Effect of Conservation Agriculture Cropping Systems on Rice Blast Disease in the Region of the Mid-West Vakinankaratra

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Introduction

In the Vakinankaratra region of Madagascar, increasing demand for rice combined with increasing land pressure in lowland areas has led to the extensive cultivation of upland rice on the hillsides. However, in rainfed conditions, upland rice faces many biotic and abiotic constraints including rice blast, caused by *Magnaporthe oryzae* (Pennisi, 2010), the most serious fungal disease of rice in the world. Blast occurs in all rice agrosystems but upland rice cropping systems favor particularly blast epidemics (Lai *et al*., 1999). In the context of subsistence agriculture in Madagascar, developing integrated rice blast management strategies is therefore crucial to reduce disease pressure without the use of pesticide and to improve the durability of the resistance of the diffused varieties. Conservation agriculture (CA) was proposed to Madagascan farmers to ensure the environmental and agronomic sustainability of upland crops. CA is based on three principles: minimum soil disturbance, permanent soil cover using crop residues or growing plants, and crop rotations (Scopel *et al.*, 2013). From the experiments conducted in upland conditions in the highlands of Vakinankaratra region (1640 m asl), blast severity seemed to decrease in CA cropping system compared to the conventional cropping system (Sester *et al*., 2014). In fact, in the case of upland rice grown in these cold conditions of high altitude, changing from conventional to conservation agriculture cropping systems had a major impact both on nitrogen (N) dynamics in the soil and on N uptake by rice (Dusserre *et al*., 2012). Rice plant establishment appeared to be more difficult under no tillage systems and resulted in reduced plant development and plant N uptake. Thus, we conducted, in the context of the GARP project, a 4-years trial at lower altitude in the mid-west of the Vakinankaratra region (950 m asl), to assess the impact of CA cropping systems on blast disease epidemics and on yield in warmer conditions.

Materials and Methods

Location. The experiment was conducted at Ivory (19°33’S, 46°25’E, 945 m asl) in the Mid-West of Vakinankaratra region. The tropical mid-altitude climate is characterized by dry winters and humid summers. The annual rainfall was 1819 mm in 2011, 977.5 mm in 2012, 1453.5 mm in 2013 and 1224 mm in 2014. Mean temperatures were 24.5 °C from December (at the rice sowing period in the experiment) to March (at the harvest).

Experimental design. The study took place over four growing seasons (2010-2011, 2011-2012, 2012-2013 and 2013-2014, called 2011, 2012, 2013 and 2014 respectively). Two cropping systems were compared: a 2-year rotation under conventional tillage with upland rice (*Oryza sativa* L.) the first year, followed by maize (*Zea mays* L.) associated with soybean (*Glycine max* (L) Merr.), and no-tillage cropping system with upland rice the first year, followed by maize associated with soybean and cajanus (*Cajanus cajan* L.). With conventional tillage, the residues from the preceding crop were removed before sowing, whereas in the CA cropping system, mulch made of the crop residues was left on the surface of the soil.

Under each cropping system, two levels of fertilization were used: F1 = basic fertilization (cattle manure, P and K) without N mineral fertilizer and F2 = basic fertilization plus N mineral fertilizer: 30 uN at sowing, 15 uN applied at the beginning of tillering and 15 uN at the mid-tillering stage.

A highly susceptible cultivar (FOFIFA 154 called here F 154) was used.

The experimental design is a randomized block design with four replications.

Measurements.

Blast assessment**:** Disease severity was estimated on leaves and panicles on 10 hills per plot using the method described in Sester *et al.,* (2014). Leaf severity represents an estimation of the percentage of leaf area presenting blast symptoms and panicle severity is an estimation of the percentage of grains unfilled caused by blast.

Grain yield assessment: Rice grain yield (measured using unhulled seeds after drying at 60 °C for 3 days) was measured at harvest in a 16.8 m² area, located in the center of each plot (removing 5 rows of border). The number of panicles, the number of spikelets per panicle, the number of filled and unfilled spikelets, and 1000-grain weight were determined in a subplot comprising nine hills located at the middle of the harvest area.

Results and discussion

In our trials, blast infection occurred naturally. The evolutions of leaf and panicle blast severity are shown in fig. 1. The highest levels of blast severity were recorded in 2011 for leaf blast and in 2012 and 2014 for panicle blast.

By comparing the level of blast in the two cropping system tested, it was found that the cropping system had a significant effect on blast severity. Blast attacks were significantly lower in the CA cropping system than in the conventional cropping system each year for leaf blast and in 2012 and 2013 for panicle blast.

For the impacts of Nitrogen fertilization, blast severity was higher in our experiments in the treatment with mineral Nitrogen fertilization (F2) each year, on leaves and on panicles, except in 2011 for panicle blast. Finally, the highest blast severity levels were obtained in the conventional cropping system with mineral N fertilization (conv.F2) and the lowest in the CA cropping system without mineral N fertilization (ACF1).

No significant interaction between the effects of cropping system and the effects of N fertilization was observed. That seemed contradictory with the hypothesis that the effect of the cropping system could be due to a change of the dynamics of nitrogen in the plant.

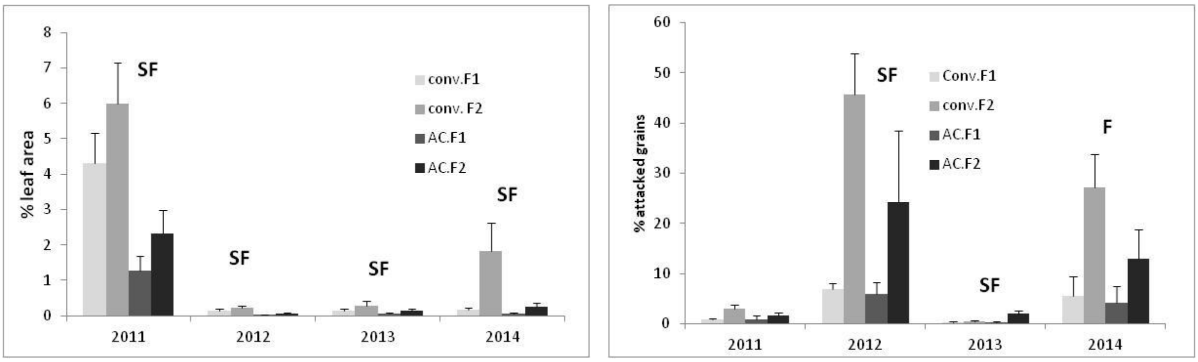

Figure 1 : Evolution of blast level on leaves (left) and panicles (right) during the project in mid altitude, for susceptible cultivar F 154. Letters indicate for each year if fertilisation (F) or cropping system (S) or the interaction (SF) have a significant impact on blast level.

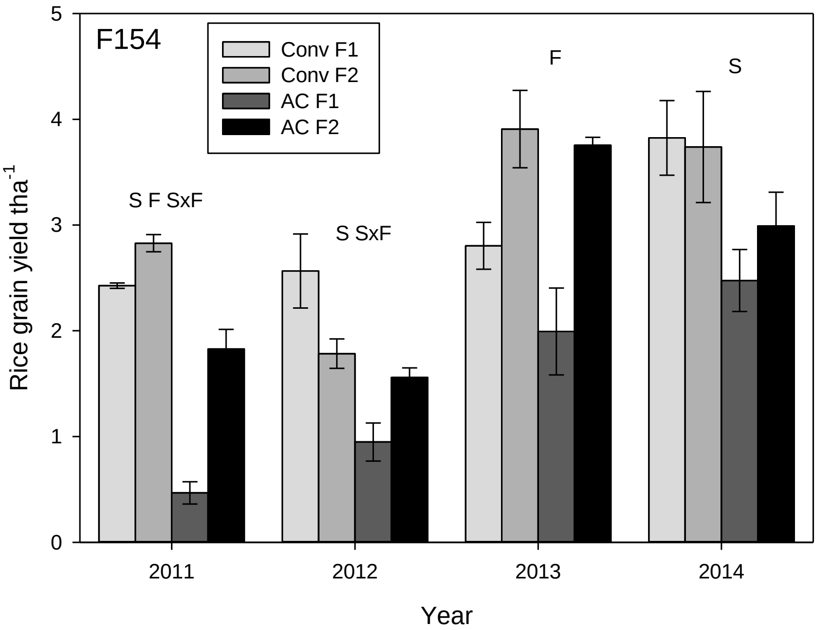

Figure 2: Rice grain yield for cultivar F 154 during the project in mid altitude. Letters indicate for each year if fertilization (F) or cropping system (S) or the interaction (SxF) have a significant impact on yield level.

In 2011, rice grain yield in CA cropping system was very low. That can be explained by the time necessary to obtain degradation of mulch and to stimulate biological in-soil processes (Giller *et al*., 2009) and yields are improved year after year. In 2012 (and slightly in 2014), in conventional system, rice grain yields were higher in F1 (without nitrogen) than F2 (with nitrogen). From figure 1, these observations coincide with higher incidences of blast in F2 than F1 in conventional system. Lower blast severity occurred in CA system, however with little impact on yield.

In the highlands rice grain yields were much better in the conventional system because of the early growth lag which could be due to restricted root growth and N immobilization (Dusserre *et al*., 2012). These differences in plant nutrition and crop growth between the CA and conventional systems may explain the impact of the system on blast epidemics (Sester *et al*., 2014). In the case of the present experiment, conducted in lower altitude, few differences in rice grain yields were observed between systems after 3 years, but there were still significant differences of blast severity, with a lower level of blast in CA system. Further investigations are needed to better understand the reasons of the reduction of blast severity under CA system such as the dynamic analysis of N uptake by rice, the analysis of the equilibrium of other mineral elements like silicon, phosphorus and the dynamics of crop development. These data were collected and will be analyzed.

Conclusion

Rice blast is a serious disease of upland rice around the world. CA cropping systems were found to reduce the severity of leaf and panicle blast in all levels of mineral N fertilization. That result could be exploited to improve the integrated blast management in the case of the subsistence agriculture of Madagascar.
Although, during the project, rice grain yields on CA systems were either lower or equivalent to conventional systems. The increase of the rice grain yield observed under CA cropping system suggests that it could be sustainable on a longer term.

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