Productivity of upland rice–bean intercropping under intensive tillage and no-tillage with organic and mineral fertiliser inputs on ferralitic soil of Malagasy highlands

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Intercropping of upland rice with common bean under no-till (NT) culture offers a way to intensify sustainable agricultural production on ferralitic soils of sloping upland regions in Madagascar known as '*tanety*'. Conservation agriculture on such soils, which are characterised by low phosphorus (P) availability, presents great potential for rural development, especially by recycling nutrients such as P and nitrogen (N), and in contributing to carbon sequestration (Razafimbelo 2005).

We compared yields of intercropped upland rice–common bean under conventional tillage (CT) and NT with mineral inputs of P (as triple superphosphate: TSP) and organic inputs of P (as compost and residues of stylosanthes: *Stylosanthes guianensis* (Aubl.)) on ferralitic soil of the Malagasy highlands.

Tanety soils are characterised by a low availability of P due to high amounts of iron and aluminium oxyhydroxide. Much work has been done to increase the availability of P and hence crop yields. We showed that soil P availability and yields of upland rice (*Oryza sativa*) and bambara groundnut (*Vigna subterranea* (L.) Verdc.) under CT were increased with P inputs on ferralitic soils (Andriamananjara 2011; Henintsoa 2011). We wanted to know whether P inputs under NT gave comparable yields.

Two crops of upland rice ('FOFIFA 154') and common bean (*Phaseolus vulgaris* 'Ranjonomby') were intercropped in 2011–2012 in a field experiment at Lazaina (18°46'53.56''S, 47°32'05.03''E, 1290 m a.s.l.). The main objective was to identify the rate of P input, the type of organic matter input and the soil management system that improved crop yields.

We combined CT and NT with 2 rates of TSP, 5 and 20 kg P ha^{-1}, which correspond respectively to a very low and a moderate input of P (TSP5 and TSP20); and with either compost to supply 20 kg P ha^{-1} (M20) or *Stylosanthes* residues to supply 20 kg P ha^{-1} as green manure (GM20). The compost was made from rice straw and cow manure and had a P content of 0.2%. The *Stylosanthes* had a P content of 0.11%. The TSP had a P content of 19%. We tested treatment combinations of CT-TSP5-M20, NT-TSP5-M20, CT-TSP20-M20, NT-TSP20-M20, CT-TSP20-GM20 and NT-TSP20-GM20.

All treatments were replicated 4 times, and their distribution within each block was completely randomised. Each plot measured 24 m² (6 m x 4 m). K_2SO_4 was added to each treatment at 40 kg K ha^{-1}. No N fertiliser was added, so as to avoid the inhibition of symbiotic N fixation.

The experiment started in November 2011 on soil that has grown maize (*Zea mays* L.), bambara groundnut and upland rice since 2006. Beans were harvested in February 2012 and rice in April 2012. After harvest, the yield data were analysed by Student's parametric t-test at $\alpha = 0.05$.

The form of tillage (NT vs. CT) had no significant effects on rice yield. These results might be explained by the low mineralisation of nutrients from the manure or residues, especially under NT, probably because of the lack of rainfall (Nachimuthu et al. 2009).The rate of mineral P input had no effect on the yield of rice under NT with manure. However, compost gave a significantly higher rice yield than green manure (NT-TSP20-M20 vs. NT-TSP20-GM20).

Similarly, the form of tillage had no significant effects on bean yield. However, the yield in CT-TSP20-M20 (250 kg ha^{-1}) was significantly higher than that in NT-TSP20-M20 (122 kg ha^{-1}), showing the effectiveness of CT under moderate mineral P input. As above, the rate of mineral P input had no effect on the yield of bean under NT with manure. In addition, the organic form of P had no significant effect.

The results from the first year of the experiment show the same effects of NT and CT on yields on account of the slow nutrient cycling in tanety soil, which is controlled by water availability. The immediate effect of NT on crop productivity was not significant because of the slow decomposition of the *Stylosanthes*. Productivity should improve in the long term.

Keywords

Conventional tillage, zero-tillage, yield, organic matter

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The 3rd International Conference
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Proceedings

Hanoi, Vietnam
December 10-15, 2012
www.conservation-agriculture2012.org

Front cover: Patricia Doucet (CIRAD)
Document design: Patricia Doucet, Martine Duportal, Damien Hauswirth (CIRAD)
English revision (abstracts and keynotes): Matthew Stevens (Science Scape Editing)
English revision (portfolio and texts): Peter Biggins (CIRAD)

Printed by: Tran Cong Co. Ltd., Hà Nội, Viet Nam

Co-published: by CIRAD, NOMAFSI, University of Queensland

ISBN CIRAD: 978-2-87614-687-7
EAN CIRAD: 9782876146877

Distributed by CIRAD, UPR SIA - TA B 01/07, Avenue Agropolis, 34398 Montpellier cedex 5, France
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