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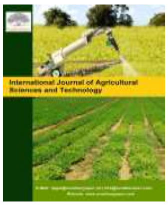

Research Paper **Open Access**

Effect of *Sesbania Sesban* Alley Cropping on Sorghum Yield and Soil Physicochemical Properties at Fedis District, East Hararghe Zone, Oromia, Ethiopia

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Abstract

Sorghum production is low due to low soil fertility. The study was to evaluate the effects of *S. sesban* alley croppig on sorghum yield and soil physicochemical properties. Four treatments (*S. sesban* alley cropping, S.*sesban* alley cropping+50% of RF, S.*sesban* AC+75% of RF and sole sorghum with 100% RF) were laid out in RCBD with three replications. The results show that the treatments differ significantly (p<0.05) in soil nutrients and sorghum grain yield. Plots treated with S. sesban AC only gave the highest Av P(8.04 mg/kg) and Av K(344.5 cmol/ kg), whereas the highest OC %(1.73%), TN(0.15%) and CEC(40.94 cmol / kg) were recorded in the S. sesban AC+50% of RF over the control. Yield and above ground biomass of sorghum were the highest recorded comparable yield (3.44 t/ha) and biomass (8.24 t/ha) in the plots of sole sorghum with 100% RF(control) than treated plots S. sesban alley cropping. Overall average yield and above ground biomass of sorghum were the highest recorded under sorghum with 100% RF (2.71t /ha) yield and above ground biomass (7.47t / ha). Significant benefits are derived from alley cropping in terms of other ecosystem services, including the provision of fuel wood and fodder, reduction of erosion and carbon sequestration. It is, therefore, concluded that sorghum with 100% recommended fertilizer to improve sorghum productivity. S. sesban alley cropping+50% of recommended fertilizer can be used to improve soil fertility in the study area and further research should be conducted across different locations for at least four seasons to substantiate this conclusion.

Keywords: *Alley cropping, Biomass transfer, Grain yield, Soil fertility*

1. Introduction

In many parts of the tropics, particularly in tropical Africa, nitrogen is the most limiting nutrient for crop productivity. High costs of inorganic fertilizers limit their use in sufficient quantities by most smallholder farmers. This has sparked renewed interest in the development of integrated soil fertility management systems that integrate woody species into crop production systems where leafy biomass delivers nitrogen to the annual crop (Hombegowda *et al.*, 2022). Farming systems in most African countries are under serious threat due to environmental degradation. Agroforestry is one of such farming systems that combine production with conservation of natural resources. It is about integrating multipurpose

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trees, like *Sesbania sesban,* in existing land use patterns to improve soil fertility. Alley cropping is a production system that combines the elements of agriculture with that of forestry and potential benefits for Africa's small-scale farmers. The trees in the alley cropping system act as pumps, moving nutrients up from the lower soil horizons, while at the same time adding organic materials to the soil through litter fall (Ferdush *et al*., 2019). In addition, the woody perennials used in this system are usually nitrogen-fixing species thus providing another important boost to soil fertility. Moreover, our farmers are not in a position to use artificial inputs or can use them only in small quantities (Bishaw, 2001).

Sesbania sesban is a small tree species that biologically fixes free atmospheric nitrogen and hence provides nitrogenous fertilizer for companion food crops such as sorghum. It is a promising agroforestry species because of its biological fixation of atmospheric nitrogen, rapid growth, and deep root system (Patrick, 2010). *Sesbania* trees can improve soil fertility through nitrogen accumulation and help prevent soil erosion. *Sesbania* can also be an important source of fuel wood, a commodity that is often in short supply, especially in areas with high population density. The perennial Sesbania species have considerable potential for use in agroforestry as they show rapid early growth, grow under various ecological conditions, and do not require difficult management procedures (Wubishet *et al.,* 2021). Leguminous trees' leaf biomass is capable of releasing considerable amounts of N that can sustain crop growth and yield (Makumba *et al.,* 2007). The use of N-rich tree pruning as a substitute to inorganic fertilizers has proven to be a viable alternative source of soil fertility replenishment in low-input smallholder subsistence farming systems where N-deficient soils are the major limitation to crop production (Makumba *et al.,* 2007). Esilaba *et al*. (2001), in Ethiopia, found that the combined application of manure and N at 40 kg N ha^{-1} and 30 t/ha for sorghum and 80 kg N /ha and 30 t/ha manure for maize increased crop yields during the second season. However, resource-poor subsistence farmers in Ethiopia cannot afford to apply this much chemical fertilizer and farmyard manure. On the other hand, as indicated by Sharma and Behera (2010) fast-growing leguminous trees and shrubs such as *Sesbania* are grown in non-agricultural lands or alley cropping systems for multiple uses including nutrient cycling from the pruned biomass i.e. biomass transfer.

Different trees react differently to different environments and different silvicultural practices (Rocheleau *et al.,* 2001). A variety that performs well in a mono-cropping system may, or may not, do the same in multiple cropping or low-external-input systems such as agroforestry, and vice versa. Proven information regarding the integration of tree species and inorganic fertilizer with sorghum varieties is so far unavailable in study area. The development of improved agricultural technologies that allow for increased food production is, therefore, necessary. Selecting the integration of tree species with an appropriate rate of inorganic fertilizer that may be high yield sorghum, associated soil, and sorghum yield for successful establishment and management of alley cropping multipurpose tree species. Therefore, alley cropping agroforestry practice is optional to reduce soil erosion, improve soil fertility, improve crop production, and improve trees/shrub products simultaneously on agricultural land. Thus, this study was designed to evaluate the contribution of alley cropping to improving sorghum yield and for soil fertility improvement in the study area.

2. Objectives

- To evaluate the effect of alley cropping of *Sesbania sesban on* sorghum yield and yield components
- To evaluate the effect of alley cropping of *Sesbania sesban* on selected soil physicochemical properties in the study area.

3. Materials and Methods

3.1. Description of the Study Site

The study was conducted at Fedis district of the East Hararghe Zone of Oromia Regional State, from 2019 to 2023 cropping season. Fedis district is located in the eastern part of the country at about 554 km East of Addis Ababa and 24 km from Harar town in the southern direction. The geographical location of the district is 8^0 22' 0" and 9^0 14' 0" N latitude and 42^0 62' 0" and 42^0 19' 0" E longitude as indicated in Figure 1. The agro ecological district of the study area is characterized by sub-humid condition with annual rainfall ranging from 650 to 850 mm, the average annual rainfall being 750 mm, i.e. from May to September (sometimes extending to October). The mean annual maximum temperature is 31°C and monthly values range between 10.0°C and 31.0°C. The mean annual minimum temperature is 10.0°C. The meteorological data for the 22022/23 cropping season of the study area is given in Figure 2. The soils of the study area are broadly categorized as fertisols (Sandy clay soils). The pH of the soil in the study area ranges from 7.60 to 8.20. The major crops grown in the area include maize, sorghum, and haricot beans are grown. Haricot bean is growing as an intercrop with maize and sorghum crops in the study area. A cash crop such as *Chat* (*Cata edulis*) is also grown predominantly in the study area. In addition to these different fruits, vegetables, cereal crops, and tuber crops are the most common agricultural products in the study area.

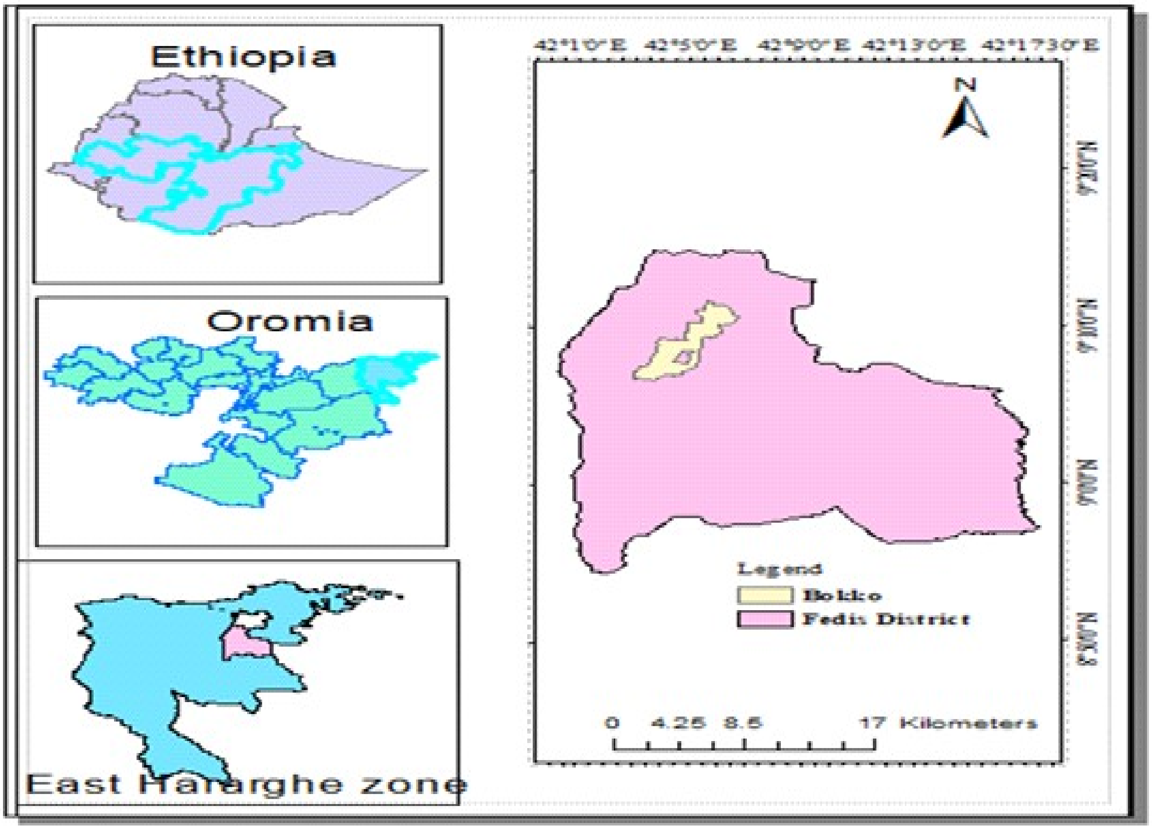

Figure 1: Location Map of the Study Area

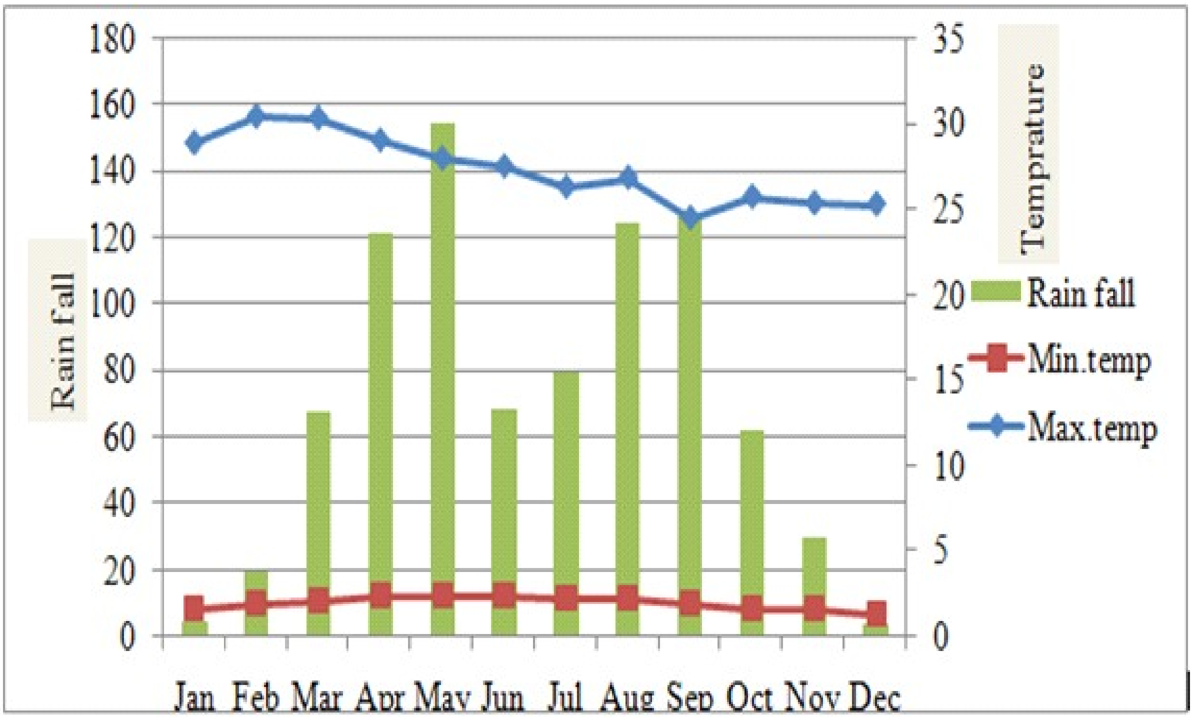

Figure 2: Rain Fall and Temperature Data of Fedis District, 2019 to 2023 GC

Climate of the Study Area: Climatic information for the study site is shown in Figure 1 below, which serves to highlight the distribution of rainfall and temperature over the study period

Species selected for this study had the following attributes: *S.sesban* is well suited to both well-drained and wetlands. However, it does not perform well on sandy soils (Akinnifesi *et al*., 2008). The fertilizer trees have specific niches they perform best. The survival of *S.sesban* is well suited to both well-drained and wetlands. Rapid growth, capable of re sprouting after coppicing, ease of establishment by seed, suitable for firewood, N-fixing systems which produce high N leaves, and rapid decomposition rates releasing available nutrients to the intercropped crops

3.2. Experimental Design and Procedures

The field experiment was conducted during the 2019 to 2022 years. Four treatments were laid out in a randomized complete block design (RCBD) with three replications. The treatments included: *S. sesban* alley cropping only, *S.sesban* alley cropping + 50% recommended dose of fertilizer, *S.sesban* alley cropping +75 % recommended fertilizer(N), and Standard treatment of 100% recommended dose of fertilizer (i.e. 100 kg urea /ha + 100 kg NPS/ha) used as a control.

Treatment Description:

Treatment 1= Sole sorghum with recommended fertilizer (100 kg/ha NPS+100 kg/ha of urea,

Treatment 2= Sorghum with *S.sesban* alley cropping without chemical fertilizer,

Treatment 3= Sorghum with *S.sesban* alley cropping + (100 kg/ha NPS+ 75% of urea,

Treatment 4= Sorghum with *S.sesban* alley cropping + (100 kg/ha NPS+50 % urea,

A uniform P application was done in all the plots at the recommended rate (100 kg/ha NPS). Other agronomic procedures for sorghum production were appropriately followed after planting. Plot area 12 m*7.5m=90 m^2 which means the width of a plot = 7.5 m and the length of a plot 12 m, Spacing between blocks = 2 m**,** Spacing between plots = 1.5 m, spacing between *S.sesban* trees 1 m (Intra row spacing of trees). Seedlings of *S.sesban* trees were raised at a nursery and then transplanted to a field plot. The field between sorghum rows was maintained during the main rainy season. A suitable sorghum variety (Melkam) was selected and used for the trials as a test crop and is widely grown in the district due to its high grain-yielding potential relative to other varieties.

Sorghum was planted 75 cm between rows and 20 cm between plants. Fresh leaves of *S.sesban* were pruned and transferred to all experimental plots except alley cropping only. The applied fresh *S.sesban* leaf biomass had transferred to the experimental plots was 4200 kg/ha (4.2 t/ha). The biomass yield of *S. sesban* species was reported up to 20 t/ha under more favorable agro-ecologies, while the world-reported average forage biomass yields range from four to twelve tons per hectare per year. The leaf biomass was applied in three months after planting the sorghum and it was incorporated into the soil using hand hoe. Good incorporation ensures that the leafy biomass and the soil are well mixed to facilitate smooth decomposition. Incorporation of leafy biomass of *S.sesban* four tons per hectare dry weight biomass, which translates to 15-20 kg per plot, is the suggested standard for 1m x 5m beds in any type of soil. The residual effects of the biomass, after harvesting vegetables, allows a farmer to plant maize or any suitable second crop on the same piece of land without requiring incorporation of more biomass.

4. Methods of Data Collection

Growth parameters of sorghum such as plant height, panicle length, panicle diameter, sorghum grain yield, and sorghum above-ground biomass were collected. Top soil samples at a depth of 0-20 cm) were collected before planting and after harvesting. During each cropping season to assess the impact of treatments on soil physical and chemical properties particularly organic carbon, total nitrogen, available P, Exchangeable K, CEC, and pH before and each implementation year to check the change in soil properties.

4.1. Soil Sampling and Laboratory Analyses

The study was conducted for four consecutive years using *Sesbanea sesban* as alley cropping practices which mainly bring a positive impact on sorghum yield production and soil properties. Composite soil samples were taken in each experimental field from 0-20cm depths to determine the baseline fertility status of the experimental fields at the beginning of the experiment. Then the collected soil samples were analyzed at the Batu Soil Research Center, soil laboratory. Soil organic carbon (OC) content was determined by using the Walkley-Black method (Walkley and Black, 1934). Available phosphorous (AP) was determined by the Bary II method. Total N was analyzed using the Kjeldahl method. Exchangeable

K in the extract was analyzed using an atomic absorption spectrophotometer. The pH of the soil was measured potentially metrically with a digital pH meter in the supernatant suspension of 1:2.5 soils: water ratio.

4.2. Method of Data Analysis

Data were analyzed using Statistical Analysis System (SAS) version 9.3 and subjected to ANOVA to determine significant differences among treatments. Means were separated using the Least Significant Difference (LSD) test at a 95% confidence interval. The grain yield of sorghum was harvested and weighed and the yield was estimated.

5. Results and Discussion

5.1. Effect of Sesbania sesban Alley Cropping on Selected Physicochemical Properties of Soil

The results of the soil properties of the study site are presented in Table 1. According to the results for the soil pH in the pH of (H_2O) suspension was 7.60. This showed that the study site was belongs to slightly alkaline range (range (Landon, 1991). In soils with a pH above 7.5, CEC may be excess. The high CEC in soil could be due to high levels of organic matter with the soil textural class of the study site was clay loam. The main reason for the change observed in pH values might be due to the sole application of alley cropping using Sesbanea species that directly modified the level of pH availability of the site. For the initial (composite) soil analysis the availability of organic carbon concentrations of the study site was found within the 1.46 % range which was considered in low rating ranges (Low OC ratings between 0.5-1.5 and low) (Tekalign, 1991; FAO, 1990). Whereas, across the treatment after the implementation of the experiment the availability of OC slightly increased, this might be due to the practice of alley cropping and application of different fertilizer rates.

Table 1: Soil Properties Before and After Experiment Site in the Study Area

	pH (H_2O)	O C (%)	TN (%)	AP (mg/kg)	AK (cmol(+)/kg)	CEC (me100/g
Initial soil (before)	7.60	1.46	0.12	1.84	298.0	17.43
Treatments						
100% RF (control)	8.19	1.56[ab]	0.13	3.10[d]	311.50[ab]	34.27
S. sesban AC only	8.15	1.46[b]	0.13	8.04[a]	344.50[a]	34.27
S. sesban AC+ 75% N and 100% P	8.19	1.43[b]	0.12	7.21[b]	311.50[b]	36.72
S. sesban AC + 50 % N +100% P	8.20	1.73[a]	0.15	5.85[c]	324.0[ab]	40.94
CV (%)	0.32	11.43	11.80	28.83	6.81	15.36
LSD (0.05)	NS	0.14	NS	2.91	17.73	NS

Note: Values along the column followed by the same letter(s) are not significantly different ($p < 0.05$); pH = pH (H_2O), OC = Organic Carbon (%), chem. Chemical fertilizer, TN = Total Nitrogen (%), P = Available Phosphorus (mg/kg) soil, K = Exchangeable Potassium ((cmol(+)/kg soil, CEC (meq/100g) soil. AC-alley cropping, 75% of recommended fertilizer, 50% of recommended fertilizer. CV = coefficient of variation, LSD = last significant differences, and NS = not significant.

The initial total N (%) and available P (mg/Kg) soils were 0.12% and 1.84 mg/kg, within the low range, respectively as indicated in Table 1. According to the rating range for the composite soil results of the study site the concentrations of total N were classified within the range of low rating (0.05-0.12) (London, 1991; FAO, 1990). A similar trend was obtained for extractable available phosphorus concentration, which falls under the very low rating range with a value of 1.84 in the study site (1-5) (London, 1991; FAO, 1990). Low available soil P content of the study site was a good indicator of the soil P supply for sorghum production according to Hazelton and Murphy (2007). Whereas, during the implementation period the values of total N and available P showed variation this variation would be due to the combined effect of the applied treatments. The results of exchangeable potassium also showed some variations among the treatments throughout the implementation period.

Plots treated with *Sesbanea* alley cropping+50% of recommended fertilizer gave significantly higher soil organic carbon OC (%), TN (%), exchangeable K (cmol kg^{-1}) and cation exchange capacity (CEC). Whereas significantly higher available P and were recorded in the *S. sesban* alley cropping only, over the control plots. Soil organic carbon (%), total N (%), CEC (cmol kg^{-1}), P (mg/kg) soil, and exchangeable K (cmol kg^{-1}) showed increments in the plots treated with *S. sesban* alley cropping+50% of recommended fertilizer as compared to the control (Table 1). OC (10.89 %), total N (15.38%), available P (88.7%), exchangeable K (4.01%) and CEC (19.46%) showed increments as compared to the control plots. The initial soil analysis of CEC of the study site was 17.43(me100/g) range which was in the moderate range (London, 1991). Whereas, across the treatment after the experiment, the CEC slightly increased, this might be due to the organic carbon increased and high levels of organic matter with the soil textural class of the study site was clay loam.

5.2. Correlation of Soil Properties

The correlation effect of different soil properties against each other's soil nutrients was displayed across the implementation periods. As presented in the Table 2, at the early stage of the experiment the soil parameters showed a positive correlation. Soil organic carbon is positively correlated with pH, total N is positively correlated with pH and soil organic carbon, Available P is positively correlated with pH, TN, and available K, and CEC is positively correlated with pH, TN, and available P nutrients. The contributions of using alley cropping with integrated inorganic fertilizers might show a positive interaction for some soil chemical properties. In addition, organic carbon is positively correlated with available N and K nutrients (Maiti and Ghose, 2007).

Table 2: Correlation Analysis Between the Measured Soil Parameters

	Ph	O C	TN	AP	AK	CEC
pH	1					
O C	0.106	1				
TN	0.095	0.989	1			
AP	-0.611	-0.308	-0.241	1		
AK	0.146	-0.040	0.026	0.040	1	
CEC	0.264	0.190	0.198	0.087	-0.016	1

Note: pH= pH (H_2O), OC= Organic Carbon (%) TN= Total Nitrogen (%), AP= Available Phosphorus, AK= Exchangeable Potassium, CEC soil.

5.3. Effect of Sesbania sesban Alley Cropping on Grain Yield and Yield Components of Sorghum

The sorghum grain yields during the four cropping seasons are displayed in comparing with different treatments (Table 3). The grain yield of sorghum was significantly ($p < 0.05$) different with treatment difference. Applications of sorghum with 100% recommended fertilizer gave significantly higher ($p < 0.05$) grain yield than other treatments. Combined analysis showed that sorghum grain yields a significant difference among treatments of sorghum alley cropping in grain

Table 3: Comparison of Grain Yield (t/ha) Values within Treatments from 2019 to 2022

Treatments	2019	2020	2021	2022
100% recommended fertilizer(control)	2.76^{a}	2.59^{a}	3.44^{a}	2.51^{a}
S. sesban AC only	1.52^{b}	1.69^{b}	2.05^{ab}	1.64^{b}
S. sesban AC+ 75% N and 100% P	1.71^{b}	1.74^{b}	2.35^{ab}	2.09^{ab}
S. sesban AC + 50 % N +100% P	1.56^{b}	1.55^{b}	1.76^{b}	1.69^{b}
CV (%)	22.97	14.54	31.09	21.98
LSD (0.05)	2.40	0.17	0.61	0.87

Note: Values along column followed by the same letter(s) are not significantly different (P < 0.05). AC–alley cropping, means in columns with the same letters are not significantly difference, recommended fertilizer, CV= coefficient of variation, LSD = last significant differences, and NS= not significant yield at ($p < 0.05$). The highest grain yield was observed for sorghum sown with a recommended fertilizer (2.71 t/ha) while the lowest grain yield of sorghum was observed for sorghum grown in plots only alley of *Sesbania sesban* (1.64 t/ha) (Table 3).

The highest total grain yield was obtained from sorghum sown with recommended fertilizer (2.71 ton/ha) in 2021 cropping season while the lowest grain yield was obtained from sorghum sown in plots alley of *Sesbania sesban* (1.64 t/ha) in 2022. The results showed a slight variation across the year, the change might be due to the implementation of *Sesbanea sesban* as alley cropping. Thus, the sorghum grain yield sown with recommended fertilizer was decreased in 2022 as compared with the grain yield of other cropping seasons. The yield increment depended on the soil micronutrients that crops gain from the soil due to alley shrubs biomass transfer to the soil and/or application of recommended fertilizer. This finding related with the finding showed maize yield increased with the increase in N level applied to plots irrespective of added fresh pruned materials (Rahman *et al*., 2009).

Regarding the above-ground biomass also differed significantly ($p<0.05$) with treatment difference. Applications of sorghum with 100% recommended fertilizer gave significantly higher ($p<0.05$) biomass than other treatments. Applications of sorghum with 100% recommended fertilizer gave maximum biomass of 8.28 t/ha in 2021 cropping seasons and *Sesbanea sesban* alley cropping+7 5% of recommended fertilizer 6.75 t/ha. According to the result from the Table 4, yield reduction from the initial indicated which might be due to the erratic rainfall distribution of the site across the years. The trend in the order of 100% + sole sorghum (Sorghum only), *Sesbanea sesban* alley cropping +75% of recommended fertilizer, *Sesbanea sesban* alley cropping +50% of recommended fertilizer, *Sesbanea sesban* alley cropping only, 100%

Table 4: Comparison of Biomass (t/ha) Values Within Treatments From 2019 to 2022

Treatments	2019	2020	2021	2022
100% recommended fertilizer(control)	6.602	6.38	8.28[a]	7.47[a]
Sesbanea sesban AC only	5.011	5.07	4.84[b]	4.83[b]
Sesbanea AC+ 75% N and 100% P	5.137	5.48	6.75[ab]	5.96[ab]
Sesbanea AC + 50 % N +100% P	5.073	5.28	5.06[ab]	5.37[b]
CV (%)	23.39	14.25	27.64	15.79
LSD(0.05)	NS	NS	0.61	2.64

Note: Values along the column followed by the same letter(s) are not significantly different ($p < 0.05$). AC - alley cropping, means in columns with the same letters are not significantly difference, CV = coefficient of variation, LSD = last significant differences, and NS = not significant.

Moreover, agroforestry systems complement conservation agriculture systems in the provision of soil cover, animal feed, nutrients, household fuel, and hillside protection against soil erosion and wind erosion control through shelter belts (Chandrakar *et al,* 2014).

5.4. Mean of Yield and Yield Components

The result revealed that there were no significant variations among treatments at ($p < 0.05$) in sorghum yield component parameters but significant variations in sorghum yield and biomass. There is a significant increase in sorghum yield due to alley cropping practices, but there were no significant variations among sorghum yield component parameters. The average mean of Plant height, panicle length, and panicle diameter were no significant variations across the year.

The benefits of alley cropping include a significant increase in crop yield, improvement in soil health, and savings on mineral fertilizer costs and labor. Significant benefits are also derived from alley cropping in terms of other ecosystem services, including the provision of fuel wood and fodder, reduction of erosion, and carbon sequestration. The state of knowledge on the various ecosystem services of agroforestry has been reviewed by Gudeta *et al.* (2014). One of the direct benefits of alley cropping is the sorghum yield response. Sorghum yields were achieved using alley cropping across a range of sites in Malawi, Zambia, Zimbabwe, and Tanzania. On average, *Gliricidia* gave 55–350% yield increase over the control, while *sesbania* gave 160-583% increase. In a long-term trial in Kenya, *Gliricidia* intercropping with maize increased maize yield in the range of 100 to 500%, averaging 315% over a ten-year period (Akinnifesi *et al.,* 2008). Increase in yield is more apparent from the third year after tree establishment and onwards (Akinnifesi *et al.,* 2008). Unfertilized maize under *Gliricidia* maintained yield at 3 to 4 t/ha. When the intercrop plots were amended with 46 kg N/

Table 5: Average Mean of Sorghum Yield and Yield Component Parameters Measured in Alley Cropping

Treatments	PH(m)	Pl(cm)	Pd(cm)	Grainyield(t/ha)	Biomass Yield (t/ha)
100% recommended fertilizer(control)	1.63	24.35	7.64	2.71[a]	7.466[a]
Sesbanea sesban AC only	1.48	25.67	8.44	1.64[b]	4.831[b]
Sesbanea AC+ 75% N and 100% P	1.53	26.66	8.43	2.09[ab]	5.96[ab]
Sesbanea AC + 50 % N +100% P	1.38	25.93	8.08	1.79[b]	5.372[b]
CV (%)	7.57	8.13	15.99	21.98	15.79
LSD (0.05)	NS	NS	NS	1.07	2.64

Note: PH: plant height, Pl: panicle length, Pd: panicle diameter, AC – alley cropping, means in columns with the same letters are not significantly difference, CV= coefficient of variation, LSD = list significant differences and NS = not significant.

ha and 40 kg P_2O_5 /ha (representing 50% N and 100% P, respectively), there was a 79% increase in grain yield over the recommended practice, indicating complementarity between the applied fertilizer and organic inputs from *Gliricidia* (Akinnifesi *et al*., 2008).

6. Conclusion

The results obtained in this study showed that there was a significant increase in soil fertility status and sorghum yield due to alley cropping practices. The findings revealed that application of *Sesbanea sesban* alley cropping +50% of recommended fertilizer resulted in significantly ($p < 0.05$) higher % OC, total N content, exchangeable K, and CEC than control plots. Available P was highest in the *Sesbanea sesban* alley cropping +50% of recommended fertilizer-treated plots, followed by the *Sesbanea sesban* alley cropping only treated plots as compared to control plots. The improvement in these soil fertility parameters resulted in not significant ($p < 0.05$) resulted in grain yield and above-ground biomass of sorghum but due to application of inorganic fertilizer in the control plots. But plant height, panicle length, and panicle diameter were no significant differences. Generally, the application of *Sesbanea sesban* alley cropping +50% of recommended fertilizer can improve soil fertility parameters. Therefore, it is recommended that the application of S*esbanea sesban* alley cropping +50% of recommended fertilizer should be considered as one option to improve soil fertility and increase sorghum productivity through time in Fedis District due to long-term effect of applying *Sesbanea sesban* biomass in terms of soil fertility improvement and crop productivity.

Recommendations

The legume tree species incorporated into the soil under the alley cropping system reduced the rate of soil nutrient depletion and increased the productive base of the soil through nutrients released during decomposition. Significant benefits are derived from alley cropping in terms of other ecosystem services, including the provision of fuel wood and fodder, reduction of erosion, and carbon sequestration. Alley cropping must be considered as part of the whole farm operation. Further research should be conducted across different locations for at least four seasons to substantiate this conclusion considering the cost-benefit analysis of the practice.

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Conflicts of Interest

The authors declare no conflict of interest on the manuscript.

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