additional capital investment. Fertilizer additions can overcome specific nutrient deficiencies, but fertilizers are expensive investments in sub-Saharan Africa, including rural Uganda, and most farmers use low levels or no fertilizer at all (Benkunda et al, 2005; Lunze et al, 2012; Chianu et al, 2012) contributing to further nutrient depletion of soil. Fertilizing bean can increase root growth providing improved access to soil water and nutrients.

2.4 Soil fertility issues in common bean-based systems

Common bean is cultivated largely by resource-poor farmers, often on soils that are deficient in important plant nutrients, especially nitrogen (N) and phosphorus (P) (Beebe et al., 2011). The major soils found in bean-growing areas in Africa are classified as Alfisols, Ultisols, Oxisols and Inceptisols (Jansa et al., 2011). These tend to be acidic, low in organic matter, low in exchangeable calcium (Ca), magnesium (Mg) and potassium (K), low in available phosphorus (P), high in exchangeable aluminium (Al) and or manganese (Mn) and have often a high P fixing capacity (Wortman & Roger, 1998). Across the world, common beans are often cultivated on steep erosion-prone hillsides in soils characterized by low fertility (Cavalieri et al., 2011). According to Beebe et al. (2011), an estimated 50% of bean production suffers from low-P availability, while 40% may suffer from Al toxicity.

Low availabilities of N and P in agricultural soils are among the most wide spread plant nutritional constraints for crop growth and yields on a global scale and more specifically in Africa (Jansa et al., 2011). N and P deficiencies are major and omnipresent problems in

African agriculture (Drechsel et al., 2001). For example, according to Henao & Baanante (1999), in Ethiopia, nutrient depletion amounts to 36, 6, and 32 kg ha^{-1} $year^{-1}$ of N, P and K, respectively, while the average use of fertilizers in the country replenishes only about 10% of the nutrients removed by crops from the fields.

Soil testing of available nutrients is rarely done by smallholder farmers in sub-Saharan Africa but it is important to be aware of crop nutrient needs, especially nitrogen, phosphorus, and potassium, which are commonly deficient in these soils (Sinclair & Vadez, 2012; Ugen et al., 2002). Bean is generally considered to be a poor N fixer (Graham & Ranalli, 1997) but inoculation with appropriate Rhizobium species can increase grain yields in East Africa (Maingi & Mairura, 2010). High levels of N fixation have been documented when the crop is not limited by other constraints (Giller et al., 2009) and for that reason it is very important to address low soil fertility to prevent severely reducing symbiotic nitrogen fixation (SNF) or limiting root expansion (Graham & Ranalli, 1997; Beebe et al., 2014). Adequate K is required for improved tolerance to drought stress, protection against biotic stresses, optimal growth and productivity (Oosterhuis et al., 2014) and as cropping intensifies and higher amounts of K are exported from the field (Mengel & Kirkby, 1980). Potassium is frequently removed in large amounts from fields in sub-Saharan Africa, because crop residues are typically removed from the field at harvest rather than incorporated or left on the soil surface further worsening soil K availability (Giller et al., 2009). The addition of K can increase the competitiveness of bean and therefore may also be important for weed management (Ugen et al., 2002).

2.5 Efforts to improve common bean production

Bean production in Africa is limited, and the yields realized by farmers are far below potential yields (Jansa et al., 2011). The yields encountered on farmers' fields are usually around 500 kg ha^{-1}, while the yield potential of the crop could be as high as 5,000 kg ha^{-1} under optimal water and nutrient supply and in the absence of pests and pathogens (Verdoodt et al., 2004).

The average global per capita consumption is declining because production is unable to keep up with the population growth (Beebe et al., 2011). According to Beebe et al., (2011), there's an increasing demand for pesticide-free food products a concern for natural resources conservation, and the need to reduce production costs that offer daunting challenges to the twenty-first century policy makers, bean growers, and researchers alike, where high yielding, high quality bean cultivars that require less water, fertilizers, pesticides, and manual labor combined with integrated management of a biotic and biotic stresses will have to be developed. Significant progress has been made in improving adaptation of beans to low fertility soils (Beebe et al., 2009).

Common bean productivity can be enhanced substantially through investment in dissemination and promotion of existing technologies (agronomic practices and improved varieties) and improvements in marketing infrastructure (promotion of grading and packaging of bean grains at farm level, efficient two-way flow of market information and strengthening form a land informal seed systems (Katungi et al., 2010). In dry areas like Eastern Kenya, improving common bean productivity will require development and promotion of drought resistant varieties together with best agronomic management practices where non varietal integrated soil and fertility management practices to improve on the water harvesting techniques of farmers and the water retention capacity of soils should also be explored and beneficial ones identified and promoted alongside improved varieties (Katungi et al., 2010).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the study area

The experiment was conducted at the Department of Environmental Management backyard, College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda. Makerere University is located about 2.5km North of the center of Kampala City at coordinates of latitude of 0°20´59.99´´N, longitude 32°34´1.79E and at altitude of 1240m above sea level on Makerere hill. The University has a tropical climate, receives an annual amount of rainfall of about 1293mm and an annual temperature of 21.3°C. The highest amount of rainfall is received between March and May which made this period best suited for the experiment because of its better climatic conditions for growth of common beans.

3.2 Collection cow dung and soil

Cow dung was collected from a local farmer with only two cows from Nansana-Yesu Amala in Wakiso district and also poor soils were obtained from a farm in the same area and were transported to the Department where the experiment was conducted.

3.3 Experimental design

A completely randomized block design (CRBD) was used where 21 small buckets were filled with 5kgs of soil that was mixed with fertilizers and the soil was watered for two days to soften soil and allow proper mixing of fertilizers. For each experimental treatment, eight seeds were sown and four were removed through thinning after two weeks of sowing to leave four well-spaced plants.

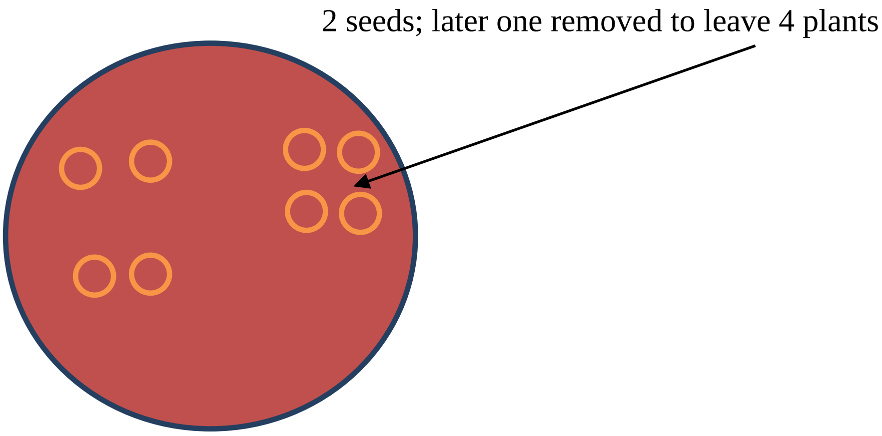
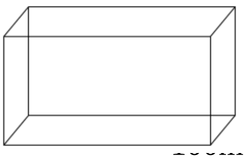


Figure 1: ***Arrangement of plants in the buckets at sowing. Later four plants were thinned leave four plants to grow to maturity.***

- At flowering one plant was will be uprooted and number of root nodules counted.

NPK 17:17:17 ➡ 17%N; 17% P; 17%K

1hectare =100M × 100M 0.3M rooting depth for beans.

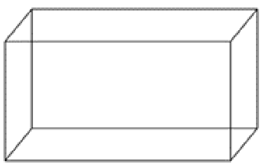


0.3m

$=3000m^3$

100m

Assuming soil bulky density $1.2gcm^{-3}$



0.01m $=0.01m \times 0.01m \times 0.01m = 0.000001m^2$

0.01m $0.000001m^3$ weigh 0.0012kg

Therefore, $3000m^3$ weigh $(0.0012 \div 0.000001) \times 3000 = 3600000kg$

But, 100kg of 17:17:17 NPK contain → 17kg N

17kg N → 100kg of 17:17:17

Therefore, 25kgN → (100÷17)×25=147kg

If 3600000kg soil in a bucket → (147÷3600000)×45=0.000204kg ≈0.204g of NPK(17:17:17)

Assuming poultry manure containing 2%of nitrogen

2kg N contained in → 100kg manure

25kg → (100÷2)×25=1250kg of manure

3600000kg of soil → 1250kg of manure

Therefore, 5kg of soil in a bucket = (1250÷3600000) ×5 =0.001736kg ≈1.74g

Table 1: Experimental treatments used in the buckets.

Treatments	**In 5kgs of soil**	**Per hectare**
T_1-control	-	-
T_2	0.204g of NPK	25kg of N
T_3	0.408g of NPK	50kgs of N
T_4	0.612g of NPK	75kgs of N
T_5	0.204g of NPK + 1.74g of manure	25kgs of N(NPK)+25kgs of manure
T_6	0.204g of NPK +3.48g of manure	25kgs of N(NPK)+50kg of N(manure)
T_7	0.816g of NPK	100kg of N

Table 2: A completely randomized block design showing distribution of treatments in the three blocks;

BLOCK1	T1	T3	T4	T2	T6	T7	T5
BLOCK2	T2	T5	T1	T3	T7	T4	T6
BLOCK3	T5	T2	T6	T4	T1	T3	T7

3.4 Experimental management

The seeds were sown at a recommended planting depth of 2-5cm. The buckets were maintained and moistened by adding water periodically depending on prevailing climatic conditions. Spraying was done once and also continuous uprooting of weeds was done to prevent them from competing with planted beans.

3.5 Data collection

The experiment was monitored and data was collected, growth parameters of number of leaves, height of stem and number of pod per plant, number of seeds per pod, weight of ten seeds and number of root nodules at flowering at an interval of two weeks. The data collected was recorded and entered into an Excel data sheets for each experimental unit.

3.5.1 Growth performance

Growth performance by counting number of leaves starting from the end of first five weeks up to about eight weeks of growth. Height was measured from the plant root collar to the tip of the bean plant using a tape measure and numbers of leaves were got by counting.

3.6 Data analysis

The data on yield and yield components were subjected to Analysis of Variance (ANOVA) using the Minitab software where mean values were separated using the standard error of difference and a 0.05 level of significance was used for all tests.

CHAPTER FOUR

RESULTS

4.1 Growth parameters

4.1.1 Number of leaves per plant versus treatment

There was no significant difference in the mean number of leaves in week five when subjected to different fertilizer treatments (P=0.430) and this was obtained by use of a tukey pairwise comparison of grouping information Week 7 showed a significant difference in the mean number of leaves when subjected to different fertilizer treatments (P=0.025). T4 had the highest leaf count whereas T1 had the lowest leaf count whereas the rest were the same (see table 3).

Table 3: Mean number of leaves per plant subjected different treatments of fertilizer

Treatments	Week5	Week 7
T_1	4	8
T_2	3	9
T_3	4	9
T_4	4	10
T_5	4	9
T6	4	9
T7	4	9
P-value	0.430	0.025
Standard Error of difference – SED	0.148849	0.5

4.1.2 Stem height per plant versus treatment

Use of a tukey pairwise comparison of grouping information showed that there is no significant difference in the mean stem height when subjected to different fertilizer treatments in week 5 (P-Value = 0.202). The mean stem height decreased in the trend of T7=T4>T3>T2>T5>T6>T1 with treatments (7and 4) having the highest mean weight and treatment (1) having the lowest mean stem height.

Week 7 shows there was a significant difference in the mean stem height on common beans subjected to different treatment levels of fertilizer (P-Value=0.026) evident in T1 and T7 whereas Treatments (2,3,4,5and 6) were almost the same. T7 had the highest mean height whereas T1 had the lowest mean height while subjected to different treatments of fertilizer (see table 4).

Table 4: Mean number of stem height subjected to different treatments of fertilizer.

Treatments	Week 5	Week 7
T_1	12.15	26.18
T_2	13.43	31.79
T_3	13.74	30.14
T_4	13.80	32.06
T_5	13.15	29.08
T6	13.03	29.97
T7	13.80	33.92
P-Value	0.202	0.026
Standard Error Of Difference (SED)	1.99196	5.38394

4.1.3 Number of root nodules per plant versus treatment

The study tested the hypothesis which states that there is no significant difference in the number of root nodules at flowering when subjected to different treatment levels of fertilizer. Use of Tukey Pairwise Comparison which groups information using the Tukey method at 95 confidence level confirmed that there was no significant difference in the number of root nodules per plant with different treatment levels.

The mean number of root nodules decreased in the trend of T3>T5>T6>T4>T2>T7>T1. with the highest mean number of root nodules in T3 and the lowest in T1 as seen in table 5.

Table 5: **mean number of root nodules subjected to different treatments of fertilizer**

Treatments	Mean
T_1	22
T_2	41
T_3	56
T_4	45
T_5	50
T6	46
T7	28
P-Value	0.838
Standard Error Of Difference	31.1731

4.1.4 Number of pods per plant versus treatment

The study hypothesized that there is no significant difference in the mean number of pods per plant subjected to different treatment levels of fertilizer and use of Tukey method of comparisons verified the hypothesis (P=0.912) as seen in table 6.

Table 6: **Mean number of pods per plant subjected to different treatments of fertilizer**

Treatments	Mean
T_1	4
T_2	4
T_3	5
T_4	4
T_5	4
T6	4
T7	4
P-Value	0.912
Standard Error Of Difference	1.48003

4.1.5 Number of seeds per plant versus treatment

The results of the study show that there is no significant difference in the mean number of seeds when subjected to different fertilizer treatments (P-Value=0.938) hence confirming the hypothesis of the study.

T5 had the highest mean number of seeds and T4 had the lowest mean number of seeds per plant subjected to different fertilizer treatments

Table 7: **Mean number of seeds per plant subjected to different treatment level of fertilizer**

Treatments	Mean
T_1	15
T_2	14
T_3	15
T_4	11
T_5	16
T6	12
T7	11
P-Value	0.938
Standard Error Of Difference	5.63577

4.1.6 Weight of 10 seeds versus treatment

The study found no significant difference in the mean weight of 10 seeds when subjected to different fertilizer treatments (P-Value =0.580). This was verified by use of Tukey Pairwise Comparison of grouping information.

T2 had the highest mean weight of 12g while T5 and T2 had the lowest mean weight of 3 g whereas the rest of the treatments were almost the same when subjected to different treatment levels of fertilizer as seen below in table 8.

Table 8: **Mean weight of 10 seeds subjected to different treatments of fertilizer.**

Treatments	Mean(g)
T_1	4
T_2	3
T_3	4
T_4	4
T_5	3
T6	4
T7	4
P-Value	0.580
Standard Error Of Difference	0.417493

4.1.7 Weight of whole beans versus treatment

The weight of whole beans showed no significant difference in the mean weight of whole beans when subjected to different fertilizer treatment through use of a tukey test of comparison of grouping information.

T5 had the highest mean weight whereas T2 had the lowest mean weight and the rest of the treatments had the same mean weight.

Table 9: **Mean weight of whole beans subjected to different treatments of fertilizer**

Treatments	Mean (g)
T_1	12
T_2	11
T_3	12
T_4	12
T_5	13
T6	12
T7	12
P-Value	0.927
Standard Error Of Difference	2.32873

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Average number of leaves per bean plant

The results of the study showed no significant difference in the mean number of leaves in the 5th week (P=0.085) when subjected to different fertilizer treatments (see table 3). This was attributed to the fact that during initial stage of plant growth, nutrition for growth is obtained from food reserves in seeds and also because fertilizers are not properly mixed in the soils.

In week 7, there was a significant difference in the mean number of leaves (P=0.031) and this was attributed to the fact that properly mixed in the soils hence supplied at different rates with regards to the treatments. T4 showed the highest leaf count and was probably due to accurate amounts of NPK which was readily available for growth.

T1 had the lowest leaf count and this was due to the fact that it's growth was based on naturally occurring nutrients in the soil. This poor performance in the mean number of leaves could have been a result of low nutrient supply to the plant since it was a control treatment.

5.2 Stem height per plant.

Week 5 showed no significant difference in the in the mean stem height when subjected to different fertilizer treatments (P=0.202) and this was because nutrients were derived from food reserves in the seeds hence cell division and stem elongation in the stems was almost the same. The mean stem height was highest in T1 and T4 and it was lowest in T1.

There was a significant difference in the mean stem height in week 7 when subjected to different fertilizer treatments (p=0.026) and this was due to fertilizers being efficiently mixed in soil hence increases uptake by plant roots hence a drastic increase in stem height is expected in reference to fertilizer applied.

Both control treatments in (week 5and 7) had the lowest stem height and this was attributed to deficiency of nutrients which reduced activities of cell division and hence limiting stem elongation.

5.3 Number of root nodules at flowering.

The results showed that there is no significant difference in the number of root nodules when subjected to different fertilizer treatments. Similarly, Hultman (2018) reported non-significant effects of manure application on nodulation of common beans which could be due to high mineralization or application of nitrogen fertilizer that decreases the amount of biologically fixed nitrogen.

5.4 Number of pods per plant

The results showed that there is no significant difference in the number of pods per plant when subjected to different fertilizer treatments. This might have been so because the amount of fertilizer applied might not have been significant to cause a drastic change in the number of pods formed on a plant or because of high temperatures.

5.5 Number of seeds per plant

The results of the study showed no significant difference with different fertilizer treatments. This could have been a result of the high temperatures during the flowering stage. This finding is in agreement with that obtained by Castaneda et al (2009) that high moisture stress during the reproductive stage exposed the plant to floral abortion and resulted in low seed yield. Generally, the reproductive stage is the most sensitive to drought-stress (Karantin et al, 2019). This phase includes flower formation, full flowering, pod formation or grain filling and reduced pollen formation in common bean (Karantin et al, 2019).

5.6 Weight of 10 seeds per plant.

The results of the study showed no significant difference in the weight of ten bean per plant when subjected to different fertilizer treatments**.** This might have been a result of either the fertilizer not being properly mixed in the soil to cause a significant difference in the weight of 10 beans and also the fact that organic manure takes a longer time to be properly mixed in the soil. This could have lowered the weight of seeds.

5.7 Weight of whole seeds per plant.

There was no significant difference in the weight of whole beans subjected to different fertilizer treatments (P=0.927). This might have been a result of inadequate fertilizer in the soil either the one applied was not well mixed in the soil or the amount applied being not significant to cause a significant difference in the weight of whole beans. This insufficient supply of nutrients might have led to falling off of flowers, miniature pods or formation of pods with less or no seeds hence no significant difference.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study was conducted to determine the effects of cow dung and NPK fertilizer and their combination on yield and yield component of common beans. It was observed that application of the correct levels of fertilizer is necessary to achieve a high yield of common beans. Combined application of fertilizer revealed a significant difference in the number of leaves per plant, stem height, number of root nodules at flowering, number of pods per plant, number of seeds per plant, weight of 10 seeds and weight of whole seeds. The results showed no significant difference in growth parameters except for exceptions in weeks 7 of leaves and stems.

6.2 Recommendations

It is recommended that in order for the growth and yield of the common beans on degraded soils in Uganda to be improved, a combination should be used. This is so because a combination improves soil fertility, productivity and reduce the impact of inorganic fertilizers on environment hence an alternative way to achieve sustainable soil fertility and productivity.

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APPENDICES

Appendix 1

Analysis of Variance of leaves per plant(Week5)

Variate: LEAVES

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	4.071	13.14%	4.071	0.6786	1.94	0.085
Error	77	26.917	86.86%	26.917	0.3496		
Total	83	30.988	100.00%				

Appendix 2

Analysis of Variance of leaves per plant (week7)

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	28.31	16.10%	28.31	4.718	2.46	0.031
Error	77	147.50	83.90%	147.50	1.916		
Total	83	175.81	100.00%				

Appendix 3

Analysis of Variance of height per stem (week 5)

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	34.86	10.24%	34.86	5.810	1.46	0.202
Error	77	305.53	89.76%	305.53	3.968		
Total	83	340.39	100.00%				

Appendix 4

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	443.5	16.58%	443.5	73.91	2.55	0.026
Error	77	2232.0	83.42%	2232.0	28.99		
Total	83	2675.5	100.00%				

Appendix 5

Analysis of Variance of number of root nodules at flowering

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	2580	15.94%	2580	430.0	0.44	0.838
Error	14	13605	84.06%	13605	971.8		
Total	20	16185	100.00%				

Appendix 6

Analysis of Variance of number of pods per plant

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	4.286	12.26%	4.286	0.7143	0.33	0.912
Error	14	30.667	87.74%	30.667	2.1905		
Total	20	34.952	100.00%				

Appendix 7

Analysis of Variance of number of seeds per plant.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	53.14	10.68%	53.14	8.857	0.28	0.938
Error	14	444.67	89.32%	444.67	31.762		
Total	20	497.81	100.00%				

Appendix 8

Analysis of Variance of weight of 10 seeds

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	161.87	91.87%	161.87	26.978	26.37	0.000
Error	14	14.32	8.13%	14.32	1.023		

Total	20	176.19	100.00%

Appendix 9

Analysis of Variance of weight of whole beans.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
TREATMENT	6	9.717	11.35%	9.717	1.620	0.30	0.927
Error	14	75.922	88.65%	75.922	5.423		
Total	20	85.639	100.00%				