Impact of a DMC rainfed rice-based system on soil pest and Striga infestation and damage in Madagascar

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Fig.ure 1: Striga-infested rainfed rice field at Ivory

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) by soil insect pests and Striga.
*While in the regions around Lake Alaotra and Manakara, dramatic damage by black beetles (*Heteronychus spp.: Coleoptera, Scarabaeidae*) was observed on rice cropped on mulch (Charpentier et al., 2001), attacks by these pests were reduced after a few years of DMC management in the Highlands of the Vakinankaratra region (Michellon et al, 2001). On the other hand, in the Middle-West of Vakinankaratra, where* Striga asiatica *(Scrophulariaceae) has become a major constraint to staple cereal crop cultivation in rainfed systems (Andrianaivo et al, 1998)(Fig. 1&2), infestation of rice and maize by this parasite was drastically reduced after just one year of DMC management based on dead or live mulches, compared to the traditional plough-based system (Michellon et al, 2005).*
The objective of the studies presented was to elucidate the factors accountable for reduction in infestation and damage by soil insect pests and Striga in DMC rainfed rice/soybean-based systems, with particular emphasis on its effect on natural enemies of pests.

Figure 2: Striga asiatica *plants flowering after rice harvest at Ivory*

Material and Methods

Studies were conducted at TAFA stations, respectively in 2002-2003 at Andranomanelatra and Ibity (Highlands of Vakinankaratra, at elevations of ca. 1500 m), and in 2004-2005 at Ivory (Middle-West of Vakinankaratra, elevation 950 m).
At Andranomanelatra and Ibity, experiments were conducted in split-plot/factorial designs, 21 m² plots, four reps, 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. 5 g of GAUCHO® T 45 WS (35% imidacloprid + 10% thirame) per kg of seeds]. 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). One month after sowing, pitfall traps were installed at the centre of each plot, and were checked for epigaeic fauna after one week. Twice a week from planting to harvest, soil samples were randomly taken in each plot, and endogaeic macrofauna was recorded. At tillering, insect damage to rice was rated on a central subplot of 96 rice hills, using a 1-5 rating scale (with 1=no damage, and 5=100% of tillers damaged). At harvest, paddy rice grain in each central subplot was weighted.
At Ivory, observations on *Striga* infestation were made on an experiment which had been conducted since 1998 (Michellon et al, 2005). Rice cultivar B22 mono-cropped, DMC-managed on soybean residues succeeding to maize on *Brachiaria ruziziensis* residues (two reps) was 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 115 days after sowing (DAS). At harvest, grain yield was weighed on 70 m² surfaces.

Results

At both Andranomanelatra and Ibity, pitfall traps and soil samplings revealed higher abundance and biodiversity of epigaeic and endogaeic macrofauna, under DMC 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* (Fig. 3) 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.

Figure 3: Hexodon unicolor unicolor *adult at Andranomanelatra*

In terms of insect damage, there was no genotypic difference between rice cultivars at both locations, and there was no difference between ploughing and DMC at Andranomanelatra. 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)(Fig. 4). Under DMC, there was no difference between control and seed-treated plots, whereas under ploughing, seed treatment resulted in reduced damage. 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 (Table 1).

Figure 4: Scarabaeid beetle damage on rice (ploughed plot) at Ibity

	DMC Treated	DMC Control	Ploughed Treated	Ploughed Control
Andranomanelatra	3.2	2.6	2.8	1.7
Ibity	3.7	2.4	2.3	1.7

Table 1. Paddy rice grain yield (t/ha) as a function of seed-dressing and soil management

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 observed on ploughed plots (Fig. 5). Rice yields were higher under DMC as compared to ploughing (2.3 ±0.47 vs. 1.2 t/ha).

Figure 5: Junonia sp. *Caterpillars feeding on* Striga asiatica *plants at Ivory*

Discussion

Figure 6: Striga plant *destroyed by* Fusarium *neighbouring a healthy plant.at Ivory*

Our results from the Highlands indicated that after four years under DMC management under high soil pest pressure, rice yield, in the absence of seed protection with imidacloprid, was equivalent to that of ploughed rice with seed treatment. In the Middle-West, results obtained in 2004-2005 confirmed the general trend observed earlier, namely: 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).
Closer observations on other systems like maize undersown with *Arachis pintoi* or *A. 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* (Fig. 6)(Andrianaivo, 2005).
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.

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