Poster presentation, III World Congress on Conservation Agriculture, Nairobi, Kenya, 3-6 0ct 2005

Impact of a Direct seeding, Mulch-based, Conservation agriculture (DMC) rainfed rice-based system on soil pest and Striga infestation and damage in Madagascar

Ratnadass, A.[1], Andrianaivo, A.[1], Michellon, R.[2], Moussa, N.[2], Randriamanantsoa, R.[1], & Séguy, L.[3]

[1]Sustainable farming & rice cropping systems Cooperative Research Unit, University of Antananarivo-FOFIFA-CIRAD, BP 230, Antsirabe, Madagascar (ratnadass@cirad.mg),
[2]TAFA-CIRAD, Antsirabe, Madagascar, and [3]CIRAD, Goiana, Brazil

Keywords : White grub, black beetle, cultural control, biological control, *Fusarium*, *Junonia*

Introduction

Direct seeding, Mulch-based, Conservation agriculture (DMC) systems are being extended in Madagascar in view of reducing erosion and loss of fertility of hill slope soils observed in conventional rainfed systems. However, little is known on their effects on infestation and damage to crops (particularly rice) of soil insect pests and *Striga*. The evaluation of the performance of these systems vis-à-vis biotic constraints, concomitantly with their development, is a warrant of their sustainability, and an illustration of the Integrated Pest Management (IPM) approach. This approach has been adopted by CIRAD and its partners the NGO TAFA ("Land and Development") and FOFIFA (National Center for Research Applied to Rural Development), notably in the framework of the Cooperative Research Unit "Sustainable Farming and Rice Cropping systems" (URP/SCRiD).

In the regions around Lake Alaotra and Manakara, dramatic damage by black beetles (*Heteronychus* spp.: Coleoptera, Scarabaeidae) has been observed at the beginning of the season on rice cropped on mulch, with a significant impact on yield. In these regions, seed treatment is mandatory for upland rice production, although its cost may hamper adoption of DMC systems (Charpentier et al., 2001). On the other hand, in the Highlands of the Vakinankaratra region, attacks by white grubs and black beetles on upland rice were demonstrably reduced after a few years of this new management (Ramanantsialonina, 1999; Michellon et al, 2001).

Since several decades, *Striga asiatica* (Scrophulariaceae) has become a major constraint to staple cereal crop cultivation in strict rainfed cropping systems, particularly in the Middle-West of Vakinankaratra (Andrianaivo et al, 1998). After one year of DMC management based on mulches, either dead (crop residue involving legumes in rotation and/or intercrops), or live (involving undersowing with fodder crops), infestation of rice and maize was drastically reduced compared to the traditional plough-based system, and yields kept improving year after year, which encourages adoption by farmers of these systems (Michellon et al, 2005).

Studies presented in this paper were conducted with an aim to elucidate the factors accountable for reduction in infestation and damage by soil insect pests and Striga in a DMC rainfed rice-based system, with particular emphasis on their effect on natural enemies of pests.

Material and Methods

Studies were conducted at TAFA stations, respectively from 2002-2003 at Andranomanelatra and Ibity (Highlands of Vakinankaratra), and from 2004-2005 at Ivory (Middle-West of Vakinankaratra). These stations are respectively located at 12 km to the North, 24 km to the South, and 100 km to the West of Antsirabe, the main city of the Vakinankaratra region, at elevations of resp. 1600 m, 1500 m and 950 m.

At Andranomanelatra and Ibity, experiments were conducted in split-plot/factorial designs, with four reps per location, with two modes of soil management (ploughing vs. direct seeding), six rice cultivars (FOFIFA 152, FOFIFA 154, FOFIFA 133, Exp 933, Exp 206 and Botramaitso), and two levels of seed treatment [unprotected control vs. application of GAUCHO® T 45 WS (35% imidaclopride + 10% thirame) at the rate of 5 g/kg of paddy seeds]. At both sites, rice was planted in succession to soybean intercropped with *Crotalaria*, which itself succeeded to rice grown on maize and soybean residues (Michellon et al, 2001).

Plot size was 21 m². One month after sowing (which took place respectively on 5 & 6 Nov 2002 at Andranomanelatra and 12 & 13 Nov 2002 at Ibity), pitfall traps were installed at the centre of each plot, and were checked after one week. Twice a week from planting to harvest a soil sample was taken in each plot. It was centred on a rice hill, whose position had been determined at random, and consisted in a parallelepiped with a square section of 20 X 20 cm and a variable height determined by the depth of the compaction surface. Macrofauna was sorted and counted on the spot. At the tillering stage of the crop and at harvest, insect damage to rice was recorded on a central subplot of 96 hills: number of missing hills, and rating on a 1-5 rating scale (with 1=no damage, and 5=100% of tillers damaged) on remaining hills. At harvest (resp. from 18 Apr to 20 May 2003 at Andranomanelatra, and from 4 Apr to 2 May 2003 at Ibity), paddy rice grain in each central subplot was weighed.

At Ivory, observations were made on an experiment on Striga control (or more generally control of over-exploitation of soils through cereal mono-cropping) on rainfed rice-maize and/or soybean rotations through DMC management, which had been conducted since 1998. Observations on Striga infestation were made on rice (cultivar B22, planted on 23 Nov 2004, with treated seeds) mono-crop, DMC-managed on soybean residues succeeding to maize on *Brachiaria ruziziensis* residues (two reps) compared to rice in continuous ploughed mono-crop (one rep). Parasitized rice hills were counted and expressed as a percentage of total number of hills, resp. 40, 55, 70, 85 & 115 days after sowing (DAS). Qualitative observations were also made on evidence of insect or disease damage on Striga plants. At harvest, grain yield was weighed on surfaces of 70 m².

Results

At both Andranomanelatra and Ibity, pitfall traps and soil samplings revealed higher abundance and biodiversity of epigaeic and endogaeic macrofauna, under DMC conditions as compared to ploughed plots, particularly in terms of "non-pest" taxa. In December 2002, resp. 2.6 & 1.6 adults of the decomposer Dynastid *Hexodon unicolor unicolor* were recorded per trap at Ibity under DMC (resp. on control and seed-treated plots), compared to zero on ploughed plots. The predatory tiger beetle *Hipparidium equestre*, with more than one catch per trap, was twice as much abundant under DMC than under ploughing conditions. At Andranomanelatra, *H. unicolor* populations were 10 times as much numerous as at Ibity, with 21 & 16 per trap under DMC (resp. on control and seed-treated plots), compared to 4 on ploughed plots. As for white grub numbers, there was no distinct difference over the survey period between the two modes of soil management, whereas earthworms were significantly more abundant under DMC: in January, at Ibity, their mean density was 300/m² under DMC, irrespective of seed treatment, compared to less than 25 under ploughing.

At Andranomanelatra, there was no difference between ploughing and DMC in terms of soil pest attacks (due to the Dynastid *Heteronychus arator rugifrons*). On the other hand, seed treatment resulted in reduced damage on both soil management systems (mean damage rate at harvest of 2.2 on control plots, compared to 1.8 on treated plots). At Ibity, damage was higher on ploughed than on DMC plots (mean rate of resp. 2.0 & 1.4 at harvest). Under DMC, there was no difference between control and seed-treated plots, whereas under ploughing, seed treatment resulted in reduced damage (rate of 2.3, compared to 1.7). At both locations, there were distinct yield differences between the two modes of soil management and seed treatment, in favour of DMC and insecticide protection. There was no genotypic difference between rice cultivars in terms of insect damage. At Andranomanelatra, seed-treated/DMC-managed plots ranked first as far as grain yield was concerned (3.2 t/ha), followed by control/ploughed plots (2.8 t/ha), then by the control/DMC plots (2.6 t/ha), and lastly the control/ploughed plots (1.7 t/ha).

At Ivory, at 115 DAS, infestation of rice hills by Striga was 2.4% on rice grown on soybean residues vs. 37.1% under ploughing. Evidence of Striga damage by the Nymphalid caterpillar *Junonia* sp was recorded on ploughed plots. This year again rice yields were higher under DMC as compared to ploughing (2.3 ±0.47 vs. 1.2 t/ha).

Discussion

As for white grubs and black beetles (Coleoptera: Scarabaeidae), our results from the Highlands indicated that after four years under DMC management (based on a rice-soybean rotation with crop residue dead mulch), rice yield, in the absence of seed protection with imidacloprid, was equivalent to that of ploughed rice with seed treatment (Michellon et al, 2001). A positive effect of DMC management on macrofauna biodiversity (including natural enemy population) was observed both at Andranomanelatra and Ibity.

The general trend earlier observed in the Middle-West on the systems based on the rainfed rice-maize rotation, was confirmed in 2004-2005. Impressive results (in terms of grain yield, attributed to reduction in Striga infestation) were obtained after the first year (3 t/ha of paddy rice, compared to 1.5 t/ha on the plowed control), and results kept improving year after year, reaching 4 t/ha, even in a cyclonic year like 2004 (Michellon et al., 2005). However, due to drought and competition with water, rice yield was low on *Arachis* covers (rainfall was only 823 mm from 25 Nov to 15 Apr, compared to 1 448 mm during the same period in the 2003-2004 season).

Closer observations on other systems like maize undersown with *Arachis pintoi* or *Arachis repens* or maize grown on dead *B. ruziziensis* mulches, revealed the presence of Striga plants which had probably been overlooked the previous years, due to the fact that they barely flowered because of heavy damage by either insects (supposedly *Junonia* sp) or *Fusarium* (despite the drought)(Andrianaivo, 2005). In all these systems, the yield of maize (a better competitor than rice) was above 3.3 t/ha, and even above 4.5 t/ha on *A. pintoi*, compared to less than 3 t/ha under ploughing.

Our results highlight the positive effect of DMC on crop growth, particularly through action on the natural enemy complex. However, mechanisms involved in the reduction of pests' adverse impacts in DMC are multiple, and there is a need to further investigate the respective part of indirect effects through natural enemies or better crop nutrition, and direct effects like mechanical barriers, shading, etc., which might vary depending on the system and the pest.

Reference list

Andrianaivo, A.P. Utilisation de microorganismes pathogens contre Striga asiatica: une perspective dans le cadre d'une production agricole pluviale intégrée. Poster presented at « Forum de la recherche », 30 Mar-1 Apr 2005, Toamasina, Madagascar : MENRS.

Andrianaivo, A.P., Kachelriess, S., Kroschel, J., Zehrer, W. Biologie et Gestion du Striga à Madagascar. 1998. Antananarivo, Madagascar: FOFIFA-DPV-GTZ.

Charpentier, H., Razanamparany, C., Rasoloarimanana, D., Rakotonarivo, B. Projet de diffusion de systèmes de gestion agrobiologique des sols et des systèmes cultivés à Madagascar. Rapport de campagne 2000/2001 et synthèse des 3 années du projet (TAFA-ANAE-CIRAD-TAFA/AFD). 2001, Antananarivo, Madagascar: TAFA.

Michellon, R., Moussa, N., Rakotoniaina, F., Razanamparany, C., Randriamanantsoa, R. Influence du traitement des semences et de la date de semis sur la production du riz pluvial en fonction du mode de gestion du sol sur les Hautes Terres. 2001, Antsirabe, Madagascar: TAFA/CIRAD/FOFIFA.

Michellon, R., Razanamparany, C., Moussa, N., Andrianasolo, H., Fara Hanitriniaina, J.C, Razakamanatoanina, R., Rakotovazaha, L., Randrianaivo, S., Rakotoniaina, F. Projet d'appui à la diffusion des techniques agro-écologiquess à Madagascar. 2005, Rapport de campagne 2003 – 2004. Hautes Terres et Moyen Ouest. GSDM. Financement AFD - FFEM - CIRAD - MAEP. Antsirabe, Madagascar: TAFA/CIRAD, 107 p.

Ramanantsialonina, H.M. Evolution de la faune et des dégâts aux cultures en fonction du mode de gestion des sols. 1999, Mémoire d'ingéniorat en agronomie ESSA, University of Antananarivo. Antananarivo, Madagascar: CIRAD/FOFIFA/TAFA.