EFFECT OF FARMYARD MANURE INTEGRATED WITH TRIPLE SUPERPHOSPHATE ON YIELD AND GRAIN QUALITY OF BIOFORTIFIEDCOMMON BEANS IN CENTRAL UGANDA

BY

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DECLARATION

I Wabusa Derrick declare that the work presented in this dissertation is my original work and has not been presented for any award in any University or Institution of higher learning.

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APPROVAL

This dissertation has been submitted for examination with our approval as University supervisors.

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DEDICATION

This work is dedicated to my dear parents: Wamurubu Sarapio and Wakooli Agrecious, Agrivil family Habomugisha Dan, Mawadri Gilbert, Thembo Godfrey, Fhilemon Wogoli and Nattabi Barbrah, all my brothers and sisters, and the entire Buwanyanga clan.

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LIST OF ABBREVIATIONS AND AGRONYMS

ANOVA: Analysis of Variance

INM : Integrated Nutrient Management

Kg ha^{-1} : kilograms per hectare

LSD : Least Significant Difference

NPK : Nitrogen Phosphorus Potassium

NARO : National Agricultural Research Organisation

OM : Organic Matter

pH : Potential of Hydrogen

SSP : Single Super Phosphate

RCBD: Randomized Complete Block Design

TSP : Triple superphosphate

UNDP : Uganda National Development Plan

USDA : United States Development of Agriculture

WHO : World Health Organization

ABSTRACT

A study was carried out to assess the effect of farmyard manure integrated with triple superphosphate on soil conditions, yield and grain quality of bio-fortified common bean Genotypes in central Uganda. The study evaluated the effect of different amendments of farmyard manure integrated with triple superphosphate (TSP) on soil conditions, yield components and grain quality of bio-fortified common bean genotypes. The experiments were set in a Randomized Complete Block Design (RCBD) conducted at Mukono Zonal Agricultural Research Institute (MUZARDI) in two rainfall seasons, where treatments included; Cattle manure + TSP, Swine manure + TSP, Chicken manure + TSP, TSP alone and control replicated five times. Bio-fortified common bean genotypes used in the study included Naro bean 1 and Naro bean 3, NABE16 a local check. Data was collected on; organic matter, soil pH, nitrogen, potassium and phosphorus content, harvest index, number of pods, pod length, number of grains per pod, weight of 100grains, grain yield, crude carbohydrates, fats, proteins, Iron and zinc content. Data collected was analyzed by a t-test for objective one and analysis of variance for objective two and three using Genstat statistical package (15th edition).

Results showed that amendment of the soil with Swine manure + TSP significantly increased Organic matter by; 1.51% and potassium 1.22% than Chicken manure + TSP, Cattle + TSP, TSP alone and a control respectively. Chicken manure + TSP highly increased soil pH and Nitrogen by 1.80 and 2.20%, TSP alone improved Phosphorus by 5.2 PPM than other treatments. Yield parameters were not significantly ($P>0.05$) affected by treatments except weight of 100 grains. However bean genotypes grown in Swine manure + TSP recorded maximum yield of 14 pods, 4 grains per pod, 32.93g weight of 100grains, grain yield was (1843kgha^{-1}) and lowest (1253 to 650kg/ha) in TSP+ cattle manure and control. Grain quality attributes were significantly ($P<0.05$) affected by all treatments however, swine manure + TSP was superior over other treatments on grain quality of bio-fortified beans by 91.82% seed purity, 56.77%crude carbohydrates, 177.20 ppm Iron and 33.58 ppm Zinc content but, crude fats and crude proteins were higher in treatment TSP alone and Chicken manure + TSP. Bio-fortified bean Genotype Naro bean 1 significantly performed better than Naro bean 3 and Nabe 16. It was therefore, concluded that swine manure + TSP significantly improved soil conditions, yield and seed qualities of bio-fortified common beans. Therefore, basing on these findings, farmers should adopt amendment of swine manure with TSP for improved soil conditions, yields and grain quality of Naro bean 1.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Malnutrition, a major cause of poor health is worldwide spread due inadequate intake of macro nutrients and micronutrients (Sidhu, Andre, Antonia, Martin , & Fadela, 2020). Developing countries especially Asia and sub-Saharan Africa are the hardest hit continents, as 60% of pregnant women and preschool aged children are Iron and Zinc deficient (Hannah, 2017), while 15% are macro nutrient deficient (Nicolai , Jallow, & James, 2018). In sub-Saharan Africa, Uganda is under threat as 39% poor households staying in urban places and villages are severely deficient in Iron, Zinc, proteins and fats (FAO, 2008; World Bank, 2017). Since their diets are heavily dominated by staple food crops like cassava, maize, yams, sweet potatoes, millet, sorghum and rice, these food stuffs are Iron, Zinc, proteins and fats deficient (Stein, 2010). They also contain more inhibitory factors like Phenolic compounds and Phytate that prevents absorption of important nutrients like Iron, Zinc, proteins, carbohydrates, vitamins and fats. Furthermore, majority of households are constrained by resources to afford diversified diets enriched by these elements for example meat, sea foods and C_3 cereal products such as: wheat, barley and rice (Joy *et al.,* 2013).

One of the cheapest strategies to the above incidence is through provision of food sources such as bio-fortified common beans. Breeders in sub-Saharan African have developed and tested bean genotypes (Bio-fortified beans) containing higher amounts of Iron, Zinc, proteins and fats which is a cheap nutritional alternative to malnutrition, with its associated defects like poor immune system, poor cell division, poor cognitive development, poor breakdown of carbohydrates, poor sense of smell, anemia and kwashiorkor (Plus, 2016).

Despite bio-fortified bean's substantial nutritional role and potential of contributing to food security, production is low due to biotic and abiotic constraints. The major substantial abiotic limitation to bean production in Africa is low soil fertility, which is commonly manifested in symptoms: poor seedling emergency, stunting, pod abortion, poor seed physical purity and seed quality attributes, poor nodulation and chlorosis (Singh, Henry, Carlos, John, & Juan , 2003). In fact, low soil fertility constraint is true, because Africa being one of the oldest continents in the world, its soils are heavily degraded by erosion and human pressure due to continuous cropping. Therefore, soil nutrients pool in some parts of African countries like Uganda are depleted and high levels of poverty has resulted into limited land that is neither fallowed nor crop rotated (FAO, 2008). Hence low bean yields accounting to 217.5- 600kg^{-}ha is produced in Northern, Central, Western and Eastern Uganda for other varieties is witnessed (Catherine , Katungi, & Zhen, 2016; CIAT 2015) compared to1750-3750$kgha^{-1}$ of achievable yield (MAAIF, 2017). Yet, beans is a reliable feeder to all households, as its per capita consumption in the country has increased from 19kg to 21kg as a result of human population increase (Karfakis, Velazco, Morena, & Covarrubias, 2011). High consumption than production, is heavily going to compromise the achievement of the second sustainable development goals of No hunger by 2030 (WFP, 2019). Consequently, to achieve no hunger by 2030, poor soil amendment techniques like, application of only fertilizers or organic manure as recommended by other studies, should be abolished or not depended on and integrated approach be adopted. Because in India the approach has been highly embraced from 1992 up to date and further supported by (FAO, 2012). As the only nutrient ammendment technology that is sustainable and can provide clean and enough food to 9 billion predicted human population come 2050. However, in sub-sahara especially Uganda very few farmers have an idea about it (Semalulu et al., 2020). Yet the technology increases yield without jeopardizing soil native nutrients or polluting the environment (Apurva, 2019). This would possibly help to increase production and reduce, 1.6 million people estimated to be going to bed on empty stomachs every day and 9.3 million Ugandans who are not sure of having a daily meal (World Bank, 2017).

So, to contribute to the strategy "Zero hunger and improved wellbeing of Ugandans by 2030". Dereje *et al* (2018) recommendations of every crop having a limiting nutrient for example; cereals and vegetables are limited to nitrogen, bananas to potassium, tubers and beans to phosphorus, for their potential growth and yield or catering for their explicit essential nutritional needs, should be followed. Yet, there is no study that has been carried out to assess the effect of farmyard manure integrated with triple superphosphate on soil conditions, yield and seed quality of bio-fortified beans. Therefore, it was from this observation that the study was conducted to address this knowledge gap as well as erasing the yield gap of bio-fortified beans.

1.2 Statement of the Problem

Despite the potential of mitigating malnutrition and food security challenges among vulnerable people (pregnant women, pre-school children, school going children) in Uganda, with bio-fortified beans (UNAP, 2011- 2016; Plus, 2016). Production is low 217.5- 600 $kgha^{-1}$ compared to potential yield 3750$kgha^{-1}$ (MAAIF, 2017; Lilies, 2018) particularly because of deficiency of a limiting nutrient phosphorus (P) to bean production. In fact, P deficiency is real because (Gregory and Bumb, 2006) reported that 75kg P ha^{-1} have been depleted from 200million hectares of cultivated land in 37 African countries including Uganda. Yet, P is a key requirement (20-30% or

10-15 mg/kg is needed by individual bean plant) in energy metabolism during nodulation and protein synthesis (Broadley, 2009). Numerous alternatives have been proposed to improve and sustain soil conditions as well as increasing productivity of bio-fortified beans. Among these, NPK, DAP and Urea fertilizer have been highly recommended by other scholars however, these fertilizers are easily leached, not absorbable in all soil pH status (Selim, 2020), not limiting to bean production and their prices are increases every year as well as suppressing symbiotic association of beans and Rhizobium bacteria species especially the R. *etli* species which the major nodulating bacterium species. Hence growth and yield is compromised (Dogra & Dudeja, 1993). Organic matter is cheap and supplies all the required micro and macronutrient; unfortunately its nutrients exist in low concentration (Ramana *et al*., 2008).

Therefore, integrated nutrient management is a better option, as it involves the use of farmyard manure and a limiting nutrient. In fact, it also promotes efficient use of resources by reducing seasonal input costs, improves required nutrient stock and efficiency, provides nutrient balances and minimise antagonistic effects (Apurva, 2019).

However, there is limited information on effect of integrated nutrient management on soil conditions, yield and seed qualities of biofortified common bean genotypes in central Uganda. Yet integrated nutrient management has bean reported to significantly sustain soils conditions, improve yield and grain quality of common beans elsewhere.

This study therefore, aimed at assessing the effect of of integrated nutrient management on soil condition, yield and seed qualities of biofortified common bean genotypes.

1.3 Objectives of the study

1.3.1 General objectives

The General objective was to assess the effect of farmyard manure integrated with triple superphosphate on soil chemical properties, yield and seed quality of bio-fortified common bean Genotypes in central Uganda.

1.3.2 Specific objectives

The study addressed the following specific objectives:

1. To assess the effect of farmyard manure integrated with triple superphosphate on soil conditions.

2. To examine the effect of farmyard manure integrated with triple superphosphate on grain yield and its components of bio-fortified common bean genotypes.

3. To evaluate the effect of farmyard manure integrated with triple superphosphate on seed qualities of bio-fortified common bean genotypes.

1.4 Research hypothesis

The study hypotheses includes:

1. Improvement of soil organic matter, pH, Nitrogen, Phosphorus and Potassium depends on the source of farmyard manure integrated with triple superphosphates.

2. Yield of bio-fortified bean genotypes varies with source of farmyard manure integrated with triple superphosphates.

3. Seed quality attributes of bio-fortified common beans genotype differs with the different source of farmyard manure integrated with triple superphosphates.

1.5 Significance of study

The study findings are to be used to make recommendations for suitable combination of farmyard manure source (chicken or cattle or swine manure) with triple superphosphate as sustainable and cost-effective strategy to remedy low soil fertility, food insecurity and malnourishment. As well as improving soil health, seed quality and grain yield per unit area of bio-fortified common bean genotype in Uganda. Additionally, dependence on either fertilizer or organic manure alone, whose nutrients are easily eroded and also exist in low concentrations yet, the process of protein synthesis and nitrogen fixation in beans requires oxidation and reduction of higher amounts of phosphorus to release enough ATP energy (Broadley, 2009).

This study findings are to help key stakeholders like, urban and peri-urban farmers on choice of suitable source of farmyard manure and TSP or fertilizer combination, on improvement of vegetables, fruits, root tubers and other legumes during the process of soil amendment.

Also, policy-makers can use these study findings to make recommendation on which suitable source of farmyard manure and fertilizers combination on other crops, when amending farm fields.

Furthermore, the results of this study are going to address the knowledge gap especially on the effect of integrating farmyard manure with triple superphosphates on soil conditions and bio-fortified beans genotypes.

1. 6 Scope of the study

The study focused on assessing the effect of farmyard manure integrated with triple super phosphate on soil conditions, yield and seed quality of bio-fortified common bean genotypes

(*Phaseolus Vulgaris*) in Uganda from 2018 to 2019. Specifically the study was conducted at Mukono Zonal Agricultural Research Development Institute (MUZARDI) and laboratories analysis was carried out from Makerere University and Kawanda Soil Research Institute.

Farmyard manure: Swine, poultry and cattle manure with triple superphosphate fertilizer formed three integrated nutrient treatments, applied at a rate of nine kilograms for each type of manure with 27 grams of triple superphosphate (TSP), TSP alone and control, formed five independent variables which were randomly applied as randomized complete block design. Dependent variables were Organic matter, soil pH, Nitrogen, Phosphorus, Potassium were variable for soil conditions while harvest index, number of pods per plant, pod length, number of grains per pod, weight of 100 grains, and yield $kgha^{-1}$were dependent variable for yield. Seed purity, carbohydrates, proteins, fats, Zinc and Iron were dependent variables for seed quality attributes.

CHAPTER TWO

LITERATURE REVIEW

2.1 History of integrated nutrient management

The idea of integrated nutrient management was started in India in the mid of eighties to 1992, when complex fertilizers were introduced and following oil crisis. Therefore, farmers were recommended to use part of organic manure and inorganic manure to harmonize nutrients properties, have a balance between crop nutrient demands, harmonized organic and inorganic nutrient combinations, have a clear method of deposing organic wastes safely and effective way of recycling waste into good quality manure, optimize nutrient supplies to maintain high nutrient-use, minimizing nutrient loss under intensive agricultural systems and increase yield without jeopardizing soil native nutrients or polluting the environment(Apurva, 2019).

In Sub-Saharan African, the system of integrated nutrient management technology is poorly adopted as very few farmers have an idea about it but, not practiced or embraced. Yet, Per capita food production is constrained by soil nutrient exhaustion especially in poor household farms (Quansah & Drechsel, 2001). In last 30 years, on average 660 kg N ha^{-1}, 75 kg P ha^{-1} and 450 kg K ha^{-1} have been depleted from about 200 million hectares of cultivated fields in 37 African countries (Bumb & Gregory, 2006). Farmers have been widely advised to Fallow their land, carry out crop rotation, intercropping with legumes, addition of organic manure or fertilizers, mixed cropping, as a traditional soil fertility improvement strategies in Uganda but, they are not adequately capable of adjusting soil fertility to sustain production (Kimetu, Kihara, Waswa, & Bationo, 2006). Therefore, replacement of a part of chemical fertilizers by organic manure through, a simple technique of using minimum effective dose of sufficient and balanced quantities of organic and inorganic fertilizer in combination has optimistic solution in maintaining soil health and agronomically bringing a drastic effect on crop growth and yield, to contain the ever rising food demands (Selim, 2020). Studies reviewed below shows existing knowledge gaps on effect of farmyard manure integrated with TSP on soil conditions.

2.1.1 Organic matter content

Soil organic matter is a key determinant of soil bio-photochemistry i.e. it's composition and break down affects soil structure, Porosity, moisture, biological diversity and plant nutrients (Jose, 2005). A study conducted to assess the effect of integrated nutrient management on organic matter showed that, there was a high organic matter build up in field plots that received organic manure, NPK and Zinc fertilizers than fields without integrated nutrients (Pintu, Murlidhar, & Das, 2010). Furthermore, Sharma, & Swarup (2013) reported an increase in organic matter in plots amended with Farmyard manure, green manure and NPK than plots amended with NPK or without fertilizer amendments. Additionally, Moshiri, *et al*(2019) compared effect of cattle manure combined with TSP and their finding showed more organic carbon in experimental units that received cattle manure combined with TSP. Organic matter content in rice field increased to a score of 0.85% on plots that received integrated nutrient (pig manure, green manure and NPK from 0.7% score of unfertilized field (Liu, Rong, Zhou, & liang, 2017).

2.1.2. Soil pH

In the study conducted by Nisha & Sneh (2018) findings showed that amendment of the soil by integrated nutrient management significantly increased the soil pH from 5.6 to 6.8. This was reported when vermin manure was integrated with NPK compared to plots amended with NPK. Furthermore, general improvement by 1.4 soil pH was noted in plots amended with Farmyard manure, green manure and NPK than plots amended with sole treatment or without fertilizer amendments (Jour, Yaduvanshi, Sharma, & Swarup, 2013). Comparison of animal manure (cattle, swine and poultry) indicated a substantial improvement on soil pH from low to normal at low and high levels of application (Ano & Ubochi, 2010). Application of phosphatic fertilizers lowered the soil pH from 6.8 to 5.6 (Saunders, 2012)

2.1.3 Nitrogen content

Kwadwo and Larbi (2015) studied the effect of amending crop field with cattle or poultry manure under maize cowpea intercrop and their finding revealed an increase on available nitrogen in plots receiving poultry manure than cattle manure because of existence of more N_2 in poultry manure on addition to what is fixed by cowpea. Increased available nitrogen was also noted by (Ghosh *et al*., 2003) in crop fields that received NPK integrated with poultry manure than fields amended with NPK and cattle manure in all season. Also, another study conducted by (Liu, Rong, Zhou, & liang, 2017) recorded an increase in nitrogen availability in paddy rice field especially on plots that received integrated nutrient of pig manure, green manure and NPK than unfertilized field. However, (Brittany, 2019) reported that an increase in phosphorus and nitrogen in the soil limits expression of potassium.

2.1.4 Phosphorus content

Amendment of the soil by integrated nutrients management (INM) significantly improves on the soil phosphorus availability. This was reported after the study was carried out by Nisha & Sneh (2018) on effect of vermin manure integrated with NPK on available phosphorus. Integrating poultry litter manure with TSP highly increased phosphorus availability to deeper layers of sandy soil, this was reported after an investigation was performed by Withers (1999). Hentz *et al* (2016) also observed a high phosphorus availability in crop fields that were amended by poultry than pig manure.

2.1.5 Potassium content

Kwadwo and Larbi (2015) studied the effect of amending crop field with cattle or poultry manure under maize cowpea intercrop, their findings revealed an increase on available potassium in plots that received poultry manure than cattle manure. Increased available nitrogen was also noted by (Ghosh, *et al*., 2003) in crop fields that received NPK integrated with poultry manure more than fields amended with NPK and cattle manure in all season. Higher potassium was noted in swine manure than in cattle and chicken manure (Teppei, Areta, & Manabu, 2012)

Integrating poultry litter manure with TSP highly increased potassium availability to deeper layers of sandy soil, when a field study was carried out, to test potassium status under INM (Withers, 1999). A small difference of 0.1 % of potassium availability was observed in crop fields that were amended by pig than poultry manure (Hentz, *et al*., 2016).

2.2 General background of bio-fortified beans

Common bean is a native of Mesoamerica and Andes. In same environment it exists as wild and domesticated species (Toro, 1990). Currently beans are found in many centers of diversity across the world because, of its substantial nutrients. However, due to increasing macro and micro nutritional challenges existing in developing continents like South America, Africa and Asia for proteins, fats, Iron and Zinc (Smith, 2016), crop breeders in the region and International Center for Tropical Agriculture (CIAT) have bred bean genotypes, bio-fortified by Iron and Zinc, as a multidisciplinary approach to combat macro and micro nutritional deficiencies (Pierrot *et al*., 2014). The parental lines of bio-fortified beans were obtained through screening from 2800 bean accessions for high Iron, Zinc, proteins, fats content and disease resistance (CIAT, 2008). The accessions were collected from nine countries in East and central African between 2001 and 2008. After screening, germplasm (MLB 49-89A) had high Iron, zinc, proteins and fats, obtained from Democratic Republic of Congo (DRC), germplasm (HRS 545) from Sudan showed good tolerance to drought and angular leaf spot as well as high Iron and Zinc concentration. Germplasm with high yielding traits was developed by combining 11 commercial varieties into a single germplasm through back crossing and the product of the back cross was obtained in 2010, which successively passed resistance to angular leaf spot, anthracnose, root rot and fusarium wilt. The three sources (MLB 49-89A, HRS 545 and high yielding germplasm) were combined into one composite variety in the screen house, at University of Kenya and further bred with different bean varieties depending on the level of genetic compatibility (Kimani & Ahmed , 2019). Bio-fortified beans are the best remedy to macro and micro nutritional challenge facing vast sectors of a Ugandan population particularly resource poor adults, women and children. Therefore, increasing their production through integrated nutrient management is probably the most effective, sustainable and potentially long lasting approach for mitigating macro and micro nutrient malnutrition as well as food security.

2.3 Effect of integrating triple supper phosphate with farmyard manure on yield parameters

2.3.1 Harvest index

The study conducted by Jayashri (2014) reported that integrated nutrient management caused a greater significant influence on harvest index of French beans, when vermin manure was combined with NPK and phosphorus stabilizing bacteria than, a combination of phosphorus stabilizing bacteria and NPK applied alone. However, in the contest of three French bean varieties, Contender showed a higher harvest index compared to other varieties under same treatments. Furthermore, a higher significant difference of harvest index was also noted by (Sushant, Dixit, & Singh, 1999), on French beans that received SSP combined with manure than treatments that were not integrated. Also soya beans that received swine manure had a higher harvest index than soya treated with fresh swine manure (Gina, et al., 2006). Priyanka (2014) also observed an increase in harvest index of French beans, grown under a combination of NPK, FYM, vermin manure and bio-fertilizer compare to French beans that received farmyard manure combined with bio-fertilizer or bio-fertilizer combined with vermin manure or NPK applied alone.

2.3.2 Number of pods

Studies reviewed here focused on integrating poultry, cattle manure, NPK and Single SuperPhosphate (SSP) on common beans for example. Combined application of poultry and NPK resulted in high number of pods on bean varieties, K131 and 132 than sole manure application (Kyebogola S, 2013). Also a study conducted by Sebuwufu, Muzar, Ugen, & Mark (2015) revealed that cattle manure integrated with Single superphosphate yielded a higher number of pods than, treatments that had either fertilizer or cattle manure. Aminul *et al*(2016), also reported that beans grown under vermin compost integrated with NPK showed a high significant increase on number of pods compared to the control however, there was a delay in bean plants to reach ripening stage. Kandil *et al.* (2013) also reported that increasing poultry manure and NPK combination increased number of pods and their weight per bean plant. A similar study was conducted on groundnuts and findings revealed that combination of poultry manure and NPK on ground nuts resulted in a higher number of pegs than plants under sole application of poultry manure or NPK. Mohanty *et al*.(2017) also reported that there was an increment on number of pods of French beans when cattle vermin manure was integrated with lime and NPK than beans plants that received one treatment. Finally (Teppei, Areta, & Manabu, 2012) also reported that high calcium, Phosphorus and potassium in swine manure increase absorption of N and Mg that are directly involved in chlorophyll formation and protein synthesis hence increased crop yield.

2.3.3 Length of pods

Foudal *et al*. (2017) conducted a study on effect of integrated nutrients on French beans and their findings revealed that integration of manure with NPK significantly increased bean pod length compared to the control that was treated with manure alone**.** Khalifeh *et al*. (2016) also revealed a positive response of beans pod length when poultry manure was integrated with NPK. Furthermore Mohanty *et al*. (2017) reported an increase on pod length of French beans when, Urea, single superphosphate and muriate of potash was combined with farmyard manure however, a combination of single super phosphate (SSP) with farmyard manure came second and very low pod length was noted in French beans grown in nutrients applied alone.

2.3.4 Number of grains per pod

Report by Jayashri (2014) revealed a greater significant influence on number of grains per pod in varieties that received integrated nutrients and, his major difference was noted in French bean variety arka komal than other varieties that received same treatment combination of vermin manure, NPK and phosphorus stabilizing bacteria.

Mohanty *et al.* (2017) also noted an increase on number of seed per pod of French beans when Urea, single superphosphate and muriate of potash were combined with farmyard manure. While plants that received farmyard manure combined with SSP become second, followed by bean plants under treatment, vermin manure combined with fertilizer NPK.

2.3.5 Weight of 100 grains

Foudal *et al*. (2017) further added that integrating manure with 100% NPK significantly increased seed weight of 100 grains compared to the control treated with manure alone. Mohanty, *et al*. (2017) still recorded a significant increase on seed weight of French beans when Urea, single supper phosphate and muriate of potash was combined with farmyard manure. This was followed by bean plants under treatment, vermin manure, Urea, single superphosphate and muriate of potash and lime. However, the lowest weight of 100 grains was observed on plants that had only one nutrient type. Khalifeh *et al*. (2016) also revealed a positive response of beans seed weight when they integrated poultry manure with NPK at recommended fertilizer rate. Ramana *et al*. (2011) stated that 75% recommended fertilizer rate integrated with vermin manure and phosphorus stabilizing fertilizer significantly increased weight of 100 grains of bean.

2.3.6 Grain yield

Mohanty *et al*. (2017) further noted a significant increase in yield per hectare of French beans when Urea, single superphosphate and muriate of potash was combined with farmyard manure. Under the same competition bean plants under treatment, vermin manure, SSP and lime came second. However the lowest grain yield was observed on plants that had only one nutrient type. Khalifeh *et al*. (2016) conducted an experiment on effect of poultry integrated with NPK on common bean and their findings revealed a significant yield in kilogram per hectare than yield obtained from treatments applied alone. Gina *et al*. (2006) reported that application of swine manure increased availability of phosphorus that eventually increased the number of roots that could scavenge for available nutrients in the soil to boost yield of soya beans.

All studies reviewed have greatly contributed to the effect of integrated nutrients on yield of common beans and other legumes. But these studies have majorly concentrated on integrating vermin manure, NPK, bio-fertilizers on French beans. However, there is no study that has reported on effect of farmyard manure integrated with TSP on yield of bio-fortified bean genotypes.

2.4 Effect of integrated nutrient management on grain quality

2.4.1 Grain purity

The combination of inorganic and organic nutrients to French beans applied in form of vermin manure and NPK resulted into healthy French bean grains with very little chef (Rajput, kumar, Sing, Singh, & Yogeshwar, 2006). Chavan *et al*. (2014) conducted a study on effect of incorporating cattle manure with a Bio fertilizer and Urea on seed purity of ground nuts, their field findings revealed that there was good yield of ground nuts and improved seed quality when cattle manure was incorporated with a Bio fertilizer and Urea, compared to plots that received Urea and no fertilizer amendments as positive and negative control. Sandeep (2014) also reported good seed quality of tomato grains from treatments that had vermin manure and single supper phosphate compared to control treatments, in his findings he noted that less inert material and damaged grains were sorted out in the samples collected. Furthermore, Mohanty, *et al*. (2017) also recorded a significant improvement on seed quality of French beans observed under treatments Urea, single supper phosphate and muriate of potash when combined with farmyard manure and bio-fertilizers compared to bean plants treated with vermin manure, fertilizer NPK and lime.

2.4.2 Carbohydrates

Cutierrez-micel *et al*. (2007) reported an increase in carbohydrate concentration when vermin manure from sheep dung was applied than treatments that had no amendment. Srivastava & Ethel(2007) also revealed that, the use of integrated nutrient management increases the nutrient pool at the Rhizophere, resulting into general improvement on plant health and vigor, which in turn increased the Photosynthates for the plant inform of carbohydrates. In a study conducted by Rakesh, Jaswinder , & Adarsh, (2014) it was reported that the use of vermin manure enriches plants quality attributes like carbohydrates that can be found in grains or in shoot systems. Another study conducted by (Singh, Rajhans, Maurya, & Meana, 2014) revealed that, the effect of integrated nutrient management influenced a significant increase on carbohydrate content of cabbage (*Brassicaoleracea var capitata*) when farmyard manure was combined with inorganic fertilizer, bio-fertilizer (pseudomonas flourescens) and humic acid.

2.4.3 Fat content

A study about agronomic bio-fortification to fight hidden hunger in sub-Saharan Africa findings revealed that use of organic and NPK under integrated nutrient management can increase the nutrient content especially lipids in plant edible parts (de valenca, Anita, Inge, & Ken, 2017). A significant increase on fat content of cabbage (*Brassicaoleracea var capitata*) was noted by (Singh, Rajhans, Maurya, & Meana, 2014), when farmyard manure was combined with inorganic fertilizer, bio-fertilizer (pseudomonas flourescens) and humic acid.

Mashooque (2015) reported that increase of NPK levels increased the fat content in okra than, treatments that had low levels of NPK. Ansari and Kumar (2010) studied the influence of integrated nutrients on okra production and they reported that increased fat content was realized when NPK and organic manure was applied than okra plants amended with only one nutrients and control. Sebuwufu (2013) studied the physiology of bean genotypes and soil fertility effects on yield and accumulation of proteins, oil in grains, iron and zinc in common bean grains. His findings revealed that, use of cattle manure on farm fields of small holder farmers increased oil content in variety K131 than kanyebwa. But, intensification of phosphorus lowered yield and iron content in field intercrop of maize and beans.

2.4.4 Crude proteins

Chavan *et al*. (2014) reported a significant yield of groundnuts and increased protein content when cattle manure was incorporated with a Bio fertilizer and Urea compared to plots that received Urea alone and plots that were not amended had less crude proteins. Also, Sandeep (2014) studied the effect of combining and sole application of vermin manure, bio-fertilizer and single superphosphate on protein content of tomato fruits and his finding showed a high amount of crude proteins, in tomato fruits that were under treatment of vermin manure, bio-fertilizer and single superphosphate treatment as compared to other treatments. Baga and Jadha (1995) conducted a study on nitrogen levels in grains of soya beans, inoculated or without. The findings showed a significant increase in crude protein content on plant inoculated with nitrogen and grown under manure mixed with Urea than, soya grains harvested from treatment with no inoculation and grown in plots amended with Urea. Finally, Shubhashree (2007) revealed that combination of inorganic and organic nutrients to French beans applied through fertilizer NPK, manure resulted into significant higher crude protein content. Increased accumulation of proteins in peanuts was noted by (Argaw, 2017), when cow dung manure was integrated with di ammonium phosphate (DAP) and biofertilizer innocum (Bradyrhizobium)

2.4.5 Iron content

Velenca (2017) studied agronomic bio-fortification to fight hidden hunger in sub-Saharan Africa, in his findings he reported that use of organic manure and NPK under integrated nutrient management can increase the amount iron partitioned in plants edible parts of the plant. Sebuwufu (2013) studied the physiology of genotype and soil fertility effects on yield and accumulation of iron and zinc in common bean grains, his findings revealed that, use of cattle manure on farm fields of small holder farmers increased iron content in variety K131 than Kanyebwe and intensification of phosphorus lowered yield and iron content in field intercrop of maize. When two pot trials and one field trial were established to investigate the effect of organic and inorganic fertilizer application to common beans, chicken manure and sewage cake integrated with NPK recorded higher amounts Iron than pots that received pig, cattle manure and control (Smith & Slater, 2020).Finally significant improvement of Iron content of lettuce was reported by (Masarirambi, et al., 2012) when chicken manure was applied than control fertilizer ammonium nitrate.

2.4.6 Zinc content

Sebuwufu (2013) studied the physiology of genotype and soil fertility effects on yield and accumulation of iron and zinc in common bean grains, findings revealed that, use of cattle manure on farm fields of small holder farmers increased zinc content in common bean variety than control, intensification of phosphorus lowered yield and zinc content in field inter-crop of maize and beans. Velenca (2017) studied agronomic bio-fortification to fight hidden hunger in sub-Saharan Africa, in his findings he reported that use of organic manure and NPK under integrated nutrient management can increase the nutrient content especially lipids in plants edible parts.

Most studies reviewed on effect of integrating urea or NPK or single super phosphate or bio fertilizers with farmyard or vermin manure on seed physical and chemical seed quality showed significant improvement of ground nuts, maize and French beans. However, there are no studies that have reported on the effect integrating farmyard manure with triple super phosphate on seed qualities of bio-fortified beans in Uganda. Furthermore, genome of bio-fortified beans is different from conventional common bean breeds and even materials used in reviewed studies are very expensive, hence cannot be afforded by a local poor resource farmer. Additionally, bio-fertilizers and stabilizing bacteria are not common on markets especially in many developing and some developed countries. Besides that, most studies have concentrated on use of NPK, on beans production, yet production of beans is limited by phosphorus which is a key element in protein synthesis and stock of energy required during nitrogen fixation. Actually, when a lot of nitrogenous and potash fertilizers are used, a lot will be leached because of their easy dissolution, so less can be absorbed by plants. On addition, application of nitrogenous fertilizers can make beans lazy to fix their own nitrogen or encourage vegetative growth at the expense of sinks or endanger other production through eutrophication. Therefore, it would be more efficient when more phosphorus is used as it dissolves slowly, and when integrated with farmyard manure, more nutrients will be held and exchanged for plant growth and yield. This study therefore, intends to address these knowledge gaps.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Site description

A field experiment was conducted at Mukono Zonal Agricultural Research and Development Institute (MUZARDI), located in Ntawo Division, Mukono District in Central Uganda. The institute is situated at 1200m above sea level and gently sloping to the western direction, along latitude 1.029^0 South and 40.29^0 North and longitude 32.77^0 East. The site has a minimum temperature range of 15^0c to 18^0c and maximum temperature range of 25^0c to 28^0c, with a bimodal rainfall regime of 1100mm-1600mm that lasts for eight months, from March through June and short rains from October to December (Mungyereza, 2014). Its soils are mainly ferresols which are shallow, well weathered with low to moderate inherent fertility (Opio & Tomma, 2018).

3.2 Soil characterization

Soil characterization was carried out at the study site to ascertain the physical and chemical properties. Twelve Soil samples were collected by transverse method from 0-25cm (Akinola, Olorunfemi, & Ademilua, 2018). Samples were mixed together thoroughly in the bucket to obtain a homogeneous composite sample, that was air dried for five days at room temperature and sieved through 2mm sieve (Burton, 1990).

Analysis on physical composition of sandy, clay, silt and texture was determined by Bouyoucos hydrometer method, whereas soil pH was determined by glass electrode pH meter and Potassium, calcium and magnesium were determined by flame photometer (Tekalign, Haque, & Aduayi, 1991). The available phosphorus was determined by Bray1 extraction method (Olsen, Cole, Watanable, & Dean, 1954) while Nitrogen and organic matter were further determined through a rapid titration (Walkley, 1934). Soil analysis was carried out from Makerere University and Kawanda soil science laboratories and results of analysis are presented in Table.3.1.

Table 3.1. Soil physical and chemical properties at MUZARDI for first and second season (2018-2019)

Sample Details	pH	OM	N	P	K	Na	Ca	Mg	Sand	Clay	Silt
		%		PPM		%					
First Season	6.14	2.65	0.16	2.62	1.46	0.05	6.68	0.08	50	44	6.0
Second Season	6.20	2.32	0.14	2.12	1.38	0.04	5.19	0.6	48	46	6.0

3.3 Management and chemical analysis of farmyard manure

Farmyard manure samples were collected from layers under cage system, cow dung from dairy cattle and pig dung from piggery unit at Kyambogo University farm. Three samples from chicken, swine and cattle dung were picked at random, wrapped separately in aluminum foil papers to enclose escape of bad smell, nitrogen, and contamination by dust particles during transportation to the laboratory for carbon (C): nitrogen (N) ratio determination (Walkley and Black, 1934). Findings revealed that, all manure samples were of poor quality as they had a low C: N ratio (chicken dung 10.2: 2, cattle dung 11.2: 1 and swine dung 13: 1.49). This means, when such manure is composted, more ammonia and carbondioxide will be produced and so, microorganisms will lack or have less to eat and multiply. Hence manure produced will be of poor quality (Charles Wortmann, David , & Charles, 2006). Therefore to improve on quality of manure, chopped dry maize straw with carbon content 30:0.4, (appendix 15 plate 1 and 2) was further quantified by calculating using equation presented by (Charles Wortmann, David , & Charles, 2006).

$$QA = 2000ibs \times N_m \times (C: N_T - C: N_m) \times DM_m \div N_A \times (C: N_A - C: N_T) \times DM_A \ldots\ldots 1$$

i.e. QA- quantity of maize straw required to improve quality of manure, 2000ibs- quantity of manure used, N_m - % N_2 in manure, C: N_T - normal carbon in manure, C: N_m- carbon in manure after analysis, DM_m % dry matter of manure, N_A - % N_2 in maize straw or material with high carbon, C: N_A -normal carbon in maize straw, C: N_T- carbon in maize straw after analysis and DM_A – dry matter in material with high carbon.

After calculation, 296kgs of maize straw was blended into 600kgs of chicken dung, 260kgs of maize straw was blended into 600kgs cow dung and 216kgs maize straw was also blended into 600kgs pig or swine dung. Thereafter, manure was organized in row piles, composted under a protected roof using wind row method for 8weeks. In the first two weeks, manure was turned trice per week (Appendix 15 Figure 3), accompanied by watering whenever temperatures could rise above 60^0c. This was followed by weekly turning since temperatures were dropping until when manure was fully composted. On the 9^{th} week, three different sample from each manure pile where pick for analysis and findings are presented in Table 3.2. The rest of the manure was packed in sacks of 50kg (Appendix 15 plate 4), transported to the experimental site (MUZARDI) for application. Same activities and procedure were followed for second season and results are presented in table.3.3 below. However, Triple SuperPhosphate (TSP) was bought and phosphorus content in it was 35 percent and blended with manure at ratio of 10t/ha manure: 30kg/ha TSP the time of planting following calibrations recommended by Nazir (2016) and Kayuki *et al* (2011)

Table 3.2. Chemical properties of manure for first season at Kyambogo university farm

Samples	pH	OM	N	Mg	K	Na	Ca	P	Zn	Fe
		%					PPM			
Cattle manure	7.49	3.22	1.46	1.04	0.05	0.01	0.01	2.53	157.67	7391.33
Swine manure	6.68	4.04	4.92	1.91	0.13	0.02	0.07	3.12	196.67	9424.17
Chicken manure	8.36	3.67	5.98	1.21	0.18	0.03	0.03	2.56	182.34	9644.00

Table 3. 3 Chemical properties of manure for second season at Kyambogo university farm

Samples	pH	OM	N	Mg	K	Na	Ca	P	Zn	Fe
		%					PPM			
Cattle manure	8.21	3.11	1.28	0.48	0.04	0.01	0.01	2.34	151.24	28810.33
Swine manure	6.88	3.49	3.98	1.53	0.14	0.01	0.06	3.81	187.87	9810.91
Chicken manure	8.48	3.47	4.37	1.30	0.09	0.02	0.03	2.49	169.01	9791.48

3.4 Experimental design and treatment structure

The experiment was laid in a Randomized Complete Block Design (RCBD) that was replicated five times. The treatments composed of three sources of farmyard manure: Chicken, Swine, and Cattle manure. During integration Chicken manure was combined with TSP (POLM), Swine manure combined with TSP (SWM), cattle manure combined with TSP (CATM). Farmyard manure was integrated with TSP at a rate of 9 Kgs: 27g TSP, followed by application of 27g of TSP alone as a positive control and control (no amendments) forming five treatments. The field was marked into 5 blocks (replicates) and 75 plots, each measuring 9m^2 separated by 1.5m width between blocks, and 1m width between plots to enable easy movement of materials and carrying out agronomic operations.

3.5 Bean genotype intrinsic nutrient determination

Bean genotypes Naro bean 1, Naro bean 3 and NABE 16 a local check were obtained from National Crop Research Resource Institute (Naccri) in Uganda and their nutrient composition were determined before planting, as presented in Table 3. 4.

Table 3.4 Intrinsic nutrients in bean genotypes before planting

Nutrient concentration	Bean Genotypes		
	NABE 16	NARO BEAN 1	NARO BEAN 3
%Carbohydrates	48	46	42
%Fats	0.31	0.51	0.60
%Proteins	17.35	19.28	19.01
Iron (ppm)	71	108.12	99.92
Zinc (ppm)	20.11	23.81	24.12

3.6 Agronomic practices

3.6.1 Field preparation

The field was deeply dug during primary and secondary cultivation to obtain a fine or right tilth and to remove roots of grasses and weed rhizomes. Using a tractor for primary tillage once, followed by use of a hand hoe three times for secondary cultivation.

3.6.2 Sowing / planting

Planting was done on the same day after application of treatments with a spacing of 10×50cm and one seed was sown per hole at the depth of 5cm.

3.6.3 Weeding

Weeding was done twice on the 14^{th} day after planting and after flowering, manually by use of a hand hoe and hand pulling.

3.6.4 Irrigation

Watering was done twice a day in the morning and evening whenever, there was a dry spell.

3.6.5 Pests and disease control

Pests and diseases control for example bean aphids and Halo blight that attacked some plants were controlled by spraying against with a concoction of 30 $mlha^{-1}$ suppasim, two leveled table spoons Bacteriomycin per hectare and $30mlha^{-1}$ vegemax in 20litres knapsack spray for Halo blight. However, bean anthracnose was controlled by spraying a solution of three table spoons per hectare of mancozeb 80% wp mixed with water in 20litres knapsack sprayer.

3.7 Data collection

3.7.1 Effect of farmyard manure integrated with TSP on Soil conditions

During data collection on objective one, chemical properties of soil were sampled twice i.e. before and after planting. Before planting, random soil sampling technique was employed to ascertain the baseline information before planting (Table 3.1). Soil samples were collected at the depth 0-25cm using a soil auger by transverse method (Akinola, Olorunfemi, & Ademilua, 2018) as earlier reported in chapter three unit 3.2. After planting or harvesting, zone sampling technique was employed at the middle of every experimental units. Samples from experimental units were collected and combined together in a block to obtain five representative samples for each block per treatments and labeled as swine + TSP block1-5, cattle + TSP block1-5, TSP block1-5, chicken + TSP block1-5 and control block1-5. The samples collected were, air dried for five days under room temperature and thereafter sieved through 2mm sieve (Burton, 1990). This was followed by analysis of organic matter, soil pH and Nitrogen, phosphorus, potassium availability. Data obtained were analyzed by a **t**- test to generate means that determined whether there was improvement in soil conditions created by treatment from means of baseline or not (Hentz, *et al*., 2016). As seen in (chapter three. Table 3.1 and chapter 4. Table 4.1- 4.2).

3.7.1.1 Organic matter content

During analysis of organic matter 0.5g of the soil was weighed and put into the boiling tube and arranged in the block digest for digestion. After 5ml of potassium dichromate solution and 7.5ml of concentrated sulphuric acid were added. Thereafter samples were placed in the heating block (digester) at 145-155^0 for 30minutes, after samples were removed to cool. Quantitatively digest was transferred to 100ml conical flask and 0.3ml of indicator was added and shaken to mix, followed by titration with ferrous ammonium sulphate. 5 reagent blanks were also titrated and recorded (Okalabo, Gathua, & Woomer, 2002).

$Oc = T \times 0.3 \times 0.2 \div Sw$……equation 2

Where Oc-organic carbon, T-reagent blanks and Sw-sample weight. Same procedures were followed to other samples.

3.7.1.2 Soil pH

Soil pH was determined using glass electrode pH meter. By addition of 50ml of deionized water in 25g of soil, the mixture was stirred for 10 minutes and allowed to cool for 30 minutes and stirred again for 2 minutes. Thereafter measurement of soil pH, of suspensions and recording was done. Same procedures were followed to other samples as per the treatments (Okalabo, Gathua, & Woomer, 2002).

3.7.1.3 Nitrogen content

In the process of analyzing nitrogen present in the soil, apparatus for distillation were steamed up using ammonia free distilled water. Aliquot or 10ml of soil sample solution in digest was transferred into a reaction chamber of steam and 10ml NaoH was added. Distillate was steamed immediately into 50ml of 1% boric acid containing 4 drops of the mixed indicator. Thereafter distillation continued for 2 minutes from the time indicator turned green. Distillate was removed and titration followed with N/140 HCl up to the end point, when indicator changes from green, grey to definite pink. Steam was passed through apparatus for 30 minutes to check the blanks by collecting 50ml distillate and titrating with N/140 HCl, according to (Okalebo, Gathua, & Woomer, 2002).

$\% N_2 = (a-b) \times 0.1 \times V \times 100 \div 100 \times W \times al$.....equation 3

Where a- volume of 1 titre HCl for blanks, b- volume of 1 titre HCl for samples, V- final volume of digestion, W- weight of the samples taken and al- aliquot of the solution taken for analysis

3.7.1.4 Phosphorus content

In the process of phosphorus extraction, 2g of soil sample was weighed out accurately into 150ml polythene shaking bottle. Followed by addition of 50ml of Olsen's or Bray1extracting solution (depending on the soil pH of the samples) to each bottle. Mechanically the mixture was shaken for 30minutes and suspensions were filtered after shaking by whatman No.44 paper. Followed by addition of charcoal to obtain a clear filtrate. Colorimetric measurement of phosphorus was done by pipetting 10ml of each P standard solution, 10ml of the sample filtrate and two reagent blanks into 50ml volumetric flask. Followed by addition of 5ml 0.8m boric acid. Addition of 10ml of ascorbic acid reagent to each flask and filling to the 50ml mark with distilled water was done. The content was shaken well after one hour, the analyte was aspirated into atomic absorption spectro-phometer (AAS) and measure of absorbance of solution was at wavelength setting 880nm and parts per million ppm calibration curve was obtained. The equation below expresses phosphorus availability in PPM (Okalebo, Gathua, & Woomer, 2002).

$$P\,(ppm) = (a-b) \times V \times f \times 1000 \div 1000 \times W$$ …..equation 4

Where a- concentration of P in extract solution, b- concentration of p in blank sample, v-extract volume, w -weight of soil, f- additional dilution factor.

3.7.1.5 Potassium content

Extraction procedures; air dried soil sample of 5g was put into a clean plastic bottle with stopper, 100ml of ammonium acetate solution NH_4OAc (pH 7) was added and shaken for 30 minutes. Thereafter the solution was filtered through No. 42 whatman paper.

Filtrates containing potassium was determined by pipetting 2ml of wet digested sample into 50ml volumetric flask and mixing well with distilled water. The solution was sprayed, starting with standard. The analyte and blank solution were directly aspirated into flame photometer and read at wave length 766.5nm, followed Reading of the amount of potassium against concentration in standard series (Tekalign, Haque, & Aduayi, 1991). Concentration of k in the sample is expressed as;

$$\% K = (a-b) \times V \times f \times 1000 \div 1000 \times W \ 1000 \ldots\text{..equation 5}$$

Where a- concentration of K in digest sample, b- concentration of K in blank digest, w- volume of the sample, v- volume of digest solution and f- dilution factor.

3.7.2 Effect of farmyard manure integrate with TSP on Growth and yield parameters

During data collection on objective two, ten plants were tagged on the middle lines of plots, leaving out plants on the opposite lines and data was collected on harvest index, number of pods, number of grains in the pod, pod length were determined when the plants had achieved their physiological maturity on the 58th after planting for Naro bean 3 and 70th day after planting for Naro bean1 and Nabe 16. On the other hand, grain yield and weight of 100 grains data were collected after threshing and drying (14% moisture content) all plants from individual plots per treatment.

3.7.2.1 Harvest index

Ten sampled plants were uprooted as per treatments, roots were cut off and abandoned. Pods were cut off from the shoot weighed and record as fresh weight, there after they were wrapped in newspapers labeled using its field tag number. The same process was done on the shoot and finally samples were oven dried at 80^{0}c, for 48 hours. Samples were removed and weighed again using electronic sensitive scale as dry weight, values obtained here were subtracted from fresh weight and recorded. The same procedures were followed on the shoot, so as to obtain harvest index (%Hi) economic yield (EY) was divided by the total biological mass (BM) of the plant and then multiplied by 100% according to (Mohanty, 2017).

$$\%Hi = EY \div BM \times 100$$ ……equation 6

3.7.2.2 Number of pods

To determine number of pods, all pods on each tagged plants were counted and recorded there after an average number was obtained per plot (Jayashri, 2014).

3.7.2.3 Number of grains per pod

Number of grains was determined by counting and recording the number of grains in each pod of the tagged plants and their average was worked out and recorded (Beebe, 2008).

3.7.2.4 Length of the pod

Length of the pods was worked out by observation and measuring the length of each pod produced per plant using a thread and meter ruler, average length of pods on the plant was obtained and recorded (Kyebogola, 2013).

3.7.2.5 Weight of 100 grains

All plants in experimental plots were uprooted and threshed by hand and grains or grains were dried to a required moisture content of 14%. Thereafter 100 grains were picked ten times as representative samples randomly from all bean genotypes in plots as per their treatments, weighed separately using a digital electronic scale and an average weight of each plot was obtained and recorded (Mohanty, 2017).

3.7.2.6 Grain yield

Weight of grains from each plot was determined as per the treatment and weighed using a digital electronic balance results obtained were extrapolated to yield per hectare as it was reported by (Beebe, 2008) and (Mohanty, 2017).

3.7.3 Effect of farmyard manure integrated with TSP on physical and chemical seed qualities of bio-fortified bean genotypes

During evaluation of physical and chemical qualities of grains, samples were dried up to the moisture content of 14% in the course of seed physical purity assessment under sun shine (Mohanty, 2017). while valuation of chemical qualities (crude carbohydrates, fats, proteins, Iron and Zinc), 30 pods were harvested from each experimental unit following their treatments one week before harvesting, labeled and air dried at room temperature for 2 weeks. Thereafter, pods were threshed by hand to remove grains, followed by air drying to a moisture content of 8% and seed were further, grinded with non-contaminant grinding mill, retch mill with Teflon chambers and zirconium balls to avoid contamination of samples. (Plus and NARO, 2016).

3.7.3.1 Grain physical Purity

Seed purity was worked out after threshing of grains manually as recorded in unit 3.9, by weighing 1000grams of grains from each sample and chuff (inert materials, weed grains, weeds, damaged and wriggled grains, rotten grains plus residual beans husks) sorted out and then weighed again (Mohanty, 2017). Grain purity according (Ferguson, Keys, Mclaughlin, & Warren, 1991) is initial weight divided by final weight after removing the chuff multiplied by 100%.

$Sp = Ws_1 \div Ws_1 \times 100\%$……equation7

SP=Seed purity, ws_1=initial weight of seed (1000g) with chuff, ws_2=final weight of seed (chuff excluded)

3.7.3.2 Carbohydrates percentage

Analysis of carbohydrate can be referred to nitrogen free extracts determination, which mean all substances soluble in weak acid alkali.

Carbohydrate percentage was determined by difference i.e. sum total of % moisture/dry matter, % ash, %crude protein, % crude fiber and % crude fat subtracted from 100% for all samples. (Hirpa, Nigussie, Dechassa, Setegn, & Bultosa, 2015)

%Carb = 100% - %DM + %ash + %CP + %Cf + % CF………equation 8

3.7.3.3 Crude protein determination

During determination of crude protein the principle of Kjeldahl was employed using very fine crushed samples. Two g of a sample was weighed and put into micro-kjeldahl flask for digestion. 5ml of concentrated Sulphuric acid was added to a sample in micro-kjeldahl. Five g selenium tablets was added as a catalyst and a mixture was heated on special heaters (digester) slowly at first and later rapidly for 45minutes until digest turned pale green and then cooled. 10mls of the digest was put into the apparatus via a funnel and also 10mls of sodium hydroxide from the measuring cylinder was added, so that ammonium is not lost. Distillation by Markham distillation apparatus was started to steam up the reagents to remove ammonia which was present. Same procedures were followed for blanks but instead of pure sample, distilled water was used. Distil (alkaline ammonium borate formed) was removed and 50mls of 2% baric acid containing screened methyl red indicator was added to titrate distil, with 0.1m Hydrochloric acid. Titration to first appearance of purple colour was done. The titre value which is the volume of the acid is recorded (Hirpa, Nigussie, Dechassa, Setegn, & Bultosa, 2015). Crude protein was calculated using formula

Crude proteins (Cp%) = (Net titre × normality of HCl × dilution factor × 14×6.25×100) ÷ (weight of a sample (g) ×1000) …………equation 9.

3.7.3.4 Crude Fats

Fat or ether extract was determined by solvent extraction gravimetric method described by (Kirk and sawyer1980) where by five grams of the sample was wrapped in a porous paper and put in a thimble. The thimble was put in a soxhlet reflux flask and mounted into a weighted extraction flask containing 200ml of petroleum ether. The upper of the reflux flask connected to a water condenser.

The solvent (petroleum ether) was heated, boiled, vaporized and condensed into a reflux flask filled up and siphoned over, carrying down its oil extracts to the boiling flask. This process was allowed to go over repeatedly for 4 hours before the defatted samples were removed. The solvent were recovered and oil extracts were left in the flask. The flask containing oil extracts were dried in the oven at 60^0c for 30 minutes to remove any residual solvent, cooled in the desiccator and weighed. The weight of the fat or oil extract were determined by difference and calculated as percentage of weight of sample analyzed (Chinyere, 2014).

% Fat = Weight of flask + fat - Weight of flask ÷ Weight of sample × 100 …..equation 10

3.7.3.5 Iron concentration

For determination of Iron, 10 grams of grains were cleaned using a cloth damped with high purity water and again dried up to the moisture content of 8% in the contaminate free oven at 60^0c. Thereafter, 5grams of seed were grinded with non-contaminant grinding mill, retch mill with Teflon chambers and zirconium balls to avoid iron and zinc contamination. During extraction of Iron, 2g of the sample was put in volumetric flask. 0.8m/l of 96% concentrated Nitric acid and hydrogen peroxide was added in the flask to releases minerals into solution. The solution was then diluted with 45ml of distilled water to form analytes. Five reagent blanks were also extracted. After extraction, aspiration of the standard series and suitable diluted analytes and blank digest into the atomic absorption- spectrophometer AAS was done. Iron was calibrated at wave length 248.3 and measure absorbed radiation from an element specific hollow cathode lamp. Plot the calibration curve of absorbance readings of the standard series against the concentration. Determine the concentration of unknown. Thereafter, calculation and quantification Iron in parts per million PPM (Okalebo, Gathua, & Woomer, 2002). i.e.

$$\text{Fe (PPM)} = (a-b) \times V \times f \times 1000 \div 1000 \times w \text{............equation 11}$$

Where a- concentration of Fe in extract solution, b- concentration of Fe in blank sample, v-extract volume, w -weight of soil, f- additional dilution factor.

3.7.3.6 Zinc concentration

Extraction of Zinc

During extraction of Zinc, 2g of the sample was put in volumetric flask. 0.8m/l of 96% concentrated Nitric acid and hydrogen period was added in the flask to releases minerals in to solution. The solution was then diluted with 45ml of distilled water to form analytes. Five reagent blanks were also extracted. After extraction aspiration of the standard series and suitable diluted analyte and blank digest into the AAS was done, followed by calibration of Zinc at wave length 213.9nm and measuring absorbed radiation from an element specific hollow cathode lamp. Plot the calibration curve of absorbance readings of the standard series against the concentration and determine the concentration of unknown. There after calculation and quantification of zinc in parts per million PPM (Okalabo, Gathua, & Woomer, 2002). i.e.

Zn (ppm) = $(a-b) \times v \times f \times 1000 \div 1000 \times w$…………equation 12

Where a= concentration of Zn in extract solution, b= concentration of Zn in blank sample, v=extract volume, w =weight of soil, f= additional dilution factor.

3.8 Data Analysis

During data analysis first season and second season data was tested for Normality Shapiro (Ghasemi & Zahediasl, 2012), Number of pods, pod length and grain yield skewed positively. So this data, was transformed to log base ten and further tested for homogeneity by Barlett test (Barlett, 1937) separately for first and second rain season. Thereafter data for all seasons was pooled or combined and imported into Genstat 2015 version using importer wizard then statistically a t-test and anova was run as seen below.

3.8.1 t-test

Data collected on Organic matter, soil pH, Nitrogen, phosphorus and potassium content was analyzed by a **t**- test.

3.8.2 Analysis of variance

Objective 2 and 3 data was analyzed by analysis of variance and the difference between treatments was declared at LSD 5% to separate the means. However, interactions between bean genotypes and treatments were established graphically in Microsoft Excel 2013; with standard error represented by bars over the mean.

CHAPTER FOUR: RESULTS

4.0 Introduction

This chapter presents results recorded on soil conditions, growth, yield and grain quality attributes during the experiment

4.1 Effect of integrating triple superphosphate with farmyard manure on soil conditions

In this section, the effect of farmyard manure integrated with TSP on soil conditions was achieved by getting a difference between means of statistical test due to the effect of treatments and the baseline values.

Table 4.1: Effect of farmyard manure integrated with TSP on organic matter and soil pH content of the soil

Treatments	Organic matter (%)[a]	Difference[b]	Soil pH[a]	Difference [b]
Swine manure + TSP	4.00	1.51*	7.29	1.18***
Chicken manure + TSP	3.48	0.99*	7.97	1.80***
Cattle manure + TSP	3.27	0.78[NS]	7.10	0.93***
TSP	2.52	0.03[NS]	6.62	0.45*
Control	1.83	-0.66[NS]	6.28	0.11[NS]

*[a] Means obtained after application of treatment, [b] difference between treatment and baseline (2.49%) for organic matter and (6.17)pH *** represents that the difference between treatment effect and baseline is significant at ($P<0.001$), * represents that the difference between treatment effect and baseline is significant at ($P<0.05$), [NS] not significant.*

The current study findings revealed that application of swine + TSP and chicken + TSP significantly ($P<0.05$) improved organic matter by 1.51% and 0.99%, respectively. By contrast on one hand, cattle + TSP, and TSP did not significantly (P>0.05) increase organic matter. Similarly though, not significant (P>0.05), there was a decline in organic matter by -0.66% in plots that did not receive treatments (Table 4.1). The increase in organic matter in field plots that received swine + TSP might have been due to existence of more carbon in swine manure (Table 3.2 and 3.3) as these favored the existence of nitrogen in the soil, which in turn probably attracted more microorganisms to break down organic matter which increased carbon turn over pool (Nisha & Sneh, 2018). When swine manure is integrated with TSP, breakdown of TSP energizes microorganisms inform of ATP to speed up decomposition and mineralization process hence more availability of organic carbon (Bot & Benites, 2005). The findings of this study concur with (Liu, Rong, Zhou, & liang, 2017) who reported an increase in organic matter when swine manure was integrated with NPK. The low amounts of organic matter in field plots that received no treatment was due to lack of fertilizers, which resulted into reduced soil organic carbon due to mineralization and oxidation processes (Bot & Benites, 2005). The findings of this current study is in agreement with (Liu, Rong, Zhou, & liang, 2017) who also observed low organic matter in unfertilized fields

Results obtained in the present study showed that, there was a significant (P<0.001) increment of soil pH by 1.8, 1.18, and 0.93 when plots were treated with swine manure + TSP, chicken + TSP, and cattle + TSP respectively, in respect to base line value of 6.17. TSP and controls increased the soil pH by 0.54 and 0.11 but, this increment was significant (P<0.05) for only TSP (Table 4. 1). A considerably improvement of field plots amended by chicken manure with TSP from baseline value probably could have been attributed to production and fixation of more nitrogen by organic matter from chicken, on addition to N_2 fixed by beans which resulted into release more of more ammonium, hence increased soil pH (Suarez & Dorivar, 2007). This study agrees with (Ano &

Ubochi, 2010) who reported an improvement in soil pH when chicken manure was applied than swine and cattle. The low soil pH in plots that received treatment TSP was probably due to the release of H^+ into the soil solution (Booth, 2005) that lowered the soil pH. This finding is in agreement with (Saunders, 2012) who observed reduction of soil pH in fields that received phosphatic fertilizers.

Table 4.2: Effect of farmyard manure and TSP on nitrogen, phosphorus and potassium content in the soil

Treatments	Nitrogen (%)[a]	Difference (%)[b]	Phosphorus (ppm)[a]	Difference (%)[b]	Potassium (%)[a]	Difference (%)[b]
Swine manure + TSP	2.50	1.88***	4.02	2.60***	2.45	1.22***
Chicken manure + TSP	2.18	2.20***	3.52	2.10***	2.06	0.83**
Cattle manure + TSP	1.29	1.09*	3.04	1.62***	2.10	0.88**
TSP	0.55	0.25NS	6.62	5.2***	0.97	-0.26NS
Control	0.76	0.46NS	1.32	0.1NS	1.11	0.31*

*[a] Means obtained after application of treatment, [b] difference between treatment and baseline value 0.3% Nitrogen, 1.42PMM phosphorus and 1.23% potassium *** represents that the difference between treatment effect and baseline is significant at (P<0.001),** significant at (P<0.01)*, * represents that the difference between treatment effect and baseline is significant at (P<0.05), NS not significant.*

Results presented in Table 4.2 and Appendix 3 revealed that, application of chicken + TSP and swine + TSP significantly (P<0.001) improved nitrogen content by 2.20% and 1.88% from baseline nitrogen value of 0.3%. Similarly, amendment of the study plots by Cattle + TSP also significantly (P>0.05) increased nitrogen content by 1.09%. On Contrary, plots that received one nutrient or no amendment were not significant ($P>0.05$) from baseline. This could be due to, the existence of nitrogen in chicken droppings that exists in form of uric acid which is a store for a commendable amount nitrogen thus, increased the amount of nitrogen, on addition to what is fixed by beans. Additionally this resulted into release of high levels of ammonium which was reduced by Nitrobacter in mineralization process to produce nitrogen (Suarez & Dorivar, 2007). This study is in conformity with results reported by (Ghosh, et al., 2003; Kwadwo and Larbi (2015) as they observed more nitrogen in plots amended by poultry manure than cattle manure.

Results on phosphorus content as influenced by effect of farmyard manure integrated with TSP presented in Table 4.5 indicated that, all plots either amended with TSP alone or TSP integrated with swine, chicken or cattle manure recorded significantly ($P<0.001$) higher P content except control that was not amended (Appendix 5). This might be due to more fossils and phosphates that were used in the manufacture of TSP fertilizers (Kaiser & Pagliari, 2021). TSP fertilizers released more phosphorus that disintegrated slowly into the soil hence, this increased its circulation. However low amounts phosphorus in control was due to uptake by bean plants or fixation or chelation by the acidic conditions of the soil because of no amendments (Brittany, 2019). This study contradicts with (Withers, 1999) findings of integration of poultry manure and NPK increased phosphorus content because, inorganic fertilizers like TSP contains high amounts of P up to 50% which even dissolves slowly than any other fertilizer therefore this increased P availability in the soil.

Results of this study indicated that application of swine + TSP, chicken + TSP and cattle + TSP significantly ($P<0.01$) improved potassium content by 1.22%, 0.83% and 0.88% respectively, in relation to baseline of 1.23%. Correspondingly, in control treatment potassium content was also significantly ($P<0.05$) improved by 0.31%. However, application of TSP alone reduced potassium content to value -0.26% (Appendix 4). Certainly because of high organic matter in pig or swine manure that exists in form of micelle, which increased stability and potentiality of swine manure to hold more potassium than other treatment (Choudhary & Grant, 1996). The current results agrees with findings of (Hentz, *et al*., 2016) who reported 1% increment in potassium in plots amended by swine manure than plots that received poultry manure. The reduction in amounts of potassium observed in treatment TSP was due to acidic conditions of the soil that chelated or antagonized expression of potassium and only facilitated existence of more P. This finding agrees with (Brittany, 2019) who reported that, an increase in phosphorus in the soil limits expression of potassium.

4.2 Effect of farmyard manure integrated with TSP on yield

Table 4.3: Effect of farmyard manure integrated with TSP on yield parameters

Treatments	Harvest index (%)	No. of pods	No. of grains	Pod length (cm)	Weight 100 grains (gm)	Grain yield (kgha^{-1})
Swine manure + TSP	71	14	4	10.71	32.93	1843
Chicken manure + TSP	54	10	4	9.53	30.21	1469
Cattle manure + TSP	49	8	3	9.14	29.68	1253
TSP	44	7	3	8.53	27.67	909
Control	42	6	3	7.75	26.19	650
$LSD_{(5\%)}$	4	1	0.3	0.66	0.71	184.4

Results presented in Table 4.3 showed that swine manure + TSP recorded the highest harvest index (71%), followed by chicken manure + TSP (54%) and the least was recorded under cattle manure+ TSP (49%) among integrated treatments. TSP and Control recorded less than 45%

values of harvest index. Though all treatments caused high significant ($P<0.001$) difference on harvest index (Appendix 6).

Findings on number of pods as influenced by farmyardmanure integrated with TSP indictated a high significant ($p<0.001$) difference among treatments. Swine manure + TSP recorded the highest number of pods among other treatments Table 4.3 and Appendix 7.

In the study to find out effect of farmyard manure integrated with TSP, application of treatments swine + TSP and chicken + TSP resulted in high numbers of grains per pod as compared to cattle + TSP and control treatment. Though, there was a high level of significance ($P<0.001$) as presented in Table 4.3 and Appendix 8.

Results in the current showed that, application of swine + TSP significantly improved pod length followed by chicken + TSP, cattle +TSP, TSP and control (Table 4.3). However, application of all treatments significantly affected ($p<0.001$) length of pods.

Results in this study indicated that, the highest weight of 100 grains was obtained in swine + TSP followed by chicken+ TSP, cattle + TSP, TSP and lastly control treatment in the descending order (Table 4. 3). Though application of all treatments significantly ($p<0.001$) influenced weight of 100 grains.

Application of swine + TSP recorded maximum yield followed by chicken + TSP and lastly cattle + TSP among integrated treatments compared to both controls (Table 4.3). However, all treatments had a significant ($p<0.05$) effect on yield (Appendix 11).

Table 4.4: Effect of Bean genotypes on yield parameters

Bean genotypes	Harvest index (%)	No. of pods	No. of grains	Pod length (cm)	Weight 100 grains (gm)	Grain yield (kgha^{-1})
Naro bean 1	53	10	3	9.40	35.84	1432
Naro bean 3	51	9	3	8.89	23.49	1109
Nabe 16	52	9	3	9.99	28.49	1134
LSD$_{(5\%)}$	3	1	0.2	0.51	1.09	142.9

Results on effect of bean genotypes on harvest index showed that, Naro bean 1 recorded numerically the highest harvest index value, compared to Nabe 16 and Naro bean 3 that recorded low harvest index. However, there was no significant difference (P>0.05) among bean genotypes for harvest index (Table 4.4).

Results on effect of bean genotype on number of pods presented in Table 4.4 indicated that, Naro bean 1 registered higher number of pods (10). Interestingly, NARO bean 3 and NABE 16 recorded the same number of pods (9). The variation between genotypes for number of pods was significant (P<0.001) Appendix7.

There was no variation on number of seed per pod among bean genotypes (Table 4.4). Similarly, there was no significant difference (P>0.05) between bean genotypes and number of grains per pod.

Results on effect of bean genotypes on pod length showed that there was no significant (P>0.05) difference between bean genotypes and pod length. NABE 16 recorded maximum pod length (9.99cm) as compared to Naro bean 3 that registered the lowest pod length (8.89cm). However, NARO bean 1 and NABE 16 statistically the same (Table 4.4).

Results obtained from the study showed that, the highest weight of 100grains was observed on NARO bean 1 followed by local check and NARO bean 3 (Table 4.4). Although, influence of bean genotypes on weight of 100 grains was significant ($p<0.001$).

Results obtained from the study revealed that NARO bean 1 was significantly superior in yield over NARO bean 3 and local check (Table 4.4). Although, yield was significantly ($P<0.05$) difference among bean genotypes.

Results of interaction between treatments and studied bean genotypes as presented in figure 1 revealed that, interaction between treatments and bean genotypes influence on harvest index was not significantly (p>0.05) Appendix 6. This might have been due to high adaptability and response of Nabe16 to swine manure + TSP. Additionally high concentration of nutrients in swine manure (Table 3.2 and 3.3) promoted photosynthesis resulting into more assimilation of food into biological and economic plant parts of bean genotypes (Choudhary & Grant, 1996). This finding is in agreement with (Gina, *et al*., 2006) who reported an increase in harvest index of soya beans grown in swine manure.

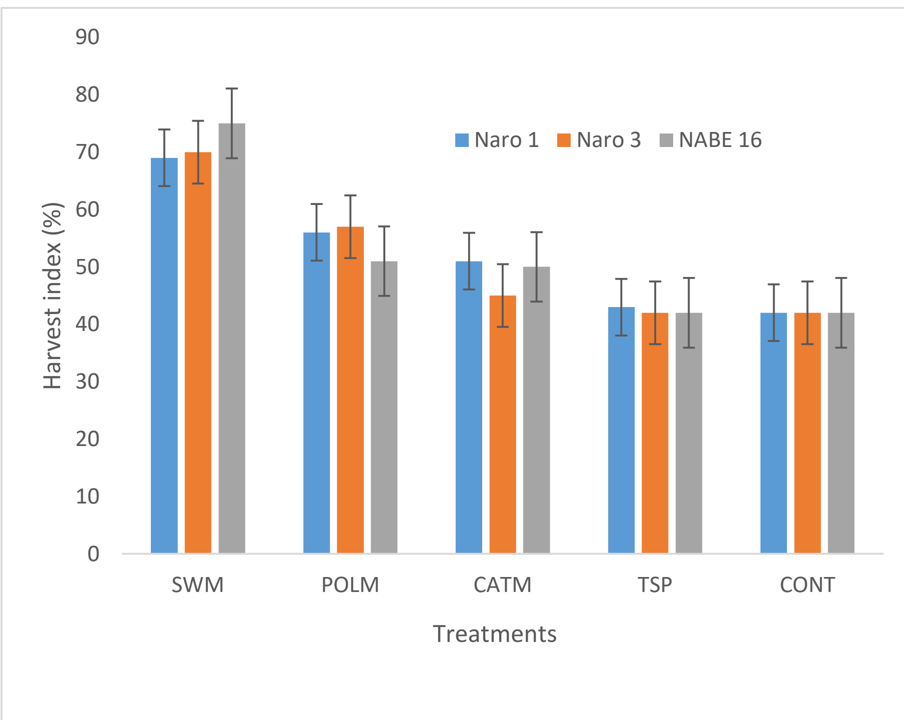

Fig 1: Harvest index as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Results in figure 2 indicated that there was no significant difference (P>0.05) between treatments and bean genotype interaction on number of pods. NARO bean 1 maintained its superiority when treated with swine manure + TSP on number of pods across all bean genotypes, followed by chicken + TSP and cattle + TSP among farmyard manure integrated TSP. Conversely, lowest average number of pod was recorded on control treatments. Certainly, because of existence of more calcium (Table 3.2 and 3. 3) that increase absorption of nitrogen, Magnesium and phosphorus (Carl, 1972). These elements are majorly involved in chlorophyll formation and protein synthesis therefore, this supported the plant to make more sinks to store photosynthates than sink abscission. Equally increased potassium in swine manure, (Table 3.2, 3 and 4.2) balanced the osmotic processes hence longer stomatal opening and more efficient carbon dioxide fixation (Pole, 2020). This study findings is supported by (Teppei, Areta, & Manabu, 2012) who reported high calcium, Phosphorus and potassium in swine manure ashes increases yield.

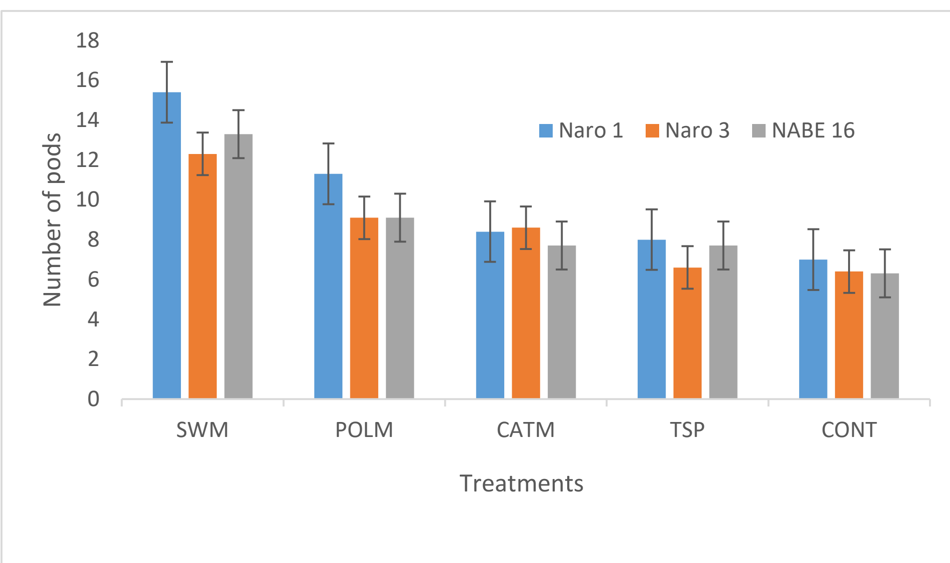

Fig 2: Number of pod as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Despite the number of grains per pod ranging from 2 to 5 (Figure 3), performance of swine + TSP recorded a maximum number of grains per pod in Nabe 16 as compared to other treatments and bean genotype. Although, there was no significant (P>0.05) difference between treatments and bean genotypes interaction on number of grains per pod. This might have been due to possession of more phosphorus and nitrogen nutrients in swine manure which are major nucleic acid components, directly involved in cell wall formation, flowering, fruiting and seed formation (Pole, 2020). Therefore due to this, Swine manure registered more grains in pods than chicken manure that had lower phosphorus (Table 4.5). likewise, the increased conductivity pull, diffusion and mass flow for Phosphorus could have been pulled and transformed to nitrogen, by mineral transforming enzymes (Weisany, Raey, Allahverdipoor, & Jour, 2013) hence, this resulted into more photosynthates, inform of grains. This finding is in agreement with report by (Gina, *et al.*, 2006) who reported an increase in number of grains in soya beans was grown in swine manure.

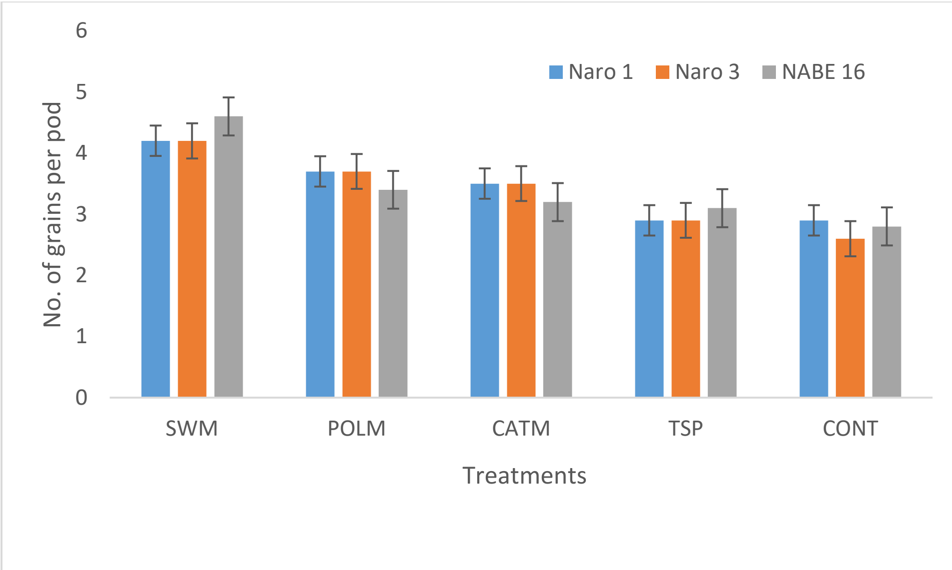

Fig 3: Number of grains per pod as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

In the study conducted to find out effect farmyard manure integrated with TSP (Figure 4), bean genotypes that received Swine + TSP recorded the longest pods. This observation was noted in bean genotype Naro bean 3 (10.86cm), followed by local check (10.77cm) and Naro 1(10.15cm). Contender chicken + TSP tied up with cattle + TSP in local check by producing similar length of pods. Still under the same observation, there was a very little variation in pod length between Naro bean 1 and Naro bean 3 in treatment with Cattle + TSP. Contrary, TSP and control recorded shorter pods across all bean genotypes, though there was no significant ($P>0.05$) difference between treatments and bean genotype interactions on pod length. Certainly, because of higher amounts of calcium in swine manure as noted in (Table 3.2, 3.3). Calcium increased absorption of nitrogen, Magnesium and phosphorus (Carl, 1972). These minerals are majorly involved in chlorophyll formation and protein synthesis. Therefore, this increased affinity for the plant to make more sinks to store photosynthates in form of grains which increased the length of pods (Pole, 2020). This finding disagrees with report by (Mohanty *et al.* 2017; Jayashri 2014)), who reported improvement of pod length of French beans grown in cattle manure integrated NPK because cattle manure contains low nutrient concentration due to rumination and yet bean plants has affinity for high amounts of Phophorus than nitrogen for ATP during nodulation and seed formation (Broadley, 2009).

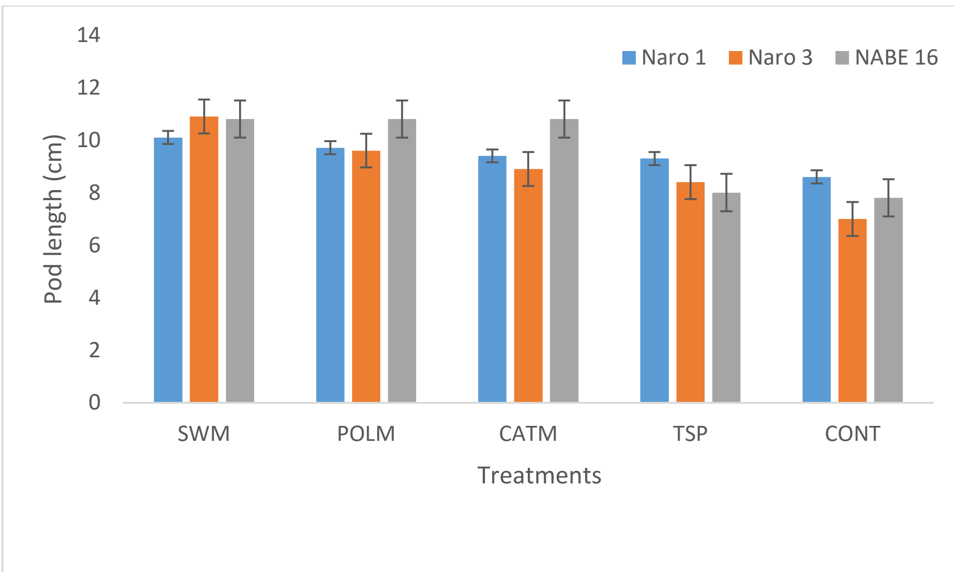

Fig 4: Pod length as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

The interactive effect between treatments and bean genotypes had a high significant effect ($P<0.001$) on weight of 100 grains. Mean values obtained on interaction between bean genotypes and treatments showed high performance of NARO bean 1 followed by Nabe 16 in respect to weight of 100 grains. But this was not the case with NARO bean 3, although, swine + TSP, was superior on weight of 100 grains across all treatment (Figure 5). This could be attributed to high nutritive mineral substances in swine manure like magnesium, zinc, phosphorus, potassium and nitrogen (Choudhary & Grant, 1996). That are greatly involved in grain filling. Also high nitrogen availability refer to Table 3.2, 3.3 and 4.2 in swine manure, led to adequate vegetative growth that increased carbon dioxide assimilation and translocation. Which in turn was directed to sinks for storage with aid of minerals like, phosphorus for ATP, nitrogen and zinc as amino acid carriers and magnesium for packing photosynthates (CIMMYT, 2019) than other treatments. Besides this, grains of Naro bean1 accumulated more weight than other genotypes because of its high affinity for photosynthates and minerals uptake. This study disagrees with (Khalifeh et, al.2016) who reported an increase on weight of 100 grains in chicken manure when integrated with NPK. This is because bean growth and yield is limited to phosphorus which is highly concentrated in swine manure Table 3.2, 3.3 and 4.2 than chicken manure rich in nitrogen, once applied more will be translocated to vegetative parts than storage in sinks (Brittany, 2019).

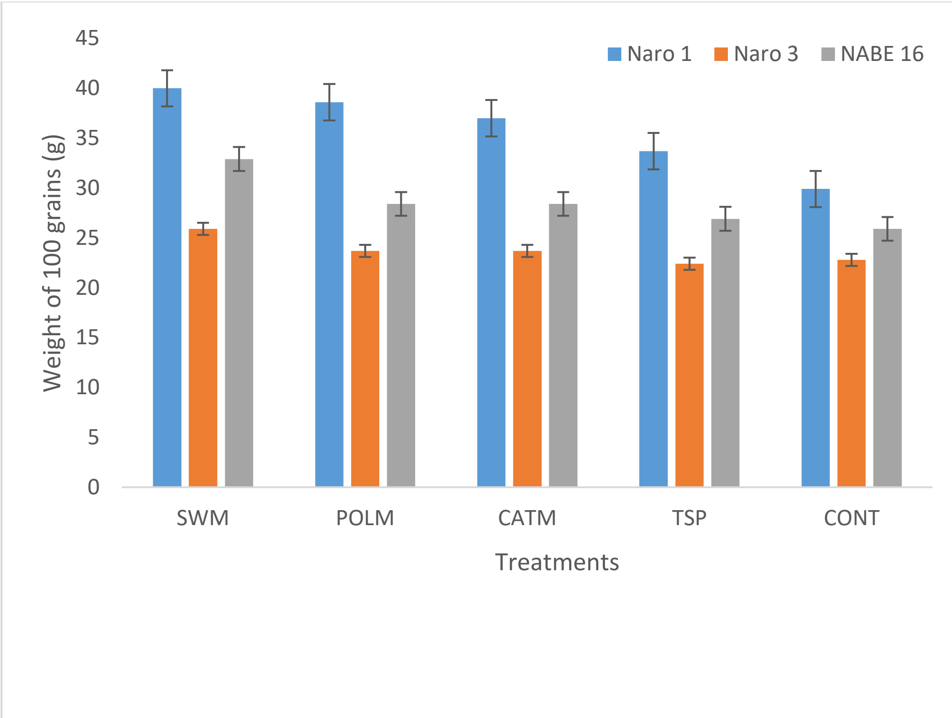

Fig 5: Weight of 100 grains as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Interaction between treatments and bean genotypes did not significantly (p>0.05) affect grain yield Figure 6. The highest yield (kg/ha) was observed in Naro bean 1 when swine + TSP was applied compared other bean genotypes and treatments. Certainly because of high phosphorus and potassium content in swine manure on addition to what was supplied by TSP (Table 3.2, 3.3 and 4.2), this significantly regulated the processing photosynthesis to take place adequately hence more photosynthates that supported grain formation than absissicion (pole, 2020). Chicken+ TSP coming second as seen in figure12, was as result of low quantities of minerals nutrients apart from nitrogen which was high (Table 3.2, 3.3) as these increased biological mass than economic yield (USDA 2019). This study is in agreement with (Gina *et al*.,2006) who revealed improvement on yield of soya bean when grown under swine manure.

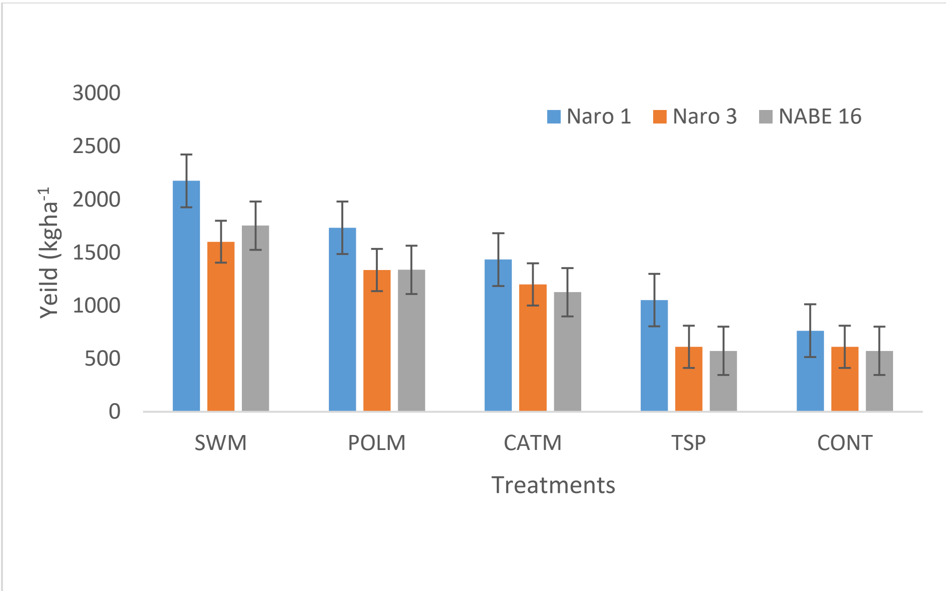

Fig 6. Yield ($kgha^{-1}$) as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

4.3 Effect farmyard manure integrated with TSP on grain quality

Table 4.5: Effect of farmyard manure integrated with TSP on grain quality

	Grain quality attributes					
Treatments	**Seed purity (%)**	**Carbohydrate (%)**	**Crude fat (%)**	**Crude proteins (%)**	**Fe (ppm)**	**Zn (ppm)**
Swine manure + TSP	91.8	56.8	1.32	24.8	177.2	33.6
Chicken manure + TSP	82.3	52.4	0.91	25.4	147.5	27.3
Cattle manure + TSP	76.4	52.0	0.86	22.6	133.7	27.0
TSP	71.4	48.6	1.43	19.9	114.9	23.6
Control	71.0	47.2	0.83	19.0	114.7	23.0
$LSD_{(5\%)}$	2.29	1.05	0.014	0.93	14.24	1.61

Application of farmyard manure integrated with TSP (swine + TSP, chicken + TSP and cattle + TSP) resulted in high grain purity compared to control treatment. In fact, swine + TSP had excellent (91.82%) grain purity followed by chicken + TSP (82.87%) and cattle + TSP (76.42%) table 4.5. However, significant ($p<0.05$) differences was observed among all treatments.

Application of swine manure + TSP increased crude carbohydrate to (56.77%) compared to chicken and cattle manure +TSP that statistically produced the same mean values (52.39%) and 52.00% respectively. However, Controls recorded lower crude carbohydrates, although there was a significant difference ($P<0.05$) between treatments and crude carbohydrates (Table 4.5).

In the study conducted to assess the effect of integrated nutrients on crude fat, TSP application scored slightly higher fat content than integrated treatments (Table 4.5). However, a significant ($P<0.05$) differences was observed in crude fat content among treatments.

In the study conducted, application of chicken manure + TSP resulted in maximum protein content compared to other treatments (Table 4.5). Though protein content was significantly ($p<0.05$) influenced by all treatments.

Application of farmyard manure integrated with TSP revealed a high concentration of iron in swine + TSP (177.20ppm), followed by chicken and cattle manure + TSP among integrated treatments although, TSP and control registered low amount of Iron (Table 4.5). Still, treatments effect showed a high significant ($P<0.001$) difference in iron content across all the treatments.

Results obtained from the study conducted indicated that, swine manure + TSP significantly attained maximum amount Zinc compared to chicken manure + TSP, cattle manure + TSP and controls (Table 4.5). However, treatment effect had high significant ($P<0.001$) difference on Zinc content.

Table 4.6: Effect of Bean genotypes on grain purity

Bean genotypes	Seed purity (%)	Carbohydrates (%)	Crude fat (%)	Crude proteins (%)	Fe (ppm)	Zn (ppm)
Naro bean 1	79.8	51.7	1.1	22.0	147.9	27.3
Naro bean 3	77.6	50.8	1.O	23	110.2	26.1
Nabe 16	78.7	51.7	1.1	22.0	156.5	27.4
$LSD_{(5\%)}$						

Generally, NARO bean 1 recorded seed purity of (79.8%), NARO bean 3 (77.57%) and NABE16 (78.72%) as seen in Table 4.6. Analysis of variance showed no statistical ($P>0.05$) differences between the bean genotypes.

Results on effect of bean genotypes and crude carbohydrates indicated that, NARO bean 3 registered slightly more carbohydrates as compared to NARO bean 1 and NABE 3 (Table 4.6). However, there was a significant ($P<0.05$) difference between bean genotypes and crude carbohydrates.

Results in this study showed that, bean genotype NARO bean 3 recorded lower values of crude fat than NARO bean 1 and NABE 16 that produced similar fat values (Table 4.6). Though there was a significant ($p<0.05$) difference exhibited on crude fat among bean genotypes.

Results on effect of bean genotypes on protein content indicated that, Naro bean3 produced more proteins than Narobean1 and NABE16 (Table 4.6). Never the less, crude proteins were significantly ($p<0.05$) influenced by bean genotypes.

Results on iron content was highly influenced ($P<0.001$) by bean genotypes. However, NARO bean 1 and NABE 16 registered higher values of Iron than NARO bean 3 (Table 4.6).

Results showed that NABE 16 and NARO bean 1 statistically attained same amount of zinc than NARO bean 3 (Table 4.6). However there was a significant ($P<0.001$) difference observed between zinc concentration and bean genotypes.

Results in the study conducted to assess the effect of farmyard manure integrated with TSP on bean genotypes showed a significant ($P<0.05$) difference on treatment and bean genotype interaction. However, excellent grain purity was obtained from Naro bean3 (94.31%), NABE 16 and Naro bean 1 statistically recorded the same grain purity when grown under swine manure + TSP. Whereas NARO bean 1 grown in plots that received chicken manure + TSP registered higher means than cattle manure + TSP, whose means were the same across all bean genotypes. However TSP and Control registered low grain purity across all bean genotypes though, their variation from cattle manure + TSP was very small Figure 7. This might have been attributed to existence of more nutrients in swine manure (Table 3.2, 3.3) that directly impacted on root growth and nodulation. Hence more uptake of adequate quantities of mineral nutrients by Naro bean 1, which resulted into clean and good vigor grains in Naro bean 1. However, low percentage seed purity in treatments amended by either one nutrient or no amendment might have been due to miss conductivity pull where potassium and calcium were transformed as a result of mass flow that partitioned photosynthates and nutrients to biological parts than sinks (USDA 2019). This made grains wriggled, thin testa, easy breaking, rotting and more chuff in harvested produce. This findings disagrees with report by Chavan *et al*. (2014) who reported that cattle manure with a Bio fertilizer and Urea improved seed purity of ground nuts compared to plots that received Urea and no fertilizer amendments. Yet, cattle manure, Bio fertilizer and Urea possess low nutrient quantities, additionally Urea contain more nitrogen which can make bean lazy and unable to produce more nitrogen (Dogra & Dudeja, 1993).

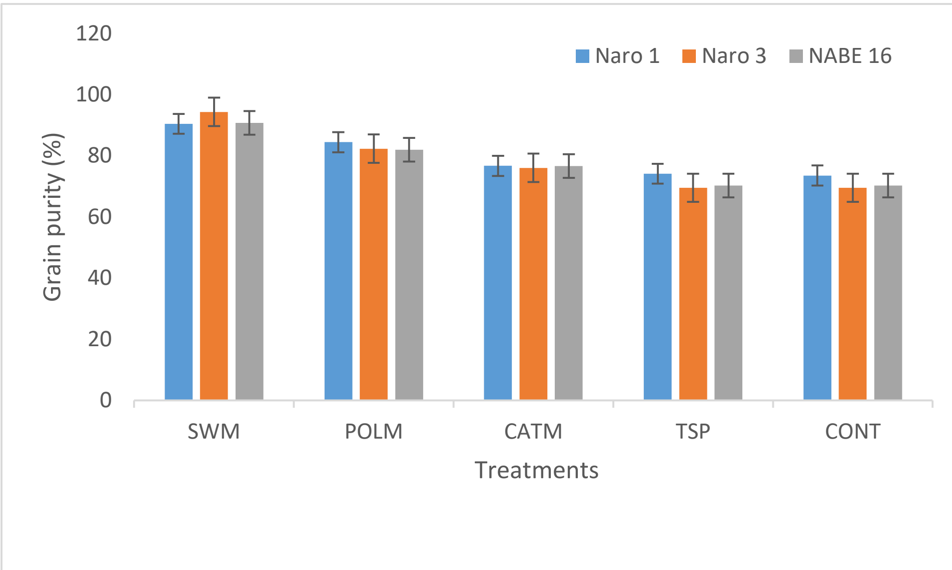

Figure 7: Grain purity as influenced by interaction between treatments and bean genotypes.

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

Results of this study revealed that combined effect of treatment and bean genotypes exerted a high significant ($P<0.001$) influence on crude carbohydrates. Bean genotypes Nabe 16, Naro bean 1 and Naro bean3 grown in swine manure + TSP, recorded maximum crude carbohydrated 57.69%, 56.69% and 55.90% respectively. When bean genotypes were grown in chicken manure + TSP, Naro bean1 and Naro bean 3 satistically recorded similar values of crude carrbohydrates 53.69%, 53.49% respectively than NABE16 (49.99%). However, there was a very small variation between means of cattle + TSP and control treatments on Naro bean 1 and Nabe 16 (Figure 8). probably because of their easy uptake of nutrients from the soil and also high nutrients concentration in swine manure than others treatment as noted in table 3.2 and 3.3 might have increased partitioning and carriage of photosynthates, (Ojeifo, 2008). The findings of this study contradicts with (Cutierrez-micel *et al*., 2007) who reported an increase in carbohydrate concentration when vermin manure from sheep dung was applied than treatments that had no amendment. This is because manure from ruminants contains low amounts of nutrients that could directly involve in the process of photosynthesis as well as boosting plants immunity to fix more photosynthates (Trouvelot, Heloir, & Marielle, 2014).

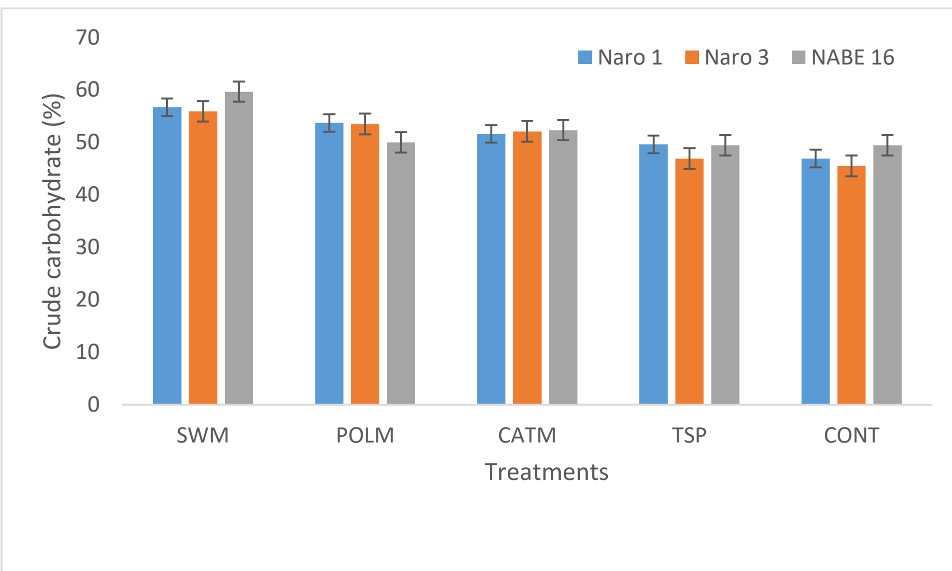

Fig 8: crude carbohydrates as influenced by interaction between treatments and bean genotypes

SWM -swine manure + TSP, POLM - chicken manure + TSP, CATM – cattle manure + TSP, TSP – Tripple super phosphate and CONT – control.

In this study conducted to find out the effect of farmyard manure combine with TSP, results revealed a significant (P<0.001) interaction between treatments and bean genotypes on crude fat (appendix 9). Bean genotypes grown under TSP produced more fats in Naro bean1 (1.58%), Naro bean 3 (1.30%) and NABE16 (1.39%) than integrated treatments. This observation was by followed by swine manure + TSP, that recorded Naro bean 3 (1.54%), Naro bean 1(1.19%) and NABE 16 (1.10%). On the other hand, chicken manure + TSP yielded moderately higher fat than cattle + TSP, though there was a significant variation of crude fat in bean genotype. Additionally, control treatment recorded the lowest amount of crude fat in Naro bean 1and Nabe 16 than Naro bean3 respectively (Figure 9). This might have been attributed to more phosphorus taken up by beans in plots treated with TSP Table 4.5. Which was more important in formation of phospholipids and lipids. Besides these, carbohydrates partitioning and storage disruption might have existed due to poor vegetative cover and acidic condition (Table 4.2) in plots that received treatment TSP alone. This disruption might have made carbohydrates take lipid metabolism path ways (Jieying et al., 2017) hence, carbohydrates were metabolized to lipids and also disruption of carbohydrate synthesis resulted into more fatty acids during stress period of low vegetation and acidic conditions of the soil (Table 4.2), as acetyl- coenzyme A carboxylase was triggered to turn carbohydrate into lipid during persistent stress (Linhui, Jilian, & Changcheng, 2018). This study findings agrees with report by (Mashooque, 2015) who revealed increased fat content in okra when NPK was applied.

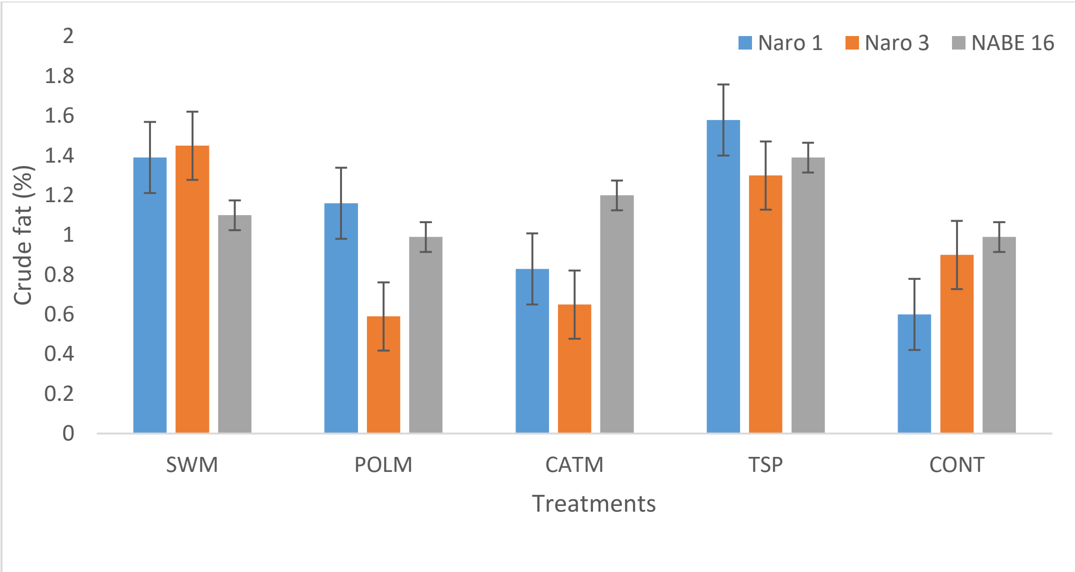

Fig 9: Crude fat as influenced by interaction between treatments and bean genotypes*SWM - swine* manure + *TSP, POLM - chicken* manure + *TSP, CATM – cattle* manure + *TSP, TSP – Tripple super phosphate and CONT – control.*

Results of crude proteins were not significantly ($p<0.05$) influenced by the interactive effect of genotypes and treatments as noted in appendix 14. Chicken manure + TSP significantly yielded more proteins especially in Naro bean 3 compared to Naro bean1 and Nabe 16. Its closest contender swine manure + TSP, recorded more proteins with Naro bean 3 and Nabe 16 compared to Naro bean1, followed by cattle manure +TSP, TSP, and lastly control (figure 10). This might have been attributed to high nitrogen concentration in chicken manure refer to Table 3.2, 3.3 and 4.2. Which is a key component in formation of amino acids and nucleic acid (Kristi, 2017). This study contradicts with a findings by; (Argaw, 2017) who reported increased proteins in French bean when cattle was integrated with DAP. Since nitrogen supply by cattle manure is low due to rumination and DAP is easily leached so supply of nitrogen was poor.

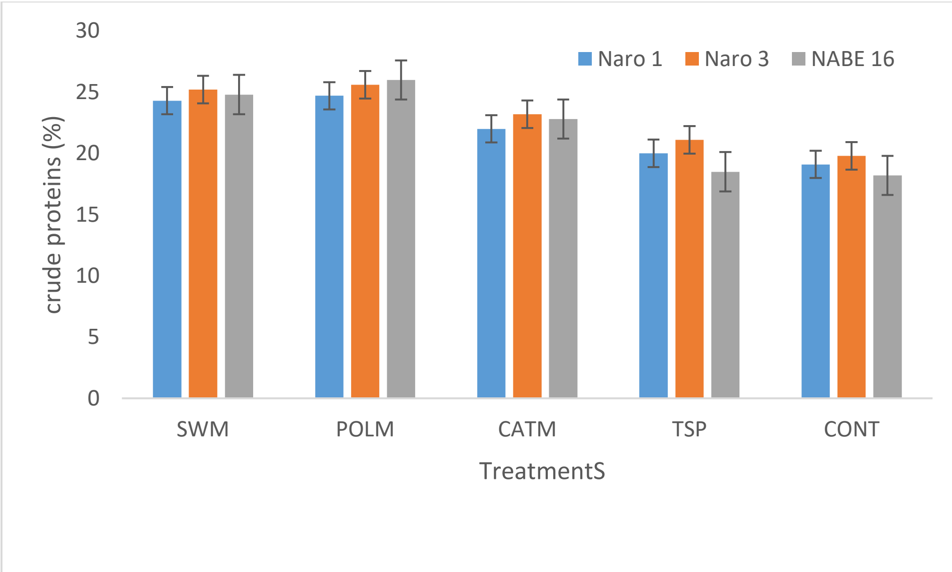

Fig10: Crude Protein as influenced by interaction between treatments and bean genotypes

SWM -swine manure + *TSP, POLM - chicken* manure + *TSP, CATM – cattle* manure + *TSP, TSP – Tripple super phosphate and CONT – control.*

A high significant ($p<0.001$) difference of Iron was due to the interactive effect of bean genotypes and treatments. However, Nabe 16 was superior to Naro bean 1 and Naro bean 3 in Iron content when grown in swine manure + TSP. Naro bean 1 performed better than Nabe 16 and Naro bean 3 when chicken + TSP was applied, cattle manure + TSP recorded the lowest amount of Iron especially in Naro bean 3 among integrated treatments. On the other hand, control treatments registered lower mean values of Iron in all bean genotypes (Figure 11). Certainly because of existence of more minerals in the soil substrate that received integrated treatments. Hence easy uptake by plants. Besides this, increase in nutrient concentration in plant Rhizophere enhances agronomic bio-fortification to economic parts of a plant (Velenca, 2017) and also, good soil pH (7.2) observed in swine + TSP Table 4.1, increased availability of Iron and uptake by Nabe 16. This study disagrees with findings by (Smith & Slater, 2020) who reported increased iron in common beans treated with poultry manure integrated NPK. Yet, common beans requires more phosphorus to increase nodulation and conductivity of nutrients to economic parts (Broadley 2009) which was low in poultry manure and NPK (Table 3.2 and 3.3).

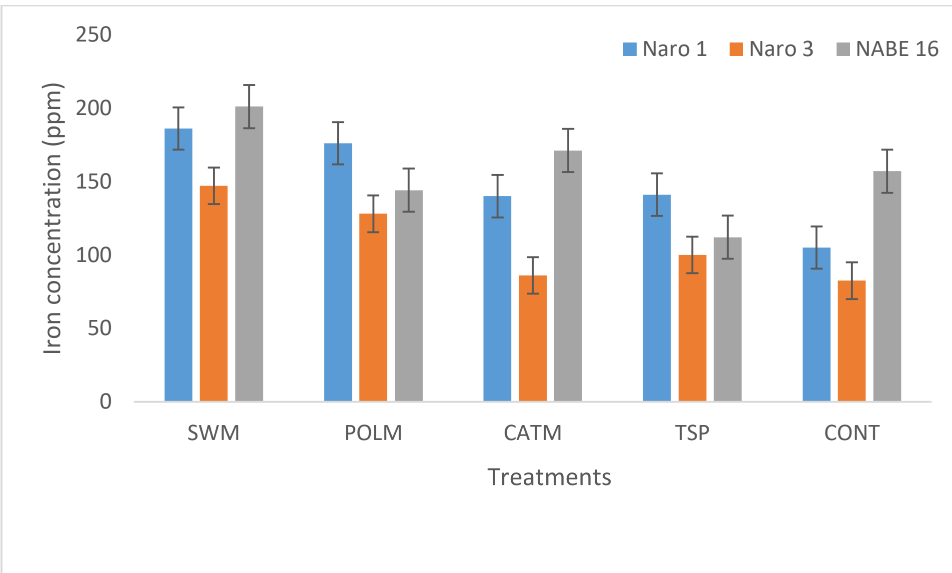

Fig 11: Iron content as influenced by interaction between treatments and bean genotypes

SWM -swine **manure** + *TSP, POLM - chicken* manure + *TSP, CATM – cattle* manure + *TSP, TSP – Tripple super phosphate and CONT – control.*

In the field study conducted to find out effect of farmyard manure integrated with TSP finding revealed, test bean genotype Naro bean 3 registered maximum amount Zinc 35ppm followed by local check 33.05ppm and lastly Naro bean 1 32.14ppm when grown in swine manure + TSP. Details of Zinc content in different genotypes and treatment is presented in Figure 12. Although, Zinc concentration was highly influenced ($P<0.001$) by interactive effect of bean genotypes and treatments. This might have been attributed to increase in nutrient concentration in the plant's Rhizophere by swine manure which enhances agronomic bio-fortification to economic parts of a plant and also, good soil pH of plots under swine manure + TSP Table 4.1 also increased availability of Zinc. Additionally, Zinc availability and adsorption increases much more at pH (5-7.8) while changing numbers of sites available for adsorption or changing concentration of zinc species for easy absorption (Parisa, Arifin, Dwain, &John, 1999; Barrow, YB, & Lui, 1997). This study disagrees with findings by Sebuwufu (2013) who reported increased zinc in common beans treated with cattle manure integrated SSP. Yet common beans requires more phosphorus to improve rooting system, nodulation and conductivity of nutrients to economic parts (Broadley 2009) which was low in cattle manure and SSP.

These findings are in line with alternative hypothesis "grain quality attributes greatly increases in bio-fortified common beans genotype depending on the source of farmyard manure integrated with triple superphosphates".

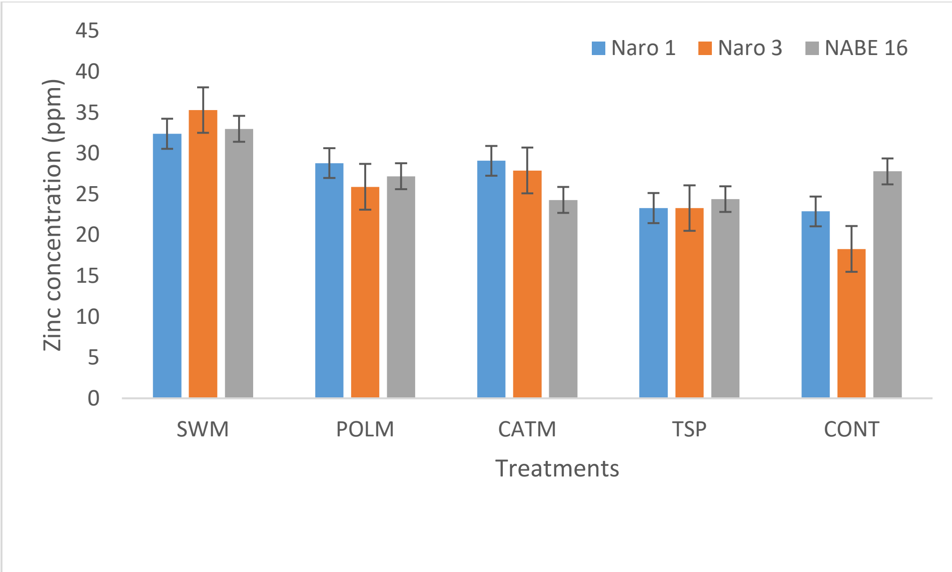

Fig 12: Zinc content Iron content as influenced by interaction between treatments and bean genotypes

SWM -swine manure + *TSP, POLM - chicken* manure + *TSP, CATM* – manure + *TSP, TSP – Tripple super phosphate and CONT – control.*

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The general objective of the study was to assess the effect of farmyard manure integrated with triple super phosphate on soil conditions, yield and seed quality of bio-fortified common bean Genotypes. Specific objectives were to (i)Assess the effect of farmyard manure integrated with triple superphosphate on soil conditions.(ii)Assess the effect of farmyard manure integrated triple superphosphate on grain yield components of bio-fortified common bean genotypes. (iii) Evaluate the effect of farmyard manure integrated with triple superphosphate on physical and chemical seed quality of bio-fortified common bean genotypes.

An experiment entitled, effect of farmyard manure integrated with triple superphosphate on soil conditions, yield and seed quality of bio-fortified common bean Genotypes in Uganda, was set up at Mukono Zonal Agricultural Research development institute.

Results of this study on objective one, showed that, farmyard manure integrated with TSP significantly ($P<0.05$) influenced organic matter, pH and nitrogen, potassium and Phosphorus content. However, application of swine + TSP significantly improved organic matter, phosphorus, and potassium content and soil pH. Whereas, application of chicken + TSP that only improved nitrogen content and soil pH. Additionally application of TSP alone reduced the soil pH to acidic conditions while control led to low organic matter due to climatic shocks.

Findings of this study on objective two, showed that, farmyard manure integrated with triple super phosphate greatly improved yield attributes of bio-fortified beans. However, swine manure integrated with TSP significantly improved: harvest index, number of pods, number of grains in pods, pod length, weight of 100 grains and grain yield of bio-fortified beans. It was followed by chicken manure + TSP, Cattle manure + TSP, was third, TSP and lastly control. Higher yield attributes were significantly observed on Naro bean 1 followed by NABE 16 and lastly Naro bean 3. Bean genotype interaction with swine manure + TSP, chicken manure + TSP, cattle manure + TSP, TSP alone and control did not significantly ($P>0.05$) improve yield attributes of bean genotypes, except weight of 100 grains. However, swine manure + TSP significantly maintained its superiority of other treatments on harvest index, average number of pod, average number grains in pod, average pod length, weight of 100 grains and yield kg/ha. It was followed by chicken manure + TSP, cattle manure + TSP, TSP alone and lastly control.

Results of objective three showed that, integrating triple superphosphate with farmyard manure, highly influenced ($P<0.001$) grain qualities across all the treatment, except crude fats that was highly influenced by application of TSP alone. However, swine manure + TSP still recorded the highest seed purity, crude carbohydrate, Iron and zinc, apart from crude protein that was markably high in chicken manure + TSP across all the treatment though not significant ($P>0.05$). Naro bean 1 significantly registered maximum seed purity, crude fat, and carbohydrate, proteins, Iron and zinc, followed by Naro bean 3 and lastly NABE16. Interaction of bio-fortified common beans with swine manure + TSP, chicken manure + TSP, cattle manure + TSP, TSP alone and control greatly ($P<0.05$) improved seed qualities of bio-fortified beans. However interaction of swine manure + TSP with bean genotypes resulted in higher concentration of Iron, Zinc, carbohydrates and good seed purity, except crude proteins that was high in bean genotypes that received chicken + TSP, and by surprise TSP recorded maximum crude fat than any other treatments.

5.2 Conclusions

It may be concluded from findings of the study that, among integrated nutrients swine manure integrated with TSP at the rate of 10t/ha manure: 30kg/ha TSP, improved organic matter, soil pH, nitrogen, phosphorus and potassium content of the soil. As well as superior performance on harvest index, number of pods, number of grains in the pod, pod length, weight of 100 grains, grain yield, seed purity, crude carbohydrate, Iron and zinc of bio-fortified common. But application of TSP displaced organic matter and potassium content in the soil, on the positive side it only improved crude fat whereas, Chicken manure+ TSP only improved nitrogen content in the soil and protein content of beans. Furthermore, bio-fortified bean genotype Naro bean1 showed maximum performance on growth, yield and seed quality attributes than Naro bean 3 and NABE 16. Interaction of treatments with bean genotypes showed best performance of swine + TSP with Naro bean 1.

5.3 Recommendations

The study recommends that, among nutrients combinations applied as integrated nutrients swine manure + TSP, is the best option for peri-urban and urban farmers intending to grow bean genotypes Naro bean 1, in order to eradicate nutritional defects and yield gap or increasing productivity per unit area since they operate on the limited scale.

When amending nutrients in the soil, farmers should consider integrating crops limiting nutrients or factors with farmyard manure to increase and sustain yield, as well as improving fertilizer use efficiency than sole application or no amendments, which lowers the pH of the soil, increases antagonism and immobility effect of nutrients hence poor yield.

For general improvement of soil productivity, swine manure + TSP should be adopted over chicken + TSP and cattle + TSP because of its high nutrient composition and performance.

Further researcher is needed to enhance productivity of beans under, different levels of farmyard manure integrated with TSP in different agro-ecological zones of Uganda. Also similar study should be carried out on different crops while integrating the plant limiting factor with farmyard manure to boost yield such that no poverty and zero hunger will be achieved come 2030.

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APPENDICES

Appendix 1: A t-test table for organic matter content

Treatments	DF	T-statistics	Standard deviation	Standard errors	P-value
Swine + TSP	4	4.25	0.79	0.35	0.01
Chicken + TSP	4	4.13	0.69	0.35	0.02
Cattle + TSP	4	2.44	0.63	0.35	0.07
TSP	4	0.07	0.41	0.27	0.94
Control	4	1.30	0.48	0.50	0.26

Appendix 2: A t-test table for soil pH

Treatments	DF	T-statistics	Standard deviation	Standard errors	P-value
Swine + TSP	4	6.97	0.35	0.35	0.001
Chicken + TSP	4	6.97	0.52	0.31	0.001
Cattle + TSP	4	6.95	0.33	0.35	0.001
TSP	4	6.18	0.81	0.27	0.05
Control	4	0.73	0.38	0.50	0.50

Appendix 3: A t-test table for Nitrogen content

Treatments	DF	T-statistics	Standard deviation	Standard errors	P-value
Swine + TSP	4	6.29	0.96	0.43	0.001
Chicken + TSP	4	5.89	0.98	0.43	0.001
Cattle + TSP	4	2.98	0.91	0.44	0.06
TSP	4	0.92	0.61	0.27	0.42
Control	4	1.34	0.78	0.35	0.25

Appendix 4: A t-test table for potassium content

Treatments	DF	T-statistics	Standard deviation	Standard errors	P-value
Swine + TSP	4	8.42	0.50	0.22	0.001
Chicken + TSP	4	8.10	0.41	0.33	0.003
Cattle + TSP	4	4.46	0.45	0.10	0.002
TSP	4	-6.30	0.49	0.88	0.48
Control	4	2.31	0.05	0.05	0.05

Appendix 5: A t-test table for phosphorus content

Treatments	DF	T-statistics	Standard deviation	Standard errors	P-value
Swine + TSP	4	17.65	0.75	0.33	0.001
Chicken + TSP	4	11.65	0.76	0.18	0.001
Cattle + TSP	4	23.11	0.15	0.06	0.001
TSP	4	11.01	1.05	0.47	0.001
Control	4	0.32	0.66	0.29	0.76

Appendix 6: ANOVA table for harvest index

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	0.229406	0.025490	5.22	
Block.*Units* stratum					
Treatments	4	1.620856	0.405214	83.06	<.001
Variety	2	0.010009	0.005005	1.03	0.361
Treatments.Variety	8	0.071084	0.008886	1.82	0.079
Residual	126	0.614704	0.004879		
Total	149	2.546059			

Appendix 7: ANOVA table for number of pods

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	61.073	6.786	2.28	
Block.*Units* stratum					
Treatments	4	956.307	239.077	80.32	<.001
Variety	2	64.653	32.327	10.86	<.001
Treatments.Variety	8	36.013	4.502	1.51	0.159
Residual	126	375.027	2.976		
Total	149	1493.073			

Appendix 8: ANOVA table for average number of grains per pod

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	15.7086	1.7454	6.03	
Block.*Units* stratum					
Treatments	4	41.7296	10.4324	36.04	<.001
Variety	2	0.0681	0.0341	0.12	0.889
Treatments.Variety	8	2.8312	0.3539	1.22	0.291
Residual	126	36.4764	0.2895		
Total	149	96.8139			

Appendix 9: ANOVA table for pod length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	14.999	1.667	1.00	
Block.*Units* stratum					
Treatments	4	148.301	37.075	22.30	<.001
Variety	2	9.793	4.896	2.95	0.056
Treatments.Variety	8	15.920	1.990	1.20	0.306
Residual	126	209.481	1.663		
Total	149	398.493			

Appendix 10: ANOVA table for grain yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	70254392.	7806044.	59.91	
Block.*Units* stratum					
Treatments	4	26197590.	6549397.	50.26	<.001
Variety	2	3220631.	1610315.	12.36	<.001
Treatments.Variety	8	649535.	81192.	0.62	0.757
Residual	126	16418086.	130302.		
Total	149	116740233.			

Appendix 11: ANOVA table of weight of 100 grains

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	169.032	18.781	2.50	
Block.*Units* stratum					
Treatments	4	793.305	198.326	26.36	<.001
Variety	2	3758.778	1879.389	249.80	<.001
Treatments.Variety	8	224.158	28.020	3.72	<.001
Residual	126	947.957	7.523		
Total	**149**	**5893.231**			

Appendix 12: ANOVA table of % seed purity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	1806.17	200.69	6.00	
Block.*Units* stratum					
Treatments	4	9229.82	2307.45	69.01	<.001
Variety	2	126.14	63.07	1.89	0.156
Treatments.Variety	8	574.93	71.87	2.15	0.036
Residual	126	4213.28	33.44		
Total	149	15950.34			

Appendix 13: ANOVA table for %crude carbohydrates

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	24.437	2.715	0.64	
Block.*Units* stratum					
Treatments	4	1667.232	416.808	98.87	<.001
Variety	2	28.967	14.483	3.44	0.035
Treatments.Variety	8	189.229	23.654	5.61	<.001
Residual	126	531.160	4.216		
Total	149	2441.025			

Appendix 14: Mean square values of ANOVA of % crude fat

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	1.04423	0.11603	1.64	
Block.*Units* stratum					
Treatments	4	9.34841	2.33710	33.11	<.001
Variety	2	0.59069	0.29534	4.18	0.017
Treatments.Variety	8	4.07180	0.50897	7.21	<.001
Residual	126	8.89501	0.07060		
Total	149	23.95013			

Appendix 15: ANOVA table for crude protein

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	99.439	11.049	3.32	
Block.*Units* stratum					
Treatments	4	975.097	243.774	73.16	<.001
Variety	2	29.896	14.948	4.49	0.013
Treatments.Variety	8	33.275	4.159	1.25	0.277
Residual	126	419.848	3.332		
Total	149	1557.555			

Appendix 16: ANOVA table for Iron concentration

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	5804.7	645.0	0.83	
Block.*Units* stratum					
Treatments	4	77669.6	19417.4	25.00	<.001
Variety	2	60673.5	30336.7	39.05	<.001
Treatments.Variety	8	30774.2	3846.8	4.95	<.001
Residual	126	97883.0	776.8		
Total	149	272805.0			

Appendix 17: ANOVA table for Zinc concentration

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	9	96.097	10.677	1.08	
Block.*Units* stratum					
Treatments	4	2101.808	525.452	53.22	<.001
Variety	2	51.442	25.721	2.61	0.078
Treatments.Variety	8	616.762	77.095	7.81	<.001
Residual	126	1244.004	9.873		
Total	149	4110.113			

Appendix 18: Pictures (plates) showing the processes of the study

Plate 1: Chopping of dry maize straw (Source: Author 2021)

Plate 2: Analysis of C:N of all manures and straw (Source: Author 2021)

Plate 3: Manureing process of manure piles (source: Author 2021)

Plate 4: Manure piles ready for application (source: Author 2021)

Plate 5: During application of TSP and manure (source: Author 2021)

Plate 6: During planting (source: Author 2021)

Plate 6 Number of pods on Naro bean 1(Source: Author 2021)

Plate:7 Number of pods on Narobean (source: Author 2021