Sustainability of continuous Stylosanthes in Northeast Thailand: Soil structure amelioration and accelerated acidification

G. Lesturgez[1,2], R. Poss[1], C. Hartmann[1], D. Tessier[2], A. Noble[3] and O. Grunberger[1]

[1] IRD (DRV-UR067), Land Development Department, Office of Science for Land Development, Paholyothin Road, Chatuchak, Bangkok 10900, Thailand.

[2] INRA, Unité de Science du Sol, Route de St Cyr, 78026 Versailles, France.

[3] IWMI, P.O. Box 1025, Kasetsart University, Bangkok 10903, Thailand

Abstract

Light textured soils are widespread in the tropics and constitute an important economic resource for agriculture despite their inherent low fertility. Such soils occupy a significant area of the Northeast Thailand plateau. In their pristine state, these soils are highly productive in that they support climax forest communities. However, when cleared and placed under agricultural production, they become problematic and their productivity declines rapidly. Sandy soils of Northeast Thailand have restricted agronomic potential due to inherent chemical and physical properties. These soils are often characterised as being acidic to depth (pH_{Ca} around 4.0) with very low exchange properties (CEC < 2.5 $cmol_c\ kg^{-1}$) and therefore a low nutrient supplying capacity. Similarly, the physical characteristics of these soils are poor with a compact layer often developing at 20-40 cm that prevents root proliferation at depth for most crops, thereby restricting the quantity of nutrients and water available for the plant growth.

Mechanical modifications of the soil profile, through deep-ploughing or subsoiling, are costly and have not been shown to be effective in overcoming compaction since these soils are unstable and collapse after the first heavy rainfall event.

Another option to improve the rooting depth of the crops consist to only perforate the compact layer, keeping the stable structure of this one. Mechanical perforation has proved the experimental benefit of artificially-made on rooting of the plants but this cannot be carried out at the field scale. In other hand, actively growing plants which have the potential to develop root systems in poor physical conditions has proved to be efficient to ameliorate macropore density by biological drilling. Decaying roots leave a continuous network of vertically-oriented macropores that the subsequent plants can use. The legume *Stylosanthes hamata* has the ability to significantly increase the number of macropores in long-term tropical legume/pasture mixes through the process of root drilling. In contrast, the growing of *Stylosanthes hamata* in a 3-4 month rotation with a non-legume crop has been shown to increase the nitrogen content of the soil and, but had no effect in ameliorating soil structure in Northeast Thailand. This may in part be attributed to the short duration of the legume component since it has been observed that the density of macropores under *Stylosanthes hamata* increases significantly only after several years of permanent pasture. In other hand, it has been shown in other regions that long term cultivation of *Stylosanthes* species may induce an accelerated acidification of the soil profile, decreasing by the way the agronomic potential for other crops.

A three year field study was undertaken to investigate the potential role of *Stylosanthes hamata* in ameliorating the structure of a compact layer in a typical light textured soil in Northeast Thailand. The effectiveness of stylos in enhancing the rooting depth of a subsequent maize was assessed with respect to; the ability of the species to penetrate a compacted layer; the creation of macropores by roots into the subsoil; and benefits to the subsequent maize crop root system. The effect of continuous *Stylosanthes* on soil pH was assessed in limed and control system. The

study consisted of two treatments, namely, (a) continuous stylos (CS) where *S. hamata* was grown for 24 months before being converted to maize (*Zea mays* cv. SW 3601) production in the third year; and (b) Stylos-Maize rotation (SM) where *S. hamata* was grown for 2 months, followed by maize for 4 month, followed by a 6 month ley annual weedy pasture over the dry season. The latter treatment represents a current farming practice. The experimental design was a randomised complete block design with 10 plots of 48 m^2 in area (8×6 m) for each treatment. For each treatment, half of the plots received previously a large amount of lime in order to increase soil pH. Root distribution, macropore density and pH were measured under the two cropping systems.

Stylosanthes is able to develop a deep root system despite of the compact layer if it is cultivated at least two years. Macropore density through the compact layer is much more higher under continous *Stylosanthes* than under usual Maize-Stylo rotations. Most of the macropores correspond to decaying roots of Stylo.

The root frequencies of the maize crop established in the third year of the study under the CS and SM treatments were similar for both treatments with 80–90 % root frequency being recorded in the 0-10 cm depth interval with no significant differences between treatments. However, in the 10–70 cm depth interval, maize root frequencies were significantly ($P<0.05$) higher under the CS treatment when compared to SM treatment. This results suggest that maize was able to take adantage of the macropore left by decaying roots of *Stylosanthes*.

Both treatment had no effect on soil pH in the no-lime plots. pH_{Ca} was around 4.0 at the beginning of experimentation and did not change despite leaching, fertilizers and crop removal. This result suggest a strong buffer effect of the soil.

In other hand, plots that received previously lime, highlight the acidification process under both treatment, mostly in the topsoil. Net acid addition rate (NAAR) was around 2 kmol $H^+.ha^{-1}.year^{-1}$ higher under continous *Stylosanthes*.

These results shown that continous *Stylosanthes* increase significantly the acidification rate in these soil as observed in other region but the effect of soil acidity is not obvious if the pH is already at 4.0; This value, common in sandy soils of the region, seems to be a limit under what pH value is buffered by kaolinite dissolution. The NAAR calculation is not applicable to this system and underestimate in all the case the proton balance.

Stylosanthes do not induce structure amelioration in the case of usual crop rotation but has proved to be efficient in continous cultivation. Decaying roots of stylos create a large number of macropores that represent significant amelioration of the compact layer. Subsequent crops are able to take advantage of this amelioration through the development of a root system in and under the compact layer. This amelioration of compacted layers by roots represents a potential low cost means of improving crop productivity and face water stresses during dry spells. In other hand, the acidification acceleration mentioned in the literature occur too in these sandy soils as the difference that, these soil are already buffered.

Continuous *Stylosanthes* induce a significant amelioration of soil structure and pH of the soil profile do not change despite of the high proton production. This could be considered as a global amelioration of the system but increase the acidification rate means increase the dissolution of kaolinites that buffer the system, and this is a long term and definitive degradation. This study raise the question of long-term sustainability of such practice.

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