American Journal of Plant Sciences, 2021, 12, 1515-1527
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Influence of *Pterocarpus erinaceus* Poir. on the Growth and Yields of Groundnut (*Arachis hypogea* L.) in Agroforestry Parks in the Districts of Tenghory and Kataba 1 (Bignona Department, Lower Casamance)

Abdou Goudiaby[1], Ismaïla Coly[1*], Aliou Badji[1], Mamadou Kane[1], Daouda Ngom[2]

[1]Laboratory of Agroforestry and Ecology (LAFE), Department of Agroforestry, Assane SECK University, Ziguinchor, Senegal
[2]Plant Ecology Laboratory, Department of Plant Biology, Cheikh Anta DIOP University, Dakar, Senegal
Email: *icoly@univ-zig.sn

How to cite this paper: Goudiaby, A., Coly, I., Badji, A., Kane, M. and Ngom, D. (2021) Influence of *Pterocarpus erinaceus* Poir. on the Growth and Yields of Groundnut (*Arachis hypogea* L.) in Agroforestry Parks in the Districts of Tenghory and Kataba 1 (Bignona Department, Lower Casamance). *American Journal of Plant Sciences*, **12**, 1515-1527.
https://doi.org/10.4236/ajps.2021.1210107

Received: September 3, 2021
Accepted: October 15, 2021
Published: October 18, 2021

Abstract

In Lower Casamance, *Pterocarpus erinaceus* occupies a very important place in agroforestry parks. It is often grown in association with the most important cash crop of the area, groundnut *(Arachis hypogea L.)*. Thus, the objective of this study is to contribute to a better understanding of the interactions between trees and groundnut cultivation in agroforestry parks in Lower Casamance. To this end, in each of the two districts (Tenghory and Kataba 1) three *Pterocarpus erinaceus* trees were selected in three separate communes. For each *P. erinaceus* tree selected and following each of the four cardinal directions, three situations were defined: at R/2, at 1.5 R and at 2 R from the trunk, with R the radius of the crown. Thus, 12 yield squares were installed around each selected tree, for a total of 72 yield squares installed in the two districts. The parameters measured were the height of the peanut plants, the number of pods produced per plant, and the yield in flakes and pods. The results show that geographical orientation significantly influenced plant height ($p = 0.004$) but not the number of pods/plant ($p = 0.6$). As for the distance to the trunk of *Pterocarpus erinaceus*, it induced a significant variation in the number of pods/plant ($p = 0.009$) but did not induce a significant effect on the other parameters. Yields varied between 1.56 Tons M S /ha and 2.02 Tons M S /ha for the hay, and between 1.03 Tons M S /ha and 1.45 Tons M S/ha for the pods. The results of this study constitute a useful source of information for a better management of the productivity of the agroforestry parks of the department of Bignona.

Keywords

Arachis hypogea, Pterocarpus erinaceus, Yield, Tenghory and Kataba 1

1. Introduction

For the past few decades, the population in Lower Casamance has been marked by a strong increase [1]. This demographic growth has resulted in strong pressure on natural resources. This results in soil degradation accentuated by climatic hazards with a corollary of a drastic decrease in agricultural yields. Indeed, in Senegal, the 2011-2012 agricultural season was marked by a sharp decline in groundnut production (59% compared to the previous year and 24% compared to the average of the last five years), following a poor distribution and early cessation of rainfall [2]. In Basse Casamance, the areas planted to groundnuts are the largest with a dominance in the department of Bignona with 24,829 ha for a production of 30,213 tons on 26,691 hectares [1]. In addition, given the problems of environmental pollution due to the chemical intensification of agriculture, farmers are tending to move towards more environmentally friendly agricultural practices. Thus, in the agrarian systems of Lower Casamance, in order to preserve soil fertility and improve their income, farmers tend to conserve woody species of agronomic or socioeconomic interest in their plots. Among these species is *Pterocarpus erinaceus*. In the fields, *Pterocarpus erinaceus* is grown in association with crops, particularly groundnuts (*Arachis hypogea* L.), which are very important in the area's farms. This traditional land use system that associates trees and crops in a random spatial arrangement is called agroforestry park [3]. The species *Pterocarpus erinaceus* is highly prized by the populations for its many uses including the production of energy wood and timber [4], the production of fodder for livestock [5], pharmacopoeia and medicine [6]. However, despite its socioeconomic importance in farming in Lower Casamance, its influence on groundnut (*Arachis hypogea*) in agroforestry parks remains little studied. It is in this context that this study has set itself the general objective of contributing to a better understanding of the interactions between *Pterocarpus erinaceus* and the groundnut crop in the agroforestry parks of the department of Bignona.

2. Materials and Methods

2.1. Presentation of the Study Area

The study was conducted in the districts of Tenghory and Kataba 1. The latter belong to the department of Bignona and the region of Ziguinchor (**Figure 1**). The Tenghory district is located in the east of the department of Bignona and is bordered to the north by the district of Sindian, to the south by the commune of Niaguis, to the west by the district of Tendouck, and to the east by the village of Djibabouya (Sédhiou region).

Belonging to the Lower Casamance, these districts have a climate marked by the existence of two seasons: a dry season and a rainy season and are characterized by rainfall that is everywhere above 1000 mm [7]. The average annual rainfall over the 1980-2018 series is 1302.04 mm [8] (**Figure 2**). The average monthly minimum and maximum temperature values are 21.5˚C and 35˚C, respectively, during the period 1990-2016 [8].

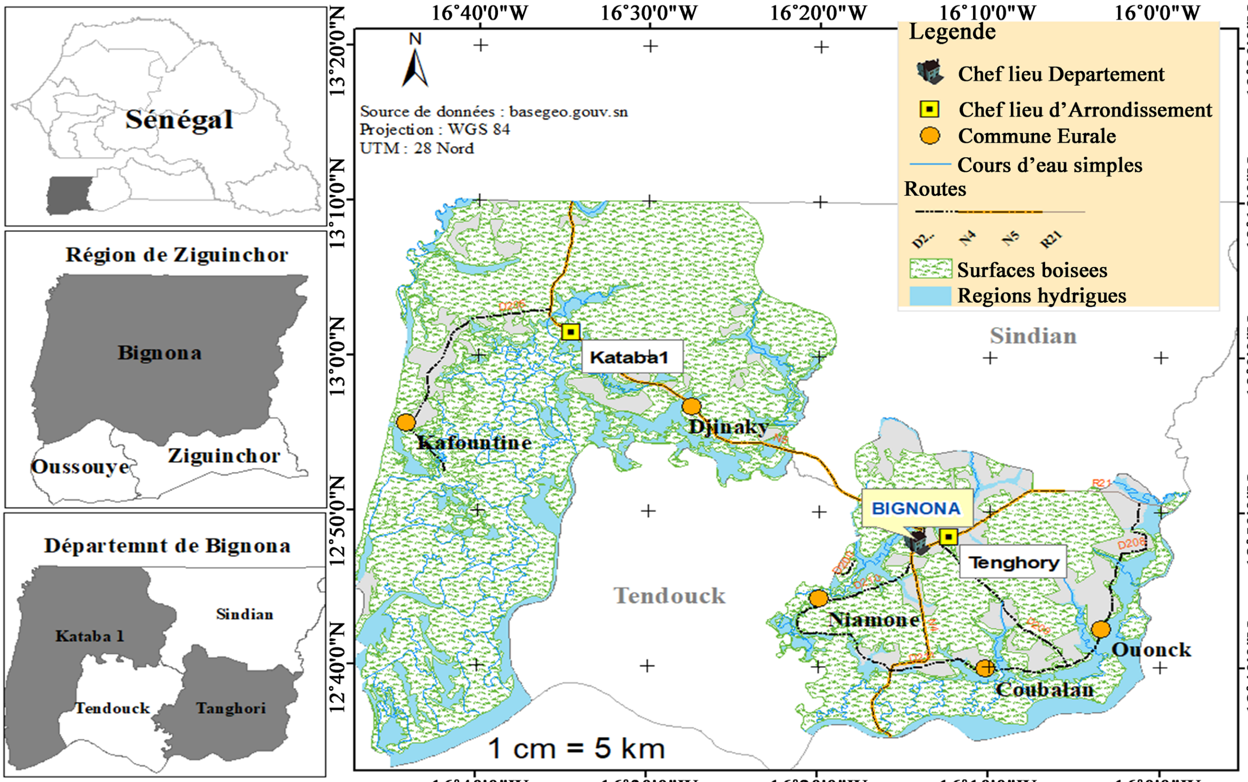

Figure 1. Location map of the study area.

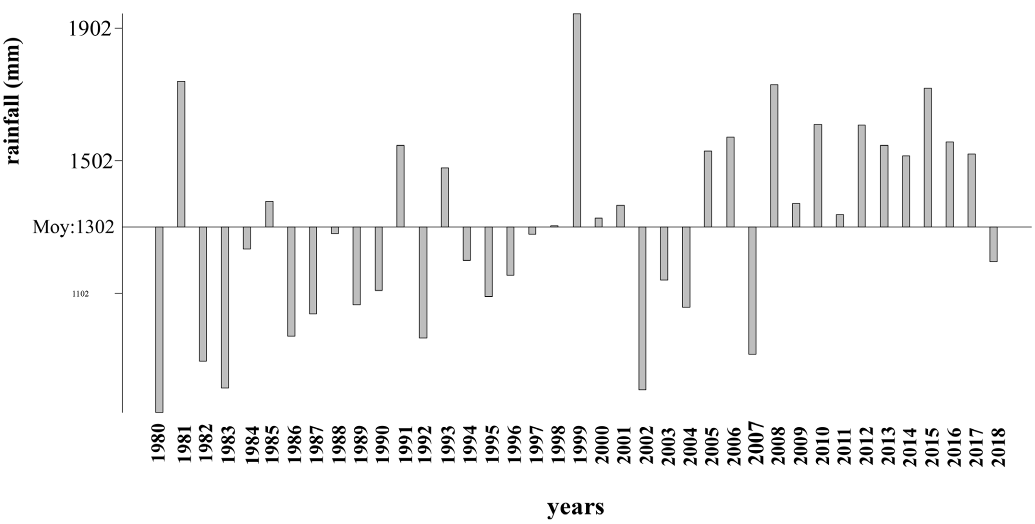

Figure 2. Interannual variation of rainfall from 1980 to 2018 in the lower Casamance recorded at the Ziguinchor regional meteorological station. Source: [8].

2.2. Methods Used

2.2.1. Choice of Communes, Plots and *Pterocarpus erinaceus* Plants for the Experimental Design

For the collection of data on the influence of *Pterocarpus erinaceus* on agro-morphological parameters of peanuts, three *Pterocarpus erinaceus* plants were identified and selected in each of the two districts. In order to take into account the heterogeneity of the environment, three different communes were selected in each district for the experimental set-up. Thus, in the Kataba 1 district, one *Pterocarpus erinaceus* plant was selected in the communes of Djinaky, Kataba 1 and Kafountine, respectively. In the district of Tenghory, one individual of *Pterocarpus erinaceus* was identified and retained in each of the following three communes: Ouonck, Tenghory and Coubalang. In total, a sample of six (6) *Pterocarpus erinaceus* plants was selected in the agroforestry parks of the two districts.

In each commune, the choice of the plot for the installation of the experimental device is based on the presence of the groundnut crop variety "Bourkouss" and the species *Pterocarpus erinaceus*. The *P. erinaceus* trees chosen are isolated ones, thus allowing the plots to be placed at distances R/2; 1.5R and 2R according to the four geographical orientations (East, West, North and South) without interactions with the crowns of other trees in the park (R = radius of the crown).

2.2.2. The Experimental Set-Up

The set-up was based on three factors: site (boroughs), geographical orientation and distance from the trunk. For each *Pterocarpus erinaceus* plant selected and following each of the four cardinal directions, three situations were defined: at R/2, at 1.5 R and at 2 R from the trunk (Figure 3). For each situation, a 1 m^2 (1 m × 1 m) yield square was set up to evaluate the agromorphological parameters of the peanut. Thus, around each selected *Pterocarpus erinaceus* plant, 12 yield squares were installed for a total of 72 yield squares (2 districts × 3 feet × 12 yield squares) installed over the two districts.

2.2.3. Measurement of Parameters

The measurement of these parameters was carried out at the time of harvest after the maturity of the peanut.

- Plant height

In each yield square, four peanut plants were randomly selected and their height measured with a ruler.

- Number of pods produced per peanut plant

As with plant height, four peanut plants were randomly selected from each yield square. The number of pods for each stand was counted.

- Pod and haulm yields

After harvesting the peanuts from the yield squares, the pods were separated from the haulm. The harvested pods and haulm from each yield square were weighed on site for fresh weight determination. Then, a composite sample of pods obtained from the four plots in each level for each stand per district was

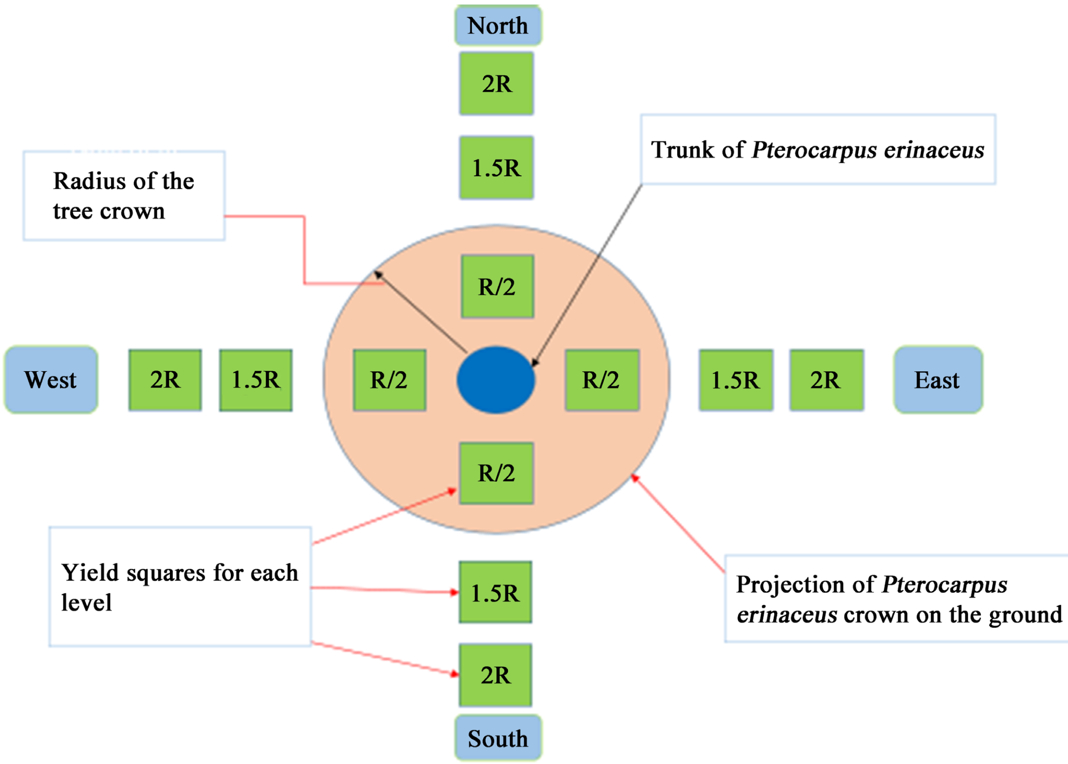

Figure 3. Experimental setup around a *Pterocarpus erinaceus* plant.

taken. A total of 18 samples of haulm and 18 samples of pods for the two (2) districts. These samples were weighed on site to determine their fresh weight using an electronic scale, then placed in an oven at a temperature of 70˚C in the laboratory of the Agroforestry Department of the Assane SECK University of Ziguinchor and weighed every 24 hours until a constant weight was obtained. This was done in order to determine the dry weight of the main production (pods) and secondary production (fane). The results obtained made it possible to evaluate the yield in dry weight of pods and fane per hectare by extrapolation according to the different levels of influence of *Pterocarpus erinaceus*.

2.2.4. Data Processing

Statistical processing of the data was carried out using XLSTAT software version 2014 which allowed for analyses of variance (ANOVA) with three factors namely site (rounding), geographical orientation and distance from the trunk. Newman and Keuls comparison of means tests were performed at the 5% significance level.

Pod yields per ha were calculated using the following formula:

$$R\ (G) = ((PFm.G\_P * PS\ Ech.G)/PF\ Ech.G) * 10,000$$

where R (G) = pod yield; PFm.G_P = average fresh weight of pods per plot; PS Ech. G = dry weight sample of pods; PF Ech.G = fresh weight sample of pods. The same formula was used to calculate the pod yield (R (F)) using the fresh weight (PF Ech.F) and dry weight (PS Ech. F) of the pod samples and the average fresh weight of the pod per plot (PFm.F_P).

3. Results

3.1. Height of Groundnut Plants

3.1.1. Effect of Geographical Orientation

The average height of the peanut plants was statistically higher in the North (52.03 ± 15.11 cm) and West (49.88 ± 15.39 cm) orientations compared to the South (45.14 ± 12.09 cm) and East (44.75 ± 14.94 cm) orientations. Thus, a highly significant (p = 0.004) geographical orientation effect in relation to the *Pterocarpus erinaceus* plant appeared on the height of the peanut plants (Table 1).

3.1.2. Effect of Distance from the Trunk

The effect of distance to the trunk of *Pterocarpus erinaceus* did not induce any significant effect (p = 0.25) on the average height of groundnut plants in the pens. However, in absolute terms, distance 2R recorded the highest mean height (49.9 ± 14.25 cm) and distance R/2 the lowest height with 46.6 ± 13.36 cm (Table 2).

Table 1. Variation in the average height of peanut plants in the parks according to geographical orientation.

	Geographical orientation			
	East	West	North	South
Average height (cm)	44.75 ± 14.94b	49.88 ± 15.39a	52.03 ± 15.11a	45.14 ± 12.09b
p. Value	0.004**			

NS = not significant; *** = very highly significant; ** = highly significant; * = significant.

Table 2. Influence of distance from the trunk of *Pterocarpus erinaceus* on average plant height.

	distance from the trunk		
	R/2	1.5R	2R
Average height (cm)	46.58 ± 13.36a	47.39 ± 16.29a	49.88 ± 14.25a
p. Value	0.25^{NS}		

NS = not significant; *** = very highly significant; ** = highly significant; * = significant.

3.2. Number of Pods Produced per Groundnut Plant

3.2.1. Effect of Geographical Orientation

The statistical analysis did not show any significant difference (p = 0.6) in the average number of pods produced per plant between the different geographical orientations in relation to the species *Pterocarpus erinaceus*. However, the North orientation gave the highest result in absolute value (17.19 ± 7.86 pods/plant) and the East orientation the lowest value with 15.58 ± 7.5 pods/plant (Table 3).

3.2.2. Effect of Distance from the Trunk

The results of the statistical analysis revealed a highly significant (p = 0.009) effect of distance from the trunk of the *Pterocarpus erinaceus* species on the number of pods produced per peanut plant. Indeed, the number of pods produced per plant was higher at distance 2R (18.16 ± 8.33 pods/plant) and lower at distance

R/2 with 15.15 ± 6.79 pods/plant (**Table 4**).

Table 3. Average number of pods produced per peanut plant in the parks according to geographical orientation.

	Geographical orientation			
	East	**West**	**North**	**South**
number of pods/plant	15.58 ± 7.5a	16 ± 7.03a	17.19 ± 7.86a	16.33 ± 7.59a
p. Value		0.6^{NS}		

NS = not significant; *** = very highly significant; ** = highly significant; * = significant.

Table 4. Average number of pods produced per peanut plant according to distance from the trunk of *Pterocarpus erinaceus.*

	distance from the trunk		
	R/2	**1.5R**	**2R**
number of pods/plant	15.15 ± 6.79 b	15.53 ± 6.95 b	18.16 ± 8.33a
p. Value		0.009**	

NS = not significant; *** = very highly significant; ** = highly significant; * = significant.

3.3. Effect of Distance from the Trunk of *P. erinaceus* on Hauln Yield

Distance from the *Pterocarpus erinaceus* trunk had no significant effect (p = 0.6) on peanut tree nut yield. However, in absolute terms, this yield was greater at distance 2R (2.02 tons DM/ha) and lower at distance 1.5R with 1.56 tons DM/ha (**Figure 4**).

Statistical analysis did not reveal any significant difference in groundnut treenut yields by district, with probabilities of 0.61 and 0.65 respectively in Tenghory and Kataba 1. However, in absolute terms, regardless of the district, the highest yields were recorded at distance 2R, with 2.52 and 1.51 tons/ha respectively in Kataba 1 and Tenghory. Regardless of the distance from the trunk, the highest treeness yields were recorded in Kataba 1 district (**Figure 5**).

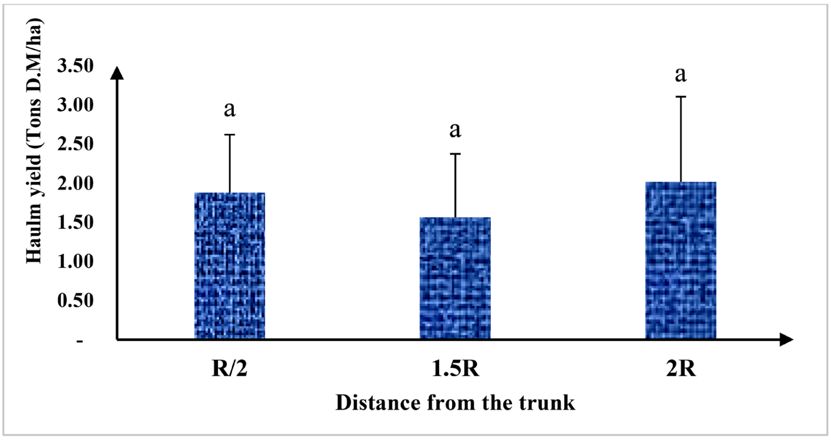

Figure 4. Variation in average haulm yield with distance from *Pterocarpus erinaceus* trunk.

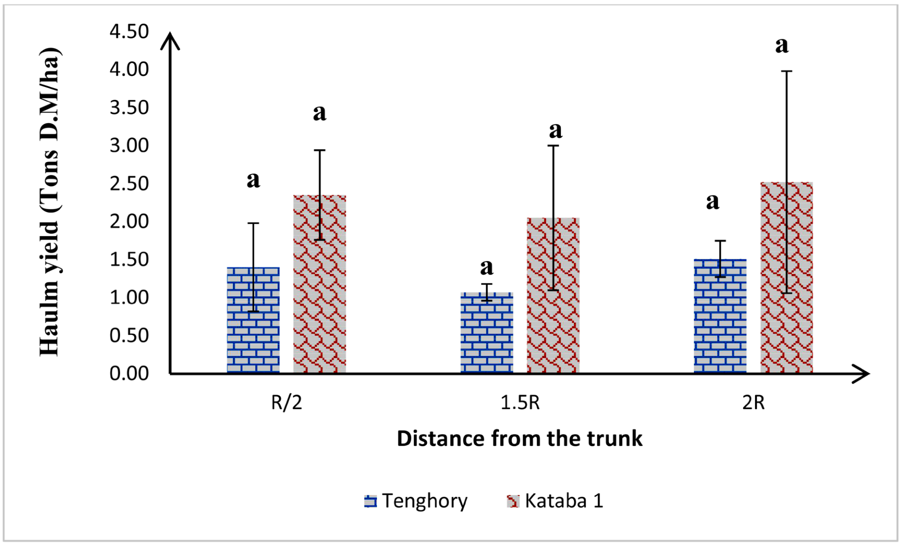

Figure 5. Variation in average haulm yield according districts and distance from *P. erinaceus trunk*.

3.4. Effect of Distance from *P. erinaceus* Trunk on Pod Yield

The results of the statistical analysis showed that the factor distance from the trunk of *Pterocarpus erinaceus* did not induce any significant effect (p = 0.15) on the pod yield of groundnut. However, in absolute terms, distance 2R gave the best result with 1.45 tons DM/ha and the lowest yield was noted at distance R/2 with 1.03 tons DM/ha (Figure 6).

In both Kataba 1 and Tenghory districts, statistical analysis revealed no significant difference in pod yield as a function of distance from the trunk, with probabilities of 0.65 and 0.61 respectively. As for the pod yield, regardless of the district, the highest absolute yield was recorded at distance 2R with 1.92 tons M.S/ha and 0.97 tons M.S/ha respectively for the districts of Kataba 1 and Tenghory, and regardless of the distance from the trunk, the best results in terms of pod yield were observed in the district of Kataba 1. This yield is significantly higher at distance 2R in Kataba 1 compared to Tenghory (Figure 7).

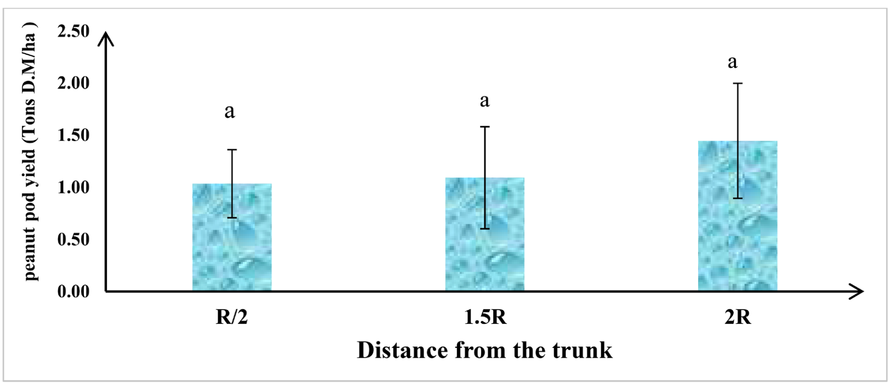

Figure 6. Variation in average peanut pod yield according distance from the *P. erinaceus* trunk.

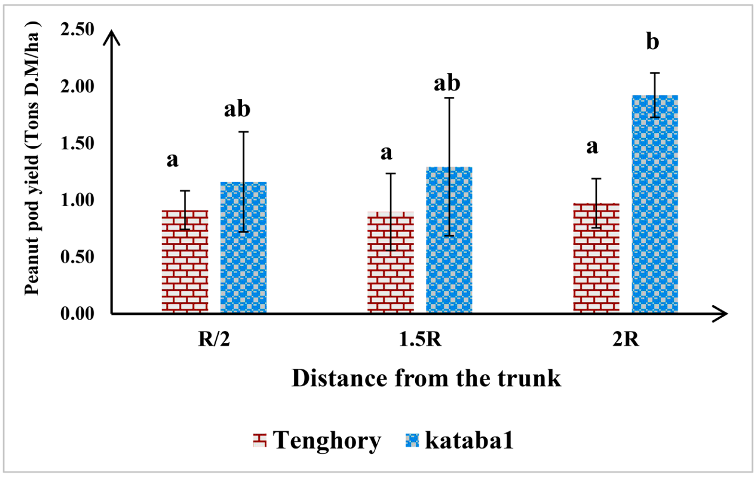

Figure 7. Variation in average peanut pod yield according distance from *P. erinaceus* trunk and districts.

3.5. Prediction of Pod Yield as a Function of Groundnut Haulm Yield

The regression line between pod and treeness yield, with a coefficient of determination (R^2) of 0.129 and a correlation coefficient of 0.36, indicates a fairly low correlation between these two parameters (Figure 8). This R^2 value indicates that only 36% of the production of groundnut pods is explained by the production of stover. It thus appears that, in addition to vegetative production (haulm production), pod yield is explained by other factors in the parks of Kataba 1 and Tenghory districts.

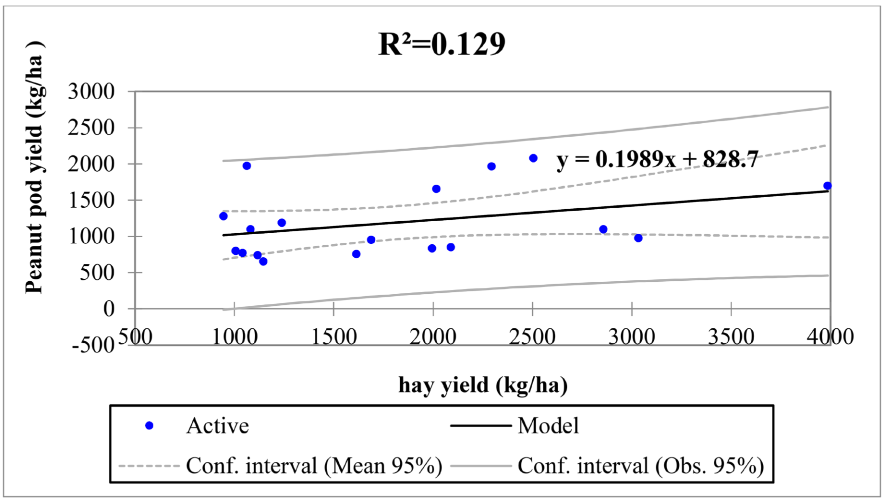

Figure 8. Linear regression of peanut pod yield and haulm yield parameters.

4. Discussion

This work is a contribution to a better understanding of the interactions between *Pterocarpus erinaceus* and peanut cultivation in agroforestry parks in the department of Bignona. The study showed that the geographical orientation of the

Pterocarpus erinaceus plant significantly influences the height of the peanut plants. Indeed, the height of the peanut plants is statistically more important in the positions less exposed to solar radiation: North (52.03 cm) and West (49.88 cm) compared to the most exposed positions (South (45.14 cm) and East (44.75 cm)). This is because as the amount of light received by the plant decreases, the plant interprets these signals as cues to the proximity of competitors [9]. Thus, the plant grows rapidly and engages in a race for light, promptly elongating its stems and petioles. Lateral buds are inhibited, which limits horizontal branching: this is apical dominance (conflicting vertical elongation or shade-avoidance syndrome). However, there was no significant difference in the number of pods produced per plant according to geographical orientation. However, in absolute value the North orientation showed the highest result (17.19 pods/plant) and the East orientation the lowest value with 15.58 pods/plant. This is justified by [10] according to whom the absence of light as well as the presence of a certain humidity linked to the pod's need for calcium, are necessary for its development. Indeed, evapotranspiration is less important on the side less exposed to light. This would explain the greater number of pods per foot on the side less exposed to sunlight. In addition [11] point out that the number of pods per peanut plant decreases as the amount of water supplied for the plants decreases.

The factor distance from the trunk of *Pterocarpus erinaceus* did not induce any significant effect on the average height of groundnut plants. This same result was found by [12] on *Sterculia setigera* indicating that after 3 months, groundnut height growth did not vary significantly with distance from the trunk. In contrast to the result observed for plant height, distance to the trunk of *Pterocarpus erinaceus* species had a highly significant effect on the number of pods produced per peanut plant. The number of pods produced per plant was higher at distance 2R (18, 16 pods) and lower at distance R/2 with 15, 15 pods/plant. These results corroborate those obtained by [13] who stated that under the tree, the number of pods/plant is lower than the control (outside the tree canopy), but this difference is only significant at the level of the *Faidherbia albida* canopy boundary. Groundnuts require maximum sunlight at flowering, so even light shading would reduce pod production.

The distance factor from the *Pterocarpus erinaceus* trunk did not induce any significant effect on peanut taffy yield and pod yield. However, in absolute terms, the yield was higher at distance 2R (2.02 tons DM/ha) and lower at distance 1.5R with 1.56 tons DM/ha for the hay. For pods, distance 2R gave the best result in absolute value with 1.45 Tons DM/ha and the lowest yield was noted at distance R/2 with 1.03 Tons DM/ha. These differences in absolute value are in accordance with those of [12] who showed that groundnut pod biomass increases with distance from the trunk of *S. setigera*. In addition, [5] found that cowpea causes a decrease in groundnut pod yield in Senegal. These results are also in line with [14] who showed a slight loss in production near the trunk and a small non-significant increase at the crown line. And that the reduction in pod production below the crown could then result from the synergy of the two factors. These factors are the increased imbalance between nitrogen, which is in sufficient quantity to promote a significant increase in tassel production, and the reduction in sunlight, which must be maximal at this stage of the plant's physiological development to obtain good fruiting. In addition, competition for water and nutrients may contribute to this reduction in groundnut yields near the tree [12]. However, the results for haulm yield differ from those of who argue that the tree significantly improves haulm yield within 5 m of the *Faidherbia albida* crown. In absolute terms, both the haulm and pod yields are higher in the Kataba 1 district than in Tenghory. Pod yields were even statistically higher in Kataba 1 than in Tenghory at the 2R distance from the *Pterocarpus erinaceus* trunk. This could be explained by a difference in soil conditions between the two districts. Indeed, the behavior of the plant stand and the yield of the crops depend on factors related to the natural environment: soil, climate; factors coming from the genetic "material" and factors coming from the farmer [10] [15]. The average yield obtained in this study varies between 1.45 Tons DM/ha and 1.03 Tons M S/ha for pods and between 2.02 Tons DM/ha and 1.56 Tons DM/ha for tops. These values are higher than those obtained by [13] in Senegal who recorded an average yield between 1289 kg DM/ha and 1179 kg DM/ha for pods and 990 kg DM/ha and 1492 kg DM/ha for haulm. These yields are also higher than those obtained on the African continent for pods, estimated on average at 1 t/ha [16]. According to [17], this difference in production is due to the fact that the yield of a groundnut variety in a given environment depends on the individual possibilities of the plants and the population density. Individual production is a function of the number of mature fruits and the average weight of each fruit.

5. Conclusions

The study aimed to evaluate the effects of *Pterocarpus erinaceus* on the agro-morphological parameters of groundnut in the parks of the districts of Kataba 1 and Tenghory. It showed that the geographical orientation of the *Pterocarpus erinaceus* plant significantly influences the height of the groundnut plants. Indeed, the height of the peanut plants was greater in the positions least exposed to solar radiation (52.02 ± 15.11 cm in the North and 49.88 ± 15.39 cm in the West) compared to the most exposed positions (South and East). However, there was no significant difference in the number of pods produced per plant according to orientation.

The factor, distance from the trunk of the *Pterocarpus erinaceus* species, did not induce any significant effect on the average height of the plants, the yields in fane and pods of groundnut. However, it did have a significant effect on the number of pods produced per peanut plant. The number of pods produced per peanut plant was higher at distance 2R (18.16 ± 8.33 pods/plant) and lower at distance R/2 (15.15 ± 6.79 pods/plant).

However, it would be interesting to continue the studies to:

- Measurements of other variables such as soil fertility and water balance as a function of distance from the tree trunk in order to better explain the effect of distance from the trunk on peanut crop behavior;

- Extend this study to other crops grown in the parks of Bignona Department, such as millet.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] ANSD (2015) Situation économique et sociale régionale de la région de Ziguinchor. Ziguinchor. Service Régional de la Statistique et de la Démographie. 99 p.

[2] Amouzou, K. and Ndiaye, M. (2012) Marchés et réponses au déficit de production agricole de la campagne 2011/2012 au Sénégal. PAM Sénégal, 25 p.

[3] Boffa, J.-M. (2000) Les parcs agroforestiers en Afrique subsaharienne. Cahier FAO.

[4] Duvall, C.S. (2008) *Pterocarpus erinaceus* Poir. Fiche de PROTA4U. In: Louppe, D., Oteng-Amoako, A.A. and Brink, M., Eds., *PROTA Plant Resources of Tropical Africa*/*Ressources végétales de l'Afrique tropicale*, Pays Bas, Wageningen. https://uses.plantnet-project.org/f/index.php?title=*Pterocarpus_erinaceus*_(PROTA)&oldid=115060

[5] Sarr, O., Bakhoum, A., Diatta, S. and Akpo, L.E. (2013) L'arbre en milieu Soudano-Sahélien dans le Bassin Arachidier (Centre-Sénégal). *Journal of Applied Biosciences*, **61**, 4515-4529. https://doi.org/10.4314/jab.v61i0.85598

[6] Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. (2009) Agroforestree Database: A Tree Reference and Selection Guide, Version 4.0. 5 p.

[7] Sagna, P. (2005) Dynamique du Climat et son évolution récente dans la partie Ouest de l'afrique occidentale. Thèse de Doctorat, Université Cheikh Anta Diop de Dakar, 786 p.

[8] Coly, I., Badji, A., Ngom, D., Goudiaby, A.O.K. and Dramé, M. (2020) Structure and Diversity of Parks in the Tenghory District (Lower Casamance, Senegal). *American Journal of Agriculture and Forestry*, **8**, 198-207. https://doi.org/10.11648/j.ajaf.20200805.13

[9] Anonyme (2018) La lutte pour la lumière. La Gazette des Plantes (Blog). https://lagazettedesplantes.com/2018/01/29/la-lutte-pour-la-lumiere

[10] Doikh, N.L. (2001) Évaluation agronomique de variétés d'arachide de bouche à Nioro du Rip (Centre Sud du Bassin Arachidier). Diplôme d'Ingénieur des Travaux Agricoles, 42 p.

[11] Issa, A., Hamidou, F., Inoussa, M.M., Bakasso, Y. and Zongo, J.D. (2016) Caracterisation Agro-Morphologique des accessions d'arachide (*Arachis hypogaea* L.) pour la teneur en huile. *European Scientific Journal*, **12**, 337. https://doi.org/10.19044/esj.2016.v12n15p337

[12] Bakhoum, C., Ndiaye, S.A. and Ndour, B. (2001) *Stercula setigera* Del.: Effet sur les cultures. *Annals of Forest Science*, **58**, 207-215. https://doi.org/10.1051/forest:2001120

[13] Louppe, D., Ndour, B. and Samba, A.N.S. (1996) Influence de *Faidherbia albida* sur I'arachide et le mil au Sénégal. Méthodologie de mesure et estimations des effets d'arbres émondés avec ou sans parcage d'animaux. Les Parcs à Faidherbia, Cahier

Scientifique 12, Ed. By R. Peltier, CIRAD Forêt, Montpellier, France, janvier, 123-139.

[14] Louppe, D. (2016) Des associations bénéfiques arbres-productions agricoles au Sénégal et en Côte d'Ivoire. 6 p.

[15] Lachaud, J.P. (1960) Les références concernant les rendements physiques des cultures destinées à la vente. *Économie rurale*, **43**, 9-25. https://doi.org/10.3406/ecoru.1960.1688

[16] Foncéka, D. (2010) Elargissement de la base génétique de l'arachide cultivée (Arachis hypogaea): Applications pour la construction de populations, l'identification de QTL et l'amélioration de l'espèce cultivée. Thesis, Montpellier SupAgro. Brésil, 120 p.

[17] Forestier, J. (1973) Caractères végétatifs, croissance et rendement de l'arachide hâtive. *Cahiers ORSTOM, Série Biologie*, No. 19, 43-62.