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Dynamics of mycorrhization in agroforestry systems based on the Guiera senegalensis shrub in Sanghaïe (Commune of Niakhar) in Senegal

Ndèye Maguette Hane
Institut Sénégalais de recherches Agricoles (ISRA)
Hassna Founoune-Mboup
fhassna@yahoo.fr

Institut Sénégalais de recherches Agricoles (ISRA)
Saidou Nourou Sall
Gaston Berger University of Saint-Louis (UGB)
Moussa Ndienor
Institut Sénégalais de recherches Agricoles (ISRA)
Bassirou Diallo
Institut Sénégalais de recherches Agricoles (ISRA)
Abdoulaye Fofana Fall
Institut Sénégalais de recherches Agricoles (ISRA)
Laurent Cournac
Université de Montpellier, IRD, CIRAD, INRAE, Institut Agro
Karel Den Meersche
Université de Montpellier, IRD, CIRAD, INRAE, Institut Agro
Harun Cicek
Research Institute of Organic Agriculture (FIBL)

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Abstract

Guiera senegalensis is a dominant shrub in Sahelian agroforestry systems of Senegal and is widely associated with improved soil fertility and crop performance. This study evaluated the dynamics of arbuscular mycorrhizal fungi (AMF) associated with *G. senegalensis* and two rotational crops, pearl millet (*Pennisetum glaucum* L.) and peanut (*Arachis hypogaea* L.), under farmer-managed parkland conditions. Field experiments were conducted over two consecutive cropping seasons (2023–2024) in six plots located in the peanut basin of Senegal. A factorial design combined crop species, distance from *G. senegalensis* (under canopy, 2 m, 5 m, and plots without shrubs), and fertilization treatments (organic fertilizer: horse manure and shrub residues, and control). Arbuscular mycorrhizal fungi (AMF) were assessed using soil mycorrhizal infectivity potential (MPN) and root mycorrhizal colonization intensity, and crop productivity was evaluated through grain yield. Neither shrub presence nor fertilization significantly affected MPN, suggesting limited impact on AMF propagules. However, *Guiera senegalensis* presence significantly enhanced root mycorrhization in millet, but not in peanut, whereas organic amendments enhanced more consistently root mycorrhizal intensity than shrub proximity. In agronomical terms, millet appeared more responsive to mycorrhization than peanut, although relationships between mycorrhization and grain yield remained context-dependent and rarely significant. These findings indicate that AMF functioning in this Sahelian agroforestry system is driven more by organic soil management than by spatial distance to shrubs. Enhancing local biomass recycling and integrating native shrubs with organic fertilization may provide a promising pathway to strengthen soil biological fertility and crop resilience in dryland farming systems.

1. Introduction

The Sahel region is increasingly affected by land degradation and climate variability, which jointly undermine the sustainability of agricultural systems and rural livelihoods. In this semi-arid environment, crop productivity is severely constrained by declining soil fertility associated with low organic matter content, nutrient depletion, and altered soil biological processes (Kone et al., 2024; Stringer et al., 2012). These challenges highlight the need for management strategies that not only restore soil chemical properties but also enhance the biological components which govern nutrient cycling and ecosystem resilience. Among soil biota, arbuscular mycorrhizal fungi (AMF) play a central role in the functioning of Sahelian agroecosystems. By forming symbiotic associations with the majority of crop species, AMF enhance plant acquisition of poorly mobile nutrients; particularly phosphorus, and improve water uptake under drought conditions through their extensive extraradical hyphal networks (Smith & Read, 2010; Van der Heijden et al., 2015). In addition, AMF contribute to soil aggregation and carbon stabilization via glomalin-related soil proteins, while increasing plant tolerance to biotic and abiotic stresses (Fall et al., 2022; Rillig, 2004). In nutrient-poor and climatically harsh Sahel, these functions are particularly critical for sustaining crop production. In parallel, agroforestry systems based on native woody species represent a key pathway for ecological intensification in this region. Parkland systems, where crops are grown in association with scattered trees or shrubs, improve microclimatic conditions, reduce wind erosion, and enhance soil fertility through organic matter inputs and nutrient redistribution (Diatta et al.,

2019; Lahmar et al., 2012). *Guiera senegalensis* J.F. Gmel. is among the most widespread and ecologically significant shrubs in the Senegalese peanut basin, where it is often conserved through Farmer Managed Natural Regeneration. Numerous studies have shown that this species generates localized “fertility islands” characterized by increased soil organic carbon, enhanced nutrient availability, and elevated microbial activity beneath and around its canopy (Diakhaté et al., 2016; Diatta et al., 2019). *Guiera senegalensis* is also known to be highly mycotrophic, indicating a strong association with AMF. As a perennial shrub with an extensive root system, it may function as a long-term reservoir of mycorrhizal propagules, thereby increasing soil mycorrhizal infectivity in its immediate surroundings. Through shared mycorrhizal networks, such enrichment may facilitate nutrient transfer or enhance nutrient acquisition by neighboring annual crops (Bogie et al., 2018). Nevertheless, shrub–crop interactions within agroforestry systems remain complex and can involve both facilitative and competitive processes, particularly belowground.

Several studies show that the presence of *Guiera senegalensis* in agroforestry systems strongly stimulates soil biological activity, particularly that of arbuscular mycorrhizal fungi. Under the canopy, the accumulation of organic residues and improved soil moisture promote decomposition, phosphorus availability, and nitrogen mineralization, thereby enhancing soil fertility (Diedhiou et al., 2009; Diedhiou-Sall et al., 2021; Mason et al., 2023). This stimulation of mycorrhizal potential contributes to crop nutrition and resilience in arid conditions. Despite the well-recognized importance of both AMF and *G. senegalensis* in Sahelian agroecosystems, their interactive dynamics, the spatial variability of soil mycorrhizal infectivity and crop root colonization as a function of distance from the shrub remains poorly understood. Furthermore, it is unclear to what extent these dynamics differ between crops with contrasting nutrient acquisition strategies, such as pearl millet (*Pennisetum glaucum*), which is highly mycotrophic, and peanut (*Arachis hypogaea*), which is partially dependent on biological nitrogen fixation. Finally, the modulating role of fertilization practices on these interactions remains insufficiently documented. To address these knowledge gaps, the present study investigates the spatial dynamics of arbuscular mycorrhizal fungi in Sahelian agroforestry systems integrating *Guiera senegalensis* with millet and peanut cultivated in annual rotation. Specifically, the objectives were to: (i) quantify changes in soil mycorrhizal infectivity potential and root colonization intensity along a distance gradient from the shrub; (ii) compare mycorrhizal responses between millet and peanut; and (iii) assess how different fertilization strategies modulate these interactions.

2. Materials and Methods

Study Site

The study was conducted during the 2023 and 2024 cropping seasons in Sanghaïe village, located in Senegal’s peanut basin (14°30' N, 16°30' W) a Sahelian agroforestry system. The region is characterized by a semi-arid Sahelian climate with a monomodal rainfall regime, averaging approximately 500 mm per year, concentrated between July and October. Mean annual temperature is around 30°C. The study site was characterized by a sandy soil with a localized fertility gradient associated with proximity to *Guiera*

senegalensis. In the 0–10 cm layer, soil organic carbon ranged from 12.4 g kg^{-1} beneath shrub canopies (D0) to 7.2 g kg^{-1} at 5 m from shrubs (D5), while total nitrogen decreased from 1.05 to 0.65 g kg^{-1} and Bray-1 available phosphorus from 8.2 to 6.4 mg kg^{-1}. Similar trends were observed in the 10–30 cm layer, where carbon varied from 7.8 to 5.5 g kg^{-1} and nitrogen from 0.66 to 0.49 g kg^{-1} between D0 and D5. Soil pH (H_2O) ranged from 5.7 to 6.1 across sampling positions. *Guiera senegalensis* J.F. Gmel. is a dominant native shrub commonly present in farmers' fields. The experiment was established in cropped fields traditionally managed under rain-fed conditions with an average density of 232 *Guiera* plants/ha.

Experimental design and cropping system

Given the strong influence of interannual climatic variability on crop performance and soil microbial processes in the Sahel, data from each cropping season were analyzed separately. A factorial experimental design was implemented, combining crop species, distance to *Guiera senegalensis*, and soil amendment treatments. Two crops were studied: pearl millet (*Pennisetum glaucum* L.), a cereal, and peanut (*Arachis hypogaea* L.), a legume. Field experiments were established in six farmer-managed plots (90 x 40 m) selected for their similar soil characteristics and management history. The agroforestry system was based on naturally regenerated *Guiera senegalensis* shrubs maintained by farmers under traditional parkland management. Selected shrubs were mature individuals (> 10 years old) and regularly coppiced according to local practices. The cropping system consisted of pearl millet (*Pennisetum glaucum* L., variety Souna 3) and peanut (*Arachis hypogaea* L., variety 55–437) cultivated in annual rotation. Every year, there were three plots of millet and three plots of peanuts. Experimental treatments (40 x17 m with a 1.5 m gap between treatments to avoid edge effects) were spatially arranged around individual *G. senegalensis* shrubs and in adjacent areas without shrubs. Distances from the shrub were defined using 16 m^2 sampling plots established as follows: (i) 0 m (D0), beneath the shrub canopy; (ii) 2 m (D2), corresponding approximately to the canopy edge; (iii) 5 m (D5), outside the immediate shrub influence; and (iv) a control treatment located in plots without *G. senegalensis* (hereafter referred to as "without shrub"). These distance classes were applied consistently for soil sampling, root sampling, and crop yield measurements so that no other *Guiera* trees were present within this distance.

Soil amendment treatments

Three fertilization treatments were applied: 1) horse manure commonly used by farmers in the region, applied at a rate of 5 t ha^{-1}; 2) Shrub residues (GR): *Guiera senegalensis* litter applied at a rate of 5 t ha^{-1}; and 3) An unfertilized control (C) which was included for comparison purposes. The organic amendments were incorporated into the soil 30 days after germination, in accordance with local agronomic recommendations.

Soil sampling and determination of mycorrhizal parameters

Soil samples were collected from the rhizosphere at the defined distances for each crop. In each plot, a composite of three measurements represents the sample for the corresponding distance. Samples were air-dried, sieved through a 2 mm mesh sieve and stored at room temperature prior to analysis. The

mycorrhizal infectivity potential of the soil was estimated using the Most Probable Number (MPN) bioassay as described by Sieverding (1991). The MPN method was chosen because it estimates the density of viable and infective AMF propagules capable of colonizing plant roots, providing a functional measure of soil mycorrhizal potential. Serial dilutions of dry soil were prepared and used to inoculate a mycotrophic trap plant (Zea mays) grown under controlled conditions. After 45 days, root colonization was assessed and MPN values were calculated following established procedures by Sieverding (1991).

In order to assess mycorrhizal root colonization intensity, roots of *G. senegalensis*, *Pennisetum glaucum* L., and *Arachis hypogaea* L. were sampled at the same distances as those used for soil sampling. Roots were carefully washed, cleared, and stained using standard protocols for arbuscular mycorrhizal assessment using Philips et Hayman, (1970) method. Mycorrhizal colonization was quantified as colonization intensity (%), defined as the proportion of root segments containing arbuscules, vesicles, or intraradical hyphae. For *G. senegalensis*, colonization intensity was assessed separately for each year to evaluate potential effects of the associated crop. For *P. glaucum* and *A. hypogaea*, colonization intensity was analyzed as a function of shrub proximity, amendment treatment, and year.

Crop yield measurements

Crop productivity was assessed at harvest. For peanut, grain yield and aboveground biomass were measured. For millet, grain yield and straw biomass were determined. The whole of the 16 m² subplot was harvested to measure the yield. The resulting crop was then dried, expressed as dry matter, and converted to kg ha^{-1}.. Yield data were analyzed as a function of fertilization treatment and distance to *G. senegalensis* for each crop and year.

Statistical analyses

Statistical analyses were conducted using R software (version 4.x; R Core Team, 2024). Data were tested for normality using the Shapiro–Wilk test and for homogeneity of variances using Levene's test. When assumptions were met, the effects of shrub presence, distance, crop species, and fertilization treatment were analyzed using analysis of variance (ANOVA). Significant effects were further explored using Tukey's Honest Significant Difference (HSD) test. When data violated parametric assumptions, even after transformation, non-parametric Kruskal–Wallis tests were applied, followed by Dunn's post hoc tests with Benjamini–Hochberg correction for multiple comparisons. For factorial designs involving non-normal data, aligned rank transform ANOVA (ART–ANOVA) was used to test main effects and interactions. Results are presented as mean for which the threshold of statistical significance has been set at $p < 0, 05$.

3. Results

3.1 Soil mycorrhizal infectivity potential (MPN)

3.1.1 Effect of distance to *Guiera senegalensis*

In soils cultivated with pearl millet (*Pennisetum glaucum*), the mycorrhizal infectivity potential (MPN) showed numerical variation according to distance from *Guiera senegalensis* in 2023 (Fig. 1A): lower mean values were observed in the immediate vicinity of the shrub (0 m), whereas higher values were recorded at 5 m, followed by without shrub and 2 m. However, statistical analyses revealed no significant effect of distance on MPN in this trial (ANOVA, p = 0.28, Kruskal–Wallis, p = 0, 25) (Fig. 1A). In 2024, nonparametric (Kruskal–Wallis) analyses revealed no significant differences in soil MPN either, between distances (p = 0.33) or between treatments (p = 0.94). Nonparametric factorial analysis (ART) confirmed the absence of significant effect of distance (p = 0.35), treatment (p = 0.83), or their interaction (p = 0.83) (Fig. 1B).

Similarly, in soils cultivated with peanut (*Arachis hypogaea*) in 2023, MPN values varied across distances, with higher mean values observed at 2 m from the shrub, followed by distances of 0 m and 5 m, while plots without shrubs had the lowest values (Fig. 1C). These differences were however not statistically significant (ANOVA, p = 0.275; Kruskal–Wallis, p = 0.13). For 2024, The ART transformation revealed no significant effect of distance (p = 0.88), type of amendment (p = 0.46), or their interaction (p = 0.73) on soil MPN. Thus, for both crops, distance to *G. senegalensis* did not exert a significant effect on soil mycorrhizal infectivity potential.

3.1.2 Effect of organic amendments on MPN

For both crops and across both years, no significant effects of organic amendment type (*Guiera* residues, horse manure, or control) were detected on MPN values (all p > 0.05). Likewise, interaction effects between amendment type and distance to *G. senegalensis* were not significant, as confirmed by ANOVA and aligned rank transform (ART–ANOVA) analyses (all p > 0.3).

3.1.3 Interannual variability and crop comparison

Across years, average MPN values remained relatively stable for both crops. In millet soils, mean MPN increased from approximately 80 ± 51 propagules·100 g^{-1} soil in 2023 to 240 ± 86 propagules·100 g^{-1} soil in 2024, although this increase was not statistically significant (p > 0.05). In peanut soils, mean MPN values decreased slightly between 2023 (398 ± 69 propagules·100 g^{-1} soil) and 2024 (325 ± 83 propagules·100 g^{-1} soil), with no significant year effect (p > 0.05). Overall, soils cultivated with peanut exhibited higher mean MPN values than those cultivated with millet, although variability among replicates was also greater in peanut soils.

3.2 Root mycorrhizal colonization intensity

3.2.1 Mycorrhizal colonization of *Guiera senegalensis*

The intensity of arbuscular mycorrhizal colonization in *G. senegalensis* roots did not differ significantly according to the associated crop in either year. In 2023 (Fig. 2a), mean colonization intensity was 21.7 ± 15.5% when associated with peanut and 29.4 ± 22% when associated with millet (one-way ANOVA, p = 0.378). In 2024 (Fig. 2b), similar results were observed, with no significant effect of associated crop

detected by either ANOVA ($p = 0.555$) or Kruskal–Wallis test ($p = 0.916$). The average values were 39.2 ± 17.6% with peanuts and 43.5 ± 9.9% with millet.

3.2.2 Mycorrhizal colonization of crops in 2023

In 2023, the presence of *G. senegalensis* had a significant effect on root mycorrhizal colonization in both crops. In peanut, colonization intensity was significantly lower in plots with shrubs (8.1 ± 6.7%) than in plots without shrubs (20 ± 15%) (Anova, $p = 4.19 \times 10^{-4}$) (Fig. 3a). A similar pattern was observed for millet, with colonization intensities of 2.73 ± 1.73% in the presence of *G. senegalensis* and 8.2 ± 4.2% in its absence (ANOVA, $p < 1 \times 10^{-7}$).(Fig. 3b)

3.2.3 Crop root colonization in 2024: effects of distance and organic amendments

In 2024, responses differed between crops. For peanut, two-way ANOVA revealed no significant effects of organic amendment type ($p = 0.184$) or distance to *G. senegalensis* ($p = 0.078$) on root colonization intensity, and no significant interaction between these factors ($p = 0.667$). Root colonization values exhibited high within-treatment variability (Fig. 3a). For millet, two-way ANOVA showed a highly significant effect of distance to *G. senegalensis* on root colonization intensity ($p = 0.0022$), whereas neither organic amendment type ($p = 0.888$) nor the interaction between distance and amendment ($p = 0.890$) was significant. Post-hoc Tukey tests indicated that colonization intensity was significantly higher at 0 m from the shrub than at 2 m, 5 m, and in plots without shrubs ($p < 0.05$). The highest colonization values were consistently observed in millet roots sampled in direct proximity to *G. senegalensis* (Fig. 3b).

3.3 Effects of shrub presence and organic fertilization on root mycorrhization and grain yield in millet and peanut

An analysis of Spearman's correlations between mycorrhization intensity and grain yield in millet and groundnuts, according to fertilization treatments and distance classes, shows that no relationship is statistically significant ($p > 0.05$ in all cases). Correlation coefficients range from negative to positive depending on the treatment. A few moderate associations emerge, particularly for millet: a negative relationship under the Control treatment at 5 m ($p = 0.297$) and a maximum positive relationship under *Guiera* residues and without shrubs ($p = 0.333$). Analysis of the effect of the cropping system, however, shows that the presence of *Guiera senegalensis* significantly influences the intensity of mycorrhization in millet ($p = 0.023$). Plots under the influence of the shrub exhibit higher levels of root colonization than those without *Guiera* in 2024. Conversely, no significant effect of root colonization was observed on grain yield ($p = 0.644$), indicating that this biological change does not directly translate into increased production. The linear model confirms this trend; plots without *Guiera* show an average decrease in mycorrhizal intensity (-15.7%), while fertilization with *Guiera* residues (+ 20%) and horse manure (+ 19.64%) increased root colonization compared to the control.For peanuts under the Control treatment, the correlations were generally negative, particularly at D5 ($p = 0.356$). Under *Guiera* residues, the trends remain negative at distances of 0 m, 2 m, and 5 m, but become strongly positive in the absence of

shrubs (p = 0.333). Under horse manure, positive relationships appear at 0 m, 2 m, and especially 5 m (p = 0.333). Wilcoxon tests also show that the presence of *Guiera senegalensis* has no significant effect on either the intensity of peanut mycorrhization (p = 0.294) or grain yield (p = 0.898). Linear modeling showed that the presence of shrubs had only a limited effect on the mycorrhizal intensity of peanut roots, whereas organic fertilization had more pronounced positive effects. Compared to the control, Guiera residues increased mycorrhizal intensity by 11% and horse manure by 17.3%.

4. Discussion

4.1 Limited spatial effect of shrub on mycorrhization

In all analyses conducted on MPN and the intensity of mycorrhization in crops (*Pennisetum glaucum* L. and *Arachis hypogaea* L.), over the two growing seasons, the effect of distance from the shrub appears to be generally weak or insignificant. Neither the MPN nor the rate of root mycorrhizal colonization showed a clear spatial gradient between locations near the shrub and distant or shrub-free areas. These results do not align with the spatially heterogeneous and fragmented distribution of infectious arbuscular mycorrhizal (AM) fungal propagules, frequently observed in semi-arid soils, where microsite variability and disturbances can mask vegetation-related gradients (Brundrett & Tedersoo, 2018). The absence of a clear pattern of decline with distance also contrasts with studies reporting a reduction in AMF spore density under the canopies of *G. senegalensis* compared to areas without shrubs (Fall et al., 2021). In millet, several statistical tests indicate no significant effect of distance, whereas in groundnuts, there is a weak spatial pattern of mycorrhization with little variation with distance and no consistent relationship with proximity to *Guiera senegalensis*. These results suggest that the influence of the shrub on arbuscular mycorrhizal fungi likely extends beyond the scale of its crown. The mycorrhizal network or the dispersion of propagules in the soil could be sufficiently extensive to homogenize colonization within the plot. The different expression of mycorrhization observed in the two crops could be attributed to the crops susceptibility and infectivity to mycorrhization, as the latter determines the expression of the former, which governs its level (Plenchette et al., 2005). The lack of correlation between mycorrhization and yield confirms this observation, as according to (Djatta et al., 2013), plant growth does not necessarily depend on the degree of colonization of their roots. Furthermore, given that *Guiera senegalensis* is a native shrub naturally found in agricultural landscapes, studies conducted over the past fifteen years (Diedhiou-Sall et al., 2013; Dossa et al., 2009, 2010; Félix et al., 2018; Richard, 2022) show that this shrub improves soil quality, enabling good yields even under conditions of low nutrient input (Dossa et al., 2012) thereby likely limiting the crop's dependence on mycorrhization. While proximity to shrub had little overall influence on MPN and mycorrhization, the interannual climate variability, particularly precipitation distribution, which is known to influence AMF activity and carbon distribution in semi-arid environments (Smith & Read, 2010) can modulate the interactions between arbuscular mycorrhizal fungi and crops.

4.2 Effect of organic inputs on mycorrhization

In contrast to distance, organic fertilizers had a more noticeable effect on mycorrhization, particularly on the intensity of root colonization. In both millet and groundnuts, treatments based on Guiera residues and farmyard manure increased mycorrhizal intensity compared to the unfertilized control. Linear models show that organic inputs have a more pronounced effect than the mere presence or absence of *Guiera senegalensis*. While the presence of trees and shrubs is often associated with a stimulation of local mycorrhizal potential (Boureima et al., 2019), the average colonization levels (~ 20–30%) confirm the strong and persistent mycotrophic nature of this shrub. This is consistent with previous studies reporting robust associations with arbuscular mycorrhizal fungi in dominant woody perennials of the Sahel, across contrasting land-use contexts (Diagne et al., 2013). This suggests that improvements in organic matter, soil moisture, or the gradual availability of nutrients create an environment favorable to the development of AMF. Our results corroborate with those of (Diedhiou et al., 2009), which indicated that AMF are among the microbial groups most responsive to shrub residues.

Our results do not align with previous observations indicating that moderate organic inputs often have neutral or context-dependent effects on the infectivity of arbuscular mycorrhizal fungi in nutrient-limited systems. In fact, increased levels of nutrients such as phosphorus generally do not promote the development of a large AMF community, as these conditions often hinder root colonization (Ceballos et al., 2013; Verbruggen et al., 2013). However, these effects do not always translate into a significant increase in yield, indicating that biological stimulation does not necessarily imply an immediate agronomic response. Nevertheless, sustainable and innovative cropping systems, particularly those that influence plant nutrition and protection such as organic fertilization should promote beneficial microbial interactions (Plenchette et al., 2005). Although the contribution of AMF appears to be secondary in this system, optimizing shrub density and managing residues could enhance synergies between water redistribution, soil organic matter accumulation, and microbial functioning (Bright et al., 2021; Luedeling et al., 2014). Similarly, certain variations observed in root colonization levels across fields suggest that mycorrhization responds more to natural crop conditions than to a fixed spatial effect. In the Sahelian context, this variability may be linked to fluctuations in rainfall, temperature, and soil moisture, as well as to crop rotation or the management practices applied, which can directly influence root growth, spore survival, and hyphal activity (Augé, 2001).

Conclusion

This study highlights that in *Guiera senegalensis*-based agroforestry systems in the Sahelian zone, arbuscular mycorrhizal fungi are more strongly influenced by organic management practices than by distance from the shrub. Organic fertilization, particularly Guiera residues and farmyard manure, has shown favorable effects on the mycorrhization intensity of associated crops, suggesting that improving soil biological fertility serves as a lever for stimulating AMF activity. Millet appears to respond more sensitively to mycorrhization than groundnuts, although the effects on yield remain variable depending on fertilization contexts and distance. Multi-year monitoring that includes climatic and microbiological parameters would be necessary to better understand the resilience and functioning of mycorrhizal symbioses in the Sahelian environment.

Declarations

Author Contribution

Les auteurs NMH et HFM ont rédigé le texte principal du manuscrit ; SNS, HC et LC ont contribué à la lecture et à la correction selon une rigueur scientifique et académique. Les expérimentations qui ont mené à la collecte des données de ce travail ont été réalisées et suivies par : NMH, MN, BD et AFF. Les traitements statistiques ont été réalisés par NMH et KVDM. Tous les auteurs ont lu le manuscrit avant sa soumission.

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Nombre total de mots (références exclues) : 4197
Nombre de mots du résumé : 248

Figures

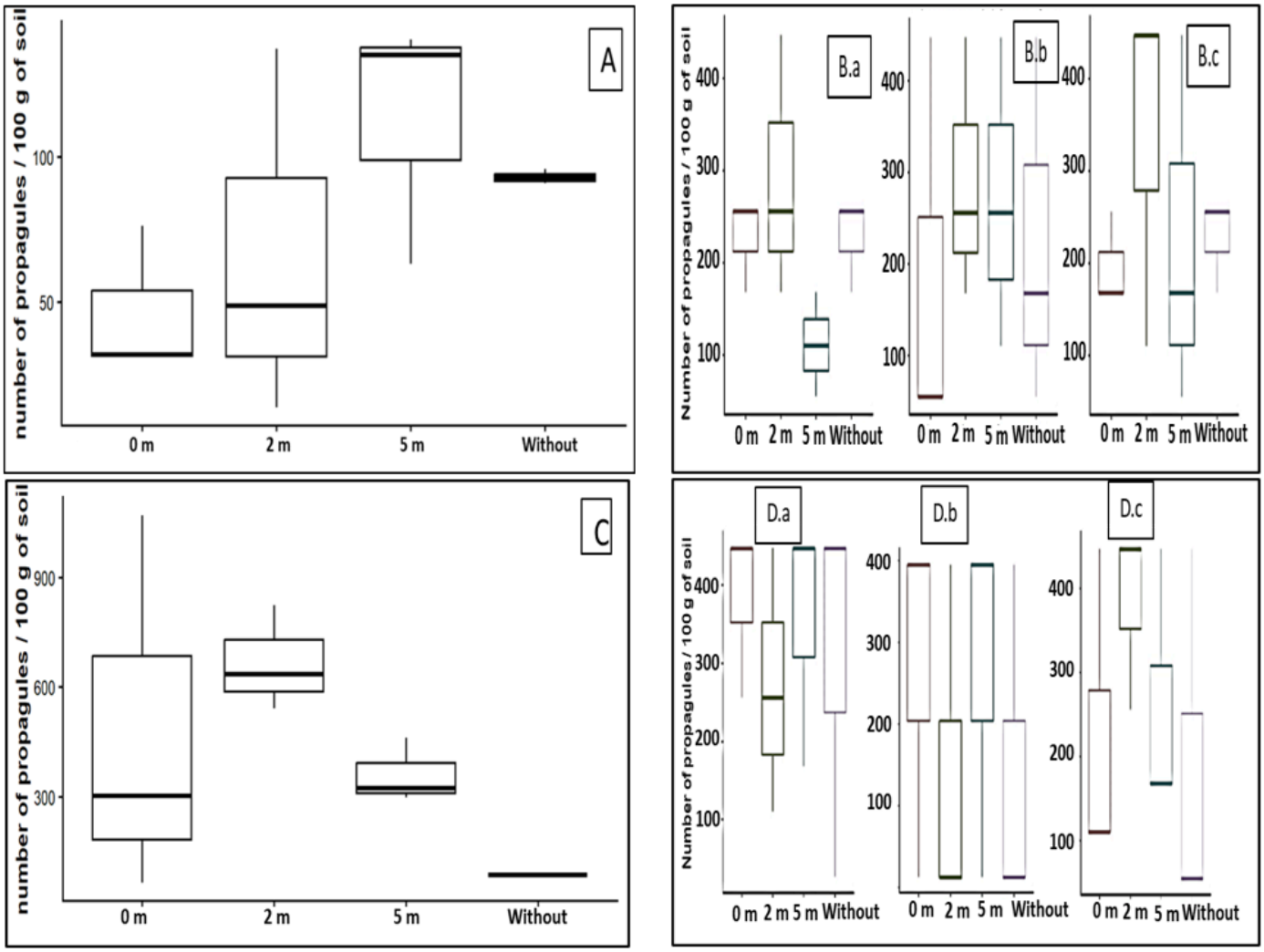


Figure 1

The soil mycorrhizal potential (MPN): A) in soil cultivated with millet in 2023 without fertilization ; B) in soils cultivated with millet and amended in 2024 ; C) in soil cultivated with groundnut in 2023 without fertilization and D) in soils cultivated with groundnut and amended in 2024 (Treatments : a = Control ; b = Horse manure and c = Guiera residues)

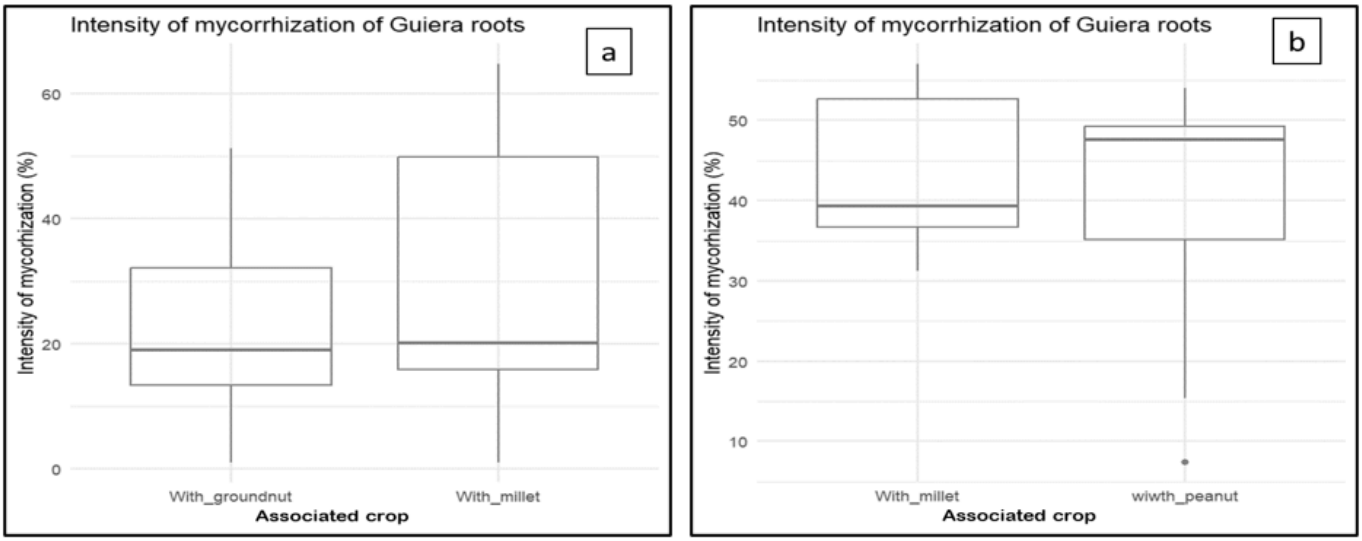


Figure 2

Dynamic of arbuscular mycorrhization in agroforestry system with Guiera senegalensis: a) in 2023; b) 2024

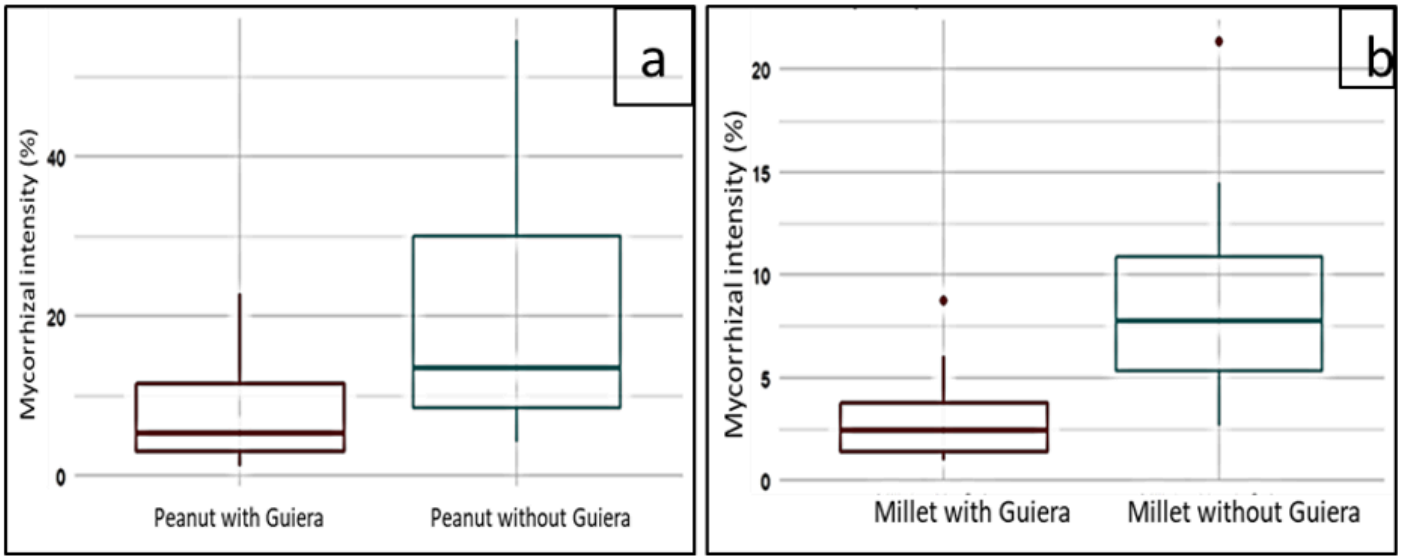


Figure 3

Mycorrhizal colonization of crops in 2023

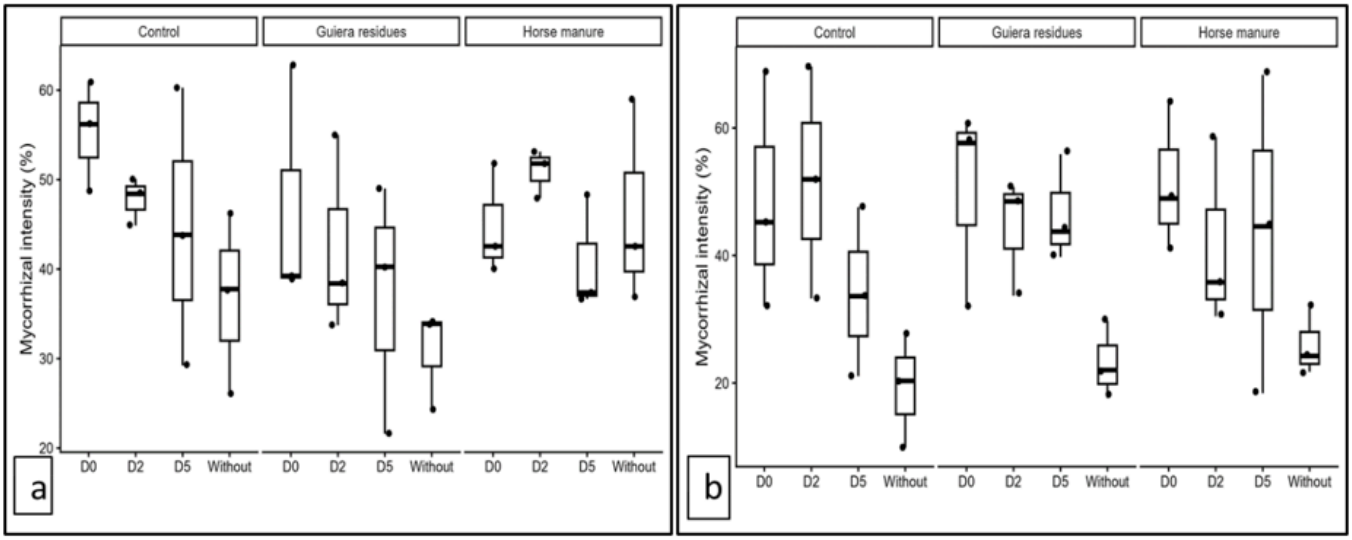


Figure 4

Mycorrhizal dynamics in response to fertility Inputs; a) with peanut; b) with millet

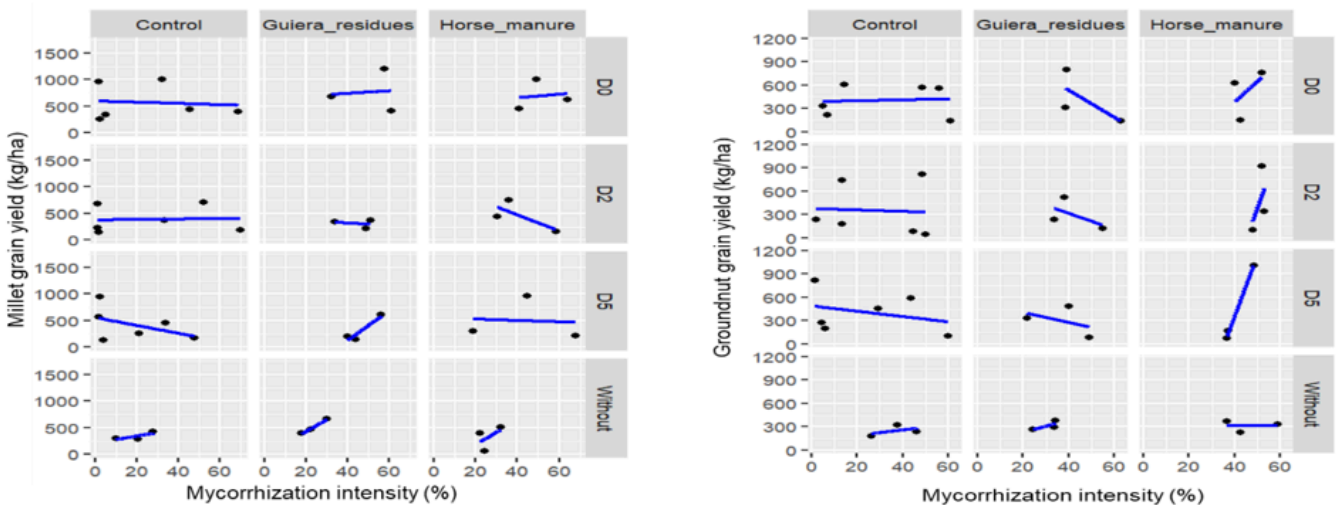


Figure 5

Mycorrhization–yield relationships depend on fertilization treatment and distance from Guiera senegalensis