NITROGEN FERTILIZER APPLICATION TO OPTIMIZE GROWTH AND LAND PRODUCTIVITY OF INTERCROPPED LONGE 10H MAIZE AND NABE 15 BEAN IN EASTERN UGANDA

BY

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DECLARATION

I, **Oyoka Mathias**, hereby declare that this thesis is my original work and has not been presented for a degree or any other award in any institution of higher learning.

Signature: .... Date: ....

APPROVAL

This is to certify that we have supervised this thesis from its start. It is now ready to be submitted for examination with our approval as appointed University supervisors.

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DEDICATION

I bestow this work to my dear spouse Grace Oyoka, my children and my parents, for being by my side and for their words of encouragement. You have all been my best cheerleaders.

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ABSTRACT

Maize yield improvement on nutrient depleted soils has relied primarily on application of expensive hard to get fertilizers. Augmenting this approach with exploitation of the ecological benefits of cereal-legume intercropping is considered a more sustainable option. The effect of nitrogen fertilizer application on growth and land productivity of intercropped Longe 10H maize and NABE 15 bean was evaluated in the field. Experiments with treatments laid in Randomised Complete Block Design and replicated thrice, were conducted during two cropping seasons at National Semi-Arid Resources Research Institute (NaSARRI), Serere district, Uganda. Maize growth, yield and land equivalent ratio (LER) of Longe 10H maize + NABE 15 bean intercrop were assessed. Results showed generally higher maize plant height, biomass and grain yield in fertilized intercrop plots compared to unfertilized plots during both season 1 and season 2, in addition to LER > 1 for all the fertilized intercrop plots. Nitrogen fertilizer application showed a degree of improving maize growth, grain yield and land efficiency of Longe 10H maize + NABE 15 bean intercrop. However, further studies involving several nitrogen fertilizer levels, different intercrop plant populations and planting geometries of Longe 10H maize + NABE 15 bean intercrop, and other agroecological zones that grow these crop varieties are necessary.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Maize (*Zea mays* L.) and beans (*Phaseolus vulgaris* L.) are among the common staple food and commercial crops globally (Chekanai et al., 2018; Hailu et al., 2018; Nassary et al., 2020). In many smallholder farming communities, intercropping legumes like beans in production of cereals such as maize is a preferred practice (Bedoussac et al., 2015). Generally, the global production trend of maize is on the rise due to its demand for food and feed (Erenstein et al., 2022). Although greatest percent domestic maize supply in Asia (79.8 %), Europe (82.1 %) and America (79.2 %) is utilised for feed and other non-food uses (Erenstein et al., 2022), it is a preferred cereal for human consumption in Africa (Badu-Apraku & Fakorede, 2017b; Ranum et al., 2014). Maize yield in Africa is estimated to be 2.1 $tonha^{-1}$ on average, compared to 7.9 $tonha^{-1}$ for the American continent (Erenstein et al., 2022). According to MAAIF (2019), the average maize yield in Uganda is estimated at 2.2 – 2.5 $tonha^{-1}$ as opposed to the potential of 8 $tonha^{-1}$. Nonetheless, such yield is still very low compared to 10.7 $tonha^{-1}$ of the United States of America (USA) (Outreach, 2017).

The observed yield gap in Uganda is attributed to reasons like pests and diseases, weather stress and declining soil fertility (MAAIF, 2019). In fact, soil fertility decline is highlighted as a key maize production constraint, resulting from nutrient mining, in situ destruction of vegetation and removal of crop residues, among others (Kayuki et al., 2012). This has threatened the food supply and livelihood of households, in spite of the existing better yielding maize hybrid varieties (Outreach, 2017). Nonetheless, the global maize yield increments are not only linked to genetic improvements, but also better agronomic practices and improved genotype x management interactions (Tollenaar & Lee, 2002). Thus, a great need arises for a package of agronomic practices to alleviate the effect of declining fertility, improve resource use efficiency and boost production of the maize in Uganda.

Among the agronomic practices explored is the application of fertilizers, and incorporating leguminous plants in the cropping cycle (Kayuki et al., 2012). Studies have also shown improved maize growth and yield through use of different fertilizers. For instance; maize growth and grain yield was reported to improve by application of: nitrogenous and phosphatic fertilizer (Beyranvand et al., 2013), foliar NPK-fertilizers (Amanullah et al., 2014), blended fertilizers (Chimdessa, 2016), Black soldier fly frass fertilizer (Beesigamukama et al., 2020; Tanga et al., 2022), among others.

In addition, intercropping is generally considered very beneficial under abiotic stressful conditions (Martin-Guay et al., 2018) and several benefits of cereal-legume intercrop were highlighted in the reviews by Bedoussac et al., (2015) and Maitra et al., (2021). In fact, maize intercrop with leguminous plants has shown better resource use efficiency according to Land equivalent ratios (LER) reported (Kermah et al., 2017; Santo et al., 2023; Suárez et al., 2022; Tsujimoto et al., 2015). Also, investigations on intercrop of maize and leguminous plants showed better maize yield than a sole crop. For example, when compared to sole maize plots, maize grain yield was higher under maize-legume intercrop with; Pigeon pea, Groundnut, Tephrosia, and Mucuna (Kamanga et al., 2010). In addition, higher grain yield was reported when intercropped with: Soybean (Tsujimoto et al., 2015); climbing bean (Tolera et al., 2005); Cow-pea, and common bean (Yilmaz et al., 2008).

Furthermore, studies on fertilization of a maize-legume intercrop have shown improvement of growth and yield of the crops. For instance; increase of grain yield due nitrogen fertilizer application of a pea-maize intercrop (Yang et al., 2018), higher yield of maize-climbing bean intercrop when treated with farmyard manure plus inorganic nitrogen and phosphorus (Tolera et al., 2005), improved growth and yield in maize + soybean intercrop due to NPK application (Usman et al., 2015), and also higher height of plants, higher dry matter and higher grain yield at the highest level of nitrogen application to the maize-common bean intercrop (Takele et al., 2017).

In the above studies, the performance of maize-legume intercrop seems to vary based on the varieties of both maize and the legume used. In Uganda, there are different agro-ecological zones and diversity of crop varieties that were bred to suit the conditions. Therefore, evaluation of performance of the intercrops of maize and bean varieties suited to a specific agro-ecological zone is paramount.

1.2 Statement of the problem

In Africa, maize growing by smallholder farmers generally takes place on degraded, nutrient-starved soils leading to low yields (Outreach, 2017). Likewise, the low maize yield in Uganda is attributed to the declining soil fertility among other factors (MAAIF, 2019). As a result, nitrogenous fertilizer application has been the obvious intervention by the farmers to improve yields, though inadequate amounts are often used (Outreach, 2017). In addition, crop diversification is considered an effective strategy against the production constraints (Badu-Apraku & Fakorede, 2017b). Accordingly, intercropping with legumes is common because of the benefits that accrue (Maitra et al., 2021; Martin-Guay et al., 2018; Outreach, 2017). Thus, diversifying the package of agronomic practices to improve the yield is viewed as a more sustainable option. Studies on maize-legume intercrop involving different varieties of both maize and legumes with fertilizer application had yielded success in various areas (Takele et al., 2017; Tolera et al., 2005; Usman et al., 2015; Yang et al., 2018). However, the observed response can never be generalised to the diverse agroecological zones and the different crop cultivars grown; just like the observed variation in maize yield under intercrop with the different legume species (Kermah et al., 2017; Madembo et al., 2020; Nwite et al., 2017). Unfortunately, scanty data on performance of the intercrop of common varieties of maize and beans in Uganda underpinned a need to undertake this study in the different agroecological zones. Therefore, this study evaluated the intercrop of Longe 10H maize and NABE15 common bean under nitrogen fertilizer application in eastern Uganda.

1.3 Objectives

1.3.1 General objective

To determine effect of nitrogen fertilization on growth, yield and land productivity of intercrop of maize and beans in the field.

1.3.2 Specific objectives

i. To determine vegetative growth of Longe 10H maize intercropped with NABE15 beans under nitrogen fertilization.

ii. To assess grain yield and land productivity of intercropped Longe 10H maize and NABE15 beans under nitrogen fertilization.

1.4 Hypotheses

i. Nitrogen fertilization does not affect vegetative growth of Longe 10H maize intercropped with NABE15 beans.

ii. Nitrogen fertilization does not affect grain yield and land productivity of intercropped Longe 10H maize and NABE15 beans.

1.5 Significance of the study

Findings will be used to educate farmers on sustainable production of maize and beans under intercrop with basic resources. Additionally, findings will be a basis to further research since they will provide literature for reference to other researchers with related studies. Furthermore, the results from this study will be useful to agricultural officers, to guide farmers on sustainable agronomic practices on intercropping systems.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of maize

Maize (*Zea mays* L.) is a significant cereal crop globally. The crop has a multitude of uses due to varied attributes in terms of grain colours, endosperm hardness, type of starch, kernel type, biofortification, among others (Erenstein et al., 2022). It forms staple human food for several African republics, with its kernel on average composed of carbohydrate (70–75%), protein (8–15%), and also enriched with carotenoids in yellow maize (Badu-Apraku & Fakorede, 2017b). In technologically advanced countries, maize is mainly a livestock feed (Erenstein et al., 2022).

The crop is also useful in production of several alcoholic drinks (Badu-Apraku & Fakorede, 2017b). Industrially, maize is used to manufacture several products (Ranum et al., 2014). It shouldn't be forgotten that production of the crop is also a source of seed (Badu-Apraku & Fakorede, 2017b). With the several uses of maize, it is widely traded globally and fetches income for many people.

2.2 Maize production constraints

Production of maize in Sub-Saharan Africa (SSA) faces biotic and abiotic challenges. Notable among the biotic constraints are: (i) diseases (Badu-Apraku & Fakorede, 2017b; Outreach, 2017); (ii) weeds (Badu-Apraku & Fakorede, 2017b); and (iii) pests, chiefly stem borers (Badu-Apraku & Fakorede, 2017b). The key field pests of maize are listed by Outreach, (2017). *Striga hermonthica* that may lead to 100% yield loss is viewed as the most important biotic constraint (Lobulu et al., 2019; Outreach, 2017).

The key abiotic constraints to maize productivity in SSA and Uganda in particular are soil fertility decline and drought stress (Badu-Apraku & Fakorede, 2017b; MAAIF, 2019). Therefore, developing sustainable interventions to address these constraints is paramount to increase maize production.

2.3 Interventions to improve maize production

The global maize yield increments are a result of genetic improvements and better agronomic practices (Tollenaar & Lee, 2002). It is very clear that none of the mentioned approaches when adopted alone can be sufficient. Integration of possible options is more sustainable. In fact, sustainable maize productivity gains require manipulation of genotype x environment × management interactions (Cairns et al., 2021).

Genetically, several maize varieties have been developed. They exhibit various resistances to key biotic constraints and tolerance to abiotic stresses (Badu-Apraku & Fakorede, 2017b). The maize variety special attributes range from difference in; duration to maturity, nutritive value, resistance to some pests, resistance to specific diseases, resistance to lodging, drought tolerance, yield potential, among others (Badu-Apraku & Fakorede, 2017a; MAAIF, 2019; Outreach, 2017). In Uganda, the varieties grown include; Longe I, Longe 8H, Longe 9H, Longe 10H, Longe 11H, WE 114, among others (MAAIF, 2019).

Agronomically, organic (manure) and inorganic fertilizer application is always done to boost production. This approach seems to be primary even in Uganda since soil fertility decline is highlighted as a key maize production constraint (Kayuki et al., 2012; MAAIF, 2019). In addition, crop diversification both in time (crop rotation) and space (intercropping), comprise the package of key practices that can be employed to improve production of the maize varieties. Combing a package of agronomic practices that improve soil productivity are considered a more sustainable approach (Badu-Apraku & Fakorede, 2017b).

The cereal/legume intercrop is generally known for the improved efficiency in producing the grain, high protein content in grain, reduced weed growth, and many other economic benefits than sole cereal cropping (Bedoussac et al., 2015). In fact, where there is shortage of nitrogenous fertilizers, farmers target the benefits of maize-legume intercropping (Ananthi et al., 2017; Outreach, 2017).

Moreso, better performance of fertilized maize-legume intercrop as compared to the sole maize culture has already been reported (El-Mehy et al., 2023; Fu et al., 2023; Takele et al., 2017).

However, the performance seems to be dependent on the suitability of the varieties to intercropping in the various environments (Bedoussac et al., 2015).

2.4 Nitrogen fertilization of maize-legume intercrop

2.4.1 Effect on vegetative growth of maize

There are evaluations of fertilizer use regarding effect on vegetative growth of maize under maize-legume intercrop and both benefits and penalties on some parameters have been reported. For instance; in a field experiment, Takele et al. (2017) reported lowest plant height (204.3 cm) in unfertilised plots. In same study, the plant height improved with increasing fertilization rates to maximum of 242.4 cm at the highest nitrogen rate of 92 $kgha^{-1}$. The same study showed the highest plant height (231.6 cm) in sole maize compared to either of the intercrops. In addition, the same study showed highest dry matter (11081.8 $kgha^{-1}$) at the highest nitrogen rate of 92 $kgha^{-1}$ and lowest (10272.2 $kgha^{-1}$) at 0 $kgha^{-1}$. The same study also showed highest dry matter (11166.8 $kgha^{-1}$) in the sole maize plots than the intercrops.

A study of Sultana et al. (2013) reported highest maize plant mean height in the different planting geometries of maize + mungbean intercrop (214.20 cm) and the lowest in sole maize plots (213.10 cm), though not significantly different. In the same study, maize biological yield was significantly highest in maize + mashbean intercrop (32.08281 ton ha^{-1}) in addition to being lowest in sole crop (31.35570 ton ha^{-1}). Also, during experiments involving the intercrops of Maize with several other legumes, the biomass yield in intercrops and sole maize was reported not significantly different (Madembo et al., 2020). Furthermore, Bekele et al. (2021)

observed higher maize biomass for the sole crop (7750 $kgha^{-1}$) than for the intercrops; Maize + vetch (7250 $kgha^{-1}$) and Maize + lablab (6625 $kgha^{-1}$).

Another study, showed more than 40% higher dry matter accumulation per maize plant in both intercrops of maize-soybean and maize-peanut than monoculture maize (Fu et al., 2023). The same study revealed more than 15% higher maize dry matter accumulation in nitrogen fertilized plots compared to unfertilized plots. Also, the same study, reported that maize leaf area in both intercrops of maize-soybean and maize-peanut was more than 30% higher than monoculture maize.

2.4.2 Effect on maize grain yield and yield components

Fertilization of maize-legume has shown improvement in yield including yield components of maize especially under poor soils. For instance, when the maize and dry bean intercrop was evaluated, significant increase of yield and yield components of maize grain was reported at different nitrogen levels compared to the unfertilised plots (El-Mehy et al., 2023).

In another study that investigated intercrops of legumes and nitrogen fertilizer level, Takele et al., (2017) observed maximum yield (5345.1 $kgha^{-1}$) at the highest nitrogen rate of 92 $kgha^{-1}$ and lowest (3731.3 $kgha^{-1}$) at 0 $kgha^{-1}$. In the same study, the intercrop with bean recorded the uppermost grain yield of 4843.3 $kgha^{-1}$ though the difference was not significant compared to sole maize (4838.2 $kgha^{-1}$). Also, the same study reported the highest hundred seed weight (33.6 g) at the highest nitrogen rate of 92 $kgha^{-1}$ and lowest (30.2 g) at 0 $kgha^{-1}$. Furthermore, the same study reported the highest hundred seed weight (32.64 g) in the maize + common bean intercrop whereas sole maize recorded the lowest (30.55 g). In addition, the same study showed highest kernel number / ear of 420.2 from treatment of 92 kgha^{-1} of nitrogen and lowest number (307.7) was observed in unfertilised treatment. Moreso, the same study indicated that sole maize with uppermost kernels / ear (383.4), nonetheless the difference being not significant compared to the intercrops.

During on-farm trials involving various maize and legume intercrops, sole crop yielded highest (3.2 tonha^{-1}) compared to all the intercrops (Madembo et al., 2020). Also, the on-station trails of the same study showed higher maize yield in maize/pigeon pea intercrop compared to sole maize plots.

A study by Sultana et al. (2013) reported highest 1000 grain weight of maize (242.07 g) in maize + mashbean intercrop, which was not significantly different from the 241.40 g of sole maize. In the same study, significant higher grain yield was reported in sole maize plots (12.54228 ton ha^{-1}) than intercrops; maize + mungbean (8.36710 ton ha^{-1}) in addition to maize + mashbean (8.344.08 kg ha^{-1}).

In another studies, maize grain yield in pea/maize intercrop with nitrogen applied increased by more than 11.07% compared to unfertilised plots (Yang et al., 2018). Furthermore, Maize + Soybean, Maize + Groundnut and Maize + Bambaranut showed significant greater grain yield than monocrop (Nwite et al., 2017). Moreso, Kermah et al. (2017) stated significant higher yield of grain for monocrop plots compared to intercrops. Also, Bekele et al. (2021) observed greatest yield of grain in monocrop (3050 $kgha^{-1}$) than the intercrops; Maize + vetch (2900 $kgha^{-1}$) and Maize + lablab (2700 $kgha^{-1}$).

2.4.3 Effect on legume grain yield and yield components

There are reports of maize-legume intercrop negatively impacting legume grain yield compared to legume monocropping (Bekele et al., 2021; Eneke et al., 2018; Fu et al., 2023; Sultana et al., 2013).

However, nitrogen fertilizer application to maize-legume intercrop improved grain yield and the components for legumes as compared to legume monocropping. For instance; Fu et al. (2023) reported 13.5% higher soybean grains per plant and a 13.8% increase of soybean grain yield after nitrogen fertilizer addition to the maize-soybean intercrop as compared to the unfertilized intercrop. In the same study, hundred-seed weight of peanut was found to increase by 5.6% in nitrogen fertilizer treated maize-peanut intercrop as compared to the unfertilized intercrop. Another study by Eneke et al. (2018) showed more soybean pods / plant, higher soybean grains / plant besides heavier soybeans from the fertilized maize-soybean intercrop compared to the unfertilized intercrop. Also, Usman et al. (2015) reported higher soybean grain yield within NPK fertilizer treated Maize-soybean intercrop as compared to unfertilized intercrop.

2.4.4 Effect on land productivity of the maize-legume intercrop

Among the ways to evaluate land productivity of the intercrops is the use of land equivalent ratio (LER) for comparability of yields of intercrops and monocultures (Maitra et al., 2021).

Studies have reported overall efficient land resource utilization from intercropping compared to monocropping. For instance; during experiments involving various maize and legume intercrops, higher productivity of intercrops reported for majority of situations compared to monocrop maize (Madembo et al., 2020).

Furthermore, several other studied have reported LER > 1 in both fertilized and unfertilized intercrops. For instance; Yang et al. (2018), observed LER >1. Also, during evaluation of productivity of maize + dry beans intercrop, LER > 1 was reported for all the intercrop treatments, highest (1.99) where the amount of nitrogen fertilizer applied was highest (El-Mehy et al., 2023). In addition, Kermah et al. (2017) reported LER > 1 for all the maize-legume intercrops; maize-soybean, maize-groundnut and maize-cowpea. The same study revealed superior LERs (1.16–1.81) in infertile areas compared to fertile fields (1.07–1.54).

Another study by Bekele et al. (2021) reported better land productivity with LER > 1 in both intercrops; Maize + vetch (1.55) and Maize + lablab (1.56). More to that, evaluation of maize-soybean intercrop showed a land equivalent ratio of 1.52 (Fu et al., 2023).

Also, an intercrop of Maize + Soybean showed LER > 1 in both the fertilized and unfertilized blocks (Eneke et al., 2018). Same study reported better LERs in fertilized plots (1.33 to 1.96) compared to the unfertilized plots (1.25 to 1.8).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental site

Field experiments were setup at the National Semi-Arid Resources Research Institute (NaSARRI), Serere district, Uganda. The area receives annual rainfall average about 1500mm and is characterised by a bi-modal rainfall pattern with peaks normally in March – June and September – November. The temperature ranges between 15°C and 30°C. The characteristics of sampled soil from the experimental field were analysed (table 3.1).

Table 3.1: Soil characteristics at the experimental field

Soil properties	Values[1]
PH	4.96
Organic carbon	0.32%
Soil organic matter	1.2%
Total N	0.16%
Exchangeable potassium	0.38 cmol/kg
P	26.2 mg/kg
Clay	71%
Sand	16%
Silt	13%

[1]Soil pH was determined using the mixture of soil and water in the ratio of 1:2.5. Organic matter was analysed using potassium dichromate wet acid oxidation technique. Total nitrogen was achieved by Kjeldhal digestion technique, extractable phosphorous by Bray P1 technique and exchangeable potassium from an ammonium acetate extract by flame photometry. Particle size distribution (texture) was determined using the Bouyoucos (hydrometer) method.

3.2. Establishment of experimental field

Land clearing, primary and secondary cultivation was done as necessary. The field was divided into experimental plots, each measuring 5 x 4 m; with inter-plot and inter-replicate space maintained at 1 m and 1.5 m, respectively. Both crops were planted in rows. The planting spacing 90 x 45 cm was adopted for maize, while 60 x 15 cm was used for the beans. Within the intercropped plots, each maize row was after two bean rows.

3.3 Treatments and experimental design.

The experiment included the following treatments:

i. Sole maize without nitrogenous fertilizer (SM)
ii. Sole maize with 50 $Kgha^{-1}$ of nitrogenous fertilizer (SM50N)
iii. Sole maize with 100 $Kgha^{-1}$ of nitrogen fertilizer (SM100N)
iv. Sole beans without nitrogenous fertilizer (SB)
v. Sole beans with 50 $Kgha^{-1}$ nitrogenous fertilizer (SB50N)
vi. Sole beans with 100 $Kgha^{-1}$ nitrogenous fertilizer (SB100N)
vii. Maize-Bean intercrop without nitrogenous fertilizer (M-B)
viii. Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer (M-B50N)
ix. Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer (M-B100N).

Randomised Complete Block Design (RCBD) with three replicates was adopted for laying out the treatments in the field.

3.4 Experimental field management

The necessary basic management like mechanical weed control, among others were performed. We adopted a blanket application of Tri-Super Phosphate (TSP) at 69 Kg / ha. Urea (46% N) fertilizer application was done, at three weeks and six weeks after planting. Harvesting of beans was done at 60 days and maize at 120 days.

3.5 Data collection

3.5.1 Assessing the effect of nitrogen fertilization on vegetative growth of Longe 10H maize intercropped with NABE15 beans

To assess effect on vegetative growth Longe 10H maize, data was collected on maize plant height, leaf area and biomass. Plant height was measured with a tape measure from ground level to the point of attachment of the flag leaf (Berchie et al., 2013). Then, an average of the measured heights of the randomly selected five plants of each plot was computed (Asghar et al., 2010). Leaf length and width of three middle leaves of five plants in each treatment plot were measured. Then, average length and width was worked out and the mean single leaf area was calculated according to the appropriate formular for maize (Bréda, 2008) as follows:

$$\text{Leaf area} = (\text{Leaf length} \times \text{Leaf breadth}) \times 0.75 \ldots\ldots\ldots\ldots\ldots\ldots \quad (i)$$

The biomass was determined as total dry weight per plant (Faheed et al., 2016) after sun drying selected plants that were routinely weighed till a constant weight, from which an average per plant was computed.

3.5.2 Assessing the effect of nitrogen fertilization on yield and land productivity of intercropped Longe 10H maize and NABE15 beans

To assess effect on productivity, data was collected on yield and some yield components of maize and beans, and the Land equivalent ratio (LER). The procedure of Chimdessa, (2016), was followed to determine the number of grain rows per ear of maize, number of grains per ear, 100 grain weight from five randomly selected maize ears per plot, and maize grain yield. The number of grain rows per ear was counted, averaged and recorded for each plot. The number of grains per ear was counted, averaged and recorded for each plot. Hundred grains were counted, weighed and the weight expressed in grams for each plot. Maize grain harvested from each plot was weighed and the weight extrapolated to yield in kilogram per hectare.

The number of bean pods, seeds per pod, hundred seed weight and bean seed yield were determined following the procedure of Alemu et al., (2018). The number of pods were counted from randomly selected five plants per plot at physiological maturity and averaged to get number of pods per plant. The seeds from randomly selected five plants per plot were counted and averaged to obtain seeds per plant, which was divided by the average number of pods to get number of seeds per pod. To obtain hundred seed weight; 100 seeds were randomly picked from a seed lot of randomly selected five plants per plot, after harvesting, drying and shelling. This was weighed and the weight recorded. The weight of dry bean seeds harvested from each plot was extrapolated to bean seed yield (kgha^{-1}) per treatment. Land equivalent ratio (LER) of the intercrop was computed according to the formular by Mead & Willey, (1980), as follows:

$$\text{LER} = \frac{\text{Yield of intercropped maize}}{\text{Yield of sole maize}} + \frac{\text{Yield of intercropped bean}}{\text{Yield of sole bean}} \text{.....(ii)}$$

3.6 Data analysis

Analysis of variance (ANOVA) was done for comparison of treatment performance regarding vegetative growth and grain/seed yield. Means were separated by Fisher's LSD at 5%. Analyses were done using GenStat. LER was evaluated according to Baijukya et al., (2016).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Assessment of effect on maize vegetative growth

4.1.1 Plant height

There were significant differences in maize plant height among experimental plots during season 1 ($p < .001$) and season 2 ($p < .001$). Plant height ranged from 175.3 ± 0.47 cm to 210.0 ± 2.41 cm during season 1 and 176.0 ± 1.51 cm to 213.7 ± 2.60 cm during season 2. During both season 1 and season 2, the plots of sole maize and maize-bean intercrop without nitrogenous fertilizer added showed significant lowest plant height (Table 4.1a).

Table 4.1a: Maize plant height under different treatments during season 1 and season 2

Treatment[1]	**Mean ± SE (cm)**	
	Season 1	**Season 2**
SM	175.3 ± 0.47 a	176.1 ± 1.83 a
SM100N	210.0 ± 2.41 c	209.7 ± 1.17 cd
SM50N	196.1 ± 1.95 b	213.7 ± 2.60 d
M-B100N	206.5 ± 1.65 c	207.1 ± 0.59 c
M-B50N	200.3 ± 6.94 bc	194.2 ± 2.06 b
M-B	176.5 ± 2.14 a	176.0 ± 1.51 a

In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).

[1]**SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SM50N** = Sole maize with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.1.2 Leaf area

Maize leaf area was not significantly different during season 1 ($p = 0.985$) whereas, significant difference was observed during season 2 ($p = 0.009$). Leaf area ranged from 530 ± 6.21 cm^2 to 602 ± 41.51 cm^2 and 567.8 ± 54.60 cm^2 to 725.9 ± 15.77 cm^2 during season 1 and season 2, respectively (Table 4.1b).

Table 4.1b: Maize leaf area under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE (cm^2)	
	Season 1	**Season 2**
SM	530 ± 6.21 a	659.4 ± 43.11 ab
SM100N	602 ± 41.51 a	724.2 ± 33.79 b
SM50N	572 ± 103.29 a	725.9 ± 15.77 b
M-B100N	543 ± 77.22 a	582.9 ± 2.99 a
M-B50N	559 ± 67.10 a	567.8 ± 54.60 a
M-B	576 ± 75.11 a	586.2 ± 29.88 a

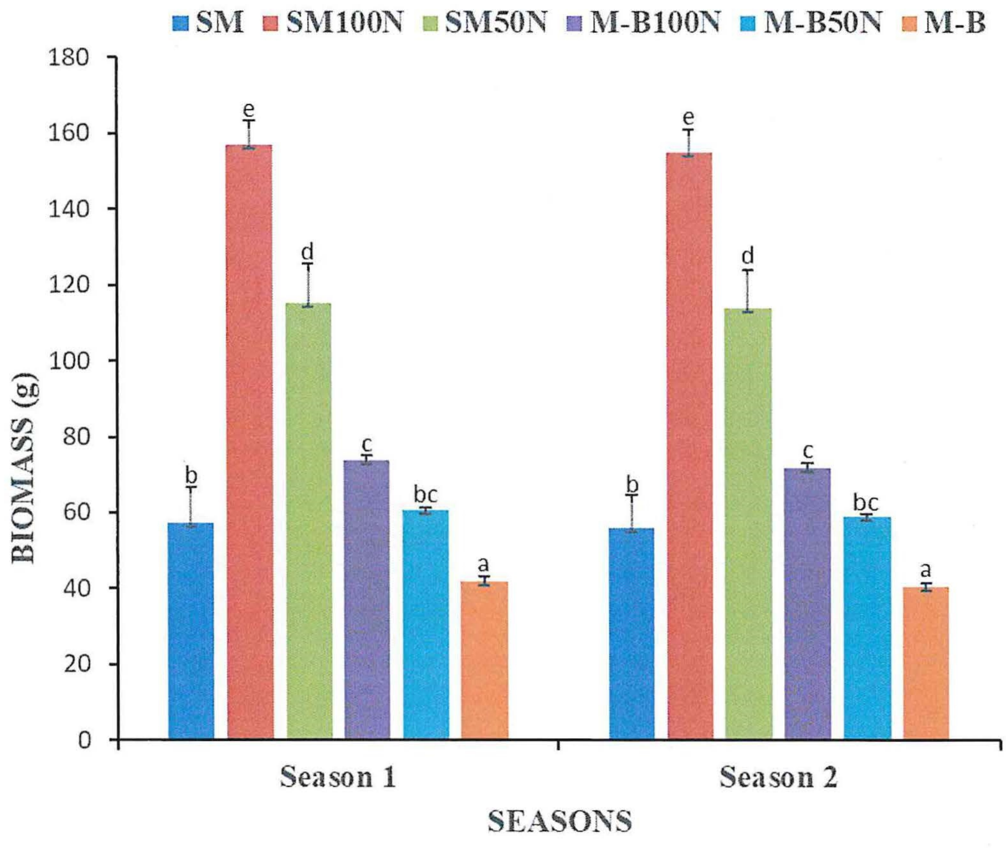
In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).

[1]**SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SM50N** = Sole maize with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.1.3 Biomass

There were significant differences in plant biomass among experimental plots during season 1 ($p < .001$) and season 2 ($p < .001$). Plant biomass ranged from

41.95 ± 1.12 g to 156.79 ± 6.34 g during season 1 and 40.48 ± 1.18 g to 2154.84 ± 6.17 g during season 2. During both season 1 and season 2, the plots of maize-bean intercrop with nitrogenous fertilizer added showed significant high biomass compared to maize-bean intercrop without nitrogenous fertilizer (Figure 4.1).



The treatments: **SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SM50N** = Sole maize with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer. In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).

Figure 4.1: Maize plant biomass under different treatments during season 1 and season 2.

The results generally indicate improved vegetative growth of maize under maize-bean intercrop due to application of nitrogenous fertilizers. Maize plant height in fertilized maize-bean intercrop plots was seen to be significantly higher than maize-bean intercrop plots without fertilizers, during both season 1 and season 2. Additionally, significant high maize biomass was observed in fertilized maize-bean intercrop plots compared to unfertilized maize-bean intercrop plots. The observed performance may be due to the depleted soil fertility reported in Uganda (Kayuki et al., 2012; MAAIF, 2019) and thus, it is not surprising that nitrogenous fertilizer application improved maize vegetative growth under the maize-bean intercrop. The study findings seem to concur with; Eneke et al. (2018) who reported higher maize plant height in the fertilized maize-soybean intercrop compared to the unfertilized plots, and Fu et al. (2023) who reported higher dry matter per maize plant in nitrogen fertilized maize-peanut and maize-soybean treatment plots compared to unfertilized plots.

4.2 Assessing the effect on productivity of intercropped Longe 10H maize and NABE15 beans

4.2.1 Number of maize grain rows per ear

Number of grain rows / ear was not significantly different among treatments during season 1 ($p = 0.811$) and season 2 ($p = 0.221$). The uppermost number of maize grain rows / ear was noted in Sole maize without nitrogenous fertilizer (13.60 ± 0.00) during season 1 and Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer (14.00 ± 0.23) during season 2 (Table 4.2a).

Table 4.2a: Number of maize grain rows per ear under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE	
	Season 1	**Season 2**
SM	13.60 ± 0.00 a	13.07 ± 0.35 a
SM100N	13.33 ± 0.35 a	14.00 ± 0.23 a
SM50N	12.93 ± 0.13 a	13.87 ± 0.53 a
M-B100N	13.33 ± 0.13 a	13.07 ± 0.35 a
M-B50N	13.33 ± 0.13 a	12.93 ± 0.13 a
M-B	13.20 ± 0.61 a	13.60 ± 0.23 a

[1]**SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SM50N** = Sole maize with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.2 Number of maize grains per ear

The number of grains per ear mong treatments was not significantly different during season 1 ($p = 0.890$) and season 2 ($p = 0.685$). The maximum number of grains / ear was observed in Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer (446 ± 35.43) during season 1 and Sole maize without nitrogenous fertilizer (477.3 ± 23.85) during season 2 (Table 4.2b).

Table 4.2b: Number of maize grains per ear under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE	
	Season 1	Season 2
SM	441± 6.23 a	477.3 ± 23.85 a
SM100N	446 ± 35.43 a	444.5 ± 12.46 a
SM50N	427 ± 46.18 a	466.6 ± 22.25 a
M-B100N	420 ± 17.41 a	440.7 ± 16.54 a
M-B50N	432 ± 14.86 a	458.2 ± 15.45 a
M-B	399 ± 24.67 a	439.7 ± 21.84 a

In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).

[1]**SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SM50N** = Sole maize with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.3 Hundred maize grain weight

The difference for 100 maize grain weight among experimental treatments was significant during season 1 ($p <.001$) and season 2 ($p <.002$). For season 1, 100 grain weight ranged from 30.20 ± 0.23 g to 39.11 ± 0.24 g. During season 2, 100 grain weight ranged from 34.27 ± 1.19 g to 39.20 ± 0.38 g. The intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer showed significant higher 100 grain weight compared to other intercrop treatments during both seasons 1 and 2 (Table 4.2c).

Table 4.2c: 100 maize grain weight under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE (g)	
	Season 1	Season 2
SM	30.20 ± 0.23 a	34.27 ± 1.19 a
SM100N	35.73 ± 0.18 b	36.33 ± 0.26 b
SM50N	37.42 ± 0.84 bc	39.20 ± 0.38 c
M-B100N	35.79 ± 0.59 b	36.13 ± 0.32 ab
M-B50N	39.11 ± 0.24 c	38.37 ± 0.32 c
M-B	30.78 ± 1.46 a	35.23 ± 0.55 ab

In a season, means that share a letter are not significantly different by Fisher's protected LSD test (p = 0.05).

[1]**SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 Kgha^{-1} of nitrogenous fertilizer; **SM50N** = Sole maize with 50 Kgha^{-1} of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 Kgha^{-1} of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 Kgha^{-1} of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.4 Grain yield

Maize grain yield varied significantly among experimental treatments during season 1 ($p <.001$) and season 2 ($p <.001$). Maize grain yield ranged from 1564 ± 118.93 kgha^{-1} to 2208 ± 41.25 kgha^{-1} during season 1, and 1441 ± 123.05 kgha^{-1} to 3043 ± 63.80 kgha^{-1} during season 2 (Table 4.2d). Sole maize with 100 Kgha^{-1} of nitrogenous fertilizer showed the highest maize grain yield during both seasons 1 and 2. During season 1, the intercrop of maize and beans with 100 Kgha^{-1} of nitrogenous fertilizer showed significant higher maize grain yield than other intercrops. During season 2, maize grain yield of the intercrops with 100 Kgha^{-1}

and 50 Kgha^{-1} nitrogenous fertilizer applied was not significantly different (Table 4.2d).

Table 4.2d: Maize grain yield under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE (Kgha^{-1})	
	Season 1	**Season 2**
SM	1564 ± 118.93 a	1441 ± 123.05 a
SM100N	2208 ± 41.25 c	3043 ± 63.80 c
SM50N	1921 ± 34.21 b	1589 ± 178.56 a
M-B100N	2167 ± 12.40 c	2355 ± 232.99 b
M-B50N	1840 ± 50.54 b	1851 ± 28.72 ab
M-B	1720 ± 97.81 ab	1499 ± 219.65 a

n a season, means that share a letter are not significantly different by Fisher's protected LSD test ͺp = 0.05).
[1]**SM** = Sole maize without nitrogenous fertilizer; **SM100N** = Sole maize with 100 Kgha^{-1} of nitrogenous fertilizer; **SM50N** = Sole maize with 50 Kgha^{-1} of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 Kgha^{-1} of nitrogenous fertilizer; **M-B50**N = Maize-Bean intercrop with 50 Kgha^{-1} of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.5 Number of bean pods per plant

The differences in number of bean pods / plant among experimental plots was significant during season 1 ($p = 0.004$) whereas, no significant differences were observed during season 2 ($p = 0.323$). During season 1, bean pods / plant was between 5.20 ± 0.81 to 12.47 ± 2.07, whereas during season 2, it ranged from 6.53 ± 1.68 to 8.93 ± 0.35 pods2 (Table 4.2e). The maximum bean pods / plant was noted in sole bean with 100 $Kgha^{-1}$ of nitrogenous fertilizer during both seasons 1 and 2 (Table 4.2e).

Table 4.2e: Number of bean pods per plant under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE	
	Season 1	**Season 2**
SB	10.40 ± 0.64 bc	7.93 ± 0.55 a
SB100N	12.47 ± 2.07 c	8.93 ± 0.35 a
SB50N	8.40 ± 0.53 ab	6.53 ± 1.68 a
M-B100N	5.80 ± 0.20 a	7.40 ± 0.20 a
M-B50N	7.20 ± 0.50 ab	6.67 ± 0.13 a
M-B	5.20 ± 0.81 a	8.13 ± 0.29 a

In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).
[1]**SB** = Sole bean without nitrogenous fertilizer; **SB100N** = Sole bean with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SB50N** = Sole bean with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.6 Number of bean seeds per pod

The difference was not significant for number of beans / pods among experimental plots during season 1 ($p = 0.186$). During season 2, the number of bean / pods was also observed not significantly ($p = 0.123$) different among the treatment plots. The beans / pod was between 3.93 ± 0.18 to 5.00 ± 0.12 seeds during season 1, and 7.53 ± 1.09 to 9.47 ± 2.38 seeds per pod during season 2 (Table 4.2f).

Table 4.2f: Number of bean seeds per pod under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE	
	Season 1	Season 2
SB	4.13 ± 0.33 a	9.67 ± 1.78 a
SB100N	5.00 ± 0.12 a	9.13 ± 4.48 a
SB50N	4.40 ± 0.42 a	9.47 ± 2.38 a
M-B100N	4.53 ± 0.24 a	7.67 ± 1.97 a
M-B50N	4.00 ± 0.20 a	7.53 ± 1.09 a
M-B	3.93 ± 0.18 a	7.87 ± 0.77 a

In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).

[1]**SB** = Sole bean without nitrogenous fertilizer; **SB100N** = Sole bean with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SB50N** = Sole bean with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.7 Hundred bean seed weight

There were no significant differences in 100 seed weight among experimental plots during season 1 ($p = 0.863$) whereas, significant differences were observed during season 2 ($p = 0.024$). 100 seed weight ranged from 34.63 ± 1.04 g to 37.20 ± 1.81 g during season 1, and 30.47 ± 1.92 g to 38.23 ± 0.19 g during season 2. The intercrop plots with 50 $Kgha^{-1}$ of nitrogenous fertilizer showed significant lower seed weight compared to intercrop plots with 100 $Kgha^{-1}$ of nitrogenous fertilizer and sole bean plots (Table 4.2g).

Table 4.2g: 100 bean seed weight under different treatments during season 1 and season 2

Treatment[1]	**Mean ± SE (g)**	
	Season 1	**Season 2**
SB	34.63 ± 1.04 a	34.93 ± 1.52 b
SB100N	36.10 ± 2.08 a	38.23 ± 0.19 b
SB50N	36.67 ± 0.33 a	35.93 ± 1.44 b
M-B100N	35.87 ± 2.33 a	36.77 ± 1.42 b
M-B50N	37.20 ± 1.81 a	30.47 ± 1.92 a
M-B	35.27 ± 0.97 a	34.23 ± 0.23 ab

In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).

[1]**SB** = Sole bean without nitrogenous fertilizer; **SB100N** = Sole bean with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SB50N** = Sole bean with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.8 Bean seed yield

The yield was significantly different among experimental plots during season 1 ($p = 0.015$) whereas, no significant differences were observed during season 2 ($p = 0.207$). Bean seed yield ranged from 137.1 ± 56.73 $kgha^{-1}$ to 561 ± 90.51 $kgha^{-1}$ during season 1, and 212 ± 75.76 $kgha^{-1}$ to 433 ± 82.78 $kgha^{-1}$ during season 2. The plots of sole bean with 100 $Kgha^{-1}$ of nitrogenous fertilizer showed the highest bean seed yield during both seasons 1 and 2 (Table 4.2h).

Table 4.2h: Bean seed yield under different treatments during season 1 and season 2

Treatment[1]	Mean ± SE ($Kgha^{-1}$)	
	Season 1	**Season 2**
SB	381 ± 94.23 bc	205 ± 38.47
SB100N	561 ± 90.51 c	433 ± 82.78
SB50N	428.8 ± 69.91 bc	432 ± 106.08
M-B100N	258.6 ± 21.92 ab	290 ± 57.82
M-B50N	337.9 ± 95.21 ab	212 ± 75.76
M-B	137.1 ± 56.73 a	264 ± 62.26

In a season, means that share a letter are not significantly different by Fisher's protected LSD test ($p = 0.05$).
[1]**SB** = Sole bean without nitrogenous fertilizer; **SB100N** = Sole bean with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **SB50N** = Sole bean with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B100N** = Maize-Bean intercrop with 100 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B50N** = Maize-Bean intercrop with 50 $Kgha^{-1}$ of nitrogenous fertilizer; **M-B** = Maize-Bean intercrop without nitrogenous fertilizer.

4.2.9 Land Equivalent Ratio (LER)

The Land Equivalent Ratio (LER) was highest (1.75) in plots with 50 $Kgha^{-1}$ of nitrogenous fertilizer during season1. During season 2, the highest LER (2.33) was recorded for plots without nitrogenous fertilizer added. Generally, LER >1 was recorded during both seasons 1 and 2 for all fertilized and non-fertilized plots (Table 4.2i).

Table 4.2i: Land Equivalent Ratio (LER) under different nitrogenous fertilizer levels of the treatments during season 1 and season 2

Fertilizer level	Treatment yield description[2]	Yield (Kgha^{-1})		LER[1]	
		Season 1	Season 2	Season 1	Season 2
0 Kgha^{-1} of Nitrogen	SBY	381	205	1.46	2.33
	IBY	137.1	264		
	SMY	1564	1441		
	IMY	1720	1499		
100 Kgha^{-1} of Nitrogen	SBY100N	561	433	1.44	1.44
	IBY100N	258.6	290		
	SMY100N	2208	3043		
	IMY100N	2167	2355		
50 Kgha^{-1} of Nitrogen	SBY50N	428.8	432	1.75	1.66
	IBY50N	337.9	212		
	SMY50N	1921	1589		
	IMY50N	1840	1851		

[1]Refer to equation (ii). [2]**SBY** = Sole bean yield without nitrogenous fertilizer; **IBY** = Intercrop bean yield without nitrogenous fertilizer; **SMY** = Sole maize yield without nitrogenous fertilizer; **IMY** = Intercrop maize yield without nitrogenous fertilizer; **SBY100N** = Sole bean yield with 100 Kgha^{-1} of nitrogenous fertilizer; **IBY100N** = Intercrop bean yield with 100 Kgha^{-1} of nitrogenous fertilizer; **SMY100N** = Sole maize yield with 100 Kgha^{-1} of nitrogenous fertilizer; **IMY100N** = Intercrop maize yield with 100 Kgha^{-1} of nitrogenous fertilizer; **SBY50N** = Sole bean yield with 50 Kgha^{-1} of nitrogenous fertilizer; **IBY50N** = Intercrop bean yield with 50 Kgha^{-1} of nitrogenous fertilizer; **SMY50N** = Sole maize yield with 50 Kgha^{-1} of nitrogenous fertilizer; **IMY50N** = Intercrop maize yield with 50 Kgha^{-1} of nitrogenous fertilizer

The results generally showed improved maize yield and overall land productivity under maize-bean intercrop due to application of nitrogenous fertilizers. Although the difference in grain rows per ear was not significant across the treatments for fertilized and unfertilized plots in both seasons, this characteristic seems to be a genetically specific for this maize hybrid. However, maize grains / ear, a hundred maize seed weight including grain yield peaked in fertilized maize-bean intercrop plots than maize-bean intercrop plots without fertilizers, during both season 1 and season 2. Additionally, Land Equivalent Ratio (LER) > 1 was observed in all fertilized maize-bean intercrops. The highest level of nitrogen fertilizer applied gave the highest yield. The observed performance may be due to the depleted soil fertility reported in Uganda (Kayuki et al., 2012; MAAIF, 2019) and thus, nitrogenous fertilizer application seem to augment the ecological benefits of cereal-legume intercropping (Bedoussac et al., 2015) to positively impact growth, development and eventual yield of maize under the maize-bean intercrop. The findings relate with other studies on fertilized maize-legume intercrops such as; greater total system yield for intercropping of Maize with various legumes (Madembo et al., 2020), increased maize yield and combined intercrop productivity of Maize + dry beans (El-Mehy et al., 2023), and other LERs > 1 for several intercrops (Bekele et al., 2021; Fu et al., 2023; Kermah et al., 2017; Takele et al., 2017).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of findings

The aim was to assess growth and land productivity of intercropped Longe 10H maize and NABE 15 bean under nitrogen fertilizer application, an integrated package of agronomic practices to optimize maize yield.

The results seem to indicate a degree of improvement in maize growth, yield and overall land productivity by application of nitrogenous fertilizer to Longe 10H maize + NABE 15 bean intercrop. Through nitrogen fertilizer application on the intercrop, we observed increased maize plant height, biomass, and grain yield including overall land efficiency with land equivalent ratio (LER) >1 across all fertilized treatment plots. With the reported limitation of soil infertility in Uganda (Kayuki et al., 2012; MAAIF, 2019), the ecological benefits of diversifying with legumes (Bedoussac et al., 2015; Maitra et al., 2021) augmented with nitrogen fertilizer application can help to improve maize production sustainably.

5.2 Conclusion

The improved maize growth, grain yield and LER > 1 observed seem to suggest that nitrogen fertilizer application is necessary to improve productivity of Longe 10H maize + NABE 15 bean intercrop in Uganda. We also observed higher yield at the highest level of nitrogen fertilizer applied indicating that perhaps that is not the optimum fertilizer level for the region. That notwithstanding, this study was done in one agroecological zone and a single intercrop plant population and planting geometry was used.

5.3 Recommendations

Further research is needed to assess:

- Several nitrogen fertilizer levels on the Longe 10H maize + NABE 15 bean intercrop
- Different intercrop plant populations in the Longe 10H maize + NABE 15 bean intercrop
- Different planting geometries of Longe 10H maize + NABE 15 bean intercrop
- Performance of fertilized Longe 10H maize + NABE 15 bean intercrop in other agroecological zones that grow these crop varieties.

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