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RESEARCH ARTICLE

EFFECT OF THE OPTIMIZED *GUIERA SENEGALENSIS* SYSTEM ON CROP PERFORMANCE (MILLET, PEANUT) IN THE NORTHERN PEANUT BASIN (SENEGAL)

Mariama Marcelle Dione[1], Ibrahima Diedhiou[1], Mbathio Sogue[1], Daouda Sarr[1], Nogaye Ndiaye[1], Amanda L. Davey[2], Katim Toure[1], Oulimata Diatta[4], Roger Bayala[3], Idrissa Wade[1] and Richard P. Dick[2]

1. Ecole Nationale Supérieure d'Agriculture, PBA 296, Thiès, Sénégal.
2. School of Environment and Natural Resources, The Ohio State University, Kottman Hall, Room 210, 2021 Coffey Rd, Columbus, OH 43210, USA.
3. Université Jean Lorougnon Guédé, BP 150, Daloa, Côte d'Ivoire.
4. Université Assane Seck de Ziguinchor, Diabir, BP 523, Zigunichor, Sénégal.

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Abstract

Subsistence farmers of the Sahel, exacerbated by climate change, are facing increasing challenges of drought, degraded soils, and encroaching desertification. Research has shown that an agroforestry system where crops are interplanted with indigenous shrubs can restore degraded soils and significantly increase crop productivity. However, there is limited information on the performance of this system when managed by farmers. Therefore, the objective was to compare farmer-managed Optimized Shrub-intercropping System (OSS) (increased density of 1200-1500 *Guiera senegalensis* shrubs ha^{-1} by planting seedlings and annual incorporation of coppiced biomass) with the Traditional Management System (TMS) (low density <100-350 shrubs ha^{-1} and annual burning of coppiced biomass). The study was done in the Meckhé zone of Senegal from 2019 to 2022 with a peanut (*Arachis hypogaea* L.) and millet (*Pennisetum glaucum* L.) rotation. The experiment had a randomized block design with fifteen replications and paired treatments of OSS and TMS where each farm was a block. Plant height, LAI, NDVI, yield components, and rainwater use efficiency were measured. Rainfall was a limiting factor in three out of the four years with 2020 being the only year of adequate and well-distributed seasonal rainfall. That year OSS significantly out-yielded TMS for grain by 32% (P<0.01). Further benefits of OSS were shown in the low rainfall years by improved growth properties other than crop yield. This included low rainfall in 2021, where OSS significantly improved peanut rainwater efficiency by >12% (P<0.05) and NDVI (during the gynophorization phase) (P<0.01), and in 2022 for millet where biomass increased by 17% (P<0.05) and grain-1000 wt. by 32% (P<0.01) over TMS. Based on previous long-term research, these crop production benefits would be expected to increase as production of shrub biomass will increase over time for the transplanted seedlings. The results are important because OSS utilizes a local resource that was successfully managed by subsistence farmers and does not require external input or new infrastructure. Furthermore, the outcomes justify scaling of OSS to the broader farming community of Senegal's Peanut Basin.

Corresponding Author:- Ibrahima Diedhiou
Address:- Ecole Nationale Supérieure d'Agriculture, PBA 296, Thiès, Sénégal.

Introduction:

In Senegal, over 15% of the population faces poverty and food insecurity due to the drop in crop yields and increasing population (ANSD, 2014; Masson-Delmotte et al., 2020; Mbow et al., 2021). This situation is due, among other things, to an agriculture dependent on erratic rainfall and on-going degradation of soils (Sacande, 2018; Sow et al., 2020). Indeed, the severe drought of 1968 to 1985 was exceptional in duration and intensity. This resulted in a 300 mm drop in rainfall and a 200 km southward shift in isohyets, which resulted in loss of vegetation cover and exposure of landscapes to wind and water erosion (Roquet, 2008; Diallo et al., 2022). Furthermore, growing populations have increased cropping intensity and loss of fallowing is degrading soils (Badiane et al., 2000). This phenomenon particularly affects the Peanut Basin, the main millet and peanut production area, where 47% of the land is experiencing some form of degradation (INP, 2013). Yields of these crops, which are of vital economic and social importance, are less than a quarter of world levels (Sow et al., 2018; Gérald et al., 2020).

It is well established that organic inputs are essential for the sandy soils of the Sahel to offset soil degradation and increase crop productivity. Organic inputs, with or without inorganic amendments are essential for these soils to optimize nutrient and water efficiencies and ultimately crop yields (Bationo et al., 1993; Sanchez et al., 1997; Badiane et al., 2000; Akinnifesi et al., 2007; Tittonell et al., 2008; Dossa et al., 2012, 2013; Bright et al, 2017,2021). Unfortunately, the availability of organic matter is limited for incorporating into soil, as crop residues compete with animal feed and domestic uses, and there is insufficient manure available to make a significant impact on all cropped fields of farms in the Peanut Basin of Senegal (Badiane et al., 2000).

Extensive research has shown that an agroforestry system, the Optimized Shrub-intercropping System (OSS) can address the agroecological challenges of the Sahel. It utilizes the native shrubs Piliostigma reticulatum or Guiera senegalensis that are established at high densities (1200 to 1500 shrubs ha-1) and unlike traditional management of burning coppiced shrub residue, this biomass is annually incorporated (Dossa et al., 2012, 2013; Bright et al, 2017,2021). The OSS sequesters more carbon in the soil (Lufafa et al., 2008a and 2008b), improves soil quality by increasing soil organic matter, nutrient/water efficiency, and increased biological activity (Dossa et al., 2008; Diedhiou et al., 2009; Diedhiou-Sall et al., 2013; Debenport et al., 2015; Diedhiou et al, 2021; Mason et al., 2023. Profoundly, these shrubs have been shown to perform hydraulic redistribution (Kizito et al., 2006, 2007, 2012) which Bogie et al., (2018) proved that G. senegalensis utilizes this phenomenon to “bioirrigate” adjacent crops. Other benefits are shortened time to harvest and cooler soils (Bogie et al., 2019; Bayala et al., 2022) – and collectively the benefits of OSS dramatically increase crop yields (Bright et al., 2017; Bright et al., 2021).

However, these results were largely obtained under researcher-managed experiments and not under farmer management. Therefore, the objective of this study was to determine the agronomic performance and water use efficiency of OSS using G. senegalensis as the companion shrub under farmer management in the Northern Peanut Basin of Senegal.

Materials and Methods:-

Characteristics of study sites

The study was carried out in seven villages (Koul, Lissar, Ndia, Femboule, Ngass, Ndiaye Thioro, and Risso) of Meckhé (16° 39' N and longitudes 15° 4'W) in Peanut Basin of Senegal. The area's climate is tropical and semi-arid, with one wet season (July to October) and a long dry season of eight months (November to June). The average annual rainfall is 471 mm. The average annual temperature ranges between 17 and 35°C (ANACIM, 2021).

The soil is Rubic Arenosol (95% sand) with low content of carbon and nitrogen (0.2% C and 0.15% N) and low cation exchange capacity (0.7 meq/100 g) (Oldmen et al., 1993; Khouma, 2002). Fallow land is mainly shrub with dominant woody species like *Faidherbia albida* Del. A. Chev., *Vachellia tortilis* Forssk., *Balanites aegyptiaca* Del., *Zizyphus mauritiana* Lam. and *Adansonia digitata* L. The herbaceous cover is mainly composed of annual grasses, with a predominance of *Cenchrus biflorus* Roxb. (Dione et al., 2008).

Plant materials

Guiera senegalensis

Guiera senegalensis J. F. Gmel is an indigenous shrub of the *Combretaceae* family. It is found from Senegal to Ethiopia, in fallow land, light sandy soils, and degraded soils (Kerharo and Adam, 1974; Sanogo, 2012). It generally occurs in bushy clumps rarely exceeding 3 m in height, branched from the stump (Kerharo and Adam, 1974; Reca, 2016). *G. senegalensis* leaves, roots, stem and galls are widely used in traditional pharmacopeia and veterinary medicine (Tine et al., 2019). During a peak season, the biomass of *G. senegalensis* could range from 0.9 to 1.4 Mg C ha^{-1} (Lufafa et al., 2008).

***Arachis hypogaea* L.**

Peanut variety used was 55-437. It has a short cycle (90 days). It is tolerant of water deficit, not very sensitive to photoperiod, resistant to aflatoxin, and susceptible to acidity, salinity, and Cercosporiosis diseases (Schilling, 2001). The crop development is subdivided into five phases: germination, which lasts 3 to 4 days after sowing (DAS), vegetative phase (5 DAS to 25 DAS), flowering (25 DAS to 60 DAS), gynophorization (60 DAS to 90 DAS) and ripening (90 DAS) (Mayeux, 2001; Schilling, 2001). The crop's water requirements are met when rainfall is between 500 and 1000 mm, albeit with a good distribution (Schilling, 2001). The crop is more sensitive to water stress during germination, flowering, and gynophorization (Schilling, 2001). The potential yield of this variety is 2 Mg ha^{-1}, but its production farmer management is typically < 800 kg ha^{-1} in the Sahel (Schilling, 2001; Bello et al., 2019). The shelling yield is 75%. The weight of 100 seeds is between 35 g and 38 g (Schilling, 2001).

***Pennisetum glaucum* L.**

The variety of millet used was Souna 3 variety. The development cycle is 90 days. It is drought-tolerant, non-photoperiodic, and has a high tillering capacity (Sy et al., 2015). The development cycle is subdivided into vegetative, productive, and ripening phases (Kadri et al., 2019). The favorable rainfall of this variety ranges between 350 and 500 mm and the optimal yield is estimated at 2.5 Mg ha^{-1}, but under farmers' practice, the yield rarely exceeds 500 kg ha^{-1} (Bamba et al., 2019; Sy and Kanfany, 2023). The average height of the Souna 3 variety is 245 cm at maturity, while the weight of 1,000 millet grains averages 7.98 g (Bekoye, 2014; Ndir et al., 2014).

Experimental design

The trial was carried out on farmers’ fields for four years (2019 to 2022). Each farmer established an Optimized Shrub-intercropping System (OSS) with *G. senegalensis* as the companion shrub next to plot that was an existing Traditional Management System (TMS) plot. The experimental design was a randomized complete block design with fifteen (15) replicates where each farm was a block. The experimental unit was 250 m^2 (10 m wide by 25 m long). Within a block, the spacing between elementary plots is 3 m.

The OSS treatment had some existing *G. senegalensis* plants that were increased to 1,200 shrubs ha^{-1} by planting seedlings. Seedlings were grown by layering that was started in February and grown in about 1 kg of soil in plastic bags and then transplanted during the early rainy season the first year of the project. TMS across the farms had shrub densities ranging from <100 to 350 shrubs ha^{-1}. For both OSS and TMS shrubs are coppiced in the spring but OSS had the stems cut to about 5 cm and all biomass incorporated. Whereas in the TMS treatment, the coppiced biomass was burned. In the OSS by year four as much as 3 Mg coppiced biomass ha^{-1} was added to soils annually.

Crop management

The crop rotation was millet-peanut. The peanut trials were conducted in 2019 and 2021 during the rainy season. Peanut fields were sown early in August 2019, and 2021 at 50 cm x 15 cm spacing. NPK fertilizer (6-20-10) was applied at a 150 kg ha^{-1} rate immediately after sowing. Weeding was carried out whenever necessary.

Millet sowing was carried out manually, from July 14 to 17 in 2020 and from August 08 to 11 in 2022 at 1 m x 1 m spacing. Thinning at 3 plants per hole was carried out between 12 and 15 days after emergence (DAS). NPK fertilizer (15-10-10) was applied at the same time at a rate of 150 kg ha^{-1}. Urea was applied with 50 kg ha^{-1} at thinning and 30 DAS. Weeding was carried out whenever necessary.

Measurements and Observations:-

Crop growth parameters

Throughout the crop development cycle, the crop height, leaf area index, and NDVI were measured on six plants per plot in 6 replications per farmer field (n=36 measurements per treatment). Measurements were made at 56 and 88 DAS in 2019; 40, 60, and 90 DAS in 2020; 15, 25, 74, and 85 DAS in 2021; 30 and 90 DAS in 2022.

Peanuts were measured from the soil surface to the collar of the highest apical bud. For millet, it was measured from the ground to the last point of ear insertion.

Leaf area index (LAI) was measured with an LP 80 ceptometer, below the canopy, on all four sides of the six plants sampled. The LP 80 ceptometer features an external sensor and a probe that measures Photosynthetically Active Radiation (PAR) both above and below the canopy. These measures, in combination with other factors such as the canopy architecture and the sun's position, allow for the direct calculation of LAI. To ensure accurate measurements, the external sensor was connected to the device and positioned horizontally which was verified with a level. Additionally, the PAR value above the canopy must exceed 600 µmol m² s^{-1} to avoid any influence from the operator's shadow on the readings. The operator always faced the sun (Devices, 2004).

The normalized difference vegetation index (NDVI) was measured using a GreenSeeker. To obtain accurate measurements, a 60 cm wire was attached to the device, which needed to be positioned horizontally with the wire suspended above the highest leaf of the monitored plants (Ishikura et al., 2020). In the case of millet, measurements could not be taken after the tillering due to the plants' height.

Crop yield

Peanut

Three subplots of 2 m² were harvested randomly in each plot (treatment). Pods were removed from biomass and dried in the sun. The weighted average of 100 grains of peanuts was measured in 3 repetitions per subplot.

(1) A sample of peanut biomass was simultaneously removed in each subplot and dried in oven at 105° C. Total of peanut biomass was calculated through equation (1)$PTs = \frac{PEms*PHT}{PEmh}$
with *PTs*: Total weight of dry biomass; *PEms*: Average weight of dry samples; *PHt:* Total weight of wet biomass; *PEmh*: Average weight of wet samples.

Millet

A subplot of 80 m² was established in each millet plot for the yield. Grain yield was measured after harvesting the ears at physiological maturity. Three samples of 1,000 grains were weighed to determine the average weight of 1,000 millet grains. The yield of straw was measured inner the subplot. Three samples of millet biomass were collected for oven-drying at 105°C for 48 hours. Total millet biomass was calculated using equation (1).

Determination of water use efficiency

Rainwater use efficiency (kg ha^{-1} mm^{-1}) was measured as described by Bright et al. (2017). This was done by dividing the total biomass or the total amount of grain harvested by the total rainfall recorded during the crop season: 327 mm (2019), 662 mm (2020), 329 mm (2021), and 451 mm (2022) which was – 30 %, +40%, -30%, and -4 %, respectively of the long-term rainfall average of 471 mm.

Data Analysis Methods:

Quality Control/Quality Assurance practices were followed in data collection that included an established chain of custody data protocol. Statistical analyses were performed with R studio software (R Core Team, 2022). The agricolae package (Mendiburu and Yaseen, 2020) was used to highlight the effect of treatments (OSS and TMS) on agro-physiological parameters, as well as millet and peanut yield components, and crop water use efficiency based on the general linear model:

$Yij = \mu + Ti + Bj + \varepsilon ij$,

Where Yij is the analyzed variable of crop ij, μ is the overall mean, Ti is the fixed effect of treatment i, Bi is the fixed effect of the plot, εij represents the residual errors assumed to be independent and following a normal distribution (0, σ^2).

Significant differences were determined at *P*< ≤ 0.05. Assumptions about heterogeneity of variance and normality of residual errors were validated by residual and quantile plots. Means separation analysis was performed using Tukey's test. Except for crop water use efficiency in 2022, the non-parametric Wilcoxon test was used, as the distribution of the variables did not follow a normal distribution. Pairwise comparisons of least squares means were presented with error bars representing 95% confidence intervals.

Results:-

Crop growth parameters

Height

In 2021, OSS significantly influenced peanut height during the vegetative phase (*P*< = 0.004) with a value of 9.94 cm compared with 8.53 cm for TMS (Fig. 1c). OSS had a significant effect on millet height in 2020 and 2022. Thus, in 2020, OSS significantly (*P*<≤ 0.005) improved millet height by 59 and 10% during the tillering and bolting phases respectively (Fig. 1b). In 2022, OSS significantly increased millet height by 59% and 24% at tillering and ripening stages respectively (Fig. 1d).

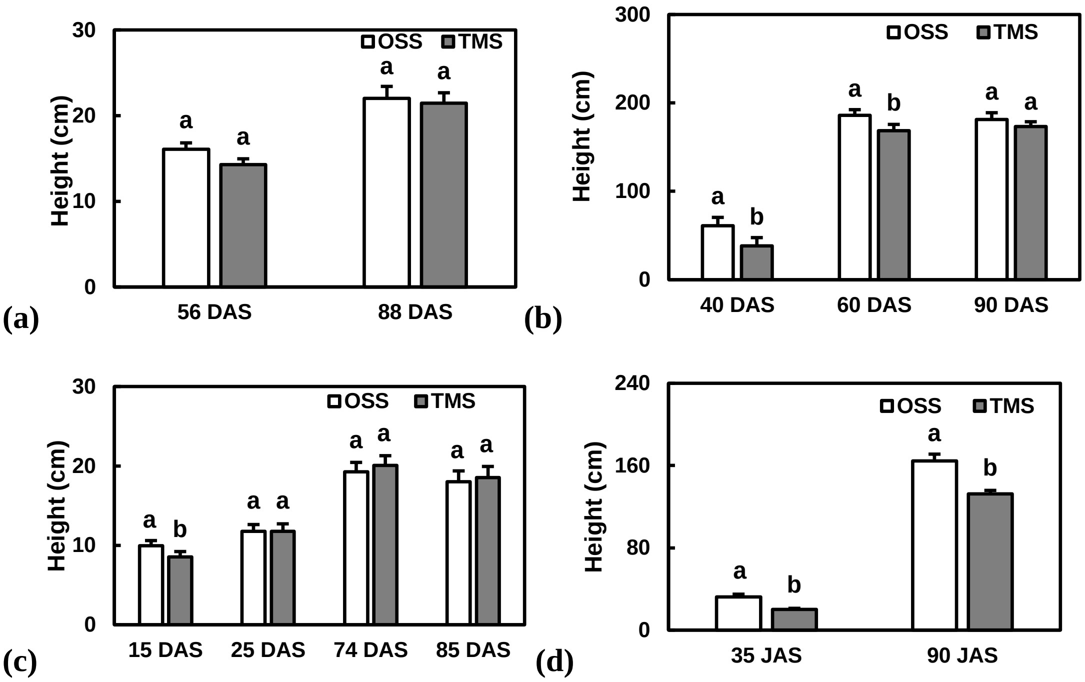

Figure 1: Effect of *G. senegalensis* optimized system on crop height evolution (a: peanuts in 2019; b: millet in 2020; c: peanuts in 2021; d: millet in 2022).

Pairs of bars with the same letter are not statistically different at P <0.05.

Leaf Area Index (LAI)

Shrub management had no significant influence on LAI for peanut in 2021 and millet in 2022 for all crop development stages except ripening in 2021 (Fig. 2a and Fig. 2b). At this last stage, OSS improved LAI by 178% compared with TMS (Fig. 2a). The Millet LAI was not significantly improved by OSS in 2022 (Fig. 2)

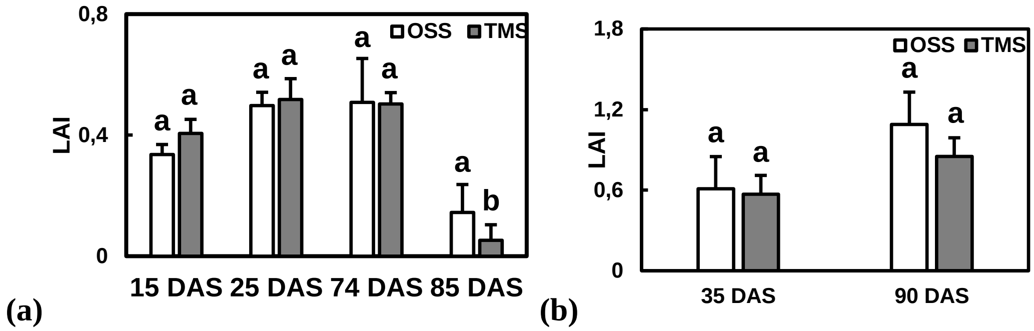

Figure 2: Effect of the optimized *G. senegalensis* system on changes in leaf area index (LAI) of peanut in 2021 (a) and millet in 2022 (b).

Pairs of bars with the same letter are not statistically different at P <0.05.

NDVI

In 2020 and 2022, OSS had a significant effect on millet NDVI during the tillering phase (40 DAS in 2020 and 35 DAS in 2022) (P< 0.01*)*. This parameter increased by 19%, with NDVI rising from 0.287 to 0.343 (Fig. 3b).

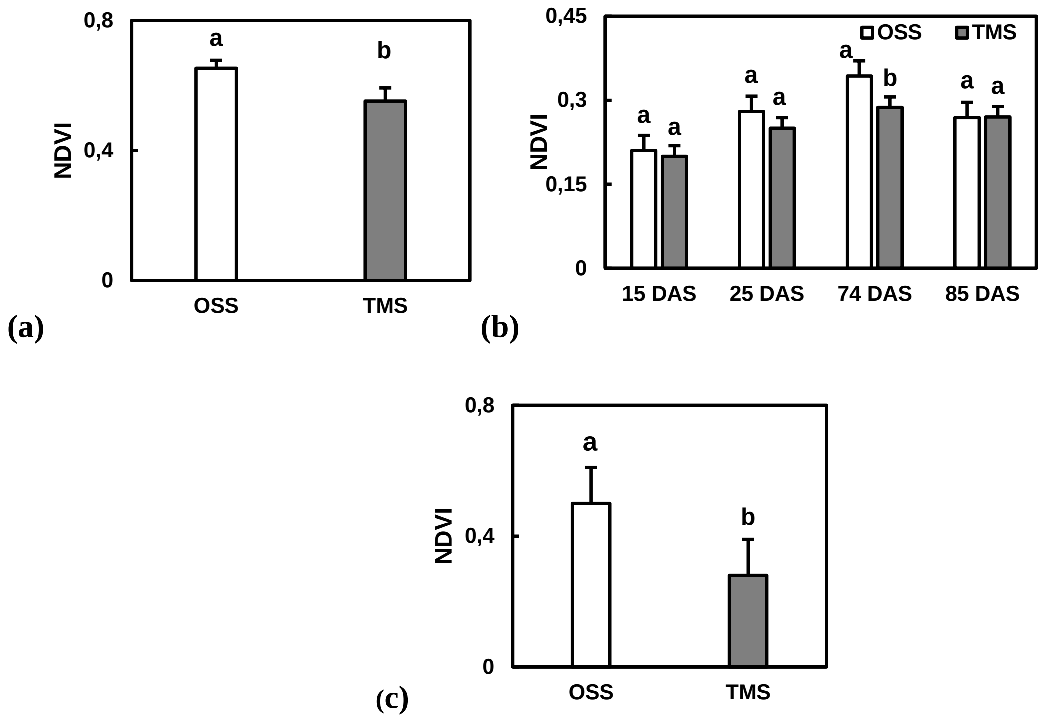

Figure 3: Effect of the optimized *G. senegalensis* system on changes in normalized difference vegetation index (NDVI) for millet in 2020 (a) and 2022 (c), and for peanut in 2021 (b).

Pairs of bars with the same letter are not statistically different at P <0.05.

Crop yields
Peanut yield

In both 2019 and 2021, there were no significant differences between the OSS and TMS treatments for any of the peanut yield parameters (Table 1).

Table 1. Effect of the Optimized Shrub-intercropping System with *G. senegalensis* as companion shrub on peanut yield components. Pairs of values between OSS and TMS within a column with the same letter are not statistically different at P <0.05.

	2019			2021
	Biomass kg ha^{-1}	Pod kg ha^{-1}	100-seed Wt. g	Biomass kg ha^{-1}
OSS	290a ± 122	124a ± 81	27a ± 3.3	2279a ± 1088
TMS	293a ± 165	108a ± 77	27a ± 3.2	2186a ± 1111
Treatment	0.93	0.17	0.89	0.65
Block + Treatment	0.001 **	1.4e-5 ***	8.4e-5 ***	0.0005 ***

**P<0.05; **P<0.01; ***P<0.001*

Millet yield

OSS significantly increased millet growth parameters in 2020 except 1000-kernel weight. Straw increased by 17.23% (1841 vs. 1570 kg ha^{-1}). Grain weight improved by 32% ($P<0.01$). The highest weights of 1,000 millet seeds were with the OSS treatment, representing an improvement of 3 %. In 2022, OSS improved harvested straw by 32 % ($P<$ = 0.02), and weight of 1,000 millet kernels by 20% (Table 2). Millet yields were very low for 2022 and although grain yield was 29% higher with OSS over TMS it was not significant at P<0.05.

Table 2. Effect of the Optimized Shrub-intercropping System with *G. senegalensis* as companion plant on millet productivity. Pairs of values between OSS and TMS within a column with the same letter are not statistically different at P <0.05.

	2020			2022		
	Biomass	Yield	1,000-seed Wt.	Biomass	Yield	1,000-seed Wt.
	kg ha^{-1}	kg ha^{-1}	g	kg ha^{-1}	kg ha^{-1}	g
OSS	1841a ± 447	698a ± 285	6.83a ± 0.48	1146a ± 1020	97a ± 77	7.2a ± 1.0
TMS	1570b ± 445	527b ± 216	6.64a ± 0.76	866b ± 1222	75a± 65	5.9b ± 3.2
Treatment	0.02 *	0.01 *	0.187	0.0231 *	0.2814	0.01961 *
Block + Treatment	0.008 **	0.00526 **	0.003**	3.96e-05 ***	0.0181 *	0.18

. **P<0.05; **P<0.01; ***P<0.001*

Rainwater use efficiency of mature crops

In 2021, the rainwater use efficiency for peanut biomass was significantly higher ($P<0.05$) by 12% with OSS over TMS (Fig. 4a). In 2020, the rainwater use efficiency for millet biomass increased significantly by 17% (Fig. 4c). Additionally, the rainwater use efficiency for millet grain was 56% greater for OSS than TMS for 2020 (Fig. 4d).

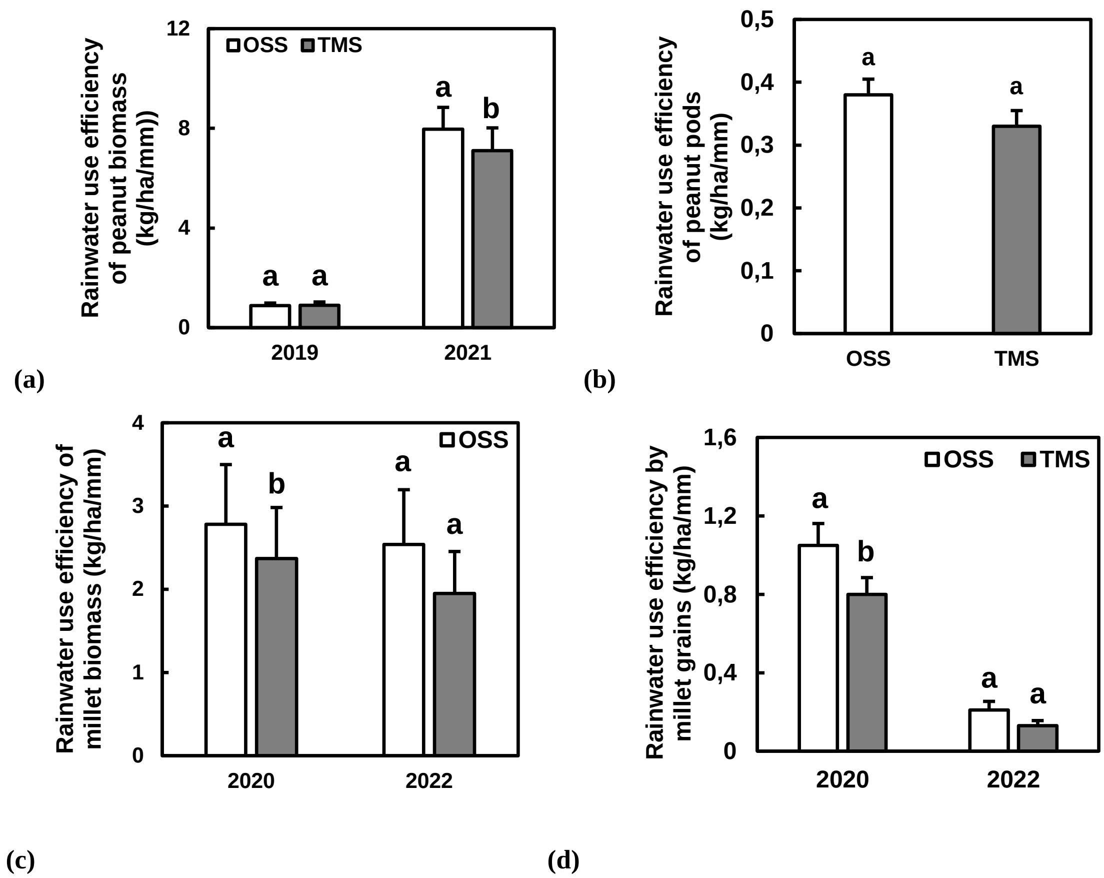

Figure 4. Effect of *G. senegalensis* optimized system on rainwater use efficiency by peanut biomass (a) and seeds (b) in 2019 and 2021; and millet biomass (c) and seeds (d) in 2020 and 2022.

Pairs of bars with the same letter are not significantly different at $P<0.05$.

Discussion:

A major factor that affected the outcomes of this study was rainfall. There was really only one good cropping year for rainfall in the amount and distribution, which was 2020 with millet. Although OSS had only been in place for one year, millet above-ground biomass increased by 17% and grain yield by 32% over TMS in 2020. This was also reflected in greater millet plant height in 2020 and 2022. Although 2022 had rainfall similar to the long-term average, rainfall came late in the season and very limited rainfall from mid-September on (personal comm. M. M. Dione) that greatly reduced crop yields. Despite the lack of significant effects of OSS on the yield of millet in 2022, likely due to water stress, other plant growth parameters indicated OSS was mitigating this stress. Notably, plant height and above-ground biomass were significantly greater with OSS over TMS.

These on-farm results for millet corroborate with Dossa et al. (2012), Bright et al. (2021), and Bayala et al. (2022) in the same region of Senegal who found the presence of *G. senegalensis* promotes the growth and yield of millet and peanuts. In a long-term study (2004 to 2016) Bright et al. (2021) found that OSS increased millet yield by 126% with OSS over a system without shrub intercropping.

The improvement in millet growth and yields would be due to a combination of several factors. *G. senegalensis* does not compete with crops for water and mineral nutrition, as 95% of the shrub's roots are located between 0.2 and 0.5 m, and the shrub preferentially uses water located above 0.9 m (Kizito et al., 2006). Furthermore, OSS provides a significant amount of organic matter inputs of 2.9 to 8.3 Mg ha^{-1} yr^{-1} (Lufafa et al., 2008a; Bright et al., 2021). This organic matter is the most limiting factor in Sahelian agroecosystems (Lahmar et al., 2012). This increase favors microbial activity, which induces nutrient mineralization and aggregate formation (Diedhiou et al., 2009; Dossa et al., 2012; Diedhiou-Sall et al., 2013); leading to increased availability of nutrients (N, P, K) to plants through their release, storage, and retention.

Peanut was planted in 2019 and 2021 which were particularly low rainfall years, each year being 30% lower than the annual average of 471 mm. Similarly for millet in 2022 rainfall was a factor. Although total rainfall was reasonable (451 mm), the rainfall was highly variable across farms from July 15 to Aug 1 which is optimal for starting the rainy season. However, in the Mecke region the rains did not really begin till early August and then had limited rain from mid-September (M. M. Dione, personal comm. 2025). Furthermore, there was variability in how much rain each farm got. One site in particular (Thiallene) had more rain that was better distributed over the 2022 season where OSS had 357 kg ha^{-1} yield compared to 125 kg ha^{-1} for TMS (data not shown). Although this is low, it is not an unusual yield for the Meckhé region because of the normal erratic and low rainfall of this region (I. Diedhiou, personal comm., 2025).

The rainwater use efficiency data provides insights into OSS ability to reduce water stress. OSS improved rainwater use efficiency of mature peanut biomass by 12% in 2021. For millet, it increased by 17% for biomass and 56% for grain. Bright et al. (2021) obtained similar results, comparing OSS with treatments without shrubs on the Keur Matar Aram site (Senegal) under soil-climatic conditions comparable to our study area. Rainwater use efficiency by millet increased by 50% for millet grains and 107% for peanut pods (Bright et al.,2021)

The favorable response of millet in 2020 and increase in rainwater use efficiency by mature crops may be due to the improvement in soil physical properties induced by the addition of *G. senegalensis* biomass. The latter should increase the amount of particulate organic matter in the soil, which promotes soil aggregation; this in turn leads to increased porosity and improved water storage and availability for crops (Kizito et al., 2007; Dossa et al., 2012; Bright et al., 2021). The organic input from shrub biomass with OSS would be expected to promote soil aggregation which in turn improves soil structure and water availability for plants (Dossa et al., 2012; Lahmar et al., 2012; Bright et al., 2021). The presence of shrubs has also been shown to reduce drainage losses and evapotranspiration by 50% (Kizito et al., 2007).

An important discovery is that *G. senegalensis* has been shown to perform hydraulic lift or distribution (Kizito et al., 2012) which is the movement of water via deep roots near the water table with high water potential to the surface roots where water is released in the dry, low water potential soil. This occurs at night when the stomata close. Notably Bogie et al., (2018) showed that the hydraulicly lifted water of *G. senegalensis* can “bioirrigate” adjacent millet plants. This mechanism also provides favorable moisture conditions for early-season crop establishment (Kizito et al., 2012; Bogie et al., 2018). Thus, hydraulic lift provides another mechanism accounting for the positive effects of OSS on rainfall water efficiency.

In addition, the reduction in soil surface temperature, due to the mulch effect of undecomposed *G. senegalensis* biomass and the cooling effect induced by water redistribution, improves the germination rate and also prevents the denaturation of certain proteins; this leads to better development during the vegetative phase (Bright et al., 2021).

OSS was found to show greater productivity over TMS. However, water stress in three out of the four years likely limited the benefits of OSS noted in other studies under Sahelian conditions (Dossa et al., 2012, Bright et al., 2021 Bayala et al., 2022). Unlike these investigations, where OSS is compared with treatments without shrubs, in the present work, the traditional management system features a low shrub density (120 to 520 shrubs ha^{-1}) with burning of coppiced biomass.

Conclusion:

This study investigated the agronomic performance under farmer management of the Optimized Shrub-intercropping System (OSS) with *Guiera senegalensis* in the northern Peanut Basin. OSS improved the growth and yield of millet one year after implementing OSS when there was no water stress (2020). OSS significantly improved peanut height, except during periods of water stress. OSS also increased LAI from the flowering phase onwards, as well as the rainwater use efficiency of the peanut, and improved NDVI of peanut during the gynophorization phase.

For millet, OSS induced better millet height growth, improved NDVI during the tillering phase, and LAI during the tillering and ripening phases in 2020 and 2022. Grain and straw yields, as well as the weight of 1,000 millet seeds, were improved by OSS, even in years of low rainfall (2022). In addition, OSS improved rainwater use efficiency, particularly for grain. The research has shown OSS through high biomass incorporation to soil, improves soil quality which would be a mechanism for the growth responses of the current study. Thus, OSS has the potential to improve the sustainability of Sahelian agroecosystems and enhance the food security of local populations. It is likely that with more time to allow the transplanted *G. senegalensis* seedlings to further grow (which was noted by Bright et al., 2021), crop productivity would be further improved. Importantly, the study showed that farmers can successfully implement OSS and that it utilizes a local resource that is available to subsistence farmers. Overcoming a major challenge of degraded soils in the Sahel and addressing food insecurity.

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