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# Effect of a sugarcane-legume cropping rotation system on cane yield under irrigated conditions in Côte d'Ivoire

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## Abstract

To find an alternative to the use of nitrogenous fertilizers in sugarcane cultivation, this study was initiated in order to improve soil fertility and sugarcane yield by growing legumes. The trials were carried out on-farm according to split-splot design in ferké 1 sugar bowl northern Côte d'Ivoire. The main factor was the cropping system (4 levels) and the subsidiary factor was the treatment with urea (3 levels). On the experimental plot, two legumes fallows (Soybean and Lablab) were grown in rotation with sugarcane. The sugarcane yields obtained were compared with those of the conventional system and those obtained after natural fallow using only nitrogenous fertilizers. In main crop as well as ratoon crop, sugarcane yields were statistically identical for all four cropping systems. Nevertheless in ratoon crop, the effect of treatment with urea was significant. Thus, the input of half-dose of urea was the best treatment with urea. During the two years of cultivation, sugarcane yields were statistically different; the effect of years being significant on sugarcane yield, with the first ratoon as the best crop year with an average yield of 58.4 Tc/ha. Legume cultivation as a preceding crop has enabled subsequent canes to provide yields that are statistically identical to those of other cropping systems that use only nitrogenous fertilizer. It has also helped to halve the use of urea in ratoon crop and finally to obtain higher sugarcane yields in ratoon crop.

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## Introduction

Sugarcane (*Saccharum officinarum* L.) is a perennial grass from the Poaceae family. He is a highly cultivated plant in the world because of its importance in terms of agri-food, economy and energy. It is generally cultivated in the tropical and subtropical regions, mainly for the exploitation of sugar contained in its stems. Indeed, the latter can have saccharine content up to 19% each (Péné *et al*., 2012). World consumption of sugar is constantly increasing, hence the need for increased sugar production. Thus, the 2014-2015 sugar season ended with a sugar production of 182.1 Mt, that is, an increase of 0.22 Mt more than the previous season (FAO, 2015). Apart from beet and sweeteners, sugarcane alone accounts for 75% of world sugar production.

In Côte d'Ivoire, its cultivation is largely ensured by two private companies (SUCAF-CI and SUCRIVOIRE) over a distribution area of more than 25000 ha (under sugarcane cultivation) located in the northern and west-central part of the country (Kouamé *et al*., 2009). With an annual national yield estimated at more than 180,000 t, it succeeds in covering domestic demand for sugar and makes Côte d'Ivoire the largest sugar producer of the West African Economic and Monetary Union (WAEMU) (Péné and Kehe, 2005). Despite its socio-economic importance in Côte d'Ivoire, sugarcane cultivation faces many difficulties. It is confronted, on the one hand, to biotic constraints due to viruses, stem borers such as *Eldana saccharina* Walker, bacteria such as *Xanthomonas albilineans* and fungi such as *Sporisorium scitamineum*, responsible for anthrax (Kouamé *et al*., 2010). On the other hand, it is facing a decline in soil biological fertility due to sugarcane monoculture systems that have been carried out for more than 30 years in the different sugar complexes (Mauboussin, 1988; Marion, 2000). All these factors play a very important role in the reduction of sugarcane yields in the sugar complexes of the country (Péné *et al*., 2012). In order to increase yields, integrated control (chemical or biological) of the different pathogens, the improvement of irrigation systems and cropping systems, the use of selected resistant and efficient varieties and mineral fertilization (nitrogenous), are popularized methods (Kouamé *et al*., 2012, Yanayana *et al*., 2012). These different methods consist in phytosanitary treatments (preventive or curative), in the use of new varieties having higher sugar content, capable of tolerating partially or totally drought and the continuous or fractionated supply of mineral fertilizers in sugarcane plantations (Péné *et al*., 2012, Yanayana *et al*., 2012).

In addition to these methods, the introduction of Legumes between two sugarcane crop cycles might be an effective means of soil biological fertilization. This would then provide good yields, but also protect the soil by mitigating the use of inputs. In fact, legumes ensure, in association with *Rhizobia* bacteria, the fixing of 65 million tons of atmospheric nitrogen that they release into the soil for the benefit of subsequent plants (Vance and Eardly, 2003). It is in this context that these crop rotation trials with these two legumes were initiated so as to see their effects on sugarcane yield. The overall objective of this study was to improve soil fertility and sugarcane yield through the cultivation of two legume species.

## Material and methods

*Description of the expérimental site*

The study was carried out at the Ferké 1 station located at the SUCAF-CI sugar complex (Fig. 1). The station is located in the southwest of the city of Ferkessédougou in the region of Tchologo, in northern Côte d'Ivoire between 9°35 north latitude and 5°12 west longitude at 323 m altitude. It is 610 km far from the city of Abidjan and is close to the borders of Burkina Faso and Mali at 80km and 110km, respectively. The climate of the zone is dry tropical characterized by two seasons. One so-called dry season extends from November to April and the other, the wet one, extends from May to October. The dry season is characterized by a dry wind, the harmattan (mid-November to late January), annual temperatures going beyond 26°C and a relative humidity often reaching 35%. This dry season tends to ensure a good maturation of sugarcane. Rainfall is unimodal and rains are concentrated in the August-September interval, with annual values of 1200 mm. Beyond this poor rainy season, irrigation systems (central pivot) must fill an annual rainfall deficit of up to 700 mm to ensure a good growth of sugarcane (Péné *et al.*, 2010). The soils encountered are ferralsols with sandy-clay texture, with arable layers marked by a lateritic induration of average depth (80cm). This texture dominates by 40% the surface area of the Ferke 1 station. Soils have a usable water reserve of the order of 90mm, that is, 60 mm of usable water. Acid ferralsols with a pH equal to 6, have low organic matter content (1.5%) and also low cation exchange capacity of the order of 8meq/100g (Péné and Koulibaly, 2011).

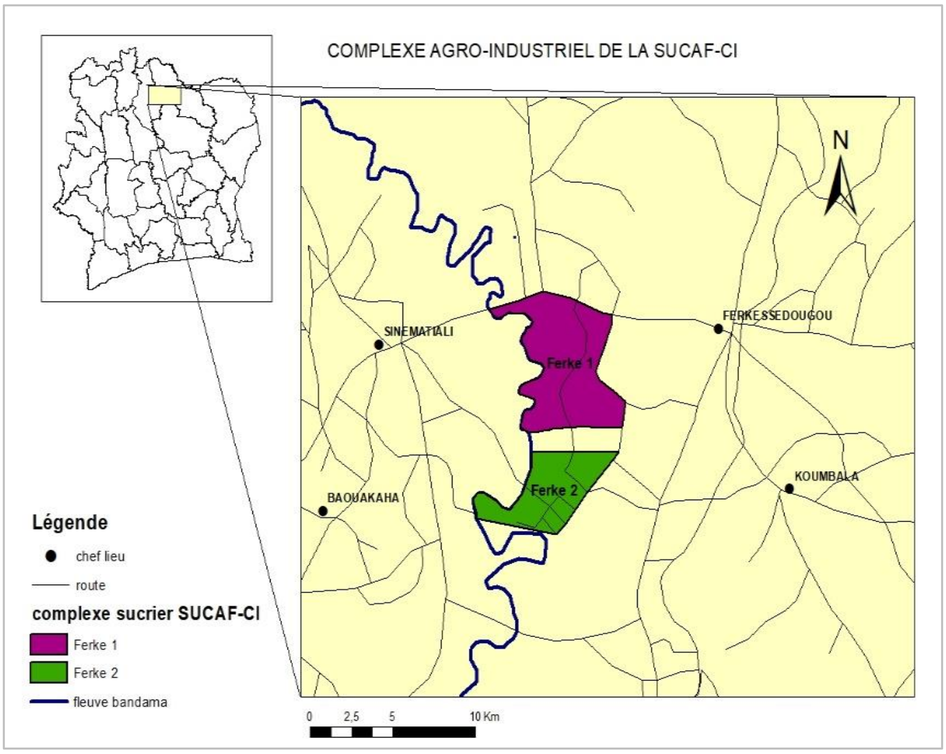


**Fig. 1.** SUCAF-CI / Ferké 1 agro-industrial complex.
Source: Roseboom & Ng Kee Kwong, 2007.

*Plant material*

The plant material used for this study consisted of:

- Sugarcane variety SP 711406, introduced in the complex more than 20 years ago. This commercial variety from São Paulo (Brazil) is grown over 12 months with an average sugar yield of 15.31t/ha. This variety is described as self-spawning with an erect habit, it can be mechanically harvested and grown in twin rows.
- Soybean variety Canarana (*Glycine* max L.), it is the most cultivated in the north-western and north-central part of the country with an average yield of 2.5t/ha. Its cultivation lasted two and a half months,
- *Lablab purpureus* L. ex Sweet, a legume species imported from Australia and grown in the complex for eight to ten weeks,

*Bacterial inoculum*

A 100 g inoculum sachet containing the bacterium *Rhizobium japonicum*, was used for the inoculation of legume seeds. It was obtained from the National Center for Agronomic Research located in the city of Bouaké, in the center of the country.

*Chemical material*

Mineral fertilizers such as urea (46% N), potassium chloride or KCl (60% K) and tricalcium phosphate or PCa3 (33.5% P) were used. And as plant protection products, RoundUp, a total herbicide, containing 360 EC Glyphosate, was used.

*Methodology*

*Experimental design*

The trials were conducted on-farm on the B3-13 industrial plot.

The design used was a split-splot whose main factor was the four-level cropping systems that are conventional system (CS1), natural fallow (CS2), rotation with soybean (SC3) and rotation with Lablab (CS4). As a secondary factor, we had treatments with urea, including three application doses: dose T0 (0kg of urea, that is, 0kg of N); dose T1 (1.8kg of urea, that is, 69kg of N) and dose T2 (3.6kg of urea, that is, 138kg of N). T0 corresponds to the treatment without urea (0%), T1 to the half-dose of urea (50%) and T2 to the total dose of urea (100%) applied on the elementary plots. This split-splot design consisted of three blocks, thus three repetitions, was made on a plot with a surface area of 4320$m^2$. Each block contained 12 elementary plots, making a total of 36 elementary plots of 120$m^2$ each (12m × 10m) as shown in Fig. 2.

| B1 | B2 | B3 |
|---|---|---|
| CS2T1 | CS3T1 | CS4T2 |
| CS2T2 | CS3T2 | CS4T1 |
| CS2T0 | CS3T0 | CS4T0 |
| CS3T1 | CS1T0 | CS2T1 |
| CS3T0 | CS1T2 | CS2T0 |
| CS3T2 | CS1T1 | CS2T2 |
| CS4T1 | CS2T2 | CS1T2 |
| CS4T0 | CS2T1 | CS1T1 |
| CS4T2 | CS2T0 | CS1T0 |
| CS1T1 | CS4T2 | CS3T0 |
| CS1T2 | CS4T0 | CS3T1 |
| CS1T0 | CS4T1 | CS3T2 |

**Fig. 2.** Plot plan of treatments according to a split-splot design.

*Soil preparation*

It consisted in the destruction of persistent ratoons and weeds with a total herbicide containing glyphosate at 360 EC, then using a reversible plow with notched discs, the soil was plowed in order to turn the organic matter over. The cuttings were then planted in the furrows made thanks to the furrow openers hanging on a tractor.

*Fertilizer spreading*

Spreading of the mineral fertilizer preceded the planting of cuttings. Urea (46% N), KCl (60% K) and PCa3 (33.5% P) was used. In each elementary plot, a particular dose of urea (0; 1.8 or 3.6kg) and standard doses of KCl (4.2kg) and PCa3 (2.1kg) were applied.

*Inoculation of legume seeds*

Soybean and Lablab seeds were inoculated with the bacterium *Rhizobium japonicum* from the method used by Kouamé *et al.*, 2007. First of all, 25 pieces of sugar were dissolved in a quarter glass of water, then the bacterial inoculum was added to the sugar solution. After mixing, the whole inoculum and sugar solution was spilled into a container containing Legume seeds. After mixing, in order to let the inoculum adhere to all the seeds, the container containing the legume seeds was sheltered from the sun.

*Establishment of trials*

*Conventional cropping system*

After harvesting the previous sugarcanes, persistent ratoons were eliminated and soil preparation was done (plowing and furrowing). As a result of the plowing, the cuttings (three internodes) were spread into each furrow, one after the other so that there would be no spacing during emergence. Thus, in each elementary plot, eight rows of sugarcane were planted over 10 m long with a conventional spacing of 1.5m between each row.

*Natural fallow system*

Following sugarcane harvesting, Persistent ratoons were eliminated and the elementary plot left fallow. After two and a half months, the land was plowed and furrowed, and the new sugarcane cuttings were planted over eight rows, each spaced 1.5 m apart.

*Cane rotation with Glycine max L. and Lablab purpureus L.*

Following sugarcane ratoons, the seeds of each legume species were randomly planted in the elementary plots. After the first emergence of the different legume species, manual weeding was carried out to eliminate weeds. Then, after two and a half months of cultivation, Legumes were eliminated with RoundUp (glyphosate, 360 EC) and their biomass was buried into the soil. Finally, the planting of the new sugarcane cuttings was carried out on the different elementary plots.

*Harvesting and sugarcane masse determination*

Once at the end of the cycle, the plots were totally burned. First, a mechanical harvest was carried out using machetes.

Then, the stems cut were collected and piled up. They were tied with cables hooked to a stand which was fixed to a weight scale tied to a loader. Finally, sugarcane masses were determined (Kouamé *et al.*, 2010).

*Sugarcane yield calculation (Tc/ha)*

Sugarcane yield calculation was done using the yield square method used by Akedrin *et al.*, (2010), using the following formula:

Yield = (Total mass of canes harvested x10.000m²)/(Usable surface area)

*Statistical analyses*

The data collected during the trials were subjected to an ANOVA analysis of variance using the STATISTICA 7.1 software. The averages were compared and classified into homogeneous groups using the Newman-Keuls test at $\alpha$ = 5% threshold.

**Results**

In this section, we presented the results from the first two years of cultivation: main crop and ratoon. Comparison of the effects of cropping systems on sugarcane yield in main crop.

*Virgin sugarcane cropping*

*Effect of the cropping system*

Following Soybean and Lablab, the average sugarcane yielded 53.6 Tc/ha and 48.9 Tc/ha, respectively. On the other hand, with the conventional system, 53.3 Tc/ha was obtained and after natural fallow a sugarcane yield of 51.4 Tc/ha was obtained (Table 1).

*Effect of urea treatment*

Sugarcane cultivation without urea provided an average yield of 47.9 Tc/ha. Sugarcanes grown with half-dose of urea and total dose of urea yielded 53.9 and 53.5 Tc/ha, respectively. The analyses of variance gave p-value 0.05, so there was no significant effect of nitrogen level on sugarcane yield (Table 1). Sugarcane cultivation without urea provided, for the fallow improved with Soybean and Lablab, yields of 54.4 and 45.5 Tc/ha, respectively. However, the conventional system and the natural fallow yielded 47.6 Tc/ha and 44.2 Tc/ha, respectively.

**Table 1.** Sugarcane yields (tc/ha) of the different trials in main crop.

| | Tc/ha of sugarcane cropping | | | | |
|---|---|---|---|---|---|
| Treatments with urea | Conventional system | Natural fallow | Soybean rotation | Lablab rotation | Averages |
| T0 | 47.6a | 44.2a | 54.4a | 45.5a | 47.9 a |
| T1 | 57.2a | 57.8a | 47.5a | 53.3a | 53.9 a |
| T2 | 55.1a | 52.2a | 58.8a | 48.0 a | 53.5 a |
| Moyennes | 53.3 ± 11.8 | 51.4 ± 9.1 | 53.6 ± 11.8 | 48.9 ± 10.5 | |
| CV (%) | 22.1 | 17.7 | 22.0 | 21.5 | |
| Effect Cropping System (CS) | | | 0.67 | | |
| Effect treatment with urea (T) | | | 0.48 | | |
| Interaction CS*T | | | 0.84 | | |

The values of a column followed by the same letter are not statistically different according to the Newman-Keuls test at 5% threshold. (*): significant difference.

After legume cultivation, the supply of half-dose of urea to sugarcanes yielded 47.5 and 53.3 Tc/ha, respectively, for Soya and Lablab. With the same treatment 57.2 Tc/ha was obtained for the conventional system and 57.8 Tc/ha after natural fallow. With the total dose of urea, after the improved fallow (Soybean and Lablab), yields of 58.8 Tc/ha and 48.0 Tc/ha, respectively, were obtained. But with the conventional system, 55.1 Tc/ha was obtained and with the natural fallow a yield of 52.2 Tc/ha was obtained (Table 1).

*Interaction between cropping system and urea treatment*

The analyses of variance, for the effects studied and their interaction, gave p-value > 0.05. This showed that there was no significant difference between the averages, so legume cultivation as preceding crop enabled the subsequent canes to provide yields similar to those of other cropping systems that use urea (Table 1).

*Sugarcane ratoon cropping*

*Effect of the cropping system*

With the conventional system and natural fallow, the sugarcane grown provided yields of 58.8 and 58.3 tc/ha, respectively. Rotation systems with Soybean and Lablab resulted in average sugarcane yields of 59.4 and 57 tc/ha, respectively (Table 2).

*Effect of urea treatment*

Sugarcane cultivation without urea provided an average 52.1 tc/ha. However, the 50% urea dose supply provided a sugarcane yield of 60.2tc/ha and the contribution of the supply of total recommended dose provided 62.8 tc/ha. Nitrogen supply had a significant effect on sugarcane yield as $p< 0.05$. Thus the Newman-Keuls post-hoc test at 5% threshold enabled to classify the averages into two homogeneous groups, with the best treatment being the half-dose urea (50% urea) supply. These results are shown in Fig. 3.

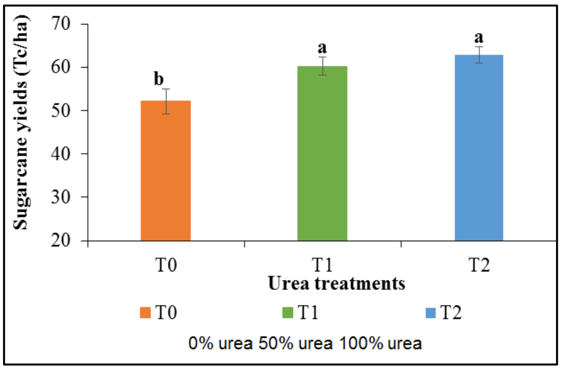


**Fig. 3.** Sugarcane yields depending on urea treatment in ratoon cropping.

*Interaction between cropping system and urea treatment*

The conventional system and the natural fallow without urea yielded 52.3 and 52.8tc/ha, respectively, while the improved fallow with Soybean and Lablab provided sugarcane yields of 53.3 and 50tc/ha, respectively. The supply of 50% urea to sugarcanes of the conventional system and those grown after natural fallow yielded 62.1 and 57.6 Tc/ha while the sugarcanes subsequent to Soybean and Lablab yielded 62.8 and 58.4 Tc/ha. With the total dose of urea, the conventional system and the natural fallow provided yields of 61.9 and 64.6 tc/ha, respectively. With the same dose of urea, the sugarcanes subsequent to Soybean and Lablab yielded 62.2 tc/ha and 62.5 tc/ha, respectively. Analyses of variance of the cropping system effect and the cropping system*urea treatment interaction gave p-value > 0.05. Therefore, the use of legumes before sugarcane cultivation has resulted in the same sugarcane yields as in the conventional system and after natural fallow. These results are reported in Table 2.

*Residual effects of legume cultivation on sugarcane yield*

For the two-year trial after growing Legumes (Soybean and Lablab), averages of 56.5 tc/ha and 52.9 tc/ha, respectively, were obtained. The conventional system yielded 56 tc/ha and the natural fallow yielded 54.8 tc/ha. Statistical analyses for the cropping system effect showed no significant difference between the averages. The p-value > 0.05 shows that the improved fallow and the other cropping systems (conventional and natural fallow) had the same effect on sugarcane yield during the two years of cropping.

**Table 2**. Sugarcane yields (tc/ha) of the different trials carried out in ratoon cropping.

| | tc/ha of sugarcane cropping | | | |
|---|---|---|---|---|
| Treatments | Conventional system | Natural fallow | Soybean rotation | Lablab rotation |
| To | 52.3a | 52.8a | 53.3a | 50a |
| T1 | 62.1a | 57.6a | 62.8a | 58.4a |
| T2 | 61.9a | 64.6a | 62.2a | 62.5a |
| Averages | 58.8 ± 11.3 | 58.3 ± 8.1 | 59.4 ± 8.8 | 57 ± 9.5 |
| CV (%) | 19.2 | 13.9 | 14.8 | 16.6 |
| Effect Cropping System | 0.95 | | | |
| Effect Urea treatment | 0.02(*) | | | |
| Interaction CS*T | 0.98 | | | |

The values of a column followed by the same letter are not statistically different according to the Newman-Keuls test at 5% threshold. (*): significant difference.

The conventional system and the natural fallow during the two-years cropping, without urea supply, yielded 49.9 and 48.5 Tc/ha, respectively. Moreover, the fallow improved with Soybean and Lablab yielded an average 53.8 and 47.7 Tc/ha.

With 50% urea, the conventional system and the natural fallow provided, for the two-years trial, average yields of 59.6 and 57.7 Tc/ha, respectively. However, with the improved fallow, 55.1 Tc/ha was obtained after Soybean cultivation and 55.8 Tc/ha after Lablab cultivation.

The supply of total urea dose to sugarcane of the conventional system and those of the natural fallow provided yields of 58.5 Tc/ha and 58.4 Tc/ha, respectively. In contrast, rotation with Soybean yielded 60.5 Tc/ha and the one with Lablab yielded 55.2 Tc/ha (Fig. 4).

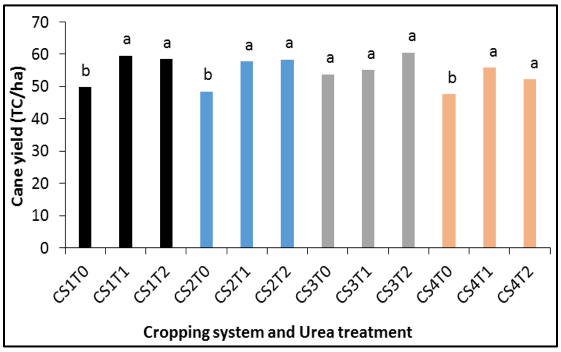


**Fig. 4.** Sugarcane yields average of cropping systems depending on urea treatment.

Analyses of variance (ANOVA) for both years trial gave p-value <0.05 for urea treatment effect as shown in Fig. 4. Thus, the Newman-Keuls test showed a significant difference between the averages, and enabled to classify urea treatments into two homogeneous groups (a and b).

With the conventional system, yields of 53.3 Tc/ha and 58.8 Tc/ha were obtained in main crop and ratoon crop, respectively. After natural fallow, the sugarcane cropping in R0 yielded 51.4 Tc/ha and 58.3 Tc/ha in R1. With the improved fallow in main crop, sugarcane yields of 53.6 and 48.9 Tc/ha was obtained after cultivation of Soybean and Lablab.

In first ratoon crop, these two cropping systems yielded 59.4 Tc/ha and 57 Tc/ha, respectively (Fig. 5).

Analyses of variance showed a significant effect ($p< 0.05$). As a result, the Newman-Keuls test used at 5% threshold enabled to classify the averages into two homogeneous groups (a and b), with the ratoon crop as best year of yield.

Analysis of Year*Cropping System and Year*Cropping System*Treatment interactions showed that there was no significant effect on sugarcane yields ($p> 0.05$). This shows that growing legumes before the main crop had had a residual effect on ratoon sugarcanes. This has helped obtain, in ratoon, the same yields as the other cropping systems (conventional and natural fallow) in which urea was used (Fig. 5).

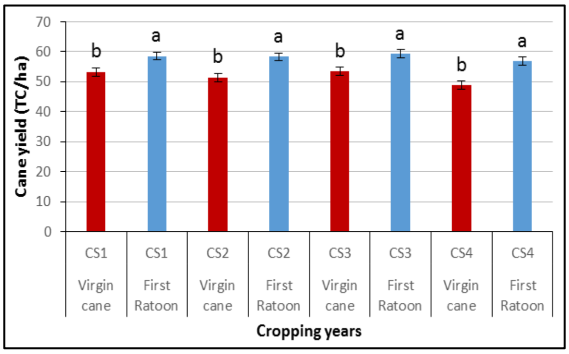


**Fig. 5.** Evolution of sugarcane yield for the cropping systems over two years trial.

**Discussion**

Sugarcanes grown following Legumes provided the same yields as those of conventional and natural fallow that used only mineral fertilizers. These results show that rotation with legumes favors an increase in the amount of nitrogen in the soil. Therefore, it improves the nitrogen nutrition, and thus increases the yields of subsequent crops. These results confirm those of Bado (2002) on rotation of Legumes, Sorghum and Cotton plant. Obtaining these results might also be due to the Rhizobium-Legume combination. Indeed, these symbiotic bacteria allow a better fixation of air nitrogen which, later, is released in various forms for the benefit of subsequent crops (Gala, 2009).

This perfect symbiotic system is dependent on both the genetic determinant of the host plant and that of the *Rhizobium* strain. Moreover, the bacteria of the genus *Rhizobium* found in Legume roots favor a perfect mineral absorption to crops. By their presence, they block the action of other plant-pathogenic microorganisms and allow the dissolving of certain insoluble mineral elements in the soil (Antoun *et al.*, 1978; Buonassisi *et al.*, 1986; Ehteshamul-Haque and Gaffar, 1993 ; Chabot *et al.*, 1996). They also play an important role in the decomposition of plant residues by releasing organic compounds that favor the formation of organic matter in the soil.

In ratoon crop, on plots with Legumes as preceding crops, the best sugarcane yields were obtained thanks to the supply of the half-dose of urea as in the works of Konaté *et al.*, 2012. Through these results, it is obvious that the Legume cultivation reduces the use of mineral fertilizers in sugarcane cultivation. It also shows that sugarcane productivity can be improved at lower cost thanks to the rotation system with Legumes. These results confirm the works of PRC (2011) showed a reduction in sugarcane production costs by 18%. Indeed, Legume cultivation as preceding crop provides a large amount of plant residues, constituting an important source of organic matter. This helps to restore the natural fertility of soils and thus enrich them with essential mineral elements (Becker *et al.*, 1996). The exudates of Legumes buried in the soil are equally responsible for the solubilization of many major mineral elements such as Phosphorus, Potassium, Calcium, etc. This increases their availability in the soil and therefore their absorption by plants as shown by Alvey *et al.* (2001) in their studies.

The fallow improved with Soybean and Lablab has helped improve soil fertility by preventing nutrient leaching due to runoff or seepage. This cropping system tends to restore soil fertility, but also to protect them from destruction due to erosion (Yost and Evans, 1988). Moreover, Legumes such as Lablab not only fight against erosion, but also favors water retention in the soil.

In contrast, sugarcanes resulting from the conventional system and natural fallow, have only benefited from the little nitrogen present in the soil due to fallow and mineral nitrogen (ammoniacal nitrogen or nitrate nitrogen) made available to them by the urea provided in sufficient quantity. Since mineral nitrogen is not the equivalent of natural nitrogen associated with other microelements produced by bacteria, it could not allow biological fertilization of soils favored by the activity of soil microflora. This explains why the yields obtained were not significantly different from those of the other cropping systems.

Furthermore, Legume cultivation between two sugarcane crop cycles is also an important system that helps overcome sugarcane monoculture that has been practiced for more than thirty years in the SUCAF-CI (Ferké 1 and 2) sugar complex according to Mauboussin, 1988 and Marion, 2000. The ANOVA analyses of variance showed no significant difference ($p > 0.05$) between sugarcane yields for An*CS and An*CS*T interactions. This is due to the great ability of Legumes to fix huge amounts of atmospheric nitrogen that they store in the soil for the benefit of subsequent sugarcanes. This release of natural nitrogen makes it possible to reconstitute the physicochemical properties of soils favorable to the good development of subsequent sugarcanes. This is why, in ratoon crop, on plots that hosted legumes as main crop, sugarcanes grown without urea had their yields equal to those of sugarcanes in the conventional system and after natural fallow. These results confirm the works of Konaté *et al.*, 2012. This shows that Legume cultivation, in main crop, has favored the fertility of soils under sugarcane cultivation, allowing ratoon crop sugarcanes to have higher yields.

## Conclusion

This study, carried out at the Ferké 1 sugar complex, which was about sugarcane cultivation in rotation with Legumes fallows, gave important results. This cropping system helped obtain yields statistically identical to those of the conventional system and the natural fallow using nitrogen fertilizers.

Moreover, subsequent canes grown without chemical fertilizers, during two years trials, gave yields similar to those of other cropping systems that use nitrogen fertilizers. Over time, natural nitrogen captured by legumes has been continuously released in favor of sugarcanes. This has favored greater yields in first ratoon crops. This crop rotation system has not only helped reduce the use of chemical fertilizers, but also sugarcane production costs.

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