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as plantas de sombra apresentaram valor de 8,8 s^{-1}. Já a A_{max} da *D. excelsa* teve sua taxa máxima em ie foi de 14,3 ±1,0 mmol m^{-2} s^{-1} e 10,1 ±2,5 mmol amente para plantas de sol e sombra.

o A_{max} máxima na estação úmida para a mínima na e 35% para as plantas de sol e sombra da *Q.* 45 e 32% para as plantas de sol e sombra da *D.* portanto que as plantas de sol foram mais sensíveis de sombra, como foi previsto pôr Mulkey *et al*, s de y para a *Q. pteridophylla* seguem a mesma lução maior para as plantas de sol em relação as de de janeiro o y foi de -0,49 e -0,56 Mpa (não houve sol e sombra, em 3 de junho, 72 dias sem chuvas, e -1,29 ±0,1Mpa, e em 12 de agosto foi de -3,60 1,19Mpa respectivamente para sol e sombra. Os a *D. excelsa* foram contraditórios pois não houve icativa entre sol e sombra em 12 de agosto, - 28±1,17 respectivamente para sol e sombra.

mparativa entre as arvores da torre ficou prejudica- de dados da mesma data para as três espécies, que 13 de janeiro, 29 de março e 2 de junho. Porem os resultados de março, onde obtivemos A_{max} s as espécies, e junho observamos que o *B. lactescens* maior redução. Os dados de 29 de março foram $^{-1}$ para o *B. lactescens* (medido nas folhas a 26m), $^{-1}$ para a laranjeira e 8,7 mmol m^{-2} s^{-1} para a *T.* 2 junho, 71 dias sem chuvas, os dados foram: mmol m^{-2} s^{-1} para o *B. lactescen*, laranjeira e *T.* seja o *B. lactescens* sofreu uma redução de 16% na que na laranjeira houve um aumento e na *T.* icamente o valor é o mesmo. Contrario ao suge- l *et al*, 1994, o *B. lactescens* parece não ter mais as arvores de menor porte, e devido a sua expo- clima mais adverso foi o que mais sofreu com o

osto os valores foram 7,1 e 7,9 mmol m^{-2} s^{-1} para *homburgkii* respectivamente, devido á problemas dados para o *B. lactescens*. A redução da A_{max} mínima foi de 43 e 9% para a laranjeira e *T.* ste caso temos duas espécies diferentes em um a com respostas contrastantes. O y em 29 de 5, -1,02 e -0,98 Mpa respectivamente para *B.* a e *T. schomburgkii*, e em 8 de agosto foi de -4,92, a para as mesmas espécies. É necessário mais erminar porque a *T. schomburgkii* tem uma resis- a, se devido a um sistema radicular mais desen- sistema fotossintetico mais eficiente.

orrelação positiva significativa entre o potencial uma regressão linear para todas as espécies, com *idophylla*. Para a *T. schomburgkii* a inclinação foi 0,99, para a laranjeira inclinação de 1,09 e R2= nclinação de 1,88 e R2= 0,95, e para a *D. excelsa* e R2= 0,87, com regressão feita com as medias s dados indicam que existe uma maior depen- o potencial hídrico para a *D. excelsa* e para o *B.* e ser explicado pelo fato da *D. excelsa* ter menor portanto a falta de água foi um fator importante Quanto ao *B. lactescens* todo o topo de sua copa que provavelmente fez com que água fosse um ortância em relação as duas outras arvores cujas o topo do dossel.

lados da D. excelsa separando as plantas em sol ados não foram tão significativos no entanto o interessantes. Para as plantas de sol, inclina- 0,56, plantas de sombra inclinação de 3,02 e as plantas de sol tiveram uma redução na A_{max} devido a diminuição do potencial hídrico muito maior que as plantas de sombra, provavelmente devido a sua maior exposição a luz.

4. Conclusões

Estes dados sugerem que os comportamentos fisiológicos de diferentes espécies em relação à seca diferem não só pelo microclima em que elas se encontram, mas também devido a particularidades próprias de cada espécie. Haja visto que a laranjeira e a *T. schomburgkii* estão no mesmo microclima e no entanto as respostas das duas são muito diferentes, a *T. schomburgkii* sofreu menos com o stress hídrico de 142 dias (y de -2.83 Mpa) que a laranjeira (y de -4,90 Mpa). A influencia de diferentes microclimas no y ficou claro na *Q. pteridophylla* (-3,60 ±0,39 e -1,79±0,19Mpa para plantas de sol e sombra) enquanto que para a *D. excelsa* não se observou diferença significativa entre plantas de sol e de clareira, embora a A_{max} das plantas de sol ter reduzido mais que das plantas de sombra (redução de 45% para as plantas de sol e 32% para plantas de sombra).

A correlação positiva entre y e A_{max} altamente significativa e com inclinações, com exceção *T. schomburgkii*, maiores que 1 indica que no local estudado a variação do NEE é devido a sazonalidade das chuvas. É necessário mais pesquisa para explicar o caso da *T. schomburgkii* que apresentou pequena variação na A_{max} (apenas 9%) mesmo após 142 dias sem chuvas.

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Effects of slash-and-mulch and slash-and-burn agriculture on emissions of nitrous oxide, nitric oxide, carbon dioxide, and methane from soil.

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1. Introduction:

The use of fire in traditional slash-and-burn agriculture causes loss of nutrients from agroecosystems and emissions of pollutants to the atmosphere. A mulching technology has been developed as an alternative to burning that conserves nutrients and eliminates emissions from fire (Vielhauer et al. 2001). However, mulching could also affect nutrient inputs to the soil and the microclimate of the topsoil, which, in turn, could effect emissions of nitrous oxide (N_2O), nitric oxide (NO), carbon dioxide (CO_2), and methane (CH_4) from the soil. The objective of this research was to compare emissions of these greenhouse gases from the soil under conventional slash-and-burn agriculture, the alternative mulching strategy, and native secondary forest (capoeira) vegetation.

2. Methods:

The study site is within the municipality of Igarape Açu, Pará, where small-holder agriculture is the dominant land use. At the Experimental Farm of the Federal Rural University of Amazonia, a 20-year-old fallow field was prepared for planting during the dry season of 2001. One field (2 ha) was cut and burned in November 2001 and another field (2 ha) was chopped and mulched in December, 2001. Both fields were planted in maize in January 2002. The mulched plot was fertilized with 12 g/plant of 60 – 60 – 30 kg ha^{-1} NPK (urea, triple superphosphate and potassium chloride). Previous research as shown that nutrients are immobilized in the mulch, and that fertilization is necessary to obtain good crop yield with mulching (Kato et al. 1999). Cassava was planted under the maize in February 2002, and the maize was harvested in May 2002. The plots were weeded, and leguminous trees *Acacia mangium*, Willd, and *Sclerolobium paniculatum*, Vogel, were planted in 2 m x 2m spacing in June 2002. The cassava was harvested in June 2003, and the site was allowed to return to fallow, enriched with the planted N-fixing trees.

Each field was subdivided into plots, and we chose two plots within each of the two fields for trace gas measurements. Eight polyvinyl chloride (PVC) rings (20cm diameter) were inserted about 2 cm into the soil in each of these four plots. An additional eight rings were installed in an adjacent fallow field with 20-year-old *capoeira* vegetation. It was necessary to remove the rings before the burning and mulching treatments and to reinstall them afterwards. Otherwise, the rings were left in place throughout the measurement period. Measurements were begun prior to treatment in November, 2001, and were repeated about every other month thereafter and sometimes more frequently to capture the effects of management operations. At each measurement date, a 20 mL sample of headspace gas was collected by syringe at 0, 10, 20, and 30 minutes after placing a vented PVC chamber over each ring. The syringe samples were returned to a laboratory in Belem where they were measured for N_2O and CH_4 by gas chromatography. We also measured fluxes of NO and CO_2 in the field from the same PVC rings using portable gas analyzers. Details for methodology of measuring these four gases are described in Cattânio et al. (2002).

3. Results:

A large pulse of N_2O emissions was observed in the burned (11.0 ng N cm^{-2} h^{-1}) and mulched (5.1 ng N cm^{-2} h^{-1}) plots in January 2002. This large emission was probably due to a release of readily available N following site clearing and wet soil conditions early in the rainy season that promoted denitrification. The N_2O fluxes in the mulched plot peaked (6 ng N cm^{-2} h^{-1}) after fertilization in March 2002 and then gradually declined over the next year, but remained elevated (0.5-1.5 ng N cm^{-2} h^{-1}) relative to the burned field and the capoeira (0.1-0.5 ng N cm^{-2} h^{-1}). The moist soil microenvironment under the mulch maintains conditions favorable for N_2O emissions from denitrification. In contrast, the N_2O emissions declined in the burned plot once the pulse of available N released during the site preparation was spent, and N_2O emissions were always low in the nutrient poor capoeira. Nitric oxide (NO) emissions were not significantly different between burned and mulched fields (1.5 – 12.6 ng N cm^{-2} h^{-1}), but were lower in the capoeira (0.3-2.2 ng N cm^{-2} h^{-1}). Apparently, the burned and mulched fields still had some residual available N to be released as NO throughout 2002 and into 2003.

Soil respiration (CO_2 flux) was elevated in the burned plots in December 2001 (0.60 g C m^{-2} h^{-1}) and January 2002 (0.53 g C m^{-2} h^{-1}), which may have been due to decomposition of dead roots. Respiration in the burned and mulched plots remained higher (0.10 - 0.53 g C m^{-2} h^{-1}) than the *capoeira* (0.07 – 0.15 g C m^{-2} h^{-1}) throughout the study, presumably because of active growth of the crop roots and gradual decomposition of the mulch. Contrary to expectation, however, the CO_2 fluxes were not significantly higher in the mulch field compared to the burned field. The decomposition of the mulch must be slow relative to the rate of crop root respiration.

The moist, carbon-rich conditions under and in the mulch also stimulated net methane production at all dates after the mulch application (1.7-4.8 mg CH_4 m^{-2} d^{-1}). The CH_4 emissions are highly variable within the mulched field, indicating "hot spots" of anaerobic microsites that are favorable for denitrification and methanogenesis. Large standard errors for CH_4 emissions in the mulch plots resulted from one or two chambers showing a very large emission of CH_4, while the others had modest fluxes. In contrast, the burned field and the capoeira were generally net consumers of atmospheric CH_4 (-1.5 to 0.0 mg CH_4 m^{-2} d^{-1}).

Because the *capoeira* was relatively old (20-years) prior to mulching, the mulch layer was relatively thick. Most fields in this area are prepared from younger *capoeiras*, so the mulch layer may not be so thick and the effect on microclimate and trace gas production may not be as great, but this speculation clearly needs further research.

4. Conclusion:

In summary, the anaerobic microsites under the mulch are promoting relatively high fluxes of N_2O and CH_4. The burning treatment and the fertilization with N in the mulched field also caused sustained elevated fluxes of NO. Although the mulching has caused increased emissions of the greenhouse gases N_2O and CH_4, the magnitude of these emissions throughout the crop cycle must be compared to the very intense emissions released during a typical site preparation fire. We are continuing to measure emissions through the fallow phase and then will compare these emissions summed over the cropping cycle to estimates of fire-induced emissions to estimate the net effect of these management practices on gaseous emissions and nutrient losses.

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