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Influence of Re-Greening on the Infiltrability of Soils in South-Central Niger

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Abstract

In the Sahel, the climate and the agricultural practices are the main factors used to observe re-greening process. But the extension of this re-greening is not uniform in the fields, so we can assume that there are other factors contributing to the greening of some areas and not others. The infiltrability of soils is considered as an important factor for these changes in the last decades. The influence of re-greening on the infiltrability of soils in the southern strip of Niger was studied through a comparison of zones according to the type of sandy soils (*Jigawa/Rerey*), silty-clay (*Guiéza*), silty-sandy (*Hako*) and clay-silty-sandy (*Laka*). The evaluated parameters are the texture, the infiltrability and the ecological characteristics (specific index of regeneration "SIR" and the Importance Value Index "IVI"). The main conclusions were: the soils of Niger South-Central are characterized by a sandy texture for more than 80%. The soils which are very sandy ("*Jigawa*", "*Rerey*" and "*Guieza*") are more permeable and have more trees contrary to the soil *Hako* and *Laka*. Their encrusting has the tendency to reduce the vegetation cover on the soil. The infiltration measurements indicated that the rate of initial and stationary infiltration diminishes while going down towards the South. In fact, it has been recorded a rate of 123 mm/min of initial infiltration and 87 mm/min stationary in Dan Saga on the sandy soils against 76 mm/min and 65 mm/min in *Daré* respectively for the initial and stationary rate. Therefore, the infiltration seems to influence the density, the SIR and the IVI of the trees from the North towards the South. Some additional work is necessary in order to determine the contribution of Farmer Managed Natural Regeneration (FMNR) in the improvement of the quality of soils and the movement of water in the superficial zones of the soil.

Keywords

Infiltrability, Specific Index of Regeneration, Importance Value Index, Superficial Zones

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1. Introduction

The arid and semi-arid areas are characterized by a precariousness of their environmental conditions, thus making the balance of the ecosystems fragile [1]. But in the last three decades, the zone of the Sahel is presented as a rare case of success of Man's action in matters of adaptation to environmental changes [2]. In fact, the satellite images of 2003 show some important re-greening areas in the Sahel since the 1980s [3] [4]. Eklundh and Olsson [5] underlined a great increase in the normalized difference vegetation index (NDVI) on large surfaces of the Sahel and Sudan during the period from 1982 to 1999. This positive tendency was confirmed by Anyamba and Tucker [6].

The re-greening identified as an increase in the normalized difference of the index of vegetation (NDVI) [5]-[7] is explained by the changes in the use of lands, some practices of the management of natural resources and some agricultural practices, notably some techniques of protecting trees by Farmer Managed Natural Regeneration [8] [9].

In Niger, various studies conducted in the Southern strip of Niger (regions of Maradi and Zinder) showed that the re-greening occurred thanks to the efforts of reclaiming lands carried out by the different actors, notably the farmers thanks to the FMNR [8] [10]. Thus, the practice of the FMNR enabled to increase the number of trees on about five million hectares between 1983 and 2005 in that Southern strip [10].

Ali and Lebel [11] and Nicholson [12] showed that the dynamics of vegetation is closely linked to that of rainfalls. Thus, the rainfall stimulated the re-greening despite the serious droughts of the years 1970 and 1980. However, the extension of re-greening not being uniform [13], some researchers such as Nemani *et al*. [14]; Reij and Smaling [15] assert that the strong tendency of the ongoing re-greening cannot be explained by only one factor as the climate. In fact, the density of trees is not uniform in the fields of farmers [16]. So, can the strong tendency of the ongoing re-greening be explained by the physical characteristics of the soils?

This article studies the texture and the infiltration of soils in order to understand the link between the physical characteristics of soil and re-greening for a durable use of these agricultural ecosystems.

2. Material and Methods

2.1. Study Sites

The study took place in four (4) village areas of two regions located in the South-Central of Niger: Dan Saga and *El Guiéza* in the region of Maradi and *Daré* and *AraSofoua* in the region of Zinder (**Figure 1**). The area of study is relatively populated (about 100 inhabitants Km^{-2}). The climate is semi-arid, characterized by a single modal model of precipitation, with a rainy season (from June to September) and a dry season (October to May). The pluvial agriculture constitutes almost 90% of the population's activities. The crops such as millet and sorghum are mainly grown for subsistence on the sandy and poor soils, entirely depending on rainfall.

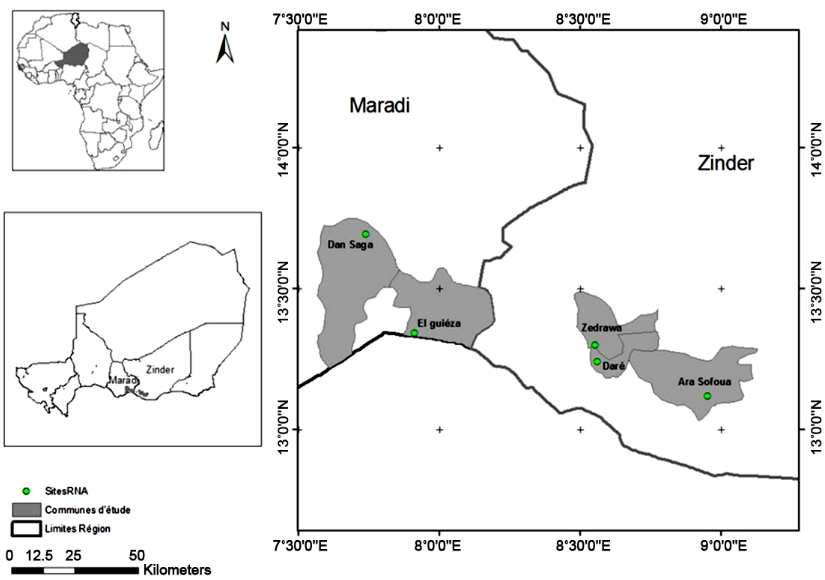


Figure 1. Location of the study sites.

2.2. Data Collection

With the purpose of evaluating the contribution of texture and that of infiltration of soils in the process of re-greening in these village areas, a participative approach including the farmers through the holding of meetings in the villages was adopted. In fact, a classification of soils was established by the farmers. One participant in the meeting was invited to draw on a Kraft paper a map for the repartition of the types of soils, thus giving a view on their spatial repartition. This framework presents an interest for the perception of the quality of soils [17], through which color and texture were used as main characteristics. Then, a visit to the fields was organized with four farmers chosen by the participants in the meeting in order to confirm the classification.

2.3. Dendrometric Parameters

The data on flora and vegetation were collected between June and July 2012 on some small squares of inventories and the plotting of the vegetation of 2000 m^2 (50 m ∗ 40 m) on the various types of soil. In each plotting, an exhaustive census of ligneous was taken. Some dendrometric measurements were taken in order to evaluate the height of trees, the circumference of the basis of the trunk (CBT) at 1.30 meters. For the multicaule individuals, the clump is considered as an individual and the measurements concerned only the dominant stalk. All the individuals whose diameter is inferior to 5 centimeters are considered as juvenile zone and systematically considered as part of the regeneration [18]. The height of individuals above 2 meters was estimated by using a graduated pole and the other individuals were measured by using a tape measure. The measurements of the circumference were taken by using a soft tape measure. Because of the irregularity of the form of certain species due to anthropic pressure, the soft tape measure was used [19]. In total, the sampling was carried out on 60 small squares; that is 4 small squares per type of soil and per village area.

2.4. Infiltration Test

The measurements of infiltration were carried out on each square during the dry season (February) in order to neglect the impact of the tenure of the soil in initial humidity [20]. The infiltration was measured by the technic of infiltrometer with dual rings following the method described by Bouwer [21]. With a height of 20 centimeters, the rings differ by their diameter, which is 11 centimeters for the internal ring against 34 centimeters for the external one. Four measurements were taken in each type of soil and by village. The samples of soil were constituted according to the types of soil at 0 - 20 cm of depth.

2.5. Analysis of the Soils

The composite samples of soil coming from each site were well dried at ambient temperature, put in plastic bag, labeled and analyzed. The texture of soils was determined by the method of granulometry with five fractions according to the standard procedures of the pipette of Robinson.

2.6. Data Analysis

The data obtained from the plotting of infiltration, of vegetation and the analysis of soils were treated and analyzed using Microsoft Office (Excel, 2007) spreadsheet and the software XLStat 7.2.

The observed density or real density was obtained by the following formula:

$$Dob = \frac{N}{S} \tag{1}$$

where: N is the total number of individuals in the sample and S is the sampled surface.

The specific importance of regeneration was obtained from the ratio in percentage between the number of young plants of a species and the total number of counted young plants [22]:

$$\text{IRS}(\%) = \frac{\text{Number of young plants of a species}}{\text{Total number of counted young plants}} \times 100 \tag{2}$$

All the subjects whose diameter is inferior or equal to 5 cm were considered to belong to the regeneration [18].

The ecological importance of species was appreciated from the Importance Value Index (IVI) that enables to appreciate better their importance in the plant community [23]. It is a synthetic and quantified expression of the importance of a species in a plant population. This index, for a species, is defined as follows:

$$IVI = (Domr) + (Fr) + (Dr) \quad (3)$$

where: *Domr* is the relative dominance, *Fr* is the relative frequency and *Dr* represents the relative density.

The values of *Domr*, *Fr* and *Dr* vary between 0% and 100% whereas those of the *IVI* of the species vary from 0 to 300%. The species with $IVI \geq 20\%$ are those ecologically important [24].

3. Results

3.1. Classification of the Types of Soils Encountered from the Zone of Study

The meetings at the level of each selected village point out two main groups of soil: the crusted soils or *Hako* and *Laka*; and the sandy soils locally called *Jigawa* and *Guéza* (**Table 1**). In fact, the division is mainly based on the texture and has two exclusive aspects (rough and fine). There is a second repartition based on the difference of color. At this level, there are four exclusive aspects (red, white, brown, black). The sandy soils have a low rate of fine elements such as silt and clay whereas the crusted soils have a high rate of more fine elements (<0.25 mm).

3.2. Physical Characteristics of the Soils of Main Study Sites

According to the granulometric analyses (**Figure 2**), the soils *Jigawa* or *Rerey* and *Guéza* present in general, a low proportion in fine particles, compared to 95% of sand. There is no significant difference between the two types of soils. However, the rate of fine elements at the level of *Hako* in *Dan Saga* (Northern Maradi) is significantly inferior to that of the three other areas (*El Guiéza*, *Daré* and *AraSofoua*) (Zinder) with respectively 2% against 10%.

3.3. Variation of the Rates of Infiltration According to the Types of Soils

At Dan Saga (Northern Maradi), the rate of initial infiltration is 123; 126 and 72 mm/min respectively on the *Jigawa*, *Guéza* and *Hako*soils against a rate of infiltration of the stationary state of 87, 61 and 54 mm/min respectively (**Figure 3(a)**). On the contrary, at *El Guiéza* (Southern Maradi), the rate of initial infiltration is 81; 73 and 50 mm/min respectively on the *Jigawa*, *Guéza* and *Hako* soils against 64, 59 and 28 mm/min, as a rate of infiltration of the stationary state (**Figure 3(a)**).

The village areas of the region of Zinder are characterized by dune grounds. At *Daré*, the initial rate of infiltration is 76, 65 and 75 mm/min respectively on the *Rerey*, *Laka* and *Hako* soils against 65, 45 and 48 mm/min, as a rate of infiltration of the stationary state (**Figure 3(b)**). On the contrary, at *AraSofoua*, the rate of initial infiltration varies 92, 81 and 2 mm/min respectively on the *Rerey*, *Laka* and *Hako* soils against 74, 21 and 2 mm/min, respectively as a rate of infiltration of the stationary state.

3.4. Ecological Importance of Ligneous Species According to the Types of Soils

In all the sites of *Rerey* and *Jigawa* soils, the density of trees is significantly more important in relation with the

Table 1. Classification of the soils at the study sites.

Farmer criteria			Scientific norms	
Name of the soils (Hausa)	Texture	Color	Classification	Texture
Jigawa or *Rérey*	Sandy	Red, white or black	Not leached out ferrigineous soils	Sandy
Guéza ou *Jigawa Hako*	Superficially sandy, but compacted	Red, white or black	Leached out ferrigineous soils	Silty-clayish
Hako	Hard, very compacted	Red, brown	Eutrophic brown soils on clayish material	Silty-sandy
Laka	Less compacted than the hako	Red, brown	Hydromorphic soils to pseudo-clay	Clayish-silty-sandy

Guiéza, *Hako* and *Laka* soils (**Table 2**). At *Dan Saga*, the density of trees is significantly different between the *Guiéza*, *Hako* and *Laka* soils whereas this difference is not significant in the areas of *El Guiéza*, *AraSofoua* and *Daré*.

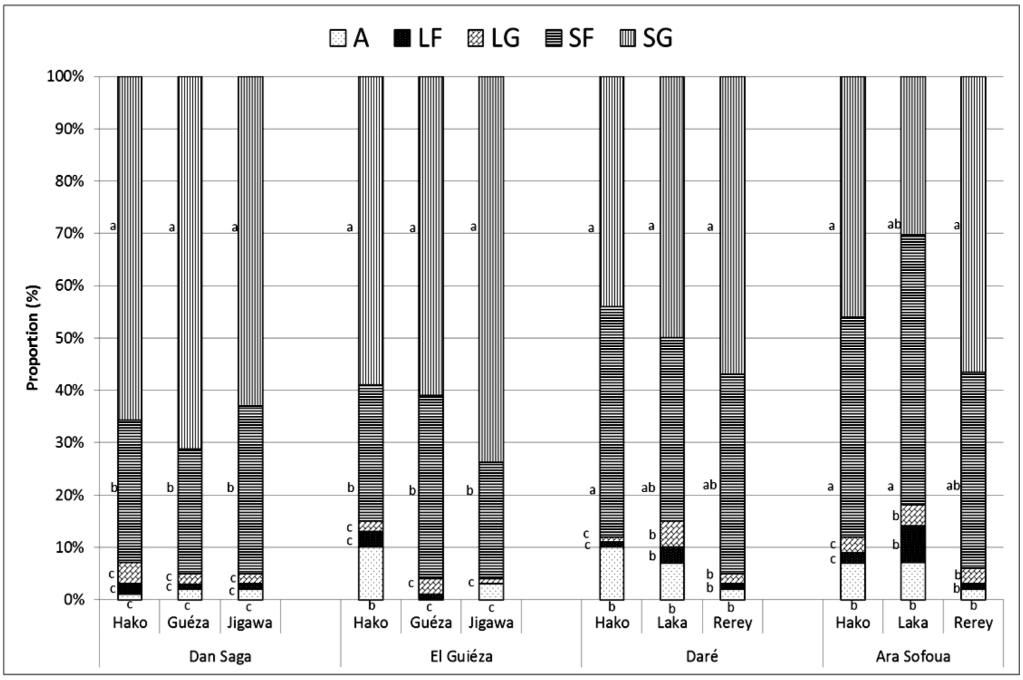
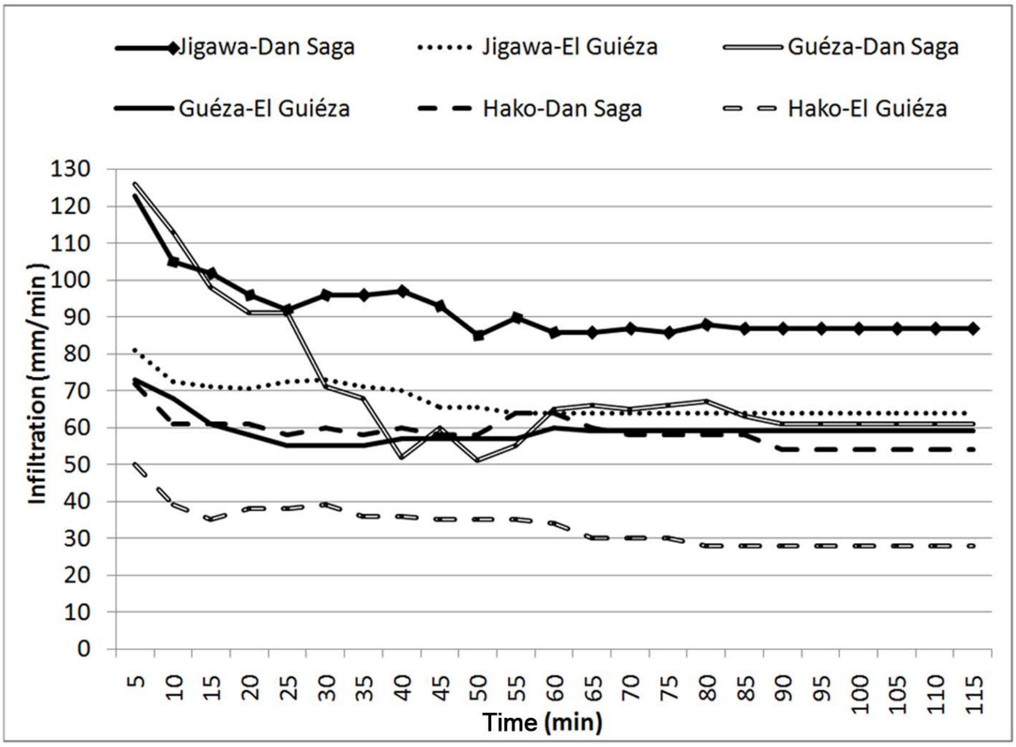
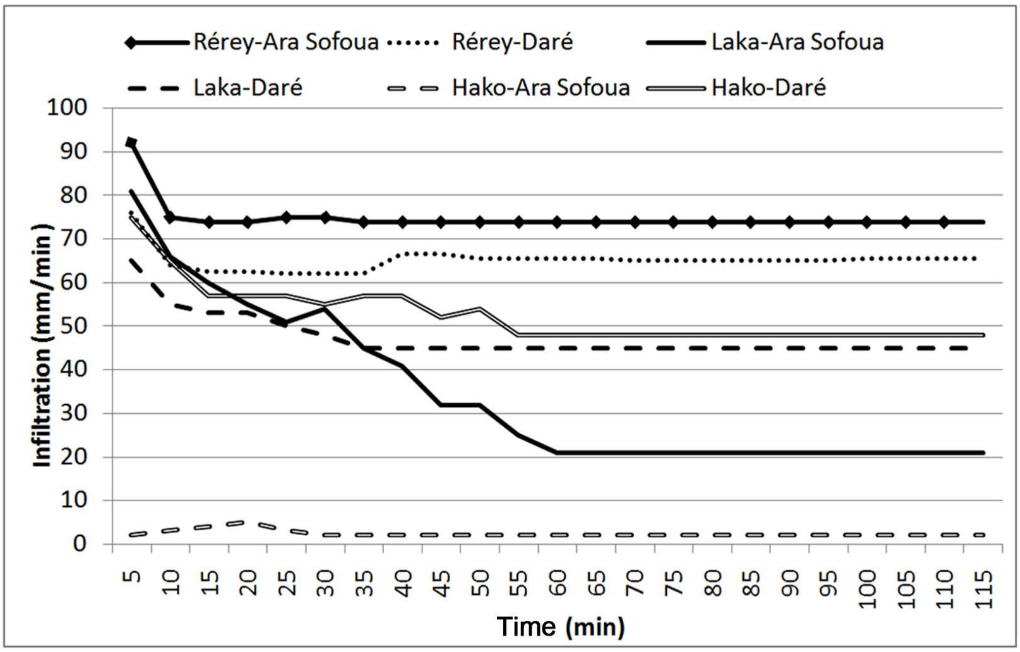


Figure 2. Average tenures in rough sands, fine sands, rough silt, fine silts and clay according to the types of soils. A: Clay; LF: Fine Silt; LG: Rough Silt; SF: Fine Sand; SG: Rough Sand.



(a)



(b)

Figure 3. (a) Variation of the rates of infiltration at the sites of Dan Saga and El Guiéza (Maradi); (b) Variation of the rate of infiltration on the sites of *Daré* and *AraSofoua* (Zinder).

Table 2. Repartition of the density of the ligneous population according to the types of soils.

Name of the species	*Dan Saga* (trees·ha^{-1})	*El Guiéza* (trees·ha^{-1})	*Daré* (trees·ha^{-1})	*AraSofoua* (trees·ha^{-1})
Hako/Laka	82c	73b	61b	36b
Rerey/Jigawa	206a	151a	180a	84a
Guiéza	177b	99b	98b	55b

The averages followed by the same letter are not significantly different at the threshold of 5%.

On the sites of the region of Maradi, it was taken a census of 10 ligneous species on the *Hako* soils against 16 on the *Guiéza* and *Jigawa* soils. 60% of the species on the *Hako* soils of *Dan Saga* have an IVI ≥ 20. On the contrary, on the *Guiéza* and *Jigawa* soils, only 25% of the species have an IVI ≥ 20 (**Table 3(a)**). Globally, the prevailing species, that represent the highest values of ecological importance are *Faidherbia albida* (89.24%) at *Dan Saga* on the *Hako*, *Piliostigma reticulatum* (82.65%), *El Guiéza* on the *Hako*, *Combretum glutinosum* (113.32%) in the North (*Dan Saga*) on the soil *Guiéza*, *Piliostigma reticulatum* (88.49%) in the South (El *Guiéza*) on the *Guiéza*, *Annona senegalensis* (33.21%), and *Azadirachta indica* (164.09%) in the North on the Jigawa, *Hyphaene thebaica* (124.02%) in the South on *Jigawa*.

The importance of regeneration according to the various species was apprehended by the calculation of the specific index of regeneration (SIR). At *Dan Saga*, the *Pilostigma reticulatum* and *Annona senegalensis* with 20.63% represent the best SIR on the *Hako* (**Table 3(b)**), *Combretum glutinosum* (30.50%) on the *Guiéza* and *Azadirachta indica* soils (31.25%) on the *Jigawa*. At *El Guiéza*, it is *Hyphaene thebaica* that has the best potential of regeneration on the *Hako*, *Guiéza* and *Jigawa* with respectively a SIR of 55.22%, 50.00% and 81.16%.

At *Daré* and *AraSofoua*, less than 10 ligneous species on the *Hako*, *Rerey* and *Laka* soils were counted. Globally, the prevailing species that represent the highest values of average ecological importance is *Faidherbia albida* on all the three types of soil.

The best potential of regeneration was recorded at the level of ligneous species such as *Annona senegalensis*, *Faidherbia albida*, *Azadirachta indica* and *Piliostigma reticulatum*.

Table 3. (a) List of species according to the specific index of regeneration (SIR) and the Importance Value Index (*IVI*) following the types of soils in the sites of Maradi; (b) The list of species according to the specific index of regeneration (SIR) and the Importance Value Index (*IVI*) following the types of soils in the sites of Zinder.

(a)

	Dan Saga			**El Guiéza**		
	Species	SIR	IVI	Species	ISR	IVI
Hako	*Albizia chevalieri*	9.52	11.91	*Albizia chevalieri*		3.74
	Annona senegalensis	20.63	**34.13**	*Annona senegalensis*	1.49	6.45
	Azadirachta indica	1.59	**20.07**	*Balanites aegyptiaca*	1.49	2.01
	Calotropis procera	3.17	11.60	*Combretum glutinosum*		7.98
	Cassia singueana	4.76	12.76	*Faidherbia albida*	1.49	**74.05**
	Combretum glutinosum	19.05	**50.32**	*Hyphaene thebaica*	55.22	**80.61**
	Faidherbia albida		**89.24**	*Lannea microcarpa*		5.26
	Guierasene galensis	19.05	**28.41**	*Maerua crassifolia*		14.51
	Pilostigma reticulatum	20.63	**35.72**	*Pilostigma reticulatum*	25.37	**82.65**
	Stereospermum kunthiam	1.59	5.84	*Prosopis africana*		2.71
				Ziziphus mauritiana	14.93	**20.04**
Guiéza	*Albizia chevalieri*	3.55	6.13	*Adansonia digitata*		5.82
	Annona senegalensis	8.51	**21.76**	*Albizia chevalieri*	7.69	14.39
	Azadirachta indica	1.42	6.24	*Annona senegalensis*		5.03
	Balanites aegyptiaca	5.67	15.31	*Azadirachta indica*	7.69	7.81
	Boscia salicifolia	1.42	7.60	*Balanites aegyptiaca*	3.85	8.96
	Calotropis procera	4.26	6.84	*Bauhinia rufescens*		5.82
	Cassia singueana	3.55	6.13	*Combretum glutinosum*		5.16
	Combretum glutinosum	30.50	**113.32**	*Faidherbia albida*	3.85	**28.58**
	Commiphora africana	0.71	3.80	*Guierasene galensis*		5.12
	Faidherbia albida		5.30	*Hyphaene thebaica*	50.00	**31.79**
	Guierasene galensis	25.53	**34.00**	*Lannea microcarpa*		**33.29**
	Hyphaene thebaica	1.42	7.60	*Maerua angolensis*	7.69	6.36
	Maerua crassifolia	1.42	4.36	*Maerua crassifolia*	3.85	6.75
	Pilostigma reticulatum	7.80	**51.71**	*Pilostigma reticulatum*	7.69	**88.49**
	Stereospermum kunthiam	1.42	4.36	*Prosopis africana*	7.69	**38.51**
	Ziziphus mauritiana	2.84	5.56	*Ziziphus mauritiana*		8.12
Jigawa	*Adansonia digitata*	2.08	9.48	*Acacia nilotica*	7.25	17.24
	Annona senegalensis		6.19	*Balanites aegyptiaca*	4.35	7.89
	Azadirachta indica	31.25	**164.04**	*Bauhinia rufescens*	4.35	7.89
	Balanites aegyptiaca	12.50	10.62	*Combretum micranthum*	1.45	7.33
	Cassia singueana	2.08	6.11	*Diospyros mespiliformis*		6.74
	Combretum glutinosum	14.58	**29.43**	*Faidherbia albida*		**94.64**
	Commiphora africana	2.08	6.11	*Hyphaene thebaica*	81.16	**124.02**
	Dichrosta chyscinerea	6.25	7.85	*Pilostigma reticulatum*	1.45	**27.30**
	Faidherbia albida	2.08	6.11	*Ziziphus mauritiana*		6.94
	Guierasene galensis	8.33	8.65			
	Hyphaene thebaica	2.08	6.10			
	Lawsonia inermis	2.08	6.12			
	Maerua crassifolia	2.08	7.11			
	Moringa oleifera	2.08	6.11			
	Pilostigma reticulatum	6.25	13.06			
	Prosopis africana	4.17	6.94			

(b)

	Daré			AraSofoua		
	Species	SIR	IVI	Species	ISR	IVI
Hako	*Annona senegalensis*	48.48	**56.27**	*Commiphora africana*		9.12
	Azadirachta indica		9.20	*Sclerocarya birrea*		**33.78**
	Balanites aegyptiaca	9.09	13.50	*Faidherbia albida*	43.75	**117.28**
	Commiphora africana	6.06	11.20	*Annona senegalensis*	12.50	**33.55**
	Faidherbia albida	21.21	**128.78**	*Pilostigma reticulatum*	12.50	**33.99**
	Lannea microcarpa		12.18	*Leptadenia pyrotechnica*	6.25	7.86
	Leptadenia hastata	6.06	17.89	*Prosopis africana*	6.25	**41.08**
	Prosopis africana	3.03	**26.97**	*Guierasene galensis*	12.50	15.58
	Tamarindus indica	6.06	**24.03**	*Leptadenia hastata*	6.25	7.79
Rerey	*Annona senegalensis*	55.56	**88.37**	*Balanites aegyptiaca*		15.98
	Azadirachta indica		**20.33**	*Commiphora africana*		13.28
	Faidherbia albida	2.78	**105.19**	*Faidherbia albida*	50.00	**88.12**
	Guierasene galensis	30.56	**29.48**	*Annona senegalensis*	22.22	12.71
	Lannea microcarpa		**22.51**	*Pilostigma reticulatum*	16.67	**78.55**
	Pilostigma reticulatum	2.78	15.72	*Prosopis africana*		**78.38**
	Sclerocarya birrea	2.78	8.51	*Guierasene galensis*	11.11	12.99
	Vitex doniana	5.56	9.88			
Laka	*Acacia nilotica*	2.50	**37.08**	*Faidherbia albida*		**123.71**
	Annona senegalensis	5.00	**24.01**	*Annona senegalensis*	25.00	**27.63**
	Azadirachta indica	62.50	**168.56**	*Pilostigma reticulatum*	50.00	**87.19**
	Eucalyptus camaldulensis	27.50	**58.50**	*Prosopis africana*	25.00	**51.23**
	Guierasene galensis	2.50	11.85	*Guierasene galensis*		10.24

4. Discussion

4.1. Influence of the Texture of Soils

In general, the soils of the area of study are characterized by a sandy texture for more than 80%. Clay and fine silts, which ensure the role of cohesion of the different constituents of the soils, the basis of a good structure, are in low proportion. The "*Jigawa*" or "*Rerey*" soils are very sandy and very poor in fine elements and more particularly in clay. Thus, several authors [25] [26] have shown that on the sandy soils of West Africa, the putting under cultivation of lands favor the elimination of the finest elements through eluviation and water erosion and/or wind erosion and therefore, the increase in rough sand on the surface.

For the *Guéza* soil on the contrary, Ambouta and Amadou [25] have pointed out its extreme sensitivity to the degradation of its physicochemical properties, thus transforming it into *Jigawa* soil.

4.2. Influence of Soil Infiltration

Infiltration is the process through which surface water penetrates in the soil. It is related to the surface outflow and that of ground water, determines the fraction of irrigation water or rain water that penetrates in the soil and therefore, affects the runoff responsible of soil erosion [27].

The results of the analysis of the infiltrability enables to notice that the soils which are very sandy ("*Jigawa*" or "*Rerey*" and "*Guiéza*") are more permeable than the *Hako* and *laka* soils. This established fact is explained by the rough and porous texture that favors rapid infiltration. The same tendency was observed by Makungo and Odiyo [28] who determined the rates of infiltration of the silty-sandy soils, sandy-clayish soils and silty-clayish soils which have some rates of initial infiltration that vary from 133.5 to 325.5; 71.6 to 124.8 and 120.4 to 160.8 mm/hour respectively whereas the rates of infiltration of the stationary state vary from 50 to 110; 19 to 22 and 30 to 40 mm/hour. Agrawal *et al.* [29] found very significant positive correlation between the tenure in sand and the final rate of infiltration. Some similar results were also obtained by several authors [30] [31], who noticed that the speed of infiltration of the rough soil is higher than that of the soils with fine and average textures. They obtained some infiltration rates which are superior to 100 mm/hour and inferior to 10 mm/hour for the average and fine soils.

The *Hako* and *laka* soils are less permeable because of their encrusting. Hillel [32] and Talaat [33] reported that the presence of layers of clay hinders the infiltration of water because of the weakness of the macro-pores.

4.3. Relation between Infiltration and Vegetation

The rate of infiltration is more important on the very sandy soils ("*Jigawa*" or "*Rerey*" and "*Guiéza*") and they also have an important density of trees. This tendency was observed by Rao *et al*., [34] in the Kenyan Savanna. Lili *et al*. [20] showed that the presence of vegetation is positively correlated with infiltration. The positive effect of trees on infiltration is due to the formation of root channels, macro pores and micro pores. Also, the litter increases the activity of the soil's faun [35] [36]. The vegetation delays the transfer of surface water, breaks the kinetic energy of rain drops, which leads to the reduction of the effect of slaking. Also, the extension of roots, the expansion of the crown can contribute to the accumulation of organic matter and nutritive elements in the arable layer of the soil leading to a physical, chemical and biological improvement in the rhizosphere [37]. A diminution of the tenure in the organic matter in the soil diminishes the macro-porosity, which reduces the infiltration [38]. The activity of the fauna was found to be an important agent for the control of the quality of soils. The macro fauna of soil (mostly termites and ants) improve the physical properties of soil and considerably contributes to increase the infiltration of the dry season ecosystems [39]-[41].

Faidherbia albida is the species that has the best SIR and IVI in the sites of the region of Zinder. Hansson [42] has noticed the capacity of infiltration of soil under *Faidherbia albida* was 69 mm/hour in the fields in the West of Burkina Faso.

But, the success of restoration is hindered by the excessive tree felling, generally carried out by the transhumant stock breeders, debarking of trees done by certain categories of people and the overexploitation make certain species vulnerable [16] [43]. The system of leading the herd into the farming fields in Niger contributes to the diminution of the vegetable cover and the biomass and increases the runoff because of crust colonization [44]. In fact, Hiernaux *et al*. [45] showed that stepping and compacting are important reducing agents of soil hydrology. This combination of factors leads to the reduction of the vegetable cover, which has as consequence the development of the crusts of the soil surface [44] thus, favoring the runoff to the detriment of infiltration [44].

5. Conclusion

The measurement of infiltration of water in the soil is an important indication of efficiency of irrigation and drainage, the optimization of the availability of water for plants, the improvement of the yields of crops and the minimization of erosion. When the soils are crusted (*Laka* and *Hako*), the infiltration of water is slow or quasi-inexistent. Also, the vegetable cover is low. As the precipitations are the main sources of water supply, ensuring the growth and production, rain water is less beneficial for the development of vegetation. But if the structure of the soil surface is improved by the work on the soil, there will be a bigger capacity of infiltration of water and the efficiency of use is improved in the long term. Other additional work is necessary in order to determine the contribution of the Farmer Managed Natural Regeneration (FMNR) in the improvement of the quality of soils and the movement of water in the superficial zones of the soil.

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