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Original Article

THE ECOLOGICAL AND AGRICULTURAL IMPACT OF PARKIA BIGLOBOSA ON GROUNDNUT YIELDS IN LOWER CASAMANCE

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Abstract: Since the 1990s, the groundnut sector in Casamance has experienced a profound crisis, characterized by a marked decline in production and the destabilization of local agricultural systems. This downturn is attributed to a combination of interrelated challenges, including severe soil degradation, the deterioration of seed quality, and the escalating impacts of climate change. Among the critical factors exacerbating this crisis is the widespread destruction of trees, driven by the need to expand settlements and secure more arable land. This practice has undermined soil fertility, disrupted ecological balances, and weakened the sustainability of groundnut cultivation.

This study conducts a comprehensive analysis of the groundnut sector crisis in Casamance, with particular attention to the historical context and the multifaceted nature of the challenges involved. Drawing from both historical sources and recent studies, the research examines how the destruction of tree cover has played a central role in aggravating soil erosion, reducing agricultural productivity, and contributing to long-term environmental degradation

Beyond immediate production losses, the study highlights the broader ecological and socio-economic consequences of the crisis. These include the loss of biodiversity, declining ecosystem services, and the weakening of livelihoods dependent on groundnut farming. By tracing the evolution of the crisis and identifying its root causes, the research aims to inform strategic policy responses and sustainable land management practices.

The insights gained from this analysis are essential for developing targeted interventions that address both environmental and agricultural dimensions of the crisis. Ultimately, the study contributes to the ongoing discourse on resilience and sustainability in West African agriculture under changing environmental conditions.

Keywords: Groundnut Sector, Agricultural Crisis, Soil Degradation, Climate Deterioration, Tree Destruction

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a leguminous plant cultivated by more than 100 countries on more than 26.4 million hectares with an average productivity of 1.4 tons per hectare in the world (FAO, 2003; Barraud and Maury, 2004; Ntare et al., 2008). The main producers are China and India, which supply more than 60% of world production. Africa provides 25% of this world ith Nigeria, Senegal and Sudan as the main producers (Kouadio, 2007). In Senegal, groundnut cultivation has indeed developed since the 1960s, as a cash crop intended for export with increasing openness to the world market (Freud, 1997). This crop was the driving force behind the development of the Senegalese economy and provided up to 80% of exports while providing most of the monetary income in rural areas (Ndéné, 2011).

However, from the 1990s, unfortunately, a real crisis in the groundnut sector was observed. This crisis has manifested itself particularly in Casamance, by a drastic drop in production, due to various constraints including the degradation of soil and seed capital, in addition to the current deterioration of the climate, etc. (Montfort, 2005; Ndéné, 2011). One of the main causes of most of these constraints was, in fact, the destruction of a large number of trees in the agricultural systems in order to enlarge the dwellings and to have more consistent land for agriculture (Chevalier, 1924; Solly et al., 2020).

To overcome these constraints and raise the level of groundnut production in rural areas while preserving the most important woody biodiversity; the judicious association of crops and trees could be one of the best solutions. Indeed, according to some authors, the association of crops and certain woody species constitutes a sustainable production system with multiple agronomic, economic and environmental benefits (Julier et al., 2014).Among the woody species likely to provide as many services in Lower Casamance, the *néré* (*Parkia biglobosa*) is one of the best candidates, in view of the multiple socio-economic and environmental advantages of which it has given itself the prestige, to the great benefit of rural populations (Juhé-Beaulaton and Gutierrez, 2002; Goudiaby, 2013; Diatta et al., 2020). Similarly, from an agronomic point of view, characterized as a deciduous species and considered as a legume, néré (*P. biglobosa*) would substantially improve fertility (Sanou et al., 2010; Buba, 2015; Alo and Aweto, 2018). This could indeed make it a very favorable species in intercropping systems, for sustainable management of soil nutrients and overall the implementation of more sustainable and profitable agricultural practices. This is of fundamental importance given the need to improve groundnut production in Senegal while making the best use of natural resources and building resilience to climate change.

Therefore, with a view to enhancing the association between *néré* (*P. biglobosa*) and food crops in production systems in Senegal and particularly in Casamance, it would be essential initially to assess the impact of litter of the species on some crops. It is in this sense that this study was conducted with the aim of determining the effect of *néré* litter on the parameters of growth and production of peanuts.

MATERIALS AND METHODS

Study area

The study was carried out in the Agroforestry application farm of the Agroforestry and Ecology Laboratory of the Assane Seck University of Ziguinchor located in the Department of Ziguinchor. This area of Lower Casamance has a climate of the South-Sudanian coastal type and is essentially characterized by two seasons: a dry season which extends from October to May and a rainy season which goes from June to mid-October. The average annual rainfall is estimated at about 1200 mm with an average temperature of 27°C (Sagna, 2005) (Figure 1).

Plant

The plant material tested in this study is the peanut variety "*Kom-Kom*". This variety newly synthesized by the Senegalese Institute of Agricultural Research is intended for popularization in order to meet the nutritional and agronomic needs of the populations.

Litter doses

The litter studied during this research consists of leaves and pods of *P. biglobosa*. The leaves were collected directly from the plants of the species and the pods collected from fruit processors. These leaves and pods were then dried at 75°C in an oven for 72 h, then ground using a mill. The shredded dried leaves on the one hand, and pods on the other hand were then taken away at different doses, in 0.48 m^2 size bins containing poor sand. The doses of shredded leaves used are F1 (500 g/m^2 of sand), F2 (1000 g/m^2 of sand), F3 (1500 g/m^2 of sand) and F4 (2000 g/m^2 of sand). The doses of ground pods used are G1 (300 g/m^2 of sand), G2 (600 g/m^2 of sand), G3 (900 g/m^2 of sand) and G4 (1200 g/m^2 of sand) (Table 1). These different doses constituted the different treatments tested during this study. A treatment consisting of 0 g/m^2 was added as a control.

Incubation

The sand-dose mixtures in the different tanks were incubated for a period of two months. These mixtures were moistened and turned every 5 days during this incubation time to accelerate the processes of humification and mineralization of the litter.

Experimental design

The experimental design adopted in the context of this study is that of the randomized block with a factor (litter dose) repeated three. Each of these blocks contains 9 trays which contain the different doses tested (four doses of shredded leaves, four doses of shredded pod and the control). A spacing of 1 m was observed between the blocks and another of 0.50 m between the different bins within each block (Figure 2).

Data collection and processing

The data collected during this study concerned the following parameters

Morphology (height, stem, leaf)

The height (in cm) of the plants was measured every 15 days until the 60th day after sowing. The number of stems and leaves were counted for each groundnut plant, also every 15 days and this, until the 60th day after sowing.

F1	Leaves	500	240
F2	Leaves	1000	480
F3	Leaves	1500	720
F4	Leaves	2000	960
G1	Pod	300	144
G2	Pod	600	288
G3	Pod	900	432
G4	Pod	1200	576
T (control)		0	0

Phenology

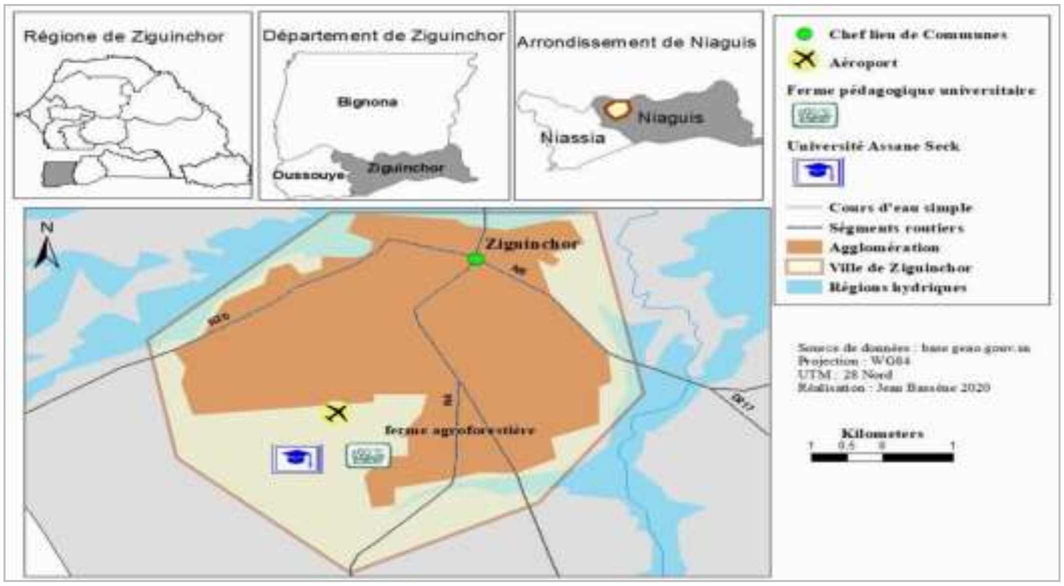


Figure 1. Location map of the study site.

Table 1. Treatments and litter doses used.

Treatment	Type	Dose (g/m^2)	Dose (g/bin)

The dates between sowing 50% flowering and sowing 80% maturity were recorded during this study.

Physiology

The chlorophyll content of the leaves in each treatment was measured using the SPAD-502 Plus chlorophyllmeter device and carried out 4 times (day) during the vegetative phase.

Potential yield

For each bin (treatment) where the groundnut reached maturity, the harvest was carried out, then the seeds detached and weighed. The variation in potential yield was calculated using the following formula:

Grain yield/m^2 = NP × NGP × PMG (CIRAD 2005), where NP = number of plants per m^2; NGP = number of grains per plant and PMG = average weight of a grain.

Biomass

The aerial and root biomass was collected and dried in an oven at a temperature of 75°C for 48 h. The dry biomasses (aerial and root) obtained were then weighed using a 1/1000 precision balance.

The data collected was subjected to analysis of variance (ANOVA) using R 4.1.1 software. The Student-NewmanKeuls (SNK) test was used to compare the means of the different treatments.

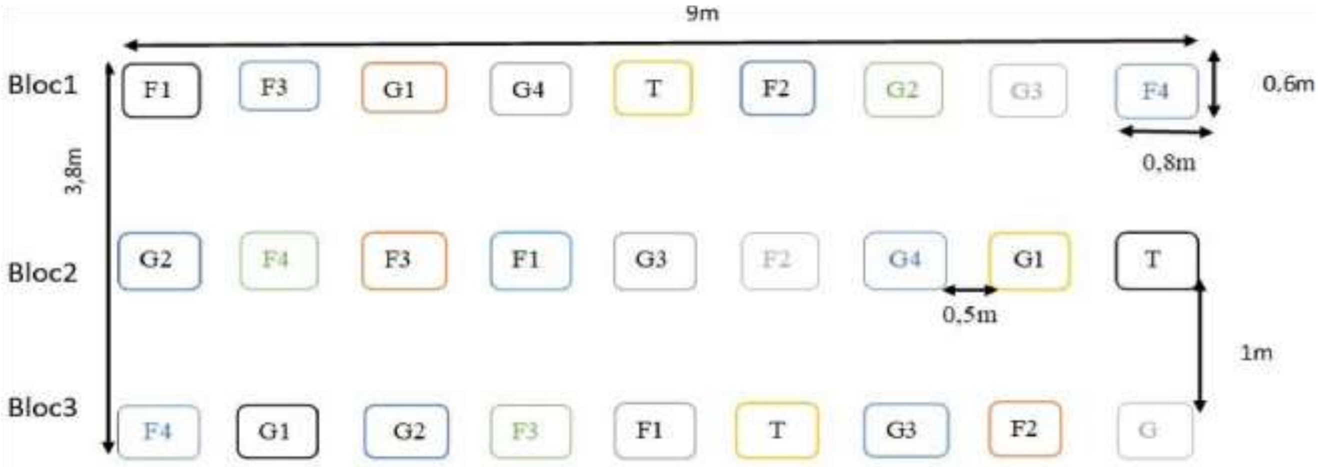


Figure 2. Experimental design.

RESULTS

Height

Figure 3 represents the growth in height (cm) of the plants of the different treatments as a function of time (between 15th and 60th Days after sowing DAS). In Figure 3, however, the curves follow a strongly increasing pace between the date 15 DAS and 45 DAS. It is from 45 DAS that all of these curves experienced a slight constancy and/or decrease in heights and this until the date 60 DAS. However, during this evolution, the growth of the height of the plants in the treatments G3, G4, F4 and F3 was stronger than the rest of the treatments and this, largely vis-à-vis the plants of the treatments F1, G1 and T. The height of groundnut plants varied greatly between the treatments studied; and this from the 15^{th} DAS, until the 60^{th} DAS with a respective probability (pr=0.0005; pr=0.0075; pr=0.0014; 0.0002) (Table 2). Thus, regardless of these measurement dates, it is globally the large doses G3 and F3 that stimulated the height growth of the groundnut more, and this, significantly compared to the control T.

Stem

Figure 4 represents the stem production of the plants in the different treatments as a function of the days after sowing (between 15 and 60th DAS). For all the curves in Figure 4, we observe a strong increase in the number of stems between the date 15 DAS and that of 45 DAS. A slight increase and/or consistency in the number of stems on all treatments was noted from the 45 DAS date to the 60 DAS date except for treatments G4, F3 and G2. During this evolution, the production of stems of the plants in the treatments G4, G3, F4 and F3 was stronger than the rest of the treatments and this, largely vis-à-vis the treatments G1, F1 and T.

The number of stems counted also varied greatly between the treatments studied at 15 DAS (pr=0.003), at 30 DAS (pr=0.006), at 45 DAS (pr<0.0001) and at 60 DAS (pr<0. 0001) (Table 3). Regardless of these observation dates, it is overall the treatments with the highest doses, namely G4, G3, F4 and F3, which produced more ramifications. These rods produced were however significantly higher compared to the low dose and no dose treatments namely G1 and F1, and the control (T).

Leaves

Figure 5 represents the leaf production of the plants in the different treatments as a function of time (between 15th and 60th DAS). For all the curves in this figure, we see a strong increase in the number of leaves between the date 15 DAS and that 60 DAS. During this evolution, the production of leaves of the plants in the treatments G4, F4 and G3 was stronger than the rest of the treatments and this, largely vis-à-vis the treatments G2, F1, G1 and T. The number of leaves counted also varied significantly between the different treatments tested at 15 days (Pr=0.00027), 30 days (Pr=0.00040), 45 days (Pr<0.0001) and 60 days (Pr=0.00019) (Table 4).

Regardless of these observation dates, the highest leaf counts were generally observed in the treatments with the highest pod litter rates (G4 and G3) and the highest leaf litter rates (F4 and F3). However, these leaf numbers were significantly higher compared to the T (control), G1 and F1 treatments overall. Treatments with the same letter are not statistically different at the 5% level (p =

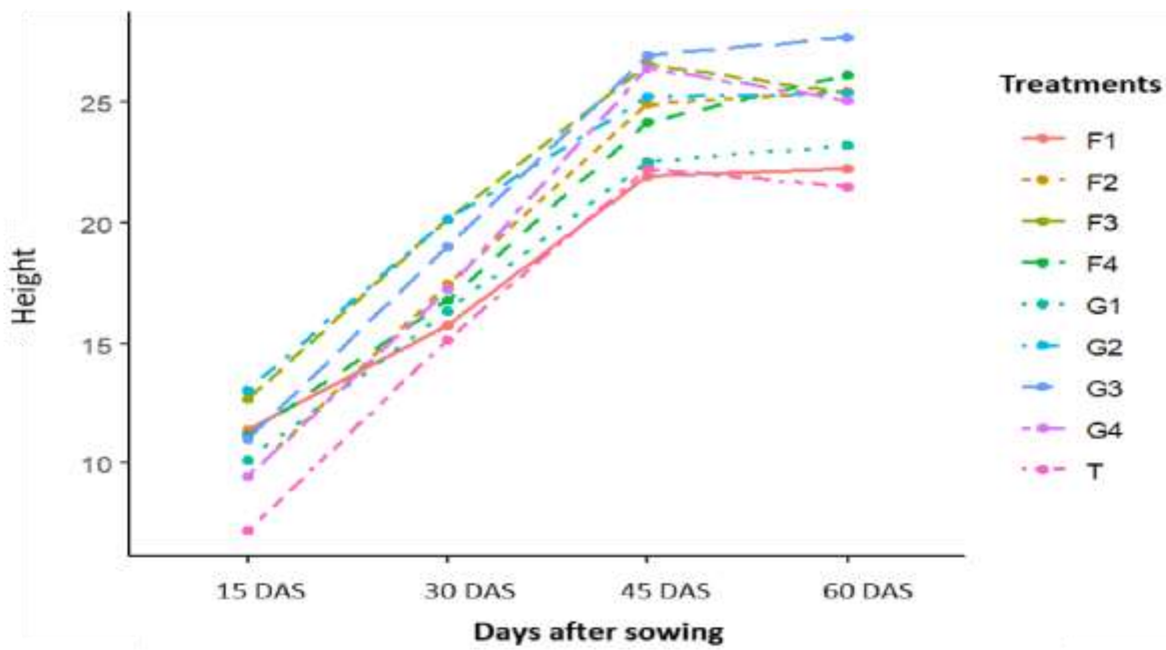


Figure 3. Evolution of the height (cm) of the plants as a function of time.

Table 2. Variation in height between treatments at each observation date.

Treatment	15DAS	30DAS	45DAS	60DAS
G3	11.04[a]	19[ab]	27.0[a]	27.7[a]
F3	12.62[a]	20.2[a]	26.6[ab]	25.4[abc]
G2	13[a]	20.2[a]	25.2[abc]	25.4[abc]
F4	11.2[a]	16.7[ab]	24.2[abc]	26.1[ab]
F2	9.4a[b]	17.4[ab]	24.9[abc]	25.5[abc]
G4	9.4[ab]	17.2[ab]	26.4[abc]	25.1[abc]

G1	10.1[ab]	16.3[ab]	22.5[abc]	23.2[bc]
F1	11.2[a]	15.7[ab]	21.9[c]	22.2[bc]
T	7.2[b]	15.1[b]	22.2[bc]	21.5[c]
Mean	10.59 ± 1.14	17.55 ± 1.38	24.56 ± 1.31	24.69 ± 1.21
Pr > F	0.0005	0.0075	0.0014	0.0002

Treatments assigned the same letter are not statistically different at the 5% threshold (p = 0.05) according to the Student-Newman Keuls test. **Chlorophyll**

Figure 6 shows the evolution of the SPAD chlorophyll values of the plants during the vegetative phase in the different treatments as a function of time (4 days). This evolution shows a relatively constant trend during the four days of measurement. Thus, treatments G1 and T with the lowest values evolved globally between 24 and 25.5 and the rest of the treatments between 26.5 and 29. The chlorophyll values obtained for each treatment varied significantly during this study (Pr= 1.69e-11) (Figure 7). In relation to these values, two significantly different groups (a and b) were illustrated. Thus, the bedding doses G1 and T belonging to group b obtained the lowest values, significantly compared to the rest of the doses.

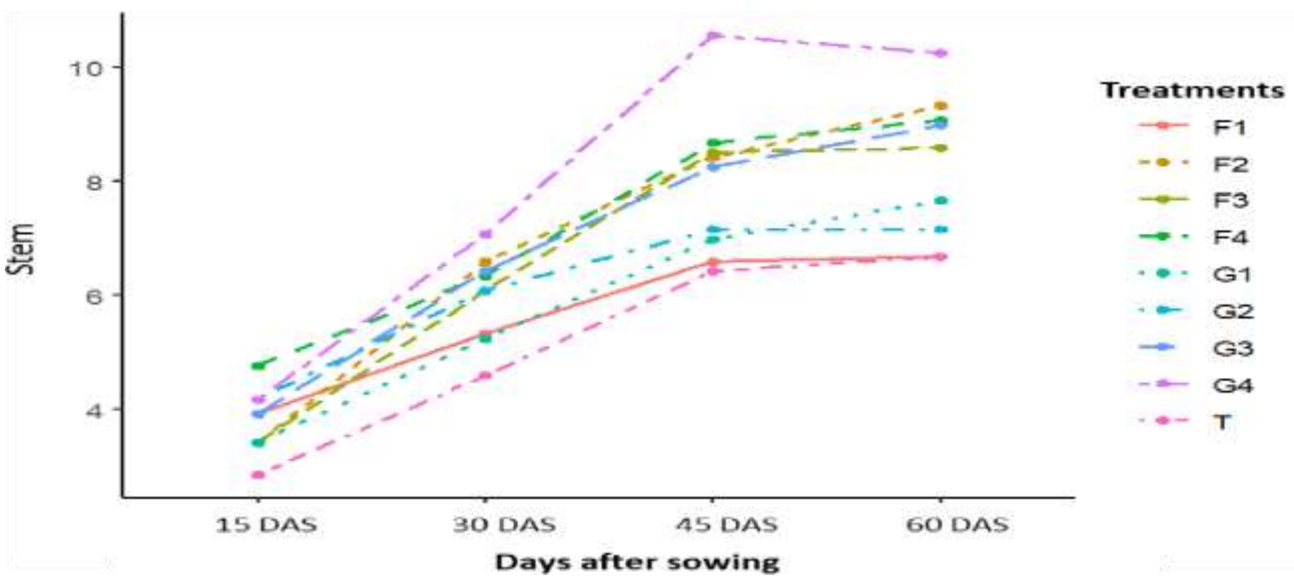


Figure 4. Evolution of stem production over time.

Table 3. Variation in tillering between treatments at each observation date.

Treatment	Tillers 15	Tillers 30	Tillers 45	Tillers 60
G4	4.2[ab]	7.1[a]	10.6[a]	10.3[a]
F4	4.7[a]	6.3[ab]	8.7[b]	9.1[abc]
F2	3.4[ab]	6.6[ab]	8.4[bc]	9.3[ab]

G3	3.9^{ab}	6.4^{ab}	8.3^{bc}	9.0^{abc}
F3	3.4^{ab}	6.1^{ab}	8.5^{bc}	8.6^{abc}
G2	4.2^{ab}	6.1^{ab}	7.2^{bc}	7.2^{bc}
G1	3.4^{ab}	5.3^{ab}	7.0^{bc}	7.6^{bc}
F1	3.9^{ab}	5.3^{ab}	6.6^{bc}	6.7^{c}
T	2.8b	4.6b	6.4c	6.7c
Means	3.77 ± 0.39	5.97 ± 0.57	7.95 ± 0.61	8.26 ± 0.71
Pr > F	0.003	0.006	<0.0001	<0.0001

Treatments assigned the same letter are not statistically different at the 5% threshold (p = 0.05) according to the Student-Newman Keuls test.

Cycle (flowering and maturity)

The number of days from sowing to 50% flowering (Pr=0.982) and from sowing to maturity (Pr=0.925) did not vary much between the different treatments tested (Figure 8). However, flowering was later in the small bedding doses (F1 and G1) and the control (T).

Concerning maturity, it was however earlier on the control dose (T) with maturities generally varying between 74 and 87 days and going down to 61 days.

Yield

A high variation (Pr = 4.22e-09) was obtained between the different doses of litter tested with respect to the seed yields obtained during this study (Figure 9). Thus, two significantly different groups (a and b) were distinguished.

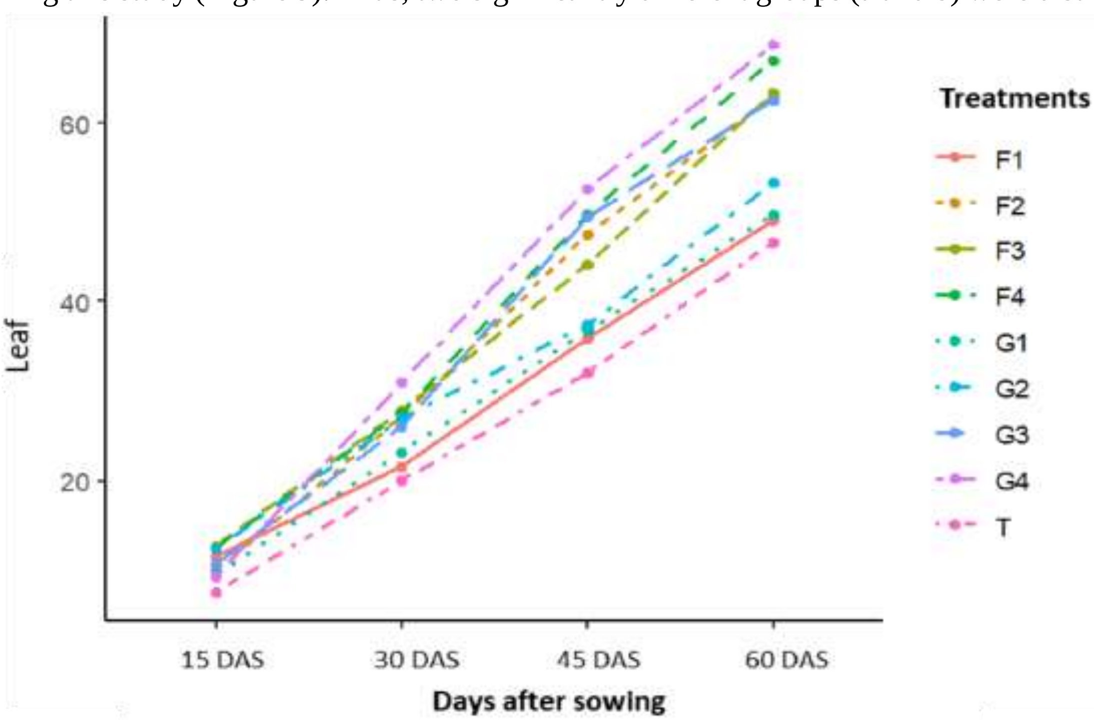


Figure 5. Evolution of leaf production as a function of time.

Table 4. Variation in number of leaves between treatments at each observation date.

Traitement	F15	F30	F45	F60
F4	12.3[a]	27.4[ab]	49.6[a]	66.8[a]
F3	12.4[ab]	27.7[ab]	44.0[abc]	63.3[ab]
G4	9.1[ab]	30.8[a]	52.5[a]	68.7[a]
F2	9.9[ab]	27.0[ab]	47.4[ab]	62.8[ab]
G2	12.3[a]	26.8[ab]	37.3[bcd]	53.3[ab]
G3	10.5[ab]	25.8[abc]	49.4[a]	62.3[ab]
F1	11.5[a]	21.5[bc]	35.7[cd]	49.0[b]
G1	9.5[ab]	23.1[bc]	36.7[bcd]	49.6[b]
T	7.4[b]	19.5[c]	31.9[d]	46.4[b]
Means	10.54 ± 1.08	25.52 ± 2.23	42.74 ± 3.78	58.05 ± 5.19
Pr > F	0.00027	0.00040	0.00000	0.00019

The first group contains the bedding doses G3, F2, F3 and F4, a group whose yields were significantly higher than the second group (F1, T, G1, G2 and G4).

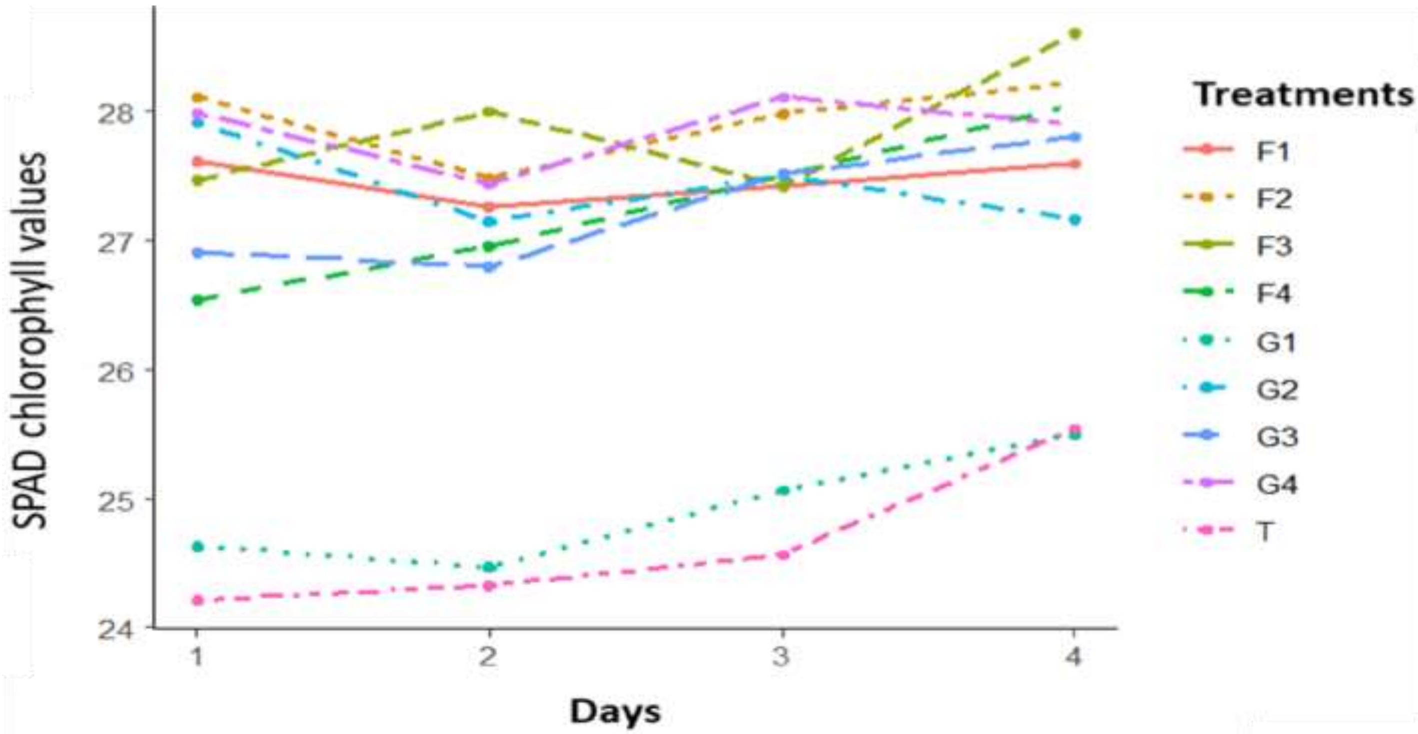
Biomass

Dry root biomass (Pr=0.0383) varied significantly between the different bedding doses tested. This was in contrast to the dry above-ground biomass (Pr=0.094), which varied little between the different bedding doses. However, the SNK test shows that for dry root biomass, the F2 dose (8.33 g) recorded the highest value compared to the T treatments (4.00). However, there is not much difference between the F2 treatment and the rest of the treatments (Figure 10).

Relations between variables and between treatments

The two axes chosen to synthesize the variables and visualize the variability between the different treatments each explain 80% of the total inertia. Thus, we observe an overall correlation between variables such as biomass (aerial and root), number of leaves and stems, height and yield. However, these variables remained uncorrelated with the 50% flowering date, as well as the maturity date. However, flowering date 50% and maturity date were very negatively correlated (-68%).

On the basis of the dispersion of these variables, it appears that the F2, F3, F4, G3 and G4 treatments are generally opposed to the G2, F1, G1 and T (control) treatments. The treatments F2, F3, F4, G3 and G4 are indeed characterized by high biomass, height, number of leaves and stems as well as high yields which were especially low in the rest of the treatments. The control treatment being marked by an early flowering, it remains however very opposed to the G2 treatment which is influenced by an early maturity and high chlorophyll values. Treatments G1 and F1 were very particular, because as for the control (T) and G2, they were very opposed to the rest of the variables for their low values of biomass, height, number of leaves and stems, but also yield (Figures 11 and 12).



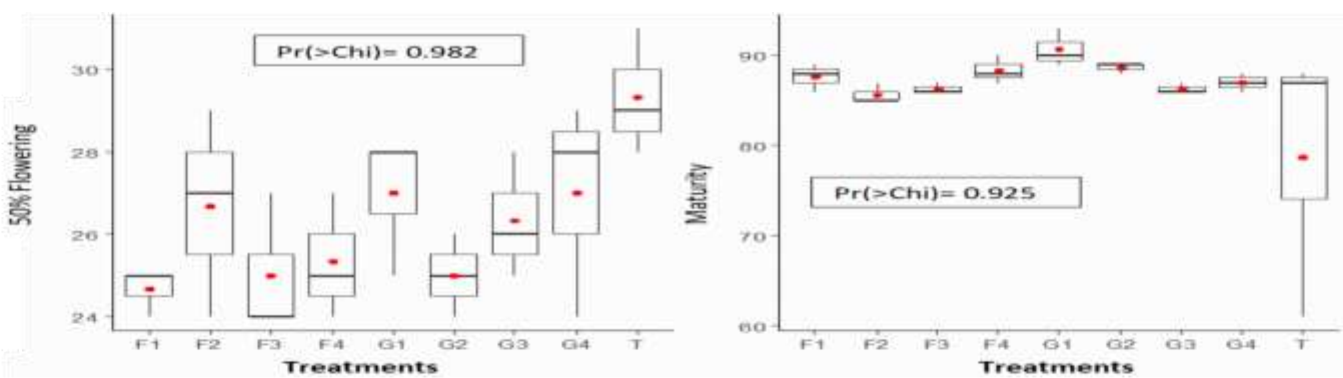


Figure 8. Cycle variation (50% flowering and maturity) according to treatments.

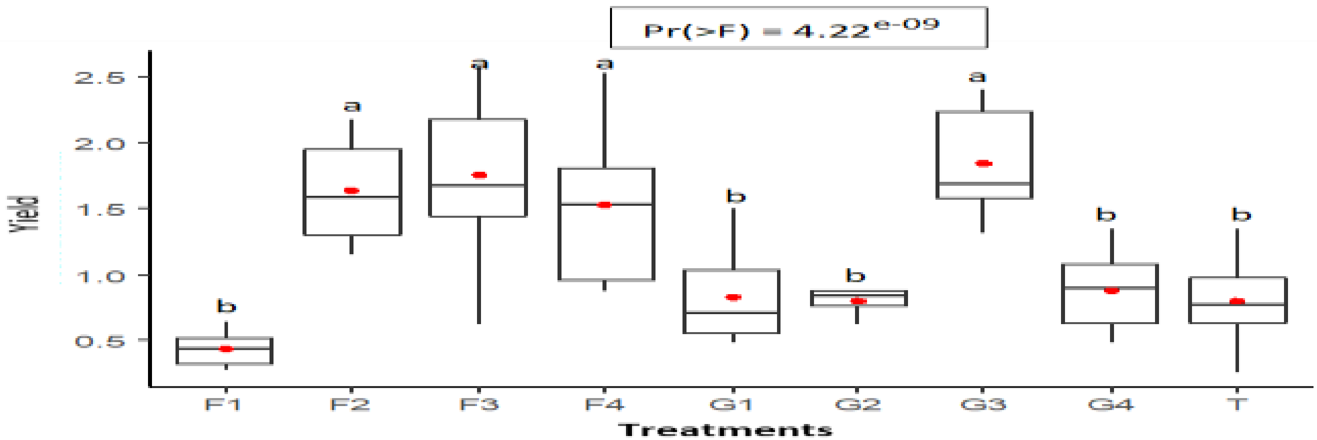


Figure 9. Variation in seed yield by treatment.

DISCUSSION

In this study, the evaluation of the effect of litter (leaf and pod) of *P. biglobosa* on peanut in station allowed to determine its influence on: the height, the production of stems and leaves, then the contents in chlorophyll of these leaves, and finally on the life cycle and the G3, F3 and F4, stimulated the most growth in height as production of peanut plants. The results obtained show well as the production of stems and leaves. This could be that the treatments with high doses of litter, notably G4, explained not only by the amount of litter provided, but also by the richness of this litter in mineral (N, P, K, trace elements...) and organic elements (Uyovbisere and Elemo, 2002; Bayala et al., 2005; Buba, 2015; Aboyeji et al., 2019). The confirmation of these results is however reported by some authors (Uyovbisere and Elemo, 2002; Massai Tchima et al., 2020) who demonstrated the very beneficial effect of P. biglobosa leaf litter on maize and tomato growth.

The evolution of height growth, as well as leaf and stalk production seemed to follow a normal cycle in the different doses of litter tested. Indeed, the growth and development of peanut plants followed the same trend in the different doses of litter tested in this study. The chlorophyll content of the leaves of the different peanut plants also varied greatly between litters doses tested in this study. Indeed, the highest SPAD chlorophyll values were mainly observed in the treatments that received the large bedding doses, significantly in contrast to the treatment consisting of the small pod bedding dose G1 and the control (T). This could be related to the significant gradual release of mineral elements made available to the plant through the decomposition of the P. biglobosa litter supplied. According to some authors, the chlorophyll content of leaves is highly correlated with the availability of nutrients, particularly nitrogen (Pouzet et al., 2007). The results of this study are similar to those of several others for which the amount of manure applied had a positive influence on the chlorophyll content of the crop studied (Habiba et al., 2012; Nakro et al., 2020). However, the very low chlorophyll content observed in the leaves of the G1 treatment plants could be related to a possible rapid depletion of the nutrient stock from the potentially accelerated decomposition of the small dose of pod litter.

Evaluation of the cycles (50% flowering and maturity) revealed that plants in the different treatments did not vary much in either their sowing (50%) heading dates or their sowing-maturity dates. This proves, in effect, that P. biglobosa litter has no impact on the peanut cycle, which is undoubtedly a varietal character little influenced by environmental conditions. With sowing (50%) flowering cycles varying between 24 and 35 days and sowingmaturity cycles varying mostly between 75 and 93 days, we can see that these results are in line with many others, regarding the peanut cycle (Schilling et al., 1996; Issa et al., 2016; Zagre et al., 2021).

The highest peanut pod yields were mainly observed with treatments consisting of P. biglobosa leaf litter, namely F2, F3 and F4. Among the pod litter treatments, it was mainly the G3 treatment that was very productive in terms of yield. These results corroborate those of many others, for whom P. biglobosa leaf litter significantly improved soil fertility, as well as the yield of the crops studied (Abdullahi et al., 2015; Aboyeji et al., 2019; Massai Tchima et al., 2020). However, it should be noted that with small doses of leaf litter, especially in this case, with the F1 dose, the yields obtained are low and are not significantly different from the control (T). Concerning the pod litter, it appears that only the G3 dose recorded significantly higher yields than the control (T). This would suggest that the G3 pod dose is an optimal dose for better peanut yield. Thus, the G4 dose, having very favorably influenced vegetative parameters and plant biomass (above and below ground), seems to induce an excess of nitrogen for the plants. According to some authors, an excess of nitrogen has this tendency to deregulate the growth and development of plants by stimulating the growth of vegetative parts and thus affect the yields especially for groundnut which is a legume (Tremblin and Marouf, 2021).

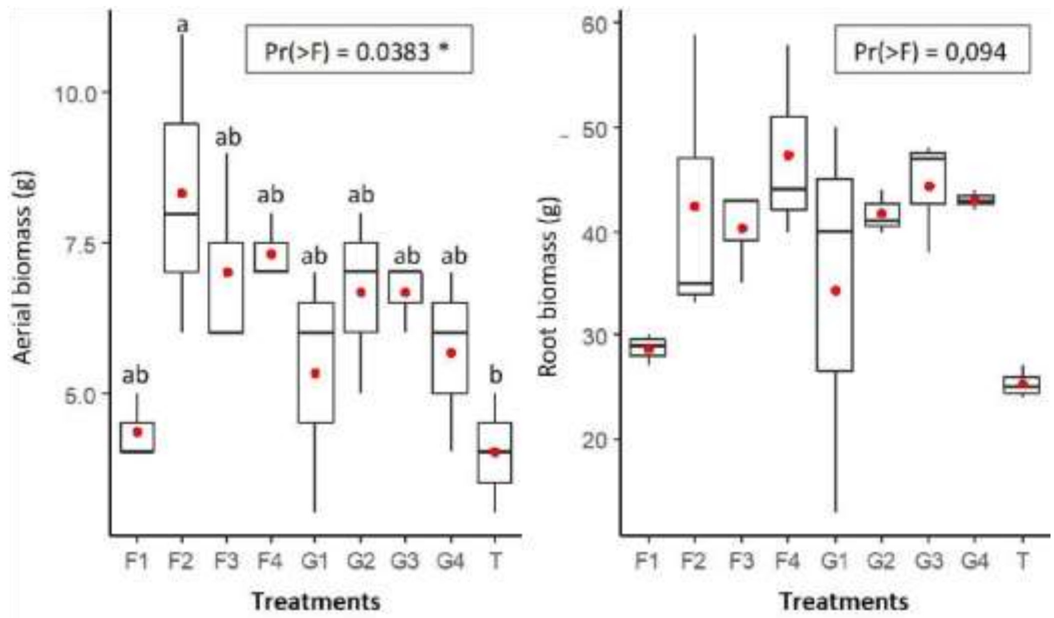


Figure 10. Variation in dry biomass (aerial and root) between treatments.

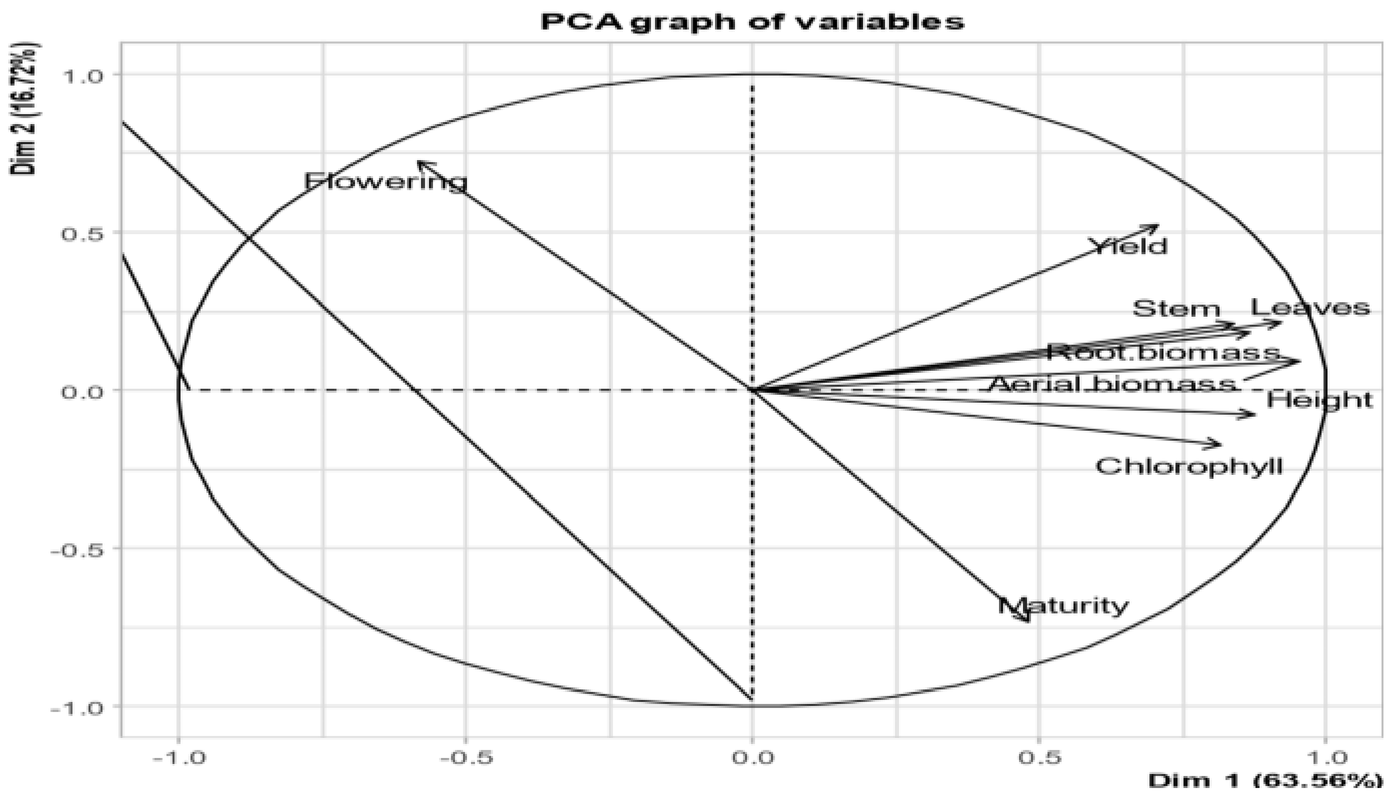


Figure 11. Graph of the principal component analysis of the different variables.

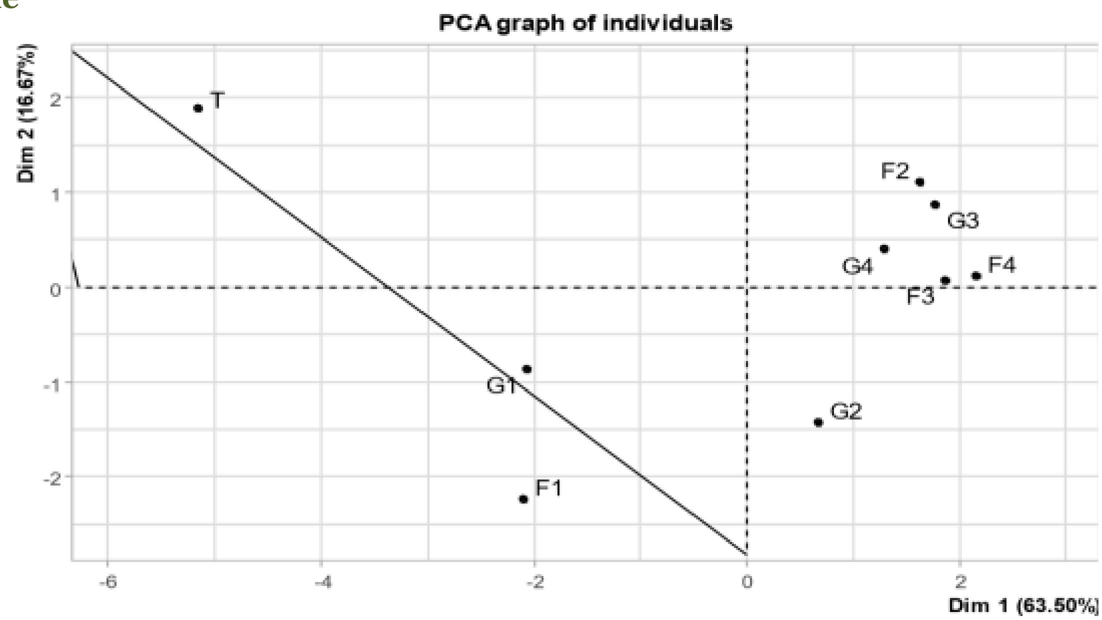


Figure 12. Principal component plot of the different treatments.

Conclusion

Enhancing soil fertility has emerged as a paramount concern in agricultural research and production. In response to this challenge, the objective of this study was to contribute to the improvement of soil fertility in lower Casamance by utilizing *P. biglobosa* litter in peanut cultivation. The findings of this study indicate that modest doses lead to a favorable increase in peanut yield. Despite this, there is an observable improvement in yields when compared to the control group. The conclusions drawn from this study reinforce the efficacy of agroforestry systems in enhancing and sustaining soil fertility, thereby facilitating an increase in overall production.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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