Journal of Plant Studies; Vol. 12, No. 1; 2023
ISSN 1927-0461 E-ISSN 1927-047X
Published by Canadian Center of Science and Education

Allometric Equations for Estimation of Below-ground Biomass of Two Dominants Shrub Species of Burkina Faso

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Received: July 17, 2022 Accepted: August 27, 2022 Online Published: April 10, 2022

doi:10.5539/jps.v12n1p37 URL: https://doi.org/10.5539/jps.v12n1p37

Abstract

Deforestation leads to a significant loss of carbon and contributes indirectly to climate change. This study was carried out in four types of formations in the Sudanian zone of Burkina Faso to assess the contribution of plant species to climate change mitigation. The below-ground biomass of two species (*Piliostigma reticulatum* and *Guiera senegalensis*) was determined by the direct method. Three classes of subjects were determined and a total of 80 shrubs of *P. reticulatum* and 90 shrubs of *G. senegalensis* were completely excavated. The results showed that *P. reticulatum* measures about 0.49 to 2.10 m in height, 3.58 to 25 cm in circumference at the base of the trunk and stores 0.18 to 3.68 tC/ha in the root biomass (respectively after 3 years and 15 years) for a 3x3m plantation. In the 15-year fallow dominated by *G. senegalensis* stands, 3.93 tC/ha are stored by the underground biomass of *G. senegalensis* shrubs. Model fit showed that there is a good correlation between circumference at the base of the trunk and below-ground biomass for *P. reticulatum*. For *G. senegalensis*, it is the total height of the foot that is most correlated with the below-ground biomass. These results provide information on the carbon sequestration potential of these two species, and can thus help in the decision-making process for climate change adaptation and/or mitigation policies.

Keywords: allometric equations, carbon storage, climate change, *Guiera senegalensis, Piliostigma reticulatum*

1. Introduction

Climate change has become an issue of alarming concern to the international scientific community. Indeed, global warming is unequivocal and is manifested by the continuous increase in the concentration of atmospheric carbon dioxide (CO_2) and in the average temperature of the planet, the strong variation in precipitation, the increase in the frequency of extreme events (floods, droughts), the melting of glaciers and the rise in the average sea level (Ciesla, 1997; IPCC, 2013; Ago, 2016). This phenomenon is mainly due to anthropogenic activities marked by the use of fossil fuels that emit CO_2 into the atmosphere and by deforestation (IPCC, 2007; Ciais *et a*l., 2011). Adaptation and mitigation are two complementary strategies to reduce and manage the risks related to climate change. Mitigation is based on an integrated approach that combines measures to reduce greenhouse gas (GHG) emissions and increase carbon sinks in terrestrial sectors (IPCC, 2013). Global forests play a major role in regulating the carbon cycle and atmospheric CO_2 concentration. They contain 53% of the carbon accumulated in terrestrial ecosystems (Boulier and Simon, 2010). At the heart of the negotiations of the Kyoto Protocol (Tsayem Demaze, 2009), forests are today the subject of a broad discussion on the possibilities offered by the initiative for reducing greenhouse gas emissions from deforestation and forest degradation (REDD), which aims to financially compensate for non-deforestation (Tsayem Demaze, 2009). Thus, scientists are increasingly called upon to provide methods for assessing the carbon quantities of various types of forest formations and/or species (Henry *et al*., 2011; Massaoudou *et al*., 2015). The development of the carbon market supports a better understanding of the carbon sequestration potential of plants. In developed countries such as Sweden, Canada, etc., this exercise is targeted at promoting environmental sustainability (Tsayem Demaze, 2009).

In Burkina Faso, there exists limited research on carbon stocks of plant species (Savadogo and Elfving, 2007;

Sawadogo et al., 2009; Koala, 2016; Dimobé, 2017, Bayen *et al*., 2020). Specifically, little or no study on the potential of shrub species for carbon sequestration have being documented in the research literature. The same is applicable to the allometric equations used to predict the quantities of carbons contained in shrubs. Equations for estimating biomass in agroforestry park systems are scarce in the research literature, and when they exist, they rarely take into account below-ground biomass (Peltier *et al*., 2007; Kuyah *et al*., 2012).

The objective of this study is to assess the potential for carbon sequestration by below-ground biomass of *P. reticulatum* and *G. senegalensis*, two dominant shrub species in the northern Sudanian zone of Burkina Faso.

2. Methodology

2.1 Study Site

This study was carried out at the Institute of Environment and Agricultural Research (INERA) in Saria, Burkina Faso. The choice of this site was justified by the presence of *Piliostigma reticulatum* and *Guiera senegalensis* formations of various ages. Saria is located in the province of Bulkièmdé, 23 km East of the city of Koudougou and 80 km Northwest of Ouagadougou, the capital (Figure 1). It lies between 12°16' North latitude and 2°09' West longitude for an altitude of 300m. The average annual rainfall recorded over the last ten years was 885.19 ± 112.23 mm. Soils are of tropical ferruginous type, with upper horizons of silty-sandy to sandy-clayey texture. The vegetation cover is the North-Sudanian phytogeographic zone (Fontès and Guinko, 1995). The annual grassy savannas are characteristic of this zone. The population density of the Bulkièmdé province is 102 hts/km^2, so there is strong pressure on the land.

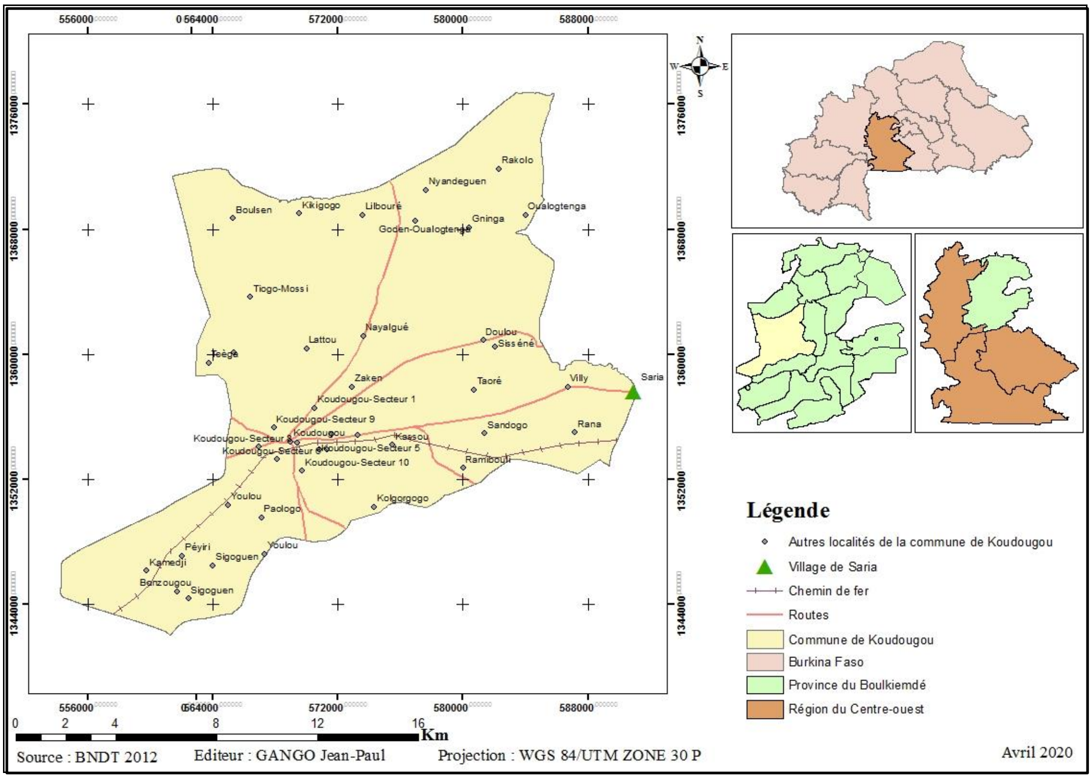

Figure 1. Location of the Study Area

2.2 Sampling

This study was carried out in four types of plant formations:

- a 15 years monospecific plantation of *P. reticulatum*,

- a 5-year monospecific plantation of *P. reticulatum*,

- a 3-year monospecific plantation of *P. reticulatum*,

- a 15-year-old fallow dominated by *G. senegalensis* shrubs

Three classes of subjects were determined and a total of 80 feet of *P. reticulatum* and 90 feet of *G. senegalensis* were retained for the estimation of the quantities of carbon stored and the elaboration of the allometric equations (Table 1). Shrubs with damaged or broken crowns or loss of branches due to pruning or natural disturbance were not considered (Koala, 2016).

Table 1. Distribution of study subjects

Classes / Species	Juveniles	Intermediary individuals	Seed producers
P. reticulatum	35 shrubs of 3 years old	35 shrubs of 5 years old	10 shrubs of 15 years old
G. senegalensis	30 shrubs of $C_{0.1}$< 10 cm	30 shrubs of 10cm≤$C_{0.1}$≤25cm	30 shrubs of $C_{0.1}$ > 25cm

$C_{0,1}$ is the circumference at 0.1 m for the rod

2.3 Determination of Below-ground Biomass

Dendrometric parameters were measured on each subject concerned in the study. These were the diameter at the base of the trunk using a soft tape, the total height of the stem using a pole, and the diameter of the crown in the North-South and East-West directions using a decameter. For multi-capped or branched trees, all stems were measured and the average circumferences were calculated by the following formula:

$$C_{0.1} = \sqrt{\sum_{i=1}^{n} C_i^2} \quad (1)$$

- n is the number of stems,

- Ci is the circumference at 0.1 m for rod i

Determination of the below-ground biomass was carried out by the direct method (Picard *et al*., 2012; Yusufu, 2014; Diatta, 2015; Koala, 2016). A complete excavation of the roots of the shrubs was carried out. The roots were excavated one by one following their direction from their insertion point at the stump. All roots with a diameter greater than 3mm were completely uncovered and excavated. The 3mm threshold represents the size at which the underestimation of root biomass is low (Koala et al., 2017). Soil particles attached to the roots were removed using a brush. The fresh biomass of the main and lateral roots was weighed separately. Then for each species, three samples of main roots and three samples of lateral roots were collected for each class of subjects. These samples, with a fresh weight of 200g, were sent to the laboratory and then dried in an oven at 105 ℃ until a stable dry weight was obtained.

2.4 Data Analysis

2.4.1 Estimation of Dry Biomass

The dry biomasses were obtained by the following formulas (Picard et al., 2012):

- the dry matter content of sample i: $Xi = \frac{(B\ Dry\ sample\ i)}{(B\ Fresh\ sample\ i)}$, where:

Xi: the dry matter content of sample i;

B dry sample i: the dry biomass of sample i ;

B fresh sample i: the fresh biomass of sample i;

the average dry matter content of the compartment (primary roots or lateral roots):

$Xm = \frac{\sum Xi}{n}$, where:

Xm: the average dry matter content of the compartment;

n: the number of samples (n=3) in the case of this study.

the dry biomass of the compartment: $Bs = Xm * Bf,$ where:

Bf: the fresh biomass of the compartment,

BS: the dry biomass of the compartment,

Xm: the average dry matter content of the compartment,

The dry root biomass of a foot:

$$\text{Bs Root} = \text{Bs Main roots} + \text{Bs Lateraloots}$$

The root biomass of a class of subjects:

$\text{Bs root mean} = \sum_{n=1}^{n}(\text{Bs Root})$

The root biomass per hectare was obtained by multiplying the average root biomass for each class of subjects by the stand density of the corresponding class. These densities were obtained for *G. senegalensis* fallow by a forest inventory. For monospecific plantations of *P. reticulatum*, the theoretical density of plants per hectare was used. This density is 1100 plants for a plantation with a spacing of 3m × 3m.

2.4.2 Estimation of Carbon Quantities

The amount of carbon contained in the dry mass is on average half of its dry mass (Yusufu, 2014). To arrive at the carbon stock, biomass estimates are converted to carbon values using the carbon fractions of the dry matter. This conversion factor is 50% by convention (GIEC, 2006).

$\text{Qc} = \text{Bs} \times \%\text{C}$

Qc: quantity of carbon in the reservoir;

Bs: dry biomass of the reservoir;

%C: carbon fraction or percentage.

The carbon stock per hectare was obtained by multiplying the average carbon stock per plant for each diameter class by the plant density of the corresponding class.

2.4.3 Establishment of the Allometric Equations

Allometric equations are of paramount importance in estimating the contribution of forest formations to the carbon cycle (Picard *et al*., 2012). The adjustment of a model assumes, on the one hand, that the data are already available and formatted and, on the other hand, that the mathematical expression of the model to be adjusted is known. The dendrometric parameters retained for model fitting in this study are the circumference at the base of the trunk and the total height of the foot, since the dimensions of the crown do not give satisfactory results. Also, as linear regressions did not give good results, non-linear models were opted for. Indeed, non-linear regression allows us to model complex phenomena that do not fall within the scope of the linear model (Xlsat). XLSTAT offers pre-programmed functions among which the user can find the model describing the phenomenon to be modeled. The following non-linear models have been fitted:

$$Y = pr1 * Log10(X1) + pr2$$

$$Y = pr1 * Exp(pr2 * X1) + pr3$$

Y: dry biomass,

pr1, pr2, pr3 are the parameters of the model

x: dendrometric parameter used to adjust the model (total height, circumference at the base of the trunk).

2.4.4 Model Evaluation and Statistical Tests

Model fitting involves the determination of precision and optimization parameters such as the coefficient of determination (R^2) and model residuals (Picard *et al*., 2012, Tyano *et al*., 2019). For each equation established, the software provides the fitting coefficients:

- the coefficient of determination R ² gives an overall idea of the model fit. This coefficient is interpreted as the ratio of the variance explained by the model to the total variance. It is between 0 and 1 and the closer it is to 1, the better the quality of the fit. We have set 0.7 as the value of R^2 below which the allometric equation is rejected.

- the sum of the squares of the errors (or residuals) of the model (SCE): this is the sum of the squares of the residual values. It quantifies the variation of the data not explained by the predictor (the dendrometric parameter). The smaller the final SCE, the better the model describes the response (Biomass).

- the mean of the squares of the errors (or residuals) of the model (MCE); it is measured in units of the response variable and represents the distance between the data values and the fitted values. The smaller it is, the better the model describes the response.

The model residuals were subjected to the normality test (Shapiro-Wilk test) at the 5% threshold to verify the normality of the residuals:

- if the p-value is >0.05, then the residuals follow the normal law.

- if the p-value is ≤0.05, then the residuals do not follow the normal law.

The statistical analyses were performed using the statistical software Xlstat (XLSTAT 2016.02.27444 Addinsoft, 2016).

3. Results

3.1 Dendrometric Parameters of the Individuals in the Study

Juvenile individuals sampled have an average height (h) of 0.49 and 1.58 m (for *P. reticulatum* and *G. senegalensis*, respectively) (Table 2). As for individuals of the intermediate class, their average dimensions are 1.29 and 2.54 m in height (respectively for *G. senegalensis* and *P. reticulatum*), 12.31 and 14.40 cm C0.1 respectively for *G. senegalensis* and *P. reticulatum*. Seed trees are 3.71 m high for G. senegalensis and 3.64 m high for *P. reticulatum*.

Table 2. Dendrometric parameters of the sampled shrubs

Parameter	Species	Juveniles				Intermediary individuals				Seed producers			
		Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max
Height	*P. reticulatum*	0.49	0.40	0.25	0.72	1.29	0.40	0.70	2.20	3.71	0.69	2.10	7.40
(h, m)	*G. senegalensis*	1.58	0.43	1.00	2.00	2.54	0.43	1.10	3.50	3.64	0.43	2.55	4.86
Basal	*P. reticulatum*	3.58	0.40	2.00	7.00	12.31	0.40	6.00	18.00	49.20	0.69	25.00	90.00
Circumference ($C_{0,10}$, cm)	*G. senegalensis*	7.01	0.43	4.00	9.60	14.40	0.43	10.20	21.00	29.41	0.43	25.10	38.00
Crown	*P. reticulatum*	0.46	0.40	0.29	0.70	0.85	0.40	0.37	1.50	2.18	0.69	1.30	4.70
diameter (D_h, m)	*G. senegalensis*	1.03	0.43	0.56	1.95	1.82	0.43	1.16	3.50	3.22	0.43	2.31	5.73

3.2 Biomass and Carbon Quantities

The average carbon stock of juvenile *P. reticulatum* is 0.17kg/tree. It is 0.28kg/tree for juvenile feet of *G. senegalensis*. Intermediate individuals store 0.71 and 0.73kgC/tree respectively for *P. reticulatum* and *G. senegalensis*. Seed companies store 6.63kgC/tree for *P. reticulatum* and 2.26 kgC/tree for *G. senegalensis* plants (Table 3).

Table 3. Biomasses and quantities of carbon stored by individuals

Parameter	Species	Juveniles				Intermediary individuals				Seed producers			
		Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max
Dry biomass	*P. reticulatum*	0.33	0.40	0.15	0.63	1.42	0.40	0.50	2.76	13.26	0.69	6.44	23.58
(Kg MS subject^{-1})	*G. senegalensis*	0.56	0.43	0.08	1.70	1.46	0.43	0.90	1.96	4.53	0.43	3.23	5.73
Carbon	*P. reticulatum*	0.17	0.40	0.07	0.31	0.71	0.40	0.25	1.38	6.63	0.69	3.22	11.79
(KgC subject^{-1})	*G. senegalensis*	0.28	0.43	0.04	0.85	0.73	0.43	0.45	0.98	2.26	0.43	1.62	2.87

Analysis of the quantities of carbon stored by the four types of formations reveals two groups. The 15-year-old *P. reticulatum* plantation and the 15-year-old *G. senegalensis* fallow have stored similar amounts of carbon in the underground part (3.93±2.66 and 3.68±1.53 respectively). The second group consists of the 5-year and 3-year *P. reticulatum* plantations (Table 4).

Table 4. Biomass and Underground Carbon Stock by Formation Type

Types of plant formations	Below-ground biomass (tMS/ha)	Below-ground carbon (tC/ha)
15-year-old *G. senegalensis* fallow	7.86 ± 5.31^a	3.93 ± 2.66^a
15-year-old *P. reticulatum* plantation	7.36 ± 3.08^a	3.68 ± 1.53^a
5-year-old *P. reticulatum* plantation	0.78 ± 0.30^b	0.39 ± 0.15^b
3-year-old *P. reticulatum* plantation	0.37 ± 0.11^b	0.18 ± 0.05^b
Pr>F	< 0.0001	< 0.0001
Significativit é	HS	HS

3.3 Allometric Equations

The adjustment coefficients of the developed allometric equations vary from model to model, species to species, subject class to subject class and dendrometric parameter to dendrometric parameter (Table 5). For the species *P. reticulatum*, the models developed from the circumference of the trunk give the best results for juveniles, individuals of the intermediate class, and seeds. The best equations have the formulas: Y = 1.65*Exp (0.04*Cb) -1.59, Y = 0.24*Exp (0.12*(Cb) +0.19, Y = 29.42*Log10(Cb)-35.52 respectively. These equations have a coefficient of determination ranging from 87 to 89%. They also have low residuals and their distribution follows the normal distribution. However, none of the equations developed for all subjects of *P. reticulatum* meet all the conditions retained for their validation. For *G. senegalensis*, it is rather the total height of the foot that gives the best results (Y = -22.91*Exp (-0.06*H) +21.22, Y = -15.63*Exp (-0.04*H) +15.64, Y = 10.58*Log10(H)-1.37, Y = 4.32*Exp (0.22*H) +5.60 respectively for juveniles, intermediate individuals, seeders and for all subjects). Indeed, the equations developed from this dendrometric parameter meet the conditions of their validation (high R^2, low SCE, low MCE and residues distributed according to the normal law). The regression curves of the selected regressions indicate that the observations are well fitted to the selected models (Figure 2).

Table 5. Allometric equations for below-ground biomass prediction

Types of subjects	Species	Formulas	R^2	SCE	MCE	p-value
Juveniles	***P. reticulatum* (n=35)**	Y= 0.68*Log10(Cb)-0.03	0.85	0.05	0.00	0.28
		Y = 0.42*Log10 (H) +0.51	0.51	0.17	0.00	0.08
		Y = 1.65*Exp (0.04*Cb) -1.59	0.87	0.04	0.00	0.31
		Y =-3.91*Exp (-0.14*H) +4.03	0.54	0.16	0.00	0.34
	***G. senegalensis* (n=30)**	Y = 3.41*Log10(Cb)-2.27	0.75	1.67	0.01	0.03
		Y = 4.46*Log10(H)-0.31	0.69	2.09	0.075	0.33
		Y = 0.008*Exp (0.53*Cb) -0.02	0.93	0.51	0.02	0.03
		Y = -22.91*Exp (-0.06*H) +21.22	0.74	1.74	0.06	0.42
Intermediary individuals	***P. reticulatum* (n=35)**	Y= 3.53*Log10(Cb)-2.36	0.77	2.37	0.07	0.67
		Y = 2.35*Log10(H) +1.20	0.27	7.51	0.23	0.02
		Y = 0.24*Exp (0.12*(Cb) +0.19	0.87	1.37	0.04	0.66
		Y = 0.10*Exp (1.22*(H) +0.87	0.33	6.88	0.22	0.00
	***G. senegalensis* (n=30)**	Y = 3.09*Log10(Cb)-2.08	0.80	0.64	0.02	0.83
		Y = 2.54*Log10(H) + 0.47	0.72	0.88	0.03	0.66
		Y = -1324211.29*Exp (-1.41*Cb) +1.56	0.40	1.87	0.07	0.14
		Y = -15.63*Exp (-0.04*H) +15.64	0.82	0.57	0.02	0.74
Seeds producers	***P. reticulatum* (n=10)**	Y = 29.42*Log10(Cb)-35.52	0.89	28.99	3.62	0.07
		Y = 4.46*Log10(H)-0.31	0.69	2.09	0.07	0.33
		Y = 8.67^ (-33) *Exp (0.85*Cb) +12.11	0.43	158.61	22.66	0.54
		Y = 106.80*Exp (0.02*H) -103.62	0.83	46.70	6.67	0.12
	***G. senegalensis* (n=30)**	Y = 13.30*Log10 (Cb)-14.98	0.69	4.40	0.16	0.01
		Y = 10.58*Log10(H)-1.37	0.92	1.12	0.04	0.29
		Y = -5.38^26*Exp (-2.42*Cb) +4.67	0.33	9.47	0.35	0.00
		Y = 5.20*Exp (0.14*H) -4.19	0.91	1.23	0.05	0.85
All subjects	***P. reticulatum* (n=80)**	Y = 8.77* Log10 (Cb)-5.43	0.60	647	8.40	< 0.0001
		Y = 9.06*Log10 (H)+3.13	0.52	788.43	10.23	< 0.0001
		Y = 2.01^ (-16) *Exp (0.43*Cb) + 2.13	0.29	1172.70	15.43	< 0.0001
		Y = 58.67*Exp(5.09^-2*H) -60.10	0.86	216.48	2.84	< 0.0001
	***G. senegalensis* (n=90)**	Y = 6.06*Log10 (Cb)- 4.78	0.86	37.65	0.43	0.68
		Y = 8.95*Log10(H)-1.24	0.78	60.11	0.70	0.008
		Y= -92.73*Exp(-1.99^-3*Cb) +91.84	0.95	12.91	0.15	0.027
		Y = 4.32*Exp (0.22*H) +5.60	0.88	34.10	0.40	0.44

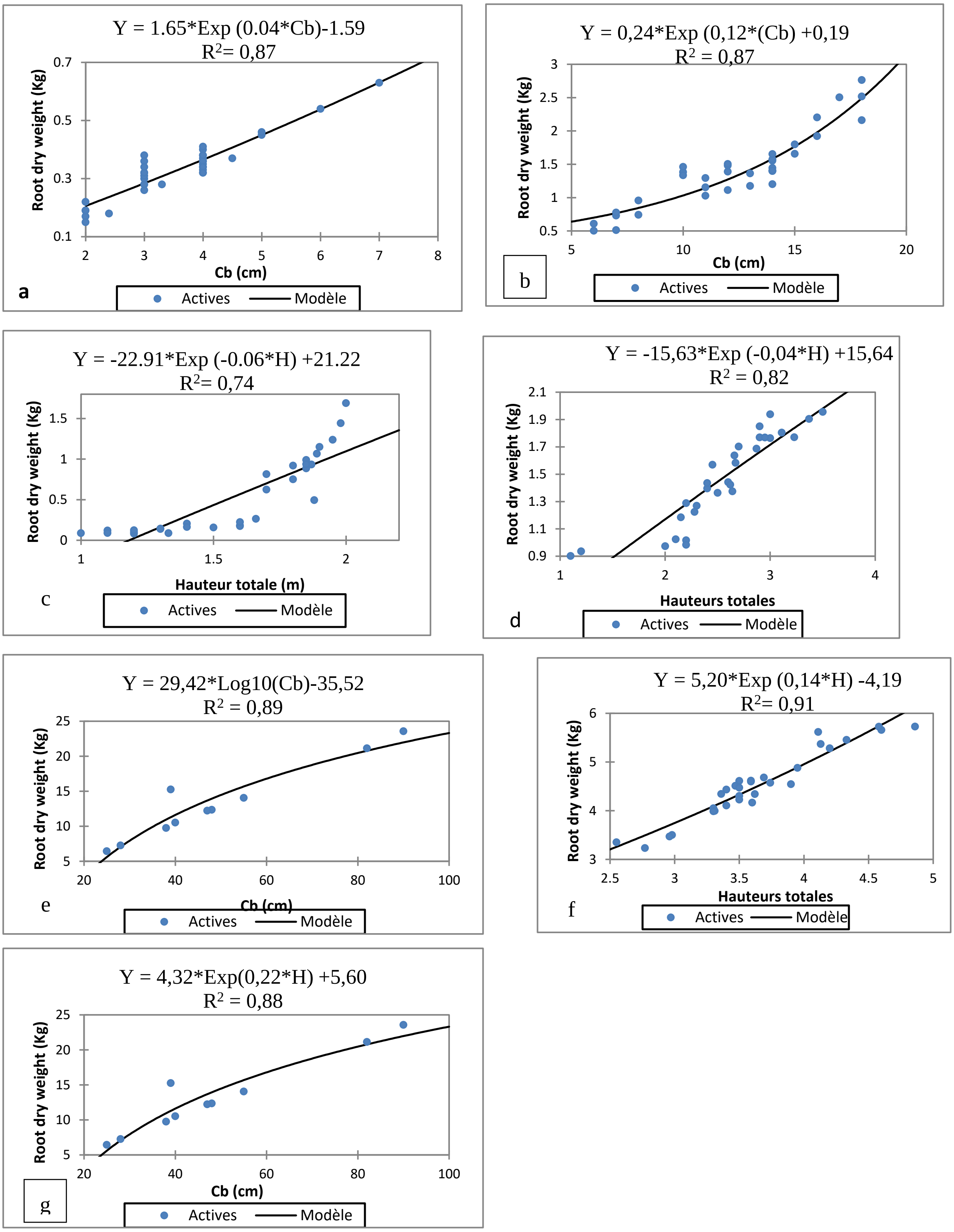

Figure 2. Adjustment curves of the selected models

a: juveniles of *P. reticulatum*, b: juveniles of *G. senegalensis*, c: intermediate individuals of *P. reticulatum*, d: intermediate individuals of *G. senegalensis*, e: seeds producers of *P. reticulatum*, f: seeds producers of *G. senegalensis*, g: all individuals of *G. senegalensis*

4. Discussion

4.1 Biomass and Carbon Quantity

The *P. reticulatum* plantations stored in their underground biomass at 0.18, 0.39, and 3.68 tC/ha at 3, 5 and 15 years, respectively, and the *G. senegalensis* fallow stored in its underground biomass 3.93 tC/ha after 15 years. Lufafa et al (2008) found an underground carbon stock in Senegal ranging from 0.78 to 1.13 tC/ha for *G. senegalensis*. These amounts are lower than that obtained in the fallow of our study site. Their study site is made up of operational parks while the present study was conducted in a fallow area. Thus, it can be inferred that fallow is a good strategy to increase the carbon stocks of woody biomass. It, therefore, contributes to the fight against global warming. For *P. reticulatum*, the same authors (Lufafa *et al*., 2008) found an underground carbon stock ranging from 1.10 to 1.75 tC/ha. These amounts are higher than those found in the 3- and 5-year-old *P. reticulatum* plantations of our study. However, the amount of carbon stored by the subsurface biomass of *P. reticulatum* plantations after 15 years is significantly higher than that obtained by Lufafa et al (2008). This suggests that for *P. reticulatum* plantations, it is necessary to wait at least more than 5 years before the beneficial effect of the plantation in carbon storage is expressed. Diédhiou et al (2017), found in the groundnut basin of Senegal for *J. curcas* plantations; 0.66 and 2.53tC/ha of root stock respectively for 3- and 5-year-old plantations. These quantities are higher than those obtained for *P. reticulatum* plantations of the same age in this study. This suggests that the root growth of *J. curcas* is faster than that of P. reticulatum. However, taking into account other factors such as agro-climatic conditions, the large quantities of root stock of *J. curcas* compared to *P. reticulatum* can be interpreted differently. Rainfall in Saria (700-900 mm) is higher than in the groundnut basin of Senegal (600-800 mm). Bayen et al (2021) found under controlled conditions that plants of four species from dry areas of Burkina Faso under water stress at half field capacity produced twice as much subsurface biomass as plants watered at 100% field capacity. The water stress therefore prompted the plants to develop their root systems to take advantage of the limited water available. The allocation of biomass to the underground part depends on several factors such as species and climatic conditions.

4.2 Allometric Equations

Allometric equations allow the estimation of tree biomass and/or carbon as a function of dendrometric parameters. The ability of an allometric model to estimate tree biomass varies from one species to another (Bognounou *et al*., 2008; Bognounou *et al*., 2013). In this study, the total height of the foot proved to be the best parameter for estimating the hypogeal biomass of *G. senegalensis*. For *P. reticulatum* it is the circumference at the base of the trunk. Koala (2016) found in the northern Sudanian zone of Burkina Faso that the diameter at breast height allows a good estimate of the root biomass of *Vitellaria paradoxa*. In this study, this parameter was not used because of the shrub morphology of the individuals studied. Specific allometric equations are preferable to global community equations. Indeed, wood density and tree architecture vary from one species to another (Ketterings *et al*., 2001). A species-specific equation improves the efficiency of biomass estimation by 12.5% compared to a global equation for a woody community (Návar *et al*., 2004). According to M'bow (2009), model evaluation is a delicate exercise, since there is no standard method of procedure. The steps are numerous and related and cannot be disconnected from the process of setting up forest models (Vanclay and Skovsgaard,1996). A model must be evaluated through quantitative tests that seek to prove that it is good enough to predict a given factor. Nevertheless, the very first parameter to be taken into account in the evaluation of allometric equations is the R^2 coefficient of determination. Models with a high R^2 lead to very low residuals (differences between the model and the observed values). For this reason, the allometric equations established during this study were selected first from the R^2 value (equations with an R^2 less than 75% were rejected). Bayern et al (2020) established allometric equations for Senegalia dudgeoni, *Senegalia gourmaensis*, *Vachellia nilitica* and *Vachelia tortilis* in Burkina Faso. The performance of their models was tested through R^2, root mean square error (RMSE), mean relative error (MRE) and mean absolute prediction error (MAPE). Koala (2016) for the elaboration of allometric equations for *Anogeissus leiocarpa*, *Detarium microcarpa*, *Piliostigma thonningii* and *Vitelaria paradoxa* tested the models through the normal distribution of residuals, the R^2, the standard error. According to this author, the best model is the one that minimizes the bias and maximizes R^2. Konaré et al (2019) in Mali tested the allometric equations they developed for the leaf biomass of *Afzelia africana*, *Ficus gnanphalocarpa* and *Pterocarpus erinaceus* through the value of R^2 only. In the present study, an effort was made in testing the robustness of the allometric equations. Thus, the validation of the equations was performed through the R^2, the sum of the squares of the model errors (or residuals) (SCE), the mean of the squares of the model errors (or residuals) (MCE) and the normal distribution of the residuals. The quality of an equation also depends on the number of feet used to construct it. The number of feet used to construct the allometric equations varies widely in the literature. There are equations established with more than 100 species (Bellefontaine et al., 1997; Bazile

1998; Sawadogo et al., 2010), equations established with 30 to 50 subjects (Cissé et al., 1980, Bagnoud et al, 1996; Guendehou et al. 2012; Koala et al. 2016) and equations established with less than 20 subjects (Manzo et al. 2015; Lawanou et al. 2010; Chaibou et al. 2012; Konaré et al. 2019). Thus, it can be said that the number of subjects used for this study (90 for *G. senegalensis* and 80 for *P. reticulatum*) allows correlations to be established between dry biomass and dendrometric parameters.

5. Conclusion

The objective of this study was to assess the carbon storage potential of *P. reticulatum* and *G. senegalensis* (two dominant shrub species in the Sudanian zone of Burkina Faso) In a bid to reducing CO_2 emissions from deforestation. The estimation of underground biomass indicated that fallowing and tree planting are two effective strategies to improve the carbon stock of agrosystems. Regressions were developed with total height and circumference at the base of the trunk as a predictor of biomass. The correlation between biomass and dendrometric parameters depends on the species. From the study, it was deduced that for *P. reticulatum*, it is the circumference at the base of the trunk that gives the best regressions while for *G. senegalensis* it is the total height of the foot. These models developed can be used to estimate the root biomass of these species by class of subject (juveniles, individuals of the intermediate class and seeders).

These results provide information on the carbon sequestration potential of *P. reticulatum* and *G. senegalensis*. The application of the models must take into account the range of dendrometric parameters used for each species and the eco-climatic characteristics of the study area.

Funding

This work was supported financially by the International Foundation of Sciences. Grant N°I-1-D-6475-1.

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