PILIOSTIGMA RETICULA TUM USED FOR SOIL ORGANIC MATTER BUILD UP: EFFECTS ON THE SOIL QUALITY AND CROI' YIELD IN THE PEANUT BASIN OF SENEGAL

M. Diack, M. Sène and A. N. Badiane

ISRA, SENEGAL

Paper prepared for the first Annual Workshop of InterCRSP West Africa Group

Kaolack, 11-14 January 1999

PILIOSTIGMA RETICULATUM USED FOR SOIL ORGANIC MATTER BUILD UP: EFFECTS ON THE SOIL QUALITY AND CROP YXELD IN THE PEANUT BASIN OF SENEGAL

M. Diack, M. Sène and A. N. Badiane

Soil Scientists, ISRA, Senegal

ABSTRACT

Given the high demand for crop residues and the insufficiency of animal manure, the use of native vegetation could be an alternative solution for improving soil quality and crop productivity. This study was conducted to determine the effect of *Piliostigma reticulatum* (PR), a native shrub, in improving the soil properties of a degraded soil and to develop management systems that effectively utilize the species ta maximize input efficiency and crop productivity. The experiment was conducted at Nioro, Kaolack, on a Deck Dior loamy sand (fine sandy, rnixed Haplic Ferric Lixisol), Eeached ferrugeneous soil tropical soil, where peanut and millet were grown. The above-ground biomass of PR, collected after each cutting from the field was applied at the soil surface, at a rate of 2 t/ha on the dry matter basis. The study compared a control (TO), PR biomass from weeding (T1), T1 + minera1 fertilizer (T2), at recommended rate for the growing crop, T2 + biomass from cutting after harvest (T3), PR biomass fi-om clear cutting during soil preparation (T4), and T4 + minera1 fertilizer at recommended rate for the growing crop (T5). As treatment application was sequential, partial results showed slight increases of 21 and 26% for T1 and T2 respectively in peanut plant population, 6 and 17% for T1 and T2 respectively in pods. As for millet, increases in stalk of 8 and 188% for T 1 and T2 respectively were recorded. For both crops, these increases in yield components were more likely due to the chemical fertilizer that is more available to plants so far.

Key words: *Piliostigma reticulatum*, biomass, soil organic matter, soil quality, crop productivity.

UTILISATION DE *PILIOSTIGMA RETICULA TUM* POUR RECONSTITUER LE STOCK DE MATIERE ORGANIQUE: EFFET SUR LA QUALITE DES SOLS ET DU RENDEMENT DES CULTURES DANS LE BASSIN ARACHIDIER DU SENEGAL

M. Diack, M. Sène et A. N. Badiane

Pédologues, ISRA, Sénégal

RESUME

Devant la forte demande des résidus de cultures et l'insuffisance des déchets animaux, l'utilisation de biomasse produite par la végétation naturelle pourrait constituer une alternative à l'amélioration de la qualité des sols et de leur productivité. Cette étude a été menée pour déterminer l'influence de *Piliostigma reticulatum* (PR), un arbuste local, sur l'amélioration des propriétés d'un sol dégradé et développer un mode de gestion qui maximiserait la productivité du sol. L'essai a été conduit à la station de Nioro, (Kaolack), sur un sol Deck Dior, sableux fin, ferrugineux tropical lessivé, où l'arachide et le mil sont en rotation. La biomasse aérienne de PR, ramassée du champ après chaque coupe, était appliquée à la surface du sol pour les traitements concernés à la dose de 2 t/ha de matière sèche. L'étude compare un témoin absolu (TO), une biomasse de PR. coupée au sarclage (T1), T1 + (N)PK à la dose recommandée pour la culture (T2), T2 + biomasse de PR coupée après récolte (T3), une biomasse de PR coupée pendant la préparation du sol (T4) et T4 + (N)PK, à la dose recommandée pour la culture (T5). Etant donné que l'application des traitements a été séquentielle, les résultats partiels montrent une légère augmentation de 21 et 26% respectivement pour les traitements Tlet T2 en terme de population des plants d'arachide, et 6 et 17% respectivement pour les traitements Tlet T2 en terme de gousses. Quant au mil, une augmentation de 8 et 188% de paille produite respectivement pour Tlet T2 a été obtenue. Pour les deux cultures, ces augmentations seraient plutôt imputables à l'effet des engrais minéraux qui pour le moment, sont plus disponibles.

Mots clés: *Piliostigma reticulatum,* biomasse, matière organique du sol, qualité du sol, productivité.

Introduction

With 1/3 of the country's area, the Peanut Basin provides 75% of the peanut and 80% of the millet production of the country. However, while the soils are intensively cultivated with a. high degree of land utilization (land in fallow less than 3%), crop production is still low. Soils are degraded.

Degradation of the soil resource, in Senegal, has resulted from the combination of decreases in rainfall, inappropriate land management practices (less land in shorter fallow periods, removal of nearly all crop residues from fields), and declining numbers of trees from traditional parkland agroforestry systems. Consequently, there has been an intense nutrient extraction of primarily N and P, and a decrease in overall soil organic matter (decreased from naturally occurring 2% down to 0.3%). The changes to the soil resource have caused decrease in food production and reduced rural income. Therefore, efforts must be redoubled to replace nutrients that have been lost from the farms through the use of fertilizers and organic matter.

Given the high demand for crop residues and the insufficiency of animal manure, the use of native vegetation could be an alternative solution for improving soil quality and thereby increasing crop productivity.

Piliostigma reticulatum, an endophitic legume, with no nodules, non-fixing N, from the *Cesalpiniaceae* family, is usually a shrub but can occasionally be a tree. It grows on sandy, clayey and lateritic soils, During the dry season, it can regrow up to 90 cm with a canopy diameter of 100 to 175 cm. Annually, 1268 g of dry weight biomass per shrub are produced, for an average density of 317 shrubs per ha (Diack et al., 1998). In some areas, these shrubs nearly cover the landscape but in others, there is a less dense distribution. This difference in density is due to differences in soil types. If left uncut, these shrubs continue to grow, but in farmers' fields they are cut at the soil surface and burned just prior to the rainy season.

A survey was conducted (Diack et al., 1998) to determine the level of appreciation and use that farmers make of *P. reticulatum* within the parkland system. The survey showed that *P. reticulatum* was the third most important species that farrners would like to conserve in the fields after two tree species: *Cordyla pinnata* and *Acacia albida*. The reasons for the choice these three species were fruit production, nutrient value of theïr biomass and forage for livestock. For *P. reticulatum*, farmers admitted that it can play an

important role in soil fertilization and help protect soil against erosion. The population of *P. reticulatum* is still acceptable despite a decrease during the past ten years, due to mecanization. The management system of *P. reticulatum* consists of cutting the shrub (april-june) for soil preparation and cutting 2 to 3 times more, depending on the crop, during the growing season. Ash as minera1 fertilizer is the main product that farmers get from the management system. According to farmers, the effect of *P. reticulatum* on crop productivity is showed by the good response of crops such as peanut, millet and to some extend cowpea, under the shrub canopy. These information collected from the survey show that *Piliostigma reticulatum* plays an important role in the farming system and has a potential of improving the soil productivity.

A decomposition study of *Piliostigma reticulatum* biomass (Diack et al., 1998) showed a greater mass loss under field conditions than under controlled 'conditions. This was probably due to the role of soil fauna which may have been involved under field conditions but would have been excluded under laboratory conditions. With such fast decomposition rate under field conditions, accumulating residue biomass at the soil surface would certainly avoid a discontinuous distribution of organic resource for the microbial activity. The specific surface area-to-mass ratio, obtained for *P. reticulatum*, should allow such a continuous application of the biomass to the soil for both cover and organic matter build up.

The objectives of this study are to determine the influence of *P. reticulatum* on the soil physical, chemical and biological properties and the crop yield.

Materials and Methods

Site

The experiment is being carried out in Paoskoto (Kaolack) in two farmers'fields which are under a two-year rotation of peanut (*Arachis hypogaea*) and millet *(Pennisetum glaucum L.).* The soil is a Deck Dior loamy sand (fine-sandy, mixed Haplic Ferric Lixisol), leached ferrugeneous tropical soil (probably Ultisol). The soil has a pH varying from 5.7 to 6.7 and a low fertility status (OC: 0.47%, N: 0.45%).

Plant materiais:

The above-ground biomass (leaves and stems) of *Piliostigma reticulatum* were collected after each cutting from the field.

Experimental design

It is a randomized complete block design with 6 treatments replicated 4 times. The treatments are the following:

TO = Control;

T1 = Biomass from cutting (weeding) and application between rows and at the soil surface, at a rate of 2 ton/ha of dry matter;

T2 = T1 + minera1 fertilizer at the recommended rate for the growing crop;

T3 = T2 + biomass from cutting after harvest and application at the soil surface, at a rate of 2 ton/ha of dry matter;

T4 = Biomass from clear cutting (soi1 preparation) and application at the soil surface, at a rate of 2 ton/ha of dry matter;

T5 = T4 + minera1 fertilizer at the recommended rate for the growing crop.

Peanut, a 73-33 variety, will be planted with interrows of 0.50 m while millet (Souna 3) will be planted with interrows of 0.90 m, in an experimental unit area of 45 m^2.

Measurements

1. On plants: N, P, K, Ca, Mg and S contents will be determined at the maximum vegetative stage and before harvesting for each crop.

2. On soils: samples will be collected before and after each growing season to monitor soil moisture in relation to soil physical, chemical, biological properties and C dynamics. The following properties will be measured:

a) Physical characteristics: moisture content, bulk density, infiltration rate, soil resistance to penetration and sealing index as a measure of aggregate stability;

b) Chemical characteristics: total C and N, NO_3^-, NH_4^+, P_2O_5, K', Ca^{2+} and Mg^{2+};

c) Biological characteristics: microbial biomass C, particulate organic C (POC) and enzyme activity (β-glucosidase).

Partial Results and Discussion

Since the application of *Piliostigma reticulatum* biomass is sequential, treatment T3 has been applied right after harvest while T4 and T5 will be applied early next season. Therefore, the yield components presented in Tables 1 and 2 are only for treatments TO, T1 and T2. The yield components recorded for T3, T4 and T5 treatments could be considered as control for the first year.

For peanut (Table 1), even though yields were relatively low, *P. reticulatum* application has showed a slight increase in yield components. For plant population at harvest, there is an increase of 2 1 and 26% for T1 and T2 respectively. For pods, there has been an increase in yield of 6 and 17% for T1 and T2 respectively whereas 6 and 29% were the respective increases in hay yield for T1 and T2.

As for millet, yields in general are low (Table 2). However, while treatment T1 has not yet shown any increase, T2 in the other hand has strongly responded in yield. Plant population has increased from 1 to 6% and stalk from 8 to 188% for Tland T2 respectively. For both crops, increases in yield components were more liltely due to the chemical fertilizer that was added to *P. reticulatum* biomass for its greater availability.

Perspectives

Since the experimentation is a 4-year program, we need to complete first the treatment applications and then monitor the soil property changes over time.

Table 1. Yield components of the peanut as affected by *Piliostigma reticulatum*

Treatment	Plant population	Pod + Hay (kg/ha)	Hay (kg/ha)	Pod (kg/ha)
TO	44480	1250	600	650
T1	54060	1320	640	690
T2	55980	1530	770	760
Mean	53300	1460	720	750

Table 2. Yield components of the millet as affected by *Piliostigma reticulatum*

Treatment	Plant population	Number of spikes /ha	Stalk (kg/ha)	Grain (kg/ha)
TO	8240	11140	1240	210
T1	8320	8170	1340	150
T2	8700	27170	3560	660
Mean	8380	18650	2040	410

FIRST ANNUAL INTERCRSP WORKSHOP

West Africa Group

Field Trip Report on January 13, 1999

by

Dr. Mateugue Diack

As part of the workshop program, the field trip gave an opportunity to the participants to visït the Koutango and Nïoro sites where the InterCRSP experïmental plots were located.

7H 30 am. The vïsïtors left Kaolack for the Koutango site, 69 km, South-west from Kaolack

9H 05 am. They arrïved at the site and were introduced to Mr. Mansour Dème, field worker and owner of the field by Dr. Modou Sène. A nutrient management progam ïs beïng carrïed out on rice under rainfed. Rock phosphate and phosphogypsum as P and Ca sources and manure are the fertïlizer forms used in the experiment (see papers).

Several questions about the perception that farmers have on the phosphogypsum progam, ïnïtïated by the Government of Senegal, were asked

Was the phosphogypsum efficient as fet-tïlïzer?

Yes, and 1 am also usïng it to control salinïty, replïed Mr. Dème.

What if the Government stopped providïng fertïlizer fi-eely?

I will purshase it, he saïd.

Beside rïce, Mr. Dème grows vegetables because water ïs avaïlable.

The site ïs wïthïn an interesting valley for whïch ISRA intends to run a research and development program under lowland conditions. Dr. Dïack, coordïnator of that program, presented prelïminary data obtained from both socio-economïc and hydrologic surveys conducted in the valley. The data showed a great agricultural potential of the valley. However, soil constraints such as salinizatïon, acïdity and water management need to be addressed. From the socio-economïc standpoint, villages established arround the valley are organized into 57 groups based on economic ïnterest. The R and D program will be carried out by a multïdïscïplinary team composed of scientists from ISRA, the University of Dakar and an NGO.

9H 45 am. The participants left Koutango for the Nioro Research Station, second site

1 1 H 45 am. As they arrived at the Research Station, the participants were introduced to,the local staff by Dr. Modou Sène. The visit started with experimental plots among which the *Piliostigma reticulatum* tria1 under peanut/millet rotation, a second tria1 where rock phosphate and phosphogypsum as P and Ca sources and manure were compared under a peanut/millet rotation and a third experiment combining nutrient management and water balance (see papers). The participants also visited the small dam implemented to control runoff/erosion in the watershed.
For each trial, several questions were asked, leading to important discussion. From the discussion, one could appreciate the amount of work done so far, meaning the InterCRSP program in Senegal is going well.

1 H 20 pm. The participants left Nioro for Kaolack.

2H 15 pm. Arriva1 at Kaolack.

The following participants took part to the field trip:

1. Russe1 YOST
2. Gaoussou TRAORE
3. Samuel BRUCE-OLIVER
4. Aminata SIDIBE
5. Isuarina BAPTISTA
6. Aminata BADIANE
7. Abou BERTHE
8. Mamadou DOUMBIA
9. Kevin BRANNAN
10. Richard KABLAN
11. Mouhamed KEBBEH
12. Babou JOBE
13. Cheikh NDIAYE
14. Modou SENE
15. Mateugue DIACK

Field Operations during the first year

Field Operations	Dates of Implementation	
	Peanut	Millet
Sowing	07/21	07/21
1st weeding	08/18	08/07
Thinning		08/07
N-P-K application	08/19	08/13
1st urea application		08/19
2nd urea application	-	09/04
P. reticulatum application	9/04	9/04
2nd weeding	09/08	09/08
Harvest	11/17	11/9
P. reticulatum application	12/11	12/11