Upland rice under zero tillage in Brazil: Cultivar performance and soil management for early vigour improvement

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Introduction

In Brazil, upland (rainfed) rice *aka* aerobic rice is planted on approximately 1.5 M ha. In the 1970s and 1980s, it was a common pioneer crop after deforestation with almost 4.5 M ha planted each year. The average grain yield of cultivars like Araguaia and Guarani ranged from 2.0 to 3.0 t ha^{-1}, but the grain type (long and wide with low amylose content) resulted in a sticky rice after cooking. It was rejected by the consumers once long and slender, non-sticky irrigated rice was introduced in the market. Embrapa's upland rice breeding program started in late 1970s resulted in increased grain yield (currently at approx. 4 t ha^{-1}) and quality standards adjusted to consumers preference (Breseghello et al., 2011). Despite being less labour and energy intensive than flooded anaerobic systems, upland rice is only grown in ploughed or heavy disk harrowed soils in rotation with other grain crops (e.g. soybean) on 200-ha farms or larger. Because of high erosive rainfall, tilled soils suffer from water erosion and become degraded in the mid term. Efforts are being made to grow upland rice under zero tillage (ZT) in rotation with both cash and cover crops. Pasture areas, which covers 48 M ha, mostly under acidic soils demanding recovery, represent another opportunity for the upland rice crop. However, some constraints hinder the adoption of ZT rice. Low early vigour, normally attributed to low nitrate reductase activity, impairs weed competitiveness of upland rice. Soil termites tend to be a large problem in ZT rice. Studies were initiated to tackle those problems, as an attempt to enable the cultivation of upland rice under ZT in acid tropical soils in the Brazilian Cerrado and Amazonia biome. Field experiments started for investigating the potential of modern upland rice cultivars at different row spacing to enable the use of the same ZT planter used for soybean (40-cm spacing), the interaction of seed chemical treatment and furrow compaction on rice plant mortality by termites in the early growth stages, and the effect of cover crops on mulching and soil NO_3^- and NH_4^+.

Material and Methods

Upland rice cultivars vs row spacing: In Santa Carmen, State of Mato Grosso (transition of Cerrado and Amazonia biome; 2065mm in 6 months; clayey Ferralsol; pH_{H2O} 6.6; 55% base saturation, and medium phosphorus levels), and Santo Antonio de Goias, State of Goias (Cerrado biome; 1343mm in 6 months; clayey Ferralsol; pH_{H2O} 5.2; 65% base saturation, but low phosphorus), field experiments were conducted during the rainy season of 2009 to evaluate the performance of five Embrapa (BRS) upland rice cultivars (Sertaneja, Pepita, Monarca, and Primavera) under ZT and to determine the effects of row spacing (17, 34, 51, and 68 cm) on rice yield. The experiment was established on a 3-year old Brachiaria pasture followed by soybean, fallow, upland rice, and maize mixed with palisade grass (*Urochloa brizantha*). All under ZT. Palisade grass was dessicated with glyphosate (2880 g AI ha^{-1}) and 20 days later the cultivars were sown with a ZT planter. Rice received fertilizers at rates of 70 kg ha^{-1} of N with additional 20 kg ha^{-1} of N as top dressing. The experiment was a split plot randomized design with three replicates.
Furrow compaction vs rice plant mortality by termites: In Santo Antonio de Goias, a field experiment

was established to evaluate the effect of ZT planter fitted with chisel (no compaction) or disc (furrow compaction of 1 kg cm^{-2}) on soil mineral N concentration and of the interaction between furrow compaction and seed chemical treatment (thiametoxam 1.4 g AI kg^{-1} seeds; imidacloprid 1.625 mL AI kg^{-1} seeds and; fipronil 0.625 mL AI kg^{-1} seeds) on rice plant mortality by termites (*Procornitermes triacifer*; *Proconitermes* spp; *Syntermes molestus*). Rice cultivar was BRS Sertaneja. Zero tillage was still in transition from ploughed system as it was in its second season. *Cover crop species vs soil ammonium- and nitrate-N, and nitrate reductase activity*: In the same field experiment used for termite evaluation, investigations were conducted to evaluate the amount of dry mass of two cover crops sown with a ZT planter in the end of the rainy season (March) and dessicated in the beginning of rainy season (October) of the same year for upland rice sowing 30 days after dessication with glyphosate (1468 g AI ha^{-1}). Cover crops were ruziziensis grass (*Urochloa ruziziensis*) and pearl millet (*Pennisetum glaucum*). Fertilization of N was at sowing time (20 kg N ha^{-1}) and top dressing 40 days after sowing (60 kg N ha^{-1}). Dry mass of cover crop residue and nitrate reductase activity (NRA) in rice leaves were measured base on Beevers and Hageman (1969) at 10, 18, 25, and 37 days after sowing.

Results and Discussion

Yields of all cultivars tested ranged between 2.5 and 6.0 t ha^{-1} in both sites (Figure 1). In Santa Carmen, yields were more contrasting and row spacing dependant than in Santo Antonio de Goias. Yields were similar to ploughed soils (data not shown). Compared to Santa Carmen, higher base saturation of the Ferralsol and less weed population could explain the lower effect of row spacing in grain yield in Santo Antonio de Goias. Yield reduction caused by weed competition at the wide interrow spacing was also reported by Chauhan and Johnson (2011). In the first year under ZT, rice plants were not affected by termite attacks probably due to soil disturbance caused by ploughing previously to ZT adoption. However, in the second year, furrow compaction combined with seed treatment with pesticides showed significant effect on termite attacks (P=0.002; Figure 2). The significant influence of soil compaction alone on tunnel network construction by termites has already been reported in Florida, USA (Tucker et al., 2004). Rice plant mortality was lower in the pesticide treated than in the control plots (Dunnet test α=0.05). The interaction of furrow compaction and seed treatment with pesticides showed higher effect (P=0.002) on termite control than furrow compaction alone. Imidacloprid and fipronil combined with furrow compaction showed best termite control. Dry matter of cover crops was adequate for mulching at both terms in ZT upland rice, but *U. ruziziensis* showed higher mulching effect than *P. glaucum* 30 days after dessication (Table 1). Cover crops showed greater effect on soil ammonium (F_{value}=46.5; P<0.01) than on soil nitrate (F_{value}=26.3; P<0.01), and soil ammonium was larger under *U. ruziziensis* than *P. glaucum* at 25 and 35 days after dessication of cover crops. However, no significant difference in NRA (Table 1) and rice yield was observed (data not shown). Nitrate reductase activity was more influenced by the time of sampling (F_{value}=360,1; P=0.01) than by cover crop residues (F_{value}=10.4; P=0.01).

References

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Figures and Tables

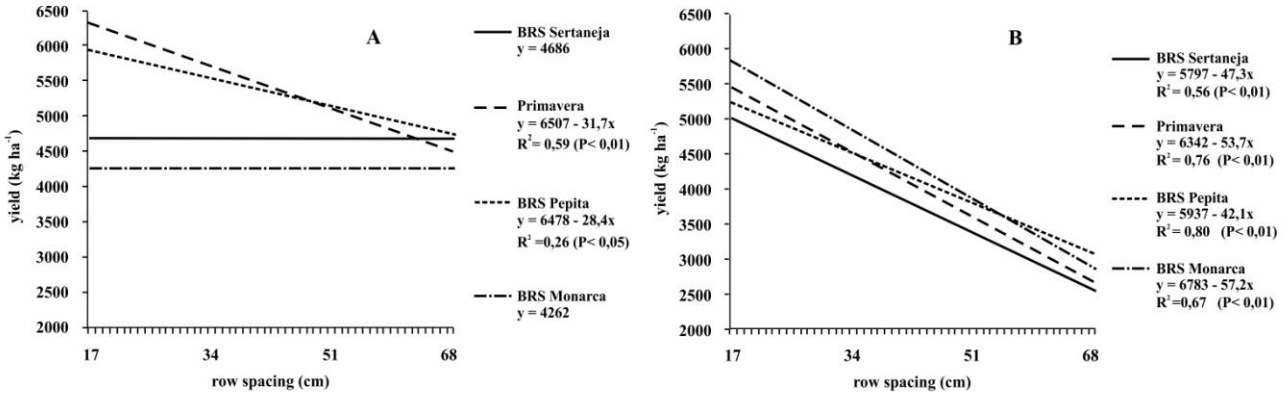

Figure 1. Effect of row spacing on yield of different upland rice cultivars on a clayey Ferralsol under 2nd-year zero tillage in Santo Antonio de Goias (A) and Santa Carmen (B), Brazil.

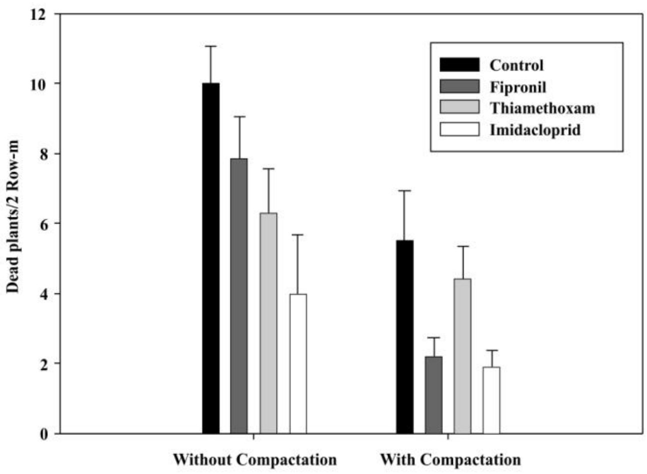

Figure 2. Rice plant mortality due to rootfeeder termites (*Procornitermes* spp. and *Syntermes molestus*) in a clayey Ferralsol under 2nd-year zero tillage.

Table 1. Dry matter (t ha^{-1}) of cover crops, soil ammonium- and nitrate-N (mg dm^{-3} soil), and nitrate reductase activity in rice leaves (NRA; µmole NO_2^- $g^{-1}.h^{-1}$) at different terms after dessicaton of cover crops in a Ferralsol from Santo Antonio de Goias, Brazil.

			Cover crops					
	U. ruziziensis				*P. glaucum*			
DAD*	DM**	NO_3^-	NH_4^+	NRA	DM	NO_3^-	NH_4^+	NRA
10	5.5a	21.9a	2.0a	0.01a	3.4a	47.8a	1.9a	0.01a
18	nd♣	5.8b	3.8a	1.48a	nd	23.4a	2.0a	1.38a
25	nd	23.6a	3.1a	9.37a	nd	22.0a	1.6b	6.78a
37	5.4a	20.8a	4.9a	9.46a	2.8b	19.2a	1.7b	9.05a

*days after dessication **Dry matter ♣not determined

♠Means followed by the same letter in a row are not significantly different at P<0.01