Effect of Natural and Mucuna *pruriens* fallow on soil properties and crop performance in Dioscorea *alata* (water yam) based systems in Liliyo and Tieningboué (Côte d'Ivoire) and Léo (Burkina Faso)

Yam (Dioscorea *spp.*) is an important staple crop and accounts worldwide for 155 million consumers. About 92% of yam production takes place in West Africa, whereby D. *alata* is one of the most cultivated and economically important yams species. Yam is an important source of carbohydrates and vital nutrients for many consumers. However, it is considered to be a high demanding crop in terms of organic matter and soil fertility. This is a major constraint in soils of Africa, which are old, highly weathered and nutrient depleted. They are vulnerable to degradation. In West Africa yam is traditionally cultivated without fertilization inputs after a long fallow period. This practice and the applied method of slash and burn are not sustainable. On the one hand, yam production is further mining the available (remaining) nutrients of the soil -especially nitrogen (N) and potassium (K), and to a smaller extend phosphorus (P)- and the crop is highly demanding on the environment and its natural resources. On the other hand, producers have to look further and further for areas suitable for their crop. Due to continuous population growth, the increasing tuber demand cannot be met anymore by enlarging cultivated surfaces as land gets scarce. Therefore, stakeholders are forced to cultivate the fields shortly again after only one year of fallow (or even none), letting soil no time for regeneration. Addition of mineral and organic fertilizer might provide the required nutrients in the system. However, these fertilizers are often beyond the financial reach of small-scale and resource-poor farming households. Additionally, these inputs might cause other trade-off effects such as prompt decomposition of soil organic matter, soil degradation, etc. which can become a major production constraint. Alternative approaches include the replacement of short season natural fallows through man-made fallows of higher quality by planting legumes. Besides being a rather cheap nitrogen source, green manure application may potentially increase water infiltration capacity by decreasing bulk density and surface crusting and improves water retention capacity and porosity.

All these trade-offs in yam cropping systems are addressed by the project YAMSYS. YAMSYS has the aim to investigate acceptable and feasible methods to develop soil and yam management innovations in Côte d'Ivoire and Burkina Faso by adopting the techniques of integrated soil fertility management (ISFM).

The present master thesis was conducted within the project YAMSYS, in collaboration with ETH Zürich, World Agroforestry Centre (ICRAF), Centre Suisse de Recherches Scientifiques (CSRS) in Côte d'Ivoire and Institut de l'Environment de Recherches Agricoles (INERA) in Burkina Faso. The objective of the thesis was to evaluate the effect of no fallow, natural fallow and man-made legume fallows such as mucuna *pruriens* on soil properties and crop performance in Dioscorea *alata* (water yam) based systems in Liliyo and Tieningboué (Côte d'Ivoire), and Léo (Burkina Faso) within the mother trials of the YAMSYS project *(figure 1)*. The aim was to analyze changes in chemical and physical soil properties between 2016 (start of experiment) and 2018 as well as the changes in tuber performance in relation to cropping rotations and fallow types within each site. No fallow included in the first and third year of the study period yam cultivation, and in the second year maize, rice or groundnut. Natural and mucuna fallow remained for the first two years fallows and only in the third year, 2018, yam was planted.

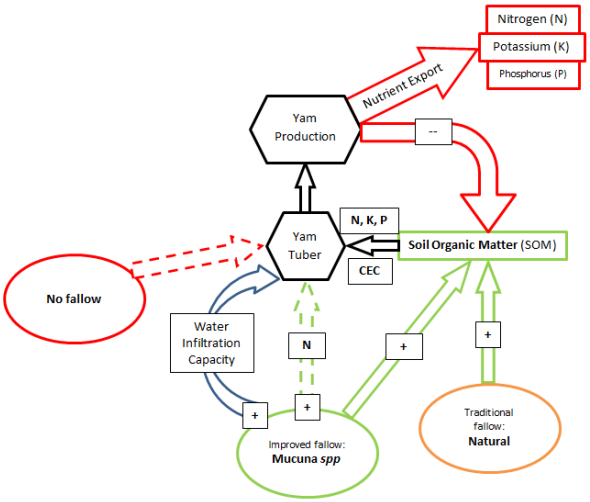

Figure 1: Sketch of established hypotheses for each rotation; no fallows, natural fallows, mucuna pruriens fallows. CEC (cation exchange capacity)

The experimental design at each site consists of a randomized-complete block (Liliyo: 50 m x 24 m, Tieningboué and Léo: 43.5 m x 34 m) with three block replications. Within each block, six subplots with different rotations were conducted. All subplots have the size of 6x7 m^2. During the years of yam production each subplot contains 20 mounds, whereas only the 6 inner mounds- elemental parcel- have been measured. The impact of the different rotations on soil properties was assessed physically by water infiltration measurements with the single ring method in 2018 and by chemical analyses of topsoil (0-20 and 0-30 cm) from the year 2016 and 2018: pH, carbon (C), nitrogen (N), plant available phosphorus (P), exchangeable cations such as potassium (K),

magnesium (Mg), calcium (Ca), manganese (Mn), sodium (Na), aluminum (Al), iron (Fe), as well as metals such as copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), and total elements Si (silicon), Al, Fe, P, K, Mg, Ca. The impact of the different fallow trials on tuber performance was assessed by measuring tuber yield in 2016 and 2018 and nutrient contents in tubers in the latter year. Statistical analyses were carried out with the program R (version 3.5.3).

Although only significant differences between the rotations were mainly observed on the site of Liliyo, the sites of Tieningboué and Léo also showed general trends. Results revealed that at all three sites yam yield was lowest for no fallows which comes along with the highest depletion of total N, available P, exchangeable cations and SOM mineralization through soil cultivation practices as well as nutrient export through harvesting. The amount of nutrients recycled or removed was highly depended on the dry matter production and SOM retention that in turn depended on soil fertility, soil characteristics and rainfall patterns. Possible explanation for these findings is that the dominant clay fraction in the soils of Liliyo, Tieningboué and Léo is expected to be kaolinite. Kaolinite has a very low specific surface area, which explains the rather low CEC at all three sites. However, soil pH, soil texture and especially SOM can contribute to a higher specific surface area. With decreasing SOM the specific surface area is lowered and therefore CEC is also decreasing due to less available binding properties. This effect was observed to relate almost on a linear function as shown in the plots of *figure 2,* especially for Liliyo and Tieningboué. Therefore, with SOM decreasing in no fallow plots, they also reported the lowest CEC compared to the other fallows.

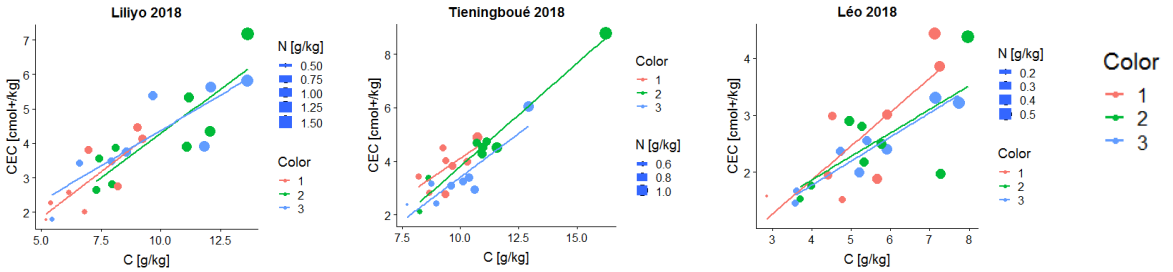

Figure 2: with, 1: no fallow (pink), 2: natural fallow (green), 3: Mucuna fallow (blue), x-axis: cation exchange capacity (CEC[cmol+/kg]), y-axis: carbon (C,[g/kg], size of circles indicate nitrogen content (N,[g/kg]) in soil for Liliyo, Tieningboué, Léo in 2018.

The different significant results of the fallow types *(figure 2)* between the sites of Liliyo, Tieningboué and Léo can also be explained due to the fact that the three sites represent a gradient across the soil and climatic conditions found in the yam belt of West Africa. Liliyo is situated in the South West region of Côte d'Ivoire and represents the most southern site of YAMSYS. Liliyo lies in the humid forest with two rainy seasons. Tieningboué, located in the North West region of Côte d'Ivoire lies in the forest-savannah transitional zone with only one rainy season. Léo, the most northern site of this thesis, is located in the Centre West region of Burkina Faso. The site belongs to the South Sudan Savanna zone and is characterized by one large dry season and a unimodal rainfall pattern. Therefore, growing season and turnover rate of SOM and SOM containing N is uniquely per site. This might be a possible explanation that only in Liliyo a significant difference between the fallow types were observed, whereas in Tieningboué and Léo only to a smaller extend. *Figure 2* and other statistical analyzes, as well as total elemental measurements of soil samples through XRF revealed that the site of Léo is rather influenced by external effects than by yam cultivation and different fallow trials. The observed increase in the total nutrient contents of P, K and Ca on the site of Léo might be aeolian, in this particular case through dust deposition of the dry wind Harmattan. The harsh harmattan wind blows in the dry season from the north-east to the south west and plays an important role of nutrient inputs. This hypothesis might gain on interest in relation to climate change and the expansion of Harmattan season.

To finish up, improved fallows with mucuna as leguminous were not yet seen to be higher productive in turns of yam yield or soil fertility/SOM retention than the traditional natural fallows. Nevertheless, it was observed that these green manure fallow types had a sustainable effect on nutrients and SOM as they were retained in the present soil after one season of yam cultivation. It will be from great importance to monitor the development of these green manure fallows, their soil fertility and SOM restraint capacities within the upcoming years in order to gain an insight of the effectiveness of traditionally-natural versus improved-leguminous fallow types on a longer perspective.

Please take further information and all literature references from the master thesis itself.