White grubs, Scarabaeidae larvae (Insecta, Coleoptera) control by plants in Conservation Agriculture: effects on macrofauna diversity

Rabary B[1], Naudin K[2], Letourmy P[2], Mze Hassani I[3], Randriamanantsoa R[1], Michellon R[2], Rafarasoa L[3], Ratnadass A[2]
[1]FOFIFA URP Systèmes de Culture et Rizicultures durables. BP 230 Antsirabe 110, Madagascar; bodo.rabary@gmail.com
[2] CIRAD UPR SCA, UPR URSIA and UPR HortSys, 34398 Montpellier France
[3]Université d'Antananarivo, Antananarivo 110, Madagascar

Keywords: rice-based cropping system, direct seeding, cover crop, Madagascar

Introduction

Adoption of conservation tillage has reduced soil erosion in many parts of the world. Conservation management practices improve soil quality through the significant amounts of organic residues left on the soil surface, and cover crops also provide many benefits. These supply residues derived from dead plant parts and organic substances released from their living roots, and may foster soil organisms' abundance and diversity. They may also enhance ecosystem functions such as nutrient cycling (Rabary et al., 2008), soil structure and C sequestration, and pest and disease control (Ratnadass et al., 2006). In some regions of Madagascar, white grubs were found to be more abundant under direct seeding mulch based cropping systems (Ratnadass et al., 2006). White grubs are C-shaped larvae of a large group of beetles (Coleoptera:Scarabaeidae). Several species in this group cause significant damage to cereal crops by feeding on plant roots. The entomopathogenic bacterium *Metarhizium anisopliae* has been proven effective in controlling white grubs in some cases (Razafindrakoto et al., 2010), However, Randriamanantsoa et al. (2010) showed that there are many species of white grubs in Madagascar and most of them are endemic. Furthermore, some species are not pests but show "soil engineering" behaviour. This wide array of white grub species makes their biological control difficult. The fundamental dilemma in pest control with insecticide application is about significant detrimental effects on non-target species in the food web, which may deplete soil diversity and increase the possibility for subsequent pest outbreaks. This paper reports the impact a number of cover crops known for their pest-suppressing on white grub control within upland rice cropping systems. We presumed that these plants toxicity would alter the composition of soil macrofauna, but not negatively affect biodiversity overall, due to the positive effects of cover crops compared to those of the conventional tillage system.

Materials and Methods

A field experiment was conducted in 2009-10 in the Highlands of Madagascar, in the district of Andranomanelatra (S 19°46'45", E 47°06'25"), Antsirabe region. The area has a cold tropical upland climate with 10 – 20 days of frost annually and a mean temperature of 16.9°C. The site is at 1600 m above sea level with an annual average rainfall of 1450 mm. The soil is an andic distrustept, pH (H_2O) 5.4. The experiment was set up in a randomized complete block (RCB) design with 48 plots in 8 treatments over 6 blocks. Plot size was 14 m x 9 m. The treatments within rice-based cropping systems were no-tillage (NT) with cover crops compared to sole rice under NT without cover crop and rice under conventional tillage (CT). The cover crops used for white grub control were: hairy vetch (*Vicia villosa*), fodder radish (*Raphanus sativus*), *Brachiaria ruziziensis* x *B. brizantha* (var. mulato), *Crotalaria grahamiana*, *Cleome hirta*, *Tagetes minuta* and *Cosmos caudatus*. The 8 treatments were: i) Rice-Brachiaria; ii) Rice-Cleome-Tagetes-Cosmos; iii) Rice- Crotalaria; iv) Rice-Vetch; v) Rice-Radish; vi) Rice-Bean NT; vii) Rice-Bean CT; viii) sole Rice. In 2010, soil macrofauna abundance and diversity were assessed within each plot. One soil monolith, 25 cm x 25 cm x 30 cm, was extracted per plot, separated into litter and three layers: 0-10 cm, 10-20 cm, and 20-30 cm in depth according to the TSBF method. Monoliths were hand-sorted to collect invertebrates larger than 2 mm. Soil macrofauna were identified, counted and weighed. ANOVA were performed, using SAS (proc glm), on data transformed for non-parametric tests based on ranks according to Conover (1999). LSD test at $P < 0.05$ was performed to assess the differences among the means of abundance and biomass of macrofauna groups of six replicates.

Results and Discussions

In 2010, 2,155 individuals were collected from all the plots, counted and classified into 20 Orders and 48 Families. Classification were done up to species when possible but many species were not identified. The highest taxa numbers were found under *Raphanus sativus* and *Vicia villosa* (respectively 31 and 30 Families), with the lowest under CT and sole rice (19 and 20 Families). The NT system increased taxa number by 12% based on the rice + beans NT and rice + beans CT comparison. The NT increased taxa number by 16% under Brachiaria and Crotalaria cover crops. It increased up to 25% under radish. In decreasing order of abundance, the major taxa present in soil monoliths were Hymenoptera (ants) 32%, Haplotaxida (earthworm, mainly *Pontoscolex corethrurus*) 23% and Coleoptera 21%. All the other taxa accounted for less than 3% each, giving 24% in total. As for the feeding strategy (Table 1), there were no significant differences of macrofauna abundance in each group except for detritiphagous. Sole rice had the lowest number of detritiphagous although this was under NT system. Even so, it had no significant difference from the rice-bean NT. Sole rice NT also had poor macrofauna diversity. Our results confirm the importance of cover crops, especially under NT. They improve soil microclimatic conditions such as temperature, moisture and physical habitat. Moreover, the soil enrichment by organic matter from these plants favoured detritiphagous activity. Concerning macrofauna biomass, there were significant differences between cropping systems only for phytophagous and the non-identified group. The lowest phytophagous biomass means were found under rice-bean CT and rice-radish NT. White grubs formed 7.7% of the macrofauna density and the non-pest species were dominant (Table 2). White grub pests were absent from only three cropping systems (rice-bean CT, sole rice and rice-radish), while they were found in highest numbers under Brachiaria and Vetch. The significant soil pest attack observed in the sole rice field suggests damage by adults (data not shown) or other pest species. There is therefore a need to identify all white grub species, of which many are endemic. We also found *Polycleis africanus* (Curculionidae) was an important pest in some systems. Radish seems promising for white grub pest control. In addition, it did not reduce macrofauna diversity and abundance. Vetch was also favourable for macrofauna abundance but it did not express white grub pest control potential. Our results emphasise the importance of studying a wide range of plants as cover crops or residue mulch for soil pest control and the need to explore more plant species, because some have specific pest-suppressive effects.

References

Conover WJ 1999 Practical nonparametric statistics, 3rd edn,Wiley, New York.

Rabary B, Sall S, Letourmy P, Husson O, Ralambofetra E, Moussa N, Chotte JL 2008 Effects of living mulches or residue amendments on soil microbial properties in direct seeded cropping systems of Madagascar, Applied Soil Ecology, 39, 236-243.

Randriamanantsoa R, Aberlenc HP, Ralisoa OB, Ratnadass A, Vercambre B 2010 Les larves des Scarabaeoidea (Insecta, Coleoptera) en riziculture pluviale des régions de haute et moyenne altitudes du Centre de Madagascar, Zoosystema, 32, 19-72.
Ratnadass A, Michellon R, Randriamanantsoa R, Séguy L 2006, 'Effects of soil and plant management on crop pests and diseases', in *Biological Approaches to Sustainable Soil Systems*, eds N Uphoff, A Ball, E Fernandes, H Herren, O Husson, M Laing, C Palm, J Pretty, P Sanchez, N Sanginga and J Thies, CRC Press-Taylor and Francis, Boca Raton, Florida, pp. 589-602.
Razafindrakoto RC, Rakotoarisoa HL, Razafindrakotomamonjy A, Ratnadass A, Vercambre B 2010 Lutte biologique intégrée contre des insectes terricoles, *Heteronychus* spp à Madagascar, par un champignon entomopathogène sur riz pluvial en semis direct sous couverture végétale, Etude et Gestion des Sols, 17, 2, 159-168.