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Research Paper

Evaluation of Nitrogen Fertilizer and *Sesbania sesban* Nitrogen Fixing Alley Cropping Species on Maize Yield and Yield Components

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Crop production is heavily dependent on available nutrient in the soil and other environmental conditions for plant growth. Alley cropping allows the farmers to effectively use available resources and yield more benefits. Choosing suitable associated crop and mitigating the competition between trees and crops are crucial for designing the alley cropping systems. Field experiments were conducted to investigate the effect of *Sesbania Sesban* alley cropping on Maize yield and yield components and to evaluate the trends in maize grain yield over time in mid lands of Bale. The experiments were conducted in the past three years at Dello Menna District of Bale. The experiments were conducted in RCBD design with combination of Maize crop, *Sesbania sesban* alley cropping with different nitrogen level fertilizer (0%N, 25%N, 50%N, 75%N, and 100% N) was evaluated in this study. The result shows that the crop yields in three alley cropping systems were better than the conventional agriculture. For Dello Menna districts the application of 50% N fertilizer rates and *Sesbania sesban* alley cropping which generated high optimum grain yield 56.66qt/ha with economically reasonable yield. Based on the this experiment, the economic analysis showed that Maize with *Sesbania sesban alley* cropping +50%N and 100% P rate tested at Dello menna location gave the highest maize yield (5666 Kg ha^{-1}) with the net benefit (150252.2 ETB ha^{-}) and the highest marginal rate of return (2342.04%) which economically feasible alternative to the other treatments. Generally maize *Sesbania sesban* alley cropping is used to improve the soil fertility, used to improve the yield sustainability, used to improve farmers' income by minimizing fertilizer cost. Therefore, the combination of application of 50% N fertilizer rates and maize *Sesbania susban sesban* alley cropping were recommended for the study location and similar agro-ecologies in the midlands of Ethiopia.

Key Words: *Benefit, combination, economic analysis* Nitrogen level, Trend

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INTRODUCTION

The growing global population is driving the intensification of agricultural production, farmlands dominate 38% of the global land surface, and almost 30% of the global net primary production is for human use. This intensive agriculture affects both the production and productivity of the soil (Haberl et al., 2007). Introducing cover crop and conservation tillage is one of the strategies to improve soil organic matter and may improve the soil fertility status sustainably. Alley cropping is one of an agroforestry practices in which perennial, preferably leguminous trees or shrubs are grown simultaneously with an arable crop. The selection of trees and shrubs that have the ability to fix or take Nitrogen (N_2) from the air and use it for growth through a symbiotic relationship with bacteria called *Rhizobia* is crucial in the design of alley cropping. This is due to the fact that Nitrogen is often a limiting nutrient for plant growth, mulch from Nitrogen fixing tree provides nitrogen. Alley cropping has been widely reported to improve soil productivity and nutrient recycling in smallholder farming system of the humid tropics (Kang, 1997). Due to the role of nitrogen-fixing trees in soil-fertility improvement in agroforestry systems alley cropping has encouraged several field trials in a number of places. Alley cropping systems are a way of combining crop and tree production on the same plot, with both an economic and environmental objective. In an alley cropping system, trees are multifunctional: the aim is to provide a range of ecosystem services alongside wood and fruits. These include shelter for crops, host beneficial organisms, increase soil fertility and carbon storage, mitigate climate change, and provide protection against soil erosion.

Alley cropping entails growing food crops between hedgerows of planted shrubs and trees preferably leguminous tree species (Nair 1993). An agroforestry intercropping system in which species of shrubs or trees are planted at spacing's relatively close within row and wide between row, to leave room for herbaceous cropping between, that is, in the alleys (Glossary for agroforestry 1997). Alley cropping or hedgerow intercropping is an agroforestry practice in which perennial, preferably leguminous trees or shrubs are grown simultaneously with an arable crop. The trees, managed as hedgerows, are grown in wide rows and the crop is planted in the interspaces or 'alley' between the trees rows. During the cropping phase the trees are pruned and the pruning's used as green manure or mulch on the crop to improve the organic matter status of the soil and to provide nutrients, particularly nitrogen, to the crop. The hedgerows are allowed to grow freely to shade the inter-rows when there are no crops. Alley cropping retains the basic restorative attributes of the bush fallow through nutrient recycling, fertility regeneration and weeds suppression and combines these with arable cropping so that all processes occur concurrently on the same land, allowing the farmer to crop the land for an extended period Ross C.Gutteridge *and* H. Max Shelton (1998).

Alley cropping is a way to diversify crop production and increase economic and environmental resilience. This approach to agriculture takes advantage of the interactions between trees and shrubs, and the crops in the alleys. However, multi-cropping systems also create complexities when it comes to some management activities. Alley cropping can also be used to transition to other forms of perennial agriculture. Alley cropping provides producers with an exciting way to improve the whole-farm yield on their farms and is increasingly being adopted by farmers in temperate areas (Quinkenstein et al., 2009). In alley cropping Agroforestry practices leaves from trees provide green mulch that enhances soil fertility and benefits understory crops. In addition, crop fertilizers, often leached through the rooting zone, can be recycled by the roots of nearby trees and brought back to the surface when the trees shed their leaves, thus benefiting the crops with both nutrients and organic matter. In addition, nitrogen fixing cover crops can be used in the alleys to enhance soil fertility (Sarah et al., 2003).

Alley cropping is a new step because the trees are used primarily for soil improvement. Alley cropping is one of an important agroforestry practice in which high organic biomass produced from the pruning's of hedgerow species and build soil organic matter constituted with beneficial soil nutrients. In alley cropping, food or fodder crops are grown between hedgerows species. In this system, arable crops are grown in between the hedges of woody species, preferably legumes, that are regularly cut back to minimize the competition between tree and crop for light, water and nutrients (Tossah el al., 1998). By combining deep rooting trees with shallow rooting crops, alley cropping systems use resources more efficiently than mono-cropping systems (Nair et al., 1999).

Maize (Zea mays L) is one of the most important cereal crops in Ethiopia, ranking second in area coverage and first in total production. Although it is one of the strategic crops for the achievement of food security in the country, more than 90% of the production is handled by small-scale farmers under rain-fed growing conditions (CSA, 2008). About 40% of the total maize growing area is also located in low-moisture stress areas, where it contributes less than 20% to the total annual production (Mandefro et al., 2002). The low yield in these areas, like other sub-Saharan African countries, is mainly attributed to recurrent drought, low levels of fertilizer use, and low adoption of improved varieties (CIMMYT and IITA, 2010).

Currently the cost and the availability of chemical fertilizer is one of the major bottle neck problems which affect the productivity of farmers. In order to minimize this problem promotion of organic fertilizer is one of the best options. Alley cropping agroforestry practices is one of those methods which recommended throughout world. Based on this the objective is to study the effects of *Sesbania Sesban* Alley Cropping on Maize Yield and yield components and to evaluate the trend in maize grain yield over time.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Bale districts of Oromia regional state of Ethiopia. Specifically, the study was conducted in Dello Menna districts of Bale which is located in South-eastern part of Ethiopia. The study area is located in from mid to lowland agroecology areas of Bale. The area was located from 1285 to 2732 m.a.s.l. altitudinal range (Figure 1). The major farming system of the study area is crop production with cereal dominant crop farming system.

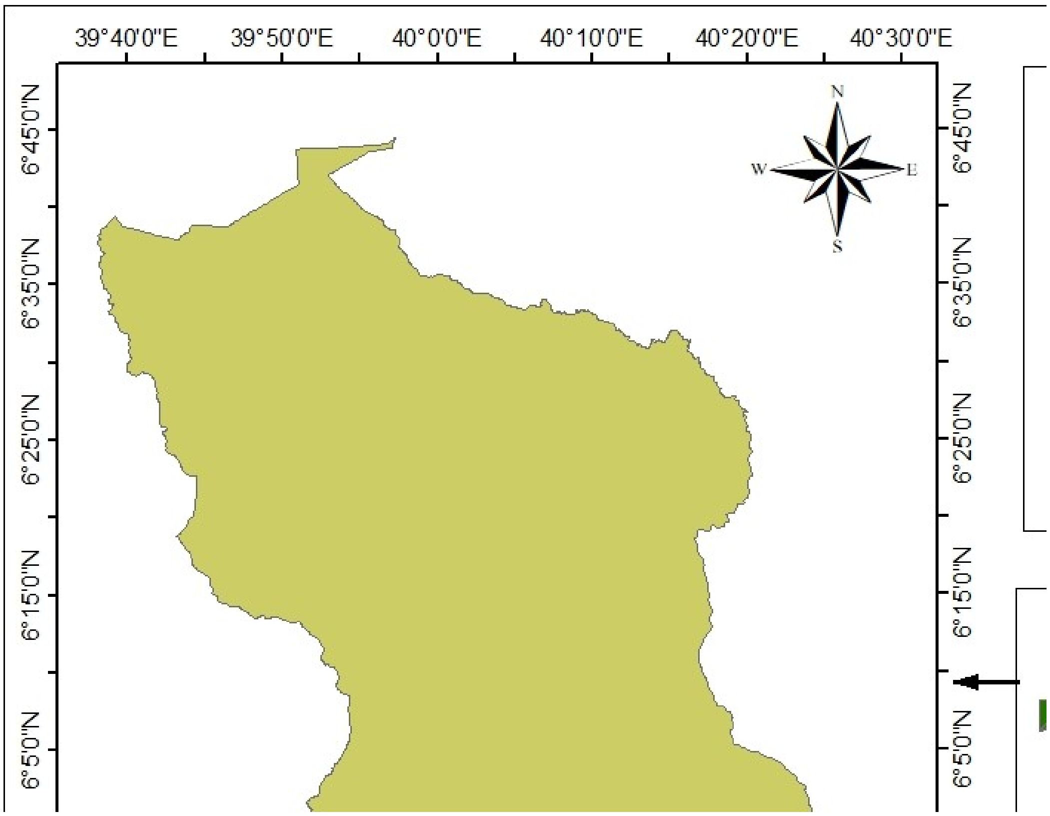


Figure 1. Map of Dello Menna districts of Bale

Experimental Design and Experimental Procedures

The study was conducted in RCBD design with combination of *Sesbania* ***sesban*** alley cropping with different nitrogen level fertilizer (Alley cropping+0%N, Alley cropping+25%N, Alley cropping+50%N, Alley cropping+75%N, Alleycropping+100%N, control (Mono cropping+0%N), Standard (mono cropping+100%N)) were evaluated in this study. The experiments were laid in randomized block design with three replications. The plot was $27m^2$ size and with spacing between plot and block were 1.50m and 2m respectively.

Each plot consists of 5 rows maize with spacing 25cm and two rows of alley with spacing 75cm. Treatments were assigned randomly to experimental plots within a block. The selected crop varieties are maize Melkasa-2 Varity and *Sesbania* ***sesban*** shrub varieties were used for the field experiment.

Collected Data

For the purpose of this study the following data were collected from the middle three rows of maize. The collected data are Plant height, Number of corn per plant, Corn diameter, Corn length, Number of row per corn, Number of kernel per row, Biomass, Thousand kernel weight and Grain Yield.

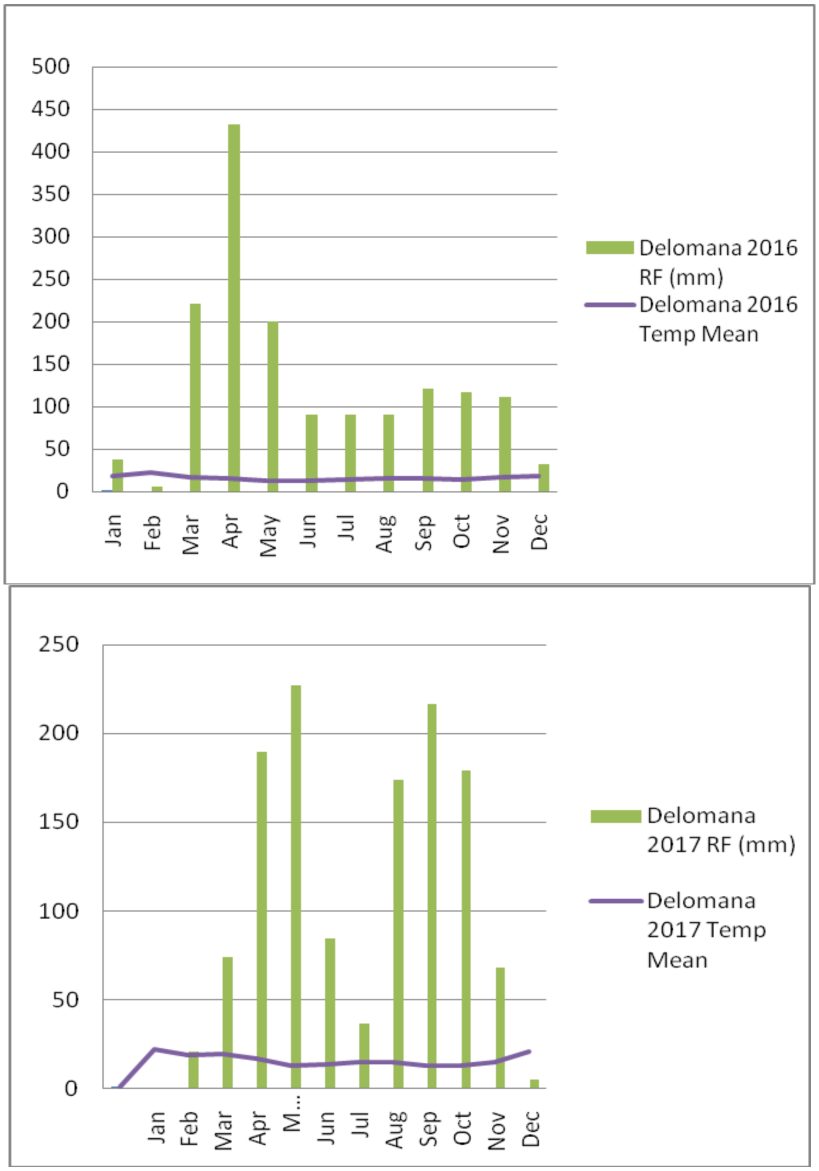
Climatic Condition

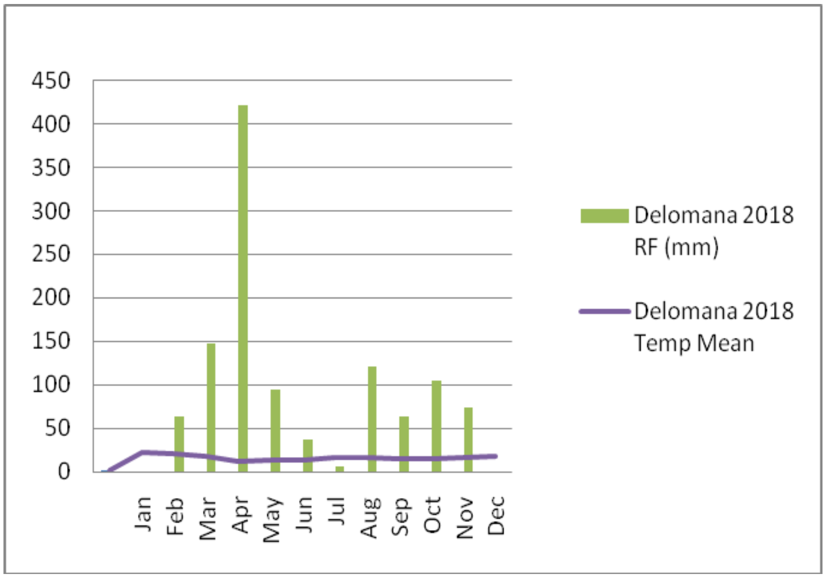
The rainfall pattern of the area is grouped as bimodal rainfall pattern with the annual average rainfall is 1282.77 (Figure 2). The overall mean temperature of Dello Menna district is 23.41°C (Bikila *et al.,* 2020).

Data Analysis

Statistical Analysis

All collected data were subjected to the analysis of variance (ANOVA) using R statistical soft ware. The significance between mean values (mean separation) was expressed by Least Significant difference tests (LSD) at 5% level of significance.





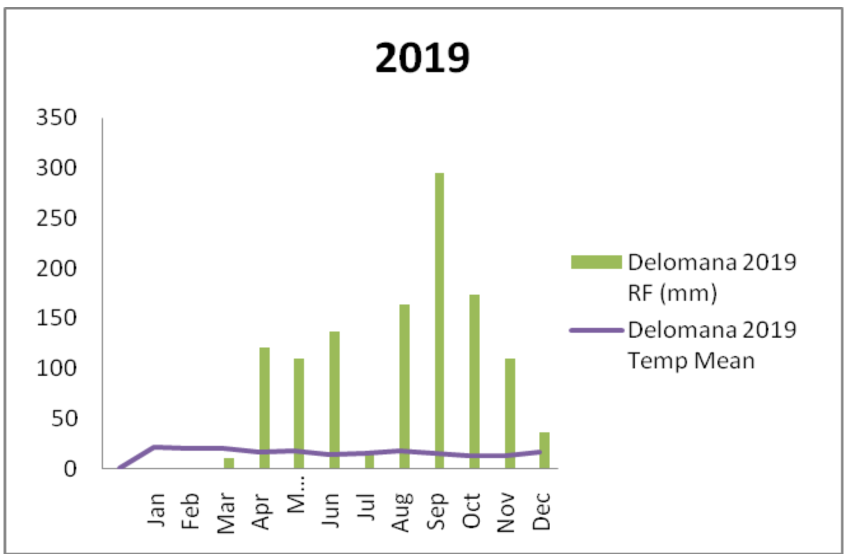


Figure 2. Mean annual temperature and rain fall distribution of Dello Menna districts of Bale.

RESULTS AND DISCUSSION

Trends of Grain Yield and Yield Components

In Dello Menna district, when we compare the overall mean of all treatment, statically different in all parameter of maize yield and yield components (Table 1). The overall PH values were statically different across all treatments. In this district, the highest PH value were observed in the treatment number 4 (1.70m) and the lowest were in the treatment number 6 (1.33m). For NCPP the highest Number of Corn per Plant were recorded in the treatment number 3 (1.15) and the lowest were recorded in the treatment number 1 and 6(1.00). For CD the highest diameter sizes were observed in the treatment number 4 (32.33mm) and the least size is the treatment number 6(27.38mm). In CL the highest corn length were recorded in treatment number 3(14.58cm) than the other treatment. The highest number of row per Corn (NRPC) were observed for the treatment number 4(13.48) and the least is for treatment number 6 (12.04). For NKPR the largest number of were recorded in the treatment number 3 (32.76) and the smallest is in the treatment number 6(23.6). In the Straw yield the largest size were recorded in the treatment number 5(63.44kg/ha) and the smallest is for treatment number 6(29.94kg/ha). Interims of TKW the largest thousand kernel weight of maize were recorded in the treatment number 4(246.37gm) and the smallest were in the treatment number 6 (195.97gm). For the average grain weight of per hectare observed in the treatment number 3(56.66 qt/ha) and the least is in the treatment number 6(31.97 qt/ha). As presented in Table 2, except for second year as the year increased the grain yields were also increased. As indicated in the result the application of 50% N fertilizer rates and *Sesbania* ***sesban*** alley cropping which generated high optimum grain yield 56.66 qt/ha with economically reasonable yield advantage. The decaling of yield recorded in second year (2018) were due to the shortage of rainfall in the area (Figure 2) (Table 1).

Table 1: Overall average of grain yield and yield components with treatments from 2016 to 2019

Tre	PH(m)	NCPP	CD(mm)	CL(cm)	NRPC	NKPR	SY(kg/ha)	TKW(gm)	GY(qt/ha)
1	1.44[bc]	1.00[b]	30.58[ab]	12.58[b]	12.71[ab]	28.47[b]	42.17[bc]	217.02[ab]	42.80[bc]
2	1.61[a]	1.07[ab]	30.26[bc]	13.62[ab]	12.76[ab]	31.09[ab]	46.72[ab]	219.56[ab]	50.65[ab]
3	1.60[ab]	1.15[a]	31.40[ab]	14.58[a]	13.29[a]	32.76[a]	55[ab]	231.27[a]	56.66[a]
4	1.70[a]	1.04[ab]	32.33[a]	13.9[ab]	13.48 [a]	31.44[ab]	60.06[a]	246.37[a]	50.82[ab]
5	1.68[a]	1.09[ab]	30.95[ab]	13.87[ab]	13.02[ab]	31.07[ab]	63.44[a]	220.96[ab]	53.05[ab]
6	1.33[c]	1.00[b]	27.38[d]	10.58[c]	12.04[b]	23.6[c]	29.94[c]	195.97[b]	31.97[c]
7	1.57[ab]	1.04[ab]	28.24[cd]	12.93[ab]	13.07 [ab]	29.67[ab]	39.06[bc]	199.54[b]	45.89[ab]
Mean	1.56	1.06	30.16	13.15	12.91	29.73	48.1	218.67	47.40
CV	11.30	12.01	7.16	14.67	9.33	13.80	16.88	15.02	28.53
LSD	0.17	0.13	18.90	2.22	1.22	4.62	34.0	82.54	20.35

T1=Alley cropping+0%**N**, **T2=**Alley cropping+25%**N, T3=**Alley cropping+50%**N, T4=**Alley cropping+75%**N, T5=**Alleycropping+100%**N**, **T6=**control **(**Mono cropping**+**0%N**)**, **T7=**Standard **(**mono cropping**+**100%**N)**
PH-Plant height, **NCPP**- Number of corn per plant, **CD-**Corn diameter, **CL**-Corn length, NRPC- Number of row per corn, **NKPR**-Number of kernel per row, **SY-** Straw Yield, **TKW-** Thousand kernel weight, **GY**- Grain Yield

For year based comparison of yield and yield components *Sesbania* ***sesban*** Maize alley cropping values within treatments, according to this study when we compare the overall mean of all treatment were statically different in all parameter across all years. Except for NCPP and SY, for the rest parameter (PH, CD, CL, NRPC, NKPR, TKW and GY) the highest values were recorded in the third year (Table 2).

For Dello Menna districts The application of 50% N fertilizer rates and *Sesbania* ***sesban*** alley cropping which generated high optimum grain yield 56.66 qt/ha with economically reasonable.

Table 2: Comparison of Grain Yield (GY) values within treatments from 2016 to 2019

Year	PH	NCPP	CD(mm)	CL(cm)	NRPC	NKPR	SY(Kg/ha)	TKW(gm)	GY(qt/ha)
1	1.45[b]	1.17 [a]	4.21[c]	13.77[a]	13.22[a]	30.93[a]	7.6[c]	223.71[b]	44.31[b]
2	1.33[b]	1.00[b]	41.72 [b]	11.46[b]	12.11[b]	26.03 [b]	78[a]	123.88[c]	31.06[c]
3	1.90 [a]	1.00 [b]	44.56[a]	14.22 [a]	13.40[a]	32.22 [a]	58.6[b]	308.42[a]	66.84[a]
Mean	1.56	1.06	30.16	13.15	12.91	29.73	48.39	218.67	474.08
CV	11.31	12.02	7.17	14.68	9.33	13.80	28.11	15.02	28.53
LSD	0.17	0.12	2.06	1.84	1.15	3.91	1.42	31.28	128.87

PH-Plant height, **NCPP**- Number of corn per plant, **CD-**Corn diameter, **CL**-Corn length, NRPC- Number of row per corn, **NKPR**-Number of kernel per row, **SY-** Straw Yield, **TKW-** Thousand kernel weight, **GY**- Grain Yield

Economic Analysis

To identify treatments with the optimum return to the farmer‘s investment, marginal analysis was performed on non-dominated treatments. For a treatment to be considered as worthwhile to farmers, 100% marginal rate of return (MRR %) was the minimum acceptable rate of return (CIMMYT, 1988). As indicated in Table 3, the partial budget and dominance analysis revealed that the highest net benefit 150252.2 ETB ha^{-1} was obtained, while the lowest net benefit 86319 ETB $ha^{-1}$was obtained from control treatment. Moreover, the highest marginal rate of return of 2342.04 % was also obtained from Maize with *Sesbania sesban alley* cropping +50%N and 100% P. According to this result, an additional income of 23.42 Ethiopian Birr per unit Birr invested was obtained from Maize with *Sesbania sesban alley* cropping +50%N and 100% P compared to the other treatments.

Table 3. Partial budget and marginal rate of return analysis for alley cropping Maize Agroforestry practices

Treatment	Variable Input (Kg ha^{-1})		Unit price (ETB)		TVC	Output (Kg ha^{-1})	Unit price (ETB)	Gross Income (ETB ha^{-1})	Net Income (ETB ha^{-1})	MRR(%)
	DAP/NPS	Urea	DAP/NPS	Urea						
Control (Mono cropping+0%N)	0	0	0	0	0	3197	27	86319	86319	_
Alley cropping+0%N and 100% P	100	0	1604.35	0	0	4280	27	115560	115560	_
Alley cropping+25%N and 100% P	100	37.5	1604.35	562.7288	2167.079	5065	27	136755	134587.9	2227.373
Alley cropping+50%N and 100% P	100	75	1604.35	1125.458	2729.808	5666	27	152982	150252.2	2342.04
Alley cropping+75%N and 100% P	100	112.5	1604.35	1688.186	3292.536	5082	27	137214	133921.5	D
Alleycropping+100%N and 100% P	100	150	1604.35	2250.915	3855.265	5305	27	143235	139379.7	1376.319
Standard (Monocropping+100%N and 100% P)	100	150	1604.35	844.0931	2448.443	4589	27	123903	121454.6	D

CONCLUSION AND RECOMMENDATION

Crop production is heavily dependent on available nutrient in the soil and other environmental conditions for plant growth. The integration of different types of multipurpose tree and shrub species with crop is very important to improve the soil fertility and crop productivity of the farm land. Alley cropping is an agroforestry practice in which perennial, preferably leguminous trees or shrubs are grown simultaneously with an arable crop. Alley-cropping Agroforestry systems are largely known a new phenomenon, but offer considerable potential to innovative farmers and landowners. Properly managed, alley cropping can provide income at different time intervals for different markets. According to this study also maize alley cropping with *Sesbania sesban* alley cropping was studied in Bale. When we see the overview to this study these kinds of study is used to improve the production and productivity through reducing the farmers cost in sustainable manner.

Alley designs can also make better use of the space available between trees and add protection and diversity to agricultural fields. Ultimately, landowners and managers can design production systems most suited to the labor and maintenance inputs they are willing to support. The bottom line is that alley cropping offers unique opportunities for generating income in a sustainable, conservation oriented manner. With appropriate Sesbania management, smallholder farmers could replenish nutrient-depleted soils with much needed N for the associated maize crop. Sesbania could reduce the dependence on mineral N fertilizer, which is beyond the reach of many smallholder farmers.

For Dello Menna districts The application of 50% N fertilizer rates and Sesbania ***sesban*** alley cropping which generated high optimum grain yield 56.66qt/ha with economically reasonable. Therefore, the combination application of 50% N fertilizer rates and maize *Sesbania* ***sesban*** alley cropping variety gave optimum grain yield and the best net benefit in the Dello Menna area and hence can be recommended for wider use at Dello Menna area. Generally maize *Sesbania* ***sesban*** alley cropping is used to improve the soil fertility, used to improve the yield sustainability, used to improve farmers' income and used to minimize fertilizer cost. Based on this experiment, the economic analysis showed that Maize with *Sesbania sesban* alley cropping +50%N and 100% P rate tested at Dello Menna location gave the highest maize yield (5666 Kg ha^{-1}) with the net benefit (150252.2 ETB ha^{-}) and he highest marginal rate of return

(2342.04%) which economically feasible alternative to the other treatments. When we see the overall result of year based comparison of this experiment, as the year increased the overall effect on maize yield and yield component were increased. These effects confirm that the residual effect of such type of conservation agriculture alley practices effect on sustainable production and productivity improvement.

Properly managed, alley cropping can provide income at different time intervals for different markets. According to this study also maize alley cropping with *Sesbania sesban* alley cropping was studied. When we see the overview to this study these kinds of study is used to improve the production and productivity through reducing the farmers cost in sustainable manner. With appropriate Sesbania management, smallholder farmers could replenish nutrient-depleted soils with much needed N for the associated maize crop. Sesbania could reduce the dependence on mineral N fertilizer, which is beyond the reach of many smallholder farmers.

Generally *Sesbania sesban* alley cropping is used to improve the soil fertility, used to improve the yield sustainability, used to improve farmers' income and used to minimize fertilizer cost. Therefore, the combination of application of 50% N fertilizer rates and maize *Sesbania sesban* alley cropping were give optimum grain yield and provide economically feasible benefit, and recommended for the study location and similar agro-ecologies in the midlands of Ethiopia.

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