UNIVERSIDADE FEDERAL DO PAMPA

***CAMPUS* SÃO GABRIEL**

PROGRAMA DE PÓS-GRADUAÇÃO *STRICTO SENSU* EM CIÊNCIAS BIOLÓGICAS

FLUXO DE ÓXIDO NITROSO E METANO EM SOLO SOB IMPLANTAÇÃO DE UM SISTEMA SILVIPASTORIL COM *Parapiptadenia rigida* (Benth.) Brenan EM CAMPO NATIVO

DÉCIO OSCAR CARDOSO FERRETO

SÃO GABRIEL, RIO GRANDE DO SUL, BRASIL

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Orientador: Prof. Dr. Frederico Costa Beber Vieira

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RESUMO

FLUXO DE ÓXIDO NITROSO E METANO EM SOLO SOB IMPLANTAÇÃO DE UM SISTEMA SILVIPASTORIL COM *Parapiptadenia rigida* (Benth.) Brenan EM CAMPO NATIVO

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Sistemas silvipastoris (SSPs) apresentam potencial para amenizar o problema do aquecimento global, pelo sequestro de CO_2 atmosférico, principalmente na biomassa vegetal. Entretanto, se faz necessário estudar nestas áreas os fluxos de metano (CH_4) e óxido nitroso (N_2O) do solo, para se ter uma melhor compreensão da dinâmica destes gases no sistema solo-atmosfera. Este estudo teve como objetivo principal avaliar os fluxos de N_2O e CH_4 em um solo sob implantação de um sistema silvipastoril com a espécie arbórea leguminosa nativa *Parapiptadenia rigida* em campo nativo do bioma Pampa e determinar um fator de emissão (FE) de N_2O para esta consorciação. O experimento foi conduzido em um Argissolo Vermelho anteriormente utilizado com pastagem nativa no município de São Gabriel, RS, Brasil. Para isso, mudas de *P. rigida* forram plantadas em outubro de 2012 em delineamento experimental de blocos ao acaso, com parcelas subdivididas. Os tratamentos nas parcelas principais foram: T1: campo nativo (NG); T2: NG + *P. rigida* com arranjo espacial de 2 x 4 m; e T3: NG + *P. rigida* com arranjo espacial de linhas duplas 6 x (2 x 2) m. A subdivisão das parcelas (18 x 30 m) constituiu a presença ou ausência de adubação mineral anual (NPK) das forrageiras nativas.Os fluxos de gases de efeito estufa do solo foram coletados a cada quinze dias ou após eventos de fertilização, no decorrer do ano de 2014, através de câmaras estáticas, com seis repetições. As concentrações de N_2O e CH_4 foram determinadas por cromatografia gasosa. Concomitantemente a cada coleta dos gases foi coletado amostras de solo (0-5 cm) para análise do teor de N-mineral e monitoramento das variáveis climáticas. Os resultados foram submetidos à análise de variância e teste de Tukey para comparação das médias ($P <0{,}10$). As taxas de fluxo diário de CH_4 e N_2O permaneceram baixa durante o período avaliado, variando de -18,3 para 23,1 µg N_2O–N m^{-2} h^{-1} e de -40 a 105 µg CH_4–C m^{-2} h^{-1}. A Fertilização mineral elevou a emissão acumulada ($P <0{,}10$) apenas para o N_2O. Foram observados dois picos de emissão de N_2O concomitantemente com o aumento do teor de nitrogênio mineral (NO_3^- e NH_4^+) no solo proporcionado pela adubação mineral. Foi encontrado um FE de N_2O de 0,26%, menor que o indicado pelo IPCC para a prática de adubação mineral de pastagens, o qual é de 1%. As maiores taxas de emissões diárias de CH_4, por sua vez, coincidiram com aumentos na umidade e temperatura do solo. Assim, a introdução de árvores de *P. rigida* em campo nativo não alterou significativamente os fluxos de CH_4 e N_2O do solo, independentemente do espaçamento de plantio após dois anos de plantio das arvores.

Palavras-chave: N_2O, CH_4, Adubação mineral, Fator de emissão

ABSTRACT

SOIL NITROUS OXIDE AND METHANE FLUXES IN SOIL UNDER IMPLANTATION OF A SILVIPASTORAL SYSTEM WITH *Parapiptadenia rigida* (Benth.) Brenan IN NATIVE GRASSLAND

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Abstract: Silvopastoral systems (SSPs) can mitigate global warming through atmospheric CO_2 sequestration, mainly in plant biomass. However, few is known about their effect on nitrous oxide (N_2O) and methane (CH_4) fluxes in the soil. This study aimed to evaluate N_2O and CH_4 fluxes in a soil with native grassland system afforested with native species of the leguminous tree *Parapiptadenia rigida* in the Brazilian Pampa and determine an N_2O emission factor for this intercropping. The experiment was carried out in an Acrisol previously used with native grassland in São Gabriel, RS, Brazil, forested in October 2012. The experiment had a randomized block design, with split plots. Treatments in the main plots were: T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. The split plots (18 x 30 m) constituted the presence or absence of annual mineral fertilizer (NPK) for the native forages. Soil greenhouse gases were taken every fortnight or after fertilization events for one year (2014) through static chambers, with six replicates. Concentrations of N_2O and CH_4 were determined by gas chromatography**,** concomitantly to the monitoring of soil (0-5 cm) for the analysis of N-mineral content and climate variables. The results were submitted to analysis of variance and Tukey test to compare means ($P<0.10$). Daily flux rates of CH_4 and N_2O remained low during the evaluated period, ranging from -18.3 to 23.1 µg N_2O–N m^{-2} h^{-1} and from -40 to 105 µg CH_4–C m^{-2} h^{-1}. Mineral fertilization increased the cumulated emission ($P < 0.10$) only for N_2O. Two peaks of N_2O emission were observed concomitantly to the increase of mineral nitrogen concentration (NO_3^- and NH_4^+) in soil due to mineral fertilization. Was found an emission factor (EF) of 0.26%, smaller than that indicated for the practice of N fertilization on pastures by the IPCC which is 1%. The largest emissions rates of CH_4, in turn, coincided with raises in soil moisture and temperature. Thus, the introduction of *P. rigida* trees in natural grassland did not altered significantly the soil fluxes of CH_4 and N_2O, independently of their arrangement, after two years from the tree plantation.

Keywords: N_2O, CH_4, Mineral fertilization, Emission factor

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1.1 Sistemas silvipastoris (SSPs) e política nacional de mudança climática

No contexto atual, as demandas mundiais, tanto por produtos florestais madeireiros quanto por produtos de origem animal, estão em constante crescimento. Pesquisadores estimam que a população mundial que nos dias atuais é de 7,2 bilhões de habitantes, atinja 12,3 bilhões até o final deste século (Gerland et al., 2014). Se esta estimativa se concretizar, praticamente dobraria a população mundial, provocando maior consumo de produtos de origem florestal e animal. Tendo em vista que as áreas para produção de alimentos já estão se esgotando, será necessário aumentar a produção agrícola, sem ampliar a área de exploração. Devido a isso, surge a necessidade de adaptar técnicas de produção que garantam o fornecimento de alimentos, sem comprometer o equilíbrio do ecossistema, realizando a utilização mais adequada dos recursos naturais.

A base da economia do estado do Rio Grande do Sul (RS) está voltada principalmente para as atividades agrícolas e pecuárias. Essas atividades são as que mais influenciam a emissão de óxido nitroso (N_2O) e metano (CH_4) para a atmosfera em nível nacional (EMBRAPA, 2006; Cerri et al., 2009; MCTI, 2013). Segundo o MCTI (2013) no ano de 2010 o setor agropecuário brasileiro colaborou com 35% das emissões totais de gases de efeito estufa (GEE). Sendo que, os fatores que mais contribuíram foram: uso de solos agrícolas, com 95% das emissões de óxido nitroso e a fermentação entérica, com 90% da emissão de metano Assim, além de estudar o comportamento das emissões de CO_2, torna-se essencial o conhecimento da dinâmica dos fluxos de N_2O e CH_4, os quais também possuem elevado potencial de aquecimento global.

O Brasil tem desenvolvido políticas públicas com o intuito de reduzir as emissões de GEE para a atmosfera. Para isso, criou o Plano Nacional Sobre Mudança do Clima – PNMC, com a finalidade de tentar frear o desmatamento e incentivar práticas de reflorestamento de áreas que sofreram algum tipo de degradação (PNMC, 2008). Entre suas metas, o plano visa dobrar a área de florestas plantadas no país, passando de 5,5 milhões de hectares para 11 milhões de hectares até 2020. Além disso, devido à grande importância ambiental das matas nativas, seu objetivo é plantar 2 milhões de hectares com espécies nativas, promovendo o plantio prioritariamente em áreas de pastos degradados, visando à recuperação econômica e ambiental destas áreas (PNMC, 2008).

A fim de que o PNMC consiga alcançar os compromissos firmados para reduzir as emissões de GEE, foi criado em 2010 o decreto 7390, o qual propõe ações a serem cumpridas para alcançar as metas estabelecidas neste plano. Por isso, o Ministério da Agricultura, Pecuária e Abastecimento (MAPA) em parceria com o Ministério do Desenvolvimento Agrário (MDA), instituíram em 2012 o plano ABC (Agricultura de Baixa Emissão de Carbono). Este plano através de iniciativas de incentivo a empresas e produtores rurais, como a redução de impostos, financiamentos com juros mais baixos e agregação de valor a práticas de mitigação das emissões de GEE, estabeleceu ações como a recuperação de 15 milhões de hectares de pastagens degradadas, com a realização de um manejo apropriado e adubação, o aumento de sistemas integradores, como lavoura-pecuária-floresta em 4 milhões de hectares, o avanço no uso de fixação biológica de nitrogênio em 5,5 milhões de hectares, visando diminuir o uso de fertilizantes nitrogenados, e ainda adequar ações de reflorestamento, com a expansão da área com florestas plantadas, passando de 6,0 milhões de hectares para 9,0 milhões de hectares (Brasil, 2012).

O uso demasiado dos recursos do solo e a exploração de novas áreas para as práticas de agricultura e pecuária, tem contribuído para a degradação de áreas potencialmente produtivas, influenciando na estabilidade do ecossistema. Segundo MAPA (2013), o total da área com pastagens no Brasil é de aproximadamente 172 milhões de hectares, sendo que 70 % desta área encontra-se em algum estado de degradação.

A atividade pecuária realizada de forma extensiva, sem o adequado manejo, é um dos fatores que mais contribui para degradação do solo. Dentre os problemas causados, está o excesso de carga animal sobre a pastagem, o que leva a um superpastejo, causando o exaurimento de nutrientes e, também a compactação do solo, pelo intenso pisoteio animal. Outras práticas impróprias como a utilização de fogo para renovação do pasto e o desmatamento para implantação de pastagens também são fatores que aceleram o processo de degradação porque expõe a superfície do solo, deixando-o suscetível ao impacto da gota da chuva, acarretando em desagregação da estrutura do mesmo, desencadeando processos erosivos. Além disso, em locais onde ocorre perda de solo e matéria orgânica (MO), a resiliência natural do ambiente pode não ocorrer ou ser muito lenta (Campello, 1998).

O conteúdo de C do solo é apontado como um dos melhores indicadores para avaliar a qualidade do solo (Vieira et al., 2007). A mudança de uso da terra pode comprometer o estoque de C no solo, pela perda de MO neste compartimento, já que 58% da MO é composta por C (Nelson & Sommers, 1996). Por isso, o desmatamento de mata nativa seguida de queima dos resíduos para limpeza do local é apontado como uma das principais causas de degradação dos solos, principalmente pela perda de MO.

Neste contexto, a utilização de Sistemas Silvipastoris (SSPs) pode servir como uma excelente estratégia contra o avanço desordenado da agricultura, servindo tanto para recuperação de ambientes já explorados, quanto para a proteção de áreas ainda não cultivadas. Estes sistemas têm capacidade de diversificar a produção, por conciliar a extração de produtos animais e madeireiros de um mesmo local, promovendo a melhor utilização da área. Sendo assim, estes sistemas são caracterizados por consorciar o cultivo de árvores, pastagem natural ou plantada e/ou a criação de animais, manejados em uma mesma área (Ribaski, et al., 2005). A utilização destes sistemas pode proporcionar um uso mais sustentável das áreas de produção, podendo também ser utilizados em áreas sujeitas à degradação ambiental. Assim, os SSPs podem proporcionar um melhor uso da terra, comparados a outros sistemas tradicionais de produção, pela inserção de produtos florestais em áreas pouco produtivas, o que acrescentaria maior valor à propriedade, sendo uma maneira de aliar aspectos econômicos, sociais e ambientais (Castilhos et al., 2009). Deste modo, estes sistemas podem contribuir para evitar a exploração de novos locais, atenuando a pressão sobre as áreas de vegetação nativa.

Na Metade Sul do estado do Rio Grande do Sul (RS), encontra-se o bioma Pampa, que é caracterizado por possuir extensas áreas com pastagens naturais, tendo sua matriz produtiva voltada principalmente para a pecuária extensiva e cultivo de arroz irrigado (Costa et al., 2010). O uso de SSP nesta região é recente e está em processo de construção e adaptação. Entretanto, esta atividade poderá servir como uma forma de incentivo para os produtores rurais permanecerem no campo, estimulados pela diversificação da matriz produtiva e maior geração de renda proporcionada por este sistema de manejo, diminuindo a pressão populacional sobre as áreas urbanas (Ribaski et al., 2009). Além disso, os SSPs tornam-se importantes estratégias de uso sustentável do solo, agregando maior valor econômico à propriedade rural por meio da exploração de madeira, colaborando para atender a demanda de produtos florestais à população, sem necessitar explorar novas áreas.

1.2 Efeito da inclusão de espécies leguminosas arbóreas em campo nativo

O uso do componente arbóreo juntamente com a pastagem propicia diversos benefícios para o ecossistema. As árvores realizam a ciclagem de nutrientes, ou seja, contribuem para a entrada de nutrientes no sistema, pela decomposição e mineralização da serrapilheira e melhorando a fertilidade do solo (Dias Filho, 2006; Macedo et al., 2008; Silva et al., 2013). Além disso, por possuírem sistema radicular profundo, elas realizam a translocação de nutrientes de camadas mais profundas para a superfície, tornando estes nutrientes disponíveis para a pastagem (Costa et al., 2014). Estes processos contribuem para elevar a capacidade nutricional da pastagem (Castro et al., 1999), proporcionando aos animais uma dieta mais rica em nutrientes. Além disso, há uma atenuação da temperatura dentro do SSP, causada pela copa das árvores, gerando um bem estar aos animais, amenizando o estresse causado por temperaturas extremas, melhorando o desempenho animal (González Rodríguez et al., 2011; Dias et al., 2006).

Estudos têm demonstrado que a utilização de espécies arbóreas leguminosas para composição dos SSPs pode trazer melhorias para o ecossistema em geral (Macedo et al., 2008; Xavier et al., 2003). Estas espécies são capazes de fixar N atmosférico e depositar em sua biomassa, aportando ao solo após a decomposição e mineralização deste material (Xavier et al., 2003; Schumacher et al., 2003). Deste modo, espécies leguminosas arbóreas são capazes de fixar até 200 kg ha^{-1} ano^{-1} de N atmosférico (N_2) (Auer & Silva, 1992). O uso destas espécies, assim, geraria benefícios econômicos e ambientais.

Em relação à parte econômica, a introdução de plantas leguminosas, reduz os gastos com insumos industriais, visto que o N é o nutriente mais exigido pelas culturas, e também o de maior valor para aquisição (Franco et al.,1997). Além disso, a adição de N pelas plantas leguminosas acontece de forma gradual, ou seja, à medida que os galhos e folhas caem sobre a superfície do solo, estes sofrem processos de decomposição. Com isso, o N é incorporado ao solo, estando menos suscetível às perdas no sistema solo-planta-atmosfera. No que se refere ao ambiente, este nutriente é difícil de ser manejado podendo ser facilmente perdido por diversas formas como: lixiviação de nitrato (NO_3^-), emissão de N_2O e volatilização de amônia (NH_3) para a atmosfera, tornando-se poluente de águas subterrâneas e do ar atmosférico, respectivamente. Junto a isso, o aporte de resíduos advindos de sua biomassa, ricos em N, com relação C:N menor eleva a taxa de mineralização. Logo, melhora a qualidade do solo, pelo maior aporte de MO (Schumacher et al., 2003; Sisti et al., 2003; Costa et al., 2004; González-Rodríguez et al., 2011).

1.3 Comportamento dos Fluxos dos GEE em Sistema Silvipastoril

O Bioma Pampa está inserido na metade sul do estado do RS, região esta que concentra uma ampla diversidade de solos, alta variabilidade pluviométrica e térmica (Streck et al., 2008; Boldrini et al., 2010). Em função disso, este bioma apresenta alta riqueza de espécies de gramíneas, as quais são caracterizadas por possuírem um vasto sistema radicular, que auxilia na estruturação do solo (Silva & Mielniczuk, 1998; Blanchart et al., 2004). Este vantajoso sistema radicular propicia um ótimo aporte de C ao solo, proporcionado pela constante renovação das raízes (Vezzani & Mielniczuk, 2011). Além disso, esta melhor estruturação do solo favorece a atividade biológica dos macro e microorganismos, que acarreta em benefícios físicos como construção de bioporos, o que melhora a infiltração de água e a aeração do solo. Desta forma, através da melhoria dos atributos físicos do solo proporcionados pelas gramíneas, o solo sob campo nativo, neste bioma, tem sua estrutura formada principalmente por macroagregados, o que lhe confere maior estabilidade a MO, preservando alto estoque de C e conferido maior qualidade ao solo deste local (Vezzani & Mielniczuk, 2011; Bayer et al., 2004).

A fim de tornar este ambiente mais produtivo, produtores rurais realizam a constante substituição do campo nativo, por espécies cultivadas de pastagens, principalmente através do plantio da espécie *Lolium multiflorium* (Azevém). Entretanto, é necessário conhecer o real potencial produtivo destas áreas, a fim de atribuir valor econômico às plantas forrageiras nativas da região. Portanto, é necessário estudar a inserção de novos modelos de produção neste ambiente em razão de sua complexidade e pouca exploração por pesquisas. A utilização de SSP nesta região pode colaborar para aumentar a renda dos produtores rurais, pela diversificação da matriz produtiva, e assim, preservar as áreas com pastagem natural destes locais (Ribaski, et al., 2005). Além disso, estes sistemas apresentam potencial para amenizar o problema do aquecimento global, pelo sequestro de CO_2 atmosférico, na forma de C em sua biomassa vegetal (Hergoualc'h et al., 2012, Denardin et al., 2014, Macedo et al., 2008). Porém, torna-se necessário a realização de estudos nestas áreas com relação aos fluxos de metano (CH_4) e N_2O no solo.

Estudos que avaliam os fluxos de GEE em SSPs no Bioma Pampa são recentes e escassos, e em relação a uso de espécies nativas para essa composição encontram-se menos trabalhos ainda. Portanto, entender o comportamento dos SSPs com espécies nativas do bioma pampa em relação às emissões de CH_4, N_2O e CO_2 é de suma importância, tendo em vista a grande preocupação mundial relacionada ao aumento das concentrações destes gases na atmosfera.

A utilização de espécies da família das leguminosas para compor o SSP pode elevar os teores de N mineral (amônio (NH_4^+) e NO_3^-) no solo, resultantes da mineralização de seus resíduos ricos em N, depositados pelas plantas na superfície do solo (Rochette e Janzen, 2005; Verchot et al, 2008). Esta maior concentração de NH_4^+ e NO_3^- no solo favorece a ocorrência dos processos de nitrificação e desnitrificação, os quais são responsáveis pelos fluxos de N_2O do solo (Gomes et al., 2009; Inagaki & Ishizuka, 2011; Konda et al., 2010). A desnitrificação ocorre quando os níveis de oxigênio no solo são baixos e neste processo as bactérias quimioheterotróficas reduzem os íons nitrito (NO_2^-) e nitrato (NO_3^-) para formas gasosas NO, N_2O e N_2 (Aita & Giacomini, 2007). A introdução de espécies arbóreas em áreas de pastagens aumenta o índice de área foliar (m^2 de folhas/m^2 de solo superficial), acarretando em maior perda de água por evapotranspiração, diminuindo a anaerobiose do solo. Este evento influencia os fluxos de N_2O no solo, visto que os maiores fluxos de N_2O do solo ocorrem por processos de desnitrificação (Velthof et al., 1997). As árvores podem alterar o microclima da região, alterando o regime de chuvas, atenuando os efeitos provocados pela temperatura e umidade do solo, podendo intervir nos fluxos de N_2O e CH_4 do solo. Em regiões de clima subtropical, as altas variações anuais de temperatura e precipitação influenciam diretamente os fluxos de N_2O do solo sob plantações florestais (Konda et al., 2010). Ao passo que solos com temperaturas e umidades baixas favorecem o influxo de N_2O (Werner et al., 2006). Portanto, a introdução de uma espécie arbórea em campo nativo pode modificar a dinâmica das variáveis que determinam a emissão de N_2O e CH_4.

O uso de adubação nitrogenada, principalmente os fertilizantes amoniacais, para nutrição da pastagem e/ou para as árvores que compõem o SSP, também podem aumentar os fluxos de N_2O e CH_4 do solo, pelos mesmos processos citados anteriormente, além de ter potencial de contaminação do lençol freático por alta concentração de NO_3^-. Fertilizantes que elevam o teor de NH_4^+ no solo podem favorecer a ocorrência do processo de metanogênese, elevando as emissões de CH_4 para a atmosfera (Bayer et al., 2012). Este maior teor de NH_4^+ no solo poderá inibir a oxidação (influxo) do CH_4 devido à competição do íon NH_4^+ com o CH_4 pela enzima mono-oxygenase (Mosier & Delgado, 1997; Konda et al., 2010). A fertilização também acarreta em picos de emissão de N_2O, logo após sua aplicação (Zanatta et al., 2010; Piva et al., 2014). Além disso, a adubação pode ser prejudicial às bactérias metanotróficas, que são as responsáveis pela oxidação de CH_4 (Hüstch, 1998).

Estudos indicam que os fluxos de N_2O dependem da produção deste gás no perfil do solo (Metay et al., 2007; Fang et al., 2006; Burton & Beauchamp, 1994). Estes autores sugerem que o conteúdo de carbono lábil, a percentagem do espaço de poros preenchido por água e a da temperatura no perfil do solo, são tão importantes quanto os fatores climáticos de superfície. Metay et al. (2007) verificaram que a concentração de N_2O no perfil do solo é 10 vezes maior que à concentração atmosférica. Além disso, estes autores constataram que, à medida que, aumenta a concentração de N_2O no perfil do solo, se elevam os fluxos de N_2O para a atmosfera. Logo, camadas mais profundas do que as usualmente avaliadas para correlacionar fluxo de gases de efeito estufa podem afetar a dinâmica destes fluxos. Em condições de um solo bem estruturado, como usualmente se verifica em campo nativo não degradado do bioma Pampa, a elevada macroporosidade e a continuidade destes poros podem agir em duas linhas principais. Uma delas é favorecendo a oxigenação de camadas de subsolo, diminuindo, portanto a anaerobiose e a produção de CH_4 e N_2O. Por outro lado, pode favorecer a difusão destes gases das camadas mais profundas para a atmosfera. Porém, a existência e a magnitude destes efeitos ambíguos são pouco conhecidas e especula-se que possam ser determinantes para fazer com que o solo se comporte como um dreno ou fonte de GEE para a atmosfera. Conforme Burton & Beauchamp (1994) se faz necessário examinar o solo como um corpo tridimensional para a produção, transporte, e armazenamento de N_2O, só assim será possível entender melhor os processos de emissões deste gás em superfície.

Estudos em sistemas agroflorestais (SAFs) com espécies arbóreas fixadoras de N têm apontado que estes sistemas podem elevar as emissões de N_2O e reduzir a oxidação de CH_4 no solo (Millar, 2002; Baggs et al., 2000), mas alguns resultados divergem. Analisando SAFs na Amazônia Verchot et al. (2008) não encontraram diferenças significativas após o plantio de árvores leguminosas em um sistema de pousio. Entretanto, pesquisas mais recentes evidenciam que a conversão de uma monocultura para um SAFs com espécies arbóreas fixadoras de N, contribui para mitigar as emissões de GEE do solo (Hergoualc'h et al., 2012).

Plantios florestais apresentam condições favoráveis à oxidação de CH_4, pela diminuição da anaerobiose no solo (Boeckx et al.,1997; Tate et al., 2007). Estudando os fluxos de CH_4 e N_2O em plantios de *Acacia mearnsii* no bioma Pampa, Godoi (2012) corroborou com estes autores. Esta autora encontrou fluxos de N_2O baixos ou próximos a zero e verificou influxo de CH_4 na maior parte das avaliações. Estes resultados indicam que a implantação de florestas com *A. mearnsii* na região do Pampa Gaúcho possui potencial para mitigar a emissão de CH_4 e N_2O, além de aumentar o sequestro de C atmosférico em áreas de campo nativo. Mas é necessário a realização de mais estudos, pois este trabalho foi realizado em um ano atípico (com baixa precipitação pluviométrica). Assim, torna-se imprescindível avaliações em anos de precipitação normal ou com maior precipitação para se ter uma melhor compreensão da dinâmica dos fluxos destes gases.

2 HIPÓTESES

A utilização de espécie arbórea leguminosa para compor sistemas silvipastoris eleva os teores de N mineral no solo. Assim, estas árvores potencializam a ocorrência dos processos de nitrificação e desnitrificação, com consequente aumento da emissão de N_2O para a atmosfera. Além disso, por elevar o teor de NH_4^+ no solo, a presença de plantas de *Parapiptadenia rigida* (Benth.) Brenan (Angico-vermelho) poderá diminuir a oxidação (influxo) do CH_4 devido à competição do NH_4^+ com o CH_4 pela enzima mono-oxigenase.

O uso de *P. rigida* associado à adubação mineral em sistemas silvipastoris eleva as emissões de N_2O e CH_4 do solo. Este aumento é proporcional ao aumento na densidade de árvores utilizadas na área.

3 OBJETIVOS

Este estudo teve como objetivo principal quantificar os fluxos de CH_4 e N_2O do solo e identificar quais fatores de solo que mais interferem nos fluxos destes gases, em plantios da espécie arbórea leguminosa nativa *Parapiptadenia rigida* (Benth.) Brenan (Angico-vermelho) em consórcio com campo nativo do bioma Pampa. Objetivou-se ainda avaliar a contribuição da adubação mineral neste sistema em período inicial de desenvolvimento, em dois espaçamentos de plantio (campo nativo + *P. rigida* com arranjo espacial de 2 x 4 m e campo nativo + *P. rigida* com arranjo espacial de linhas duplas de 6 x (2 x 2) m e em campo nativo puro (sem a introdução de angico), nas emissões de GEE.

Manuscript

Nitrous oxide and methane fluxes in silvopastoral systems with *Parapiptadenia rigida* (Benth.) Brenan in native grassland

Abstract: Silvopastoral systems (SSPs) can mitigate global warming through atmospheric CO_2 sequestration, mainly in plant biomass. However, few is known about their effect on nitrous oxide (N_2O) and methane (CH_4) fluxes in the soil. This study aimed to evaluate N_2O and CH_4 fluxes in a soil with native grassland system afforested with native species of the leguminous tree *Parapiptadenia rigida* in the Brazilian Pampa. The experiment was carried out in an Acrisol previously used with native grassland in São Gabriel, RS, Brazil, forested in October 2012. The experiment had a randomized block design, with split plots. Treatments in the main plots were: T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. The split plots (18 x 30 m) constituted the presence or absence of annual mineral fertilizer (NPK) for the native forages. Soil greenhouse gases were taken for one year (2014) through static chambers, with six replicates. Concentrations of N_2O and CH_4 were determined by gas chromatography**,** concomitantly to the monitoring of soil (0-5 cm) and climate variables. The results were submitted to analysis of variance and Tukey test to compare means (P<0.10). Daily flux rates of CH_4 and N_2O remained low during the evaluated period, ranging from -18.3 to 23.1 µg N_2O–N m^{-2} h^{-1} and from -40 to 105 µg CH_4–C m^{-2} h^{-1}. Mineral fertilization increased the cumulated emission (P < 0.10) only for N_2O. Two peaks of N_2O emission were observed concomitantly to the increase of mineral nitrogen concentration (NO_3^- and NH_4^+) in soil due to mineral fertilization. The largest emissions rates of CH_4, in turn, coincided with raises in soil moisture and temperature. Thus, the introduction of *P. rigida* trees in natural grassland did not altered significantly the soil fluxes of CH_4 and N_2O, independently of their arrangement, after two years from the tree plantation.

Keywords: N_2O, CH_4, mineral fertilization, cumulated emissions.

1 INTRODUCTION

The adoption of silvipastoral systems (SPSs) is seen as an effective strategy to promote the sustainable use of natural resources (Macedo, 2000). These systems are characterized by the cultivation of consorting trees, natural pasture or planted and breeding in the same area (Macedo et al., 2010; Ribaski et al., 2005; Daniel et al., 1999). The SPSs have the capacity to diversify production, promoting better use of the area and greater financial stability. In addition, the SPSs have the potential to mitigate the effects of global warming by C sequestration in biomass of trees that make up this system (Denardin et al, 2014; Hergoualc'h et al., 2012; Müller et al., 2009; Macedo et al., 2008).

In Brazil, according to the MCTI (2013), the agricultural sector contributed with 35% of the total emissions of greenhouse gases (GHG) into the atmosphere in 2010. Within this sector, the main gases emitted are nitrous oxide (N_2O) and methane (CH_4). The factors that contributed most to these emissions were: the use of land for agricultural practices, with 95% of emissions of N_2O and enteric fermentation of cattle, with 90% of the emission of methane CH_4 to the atmosphere.

Due to growing concern worldwide in reducing GHG emissions, Brazil has created strategies to contribute to the mitigation of this problem. The *Plano ABC* (“plan for agriculture of low carbon”) is part of the political actions aiming to achieve the mitigation. The plan was instituted in 2012 and one of its goals is to increase the use of integrated systems with crops, livestock and forest on 4 million hectares (Brazil, 2012). In addition, this plan aims to double the area of planted forests by 2020, rising from 5.5 million hectares to 11 million hectares (PNMC, 2008).

According to MAPA (2013), the total pasture area in Brazil is approximately 172 million hectares, of which 70% of this area is currently in a state of degradation. Consequently, one of the ways to make these areas productive again would be through the practice of reforestation for deployment of SPSs, increasing the annual input of residues to the soil and the organic matter and the C sequestration in the plant biomass (Carvalho et al., 2010). If the species used to compose the SPS is a legume, N stock in the soil also tends to increase due to the biological N fixation. However, despite the advantages of this fixation for soil recovery, these plants may raise the levels of mineral N as ammonium (NH_4^+) and nitrate (NO_3^-) in the soil, as a result of the mineralization of N-rich residues deposited by plants at the soil surface (Rochette & Janzen, 2005; Verchot et al., 2008). Higher contents of NH_4^+ and NO_3^- in soil favors the occurrence of nitrification and denitrification processes, which in turn can increase the emission of N_2O from the soil (Inagaki & Ishizuka, 2011; Konda et al., 2010; Gomes et al., 2009). In addition, higher levels of N-mineral in the soil can enhance the competition between the ions NH_4^+ and CH_4 by monooxygenase enzyme, rising methane emissions (Acton & Baggs, 2011; Majumdar & Mitra, 2004). Therefore, in order to assess the real effect of SPSs on the global warming potential, studies with CH_4 and N_2O are required. However, these studies are still very scarce, mainly when leguminous trees are used in SPSs on native pastures of the Pampa biome.

In addition to the N input, legume tree-based SPSs on native grasslands can modify other factors that are linked to the N_2O and CH_4 in the soil. The presence of trees can affect soil temperature and soil humidity (Konda et al., 2010. The water loss due to evapotranspiration usually increases with the raise of the leaf area index, promoting larger values of water-filled pore space in the soil and, therefore, increasing the anaerobic sites in the soil matrix. The biological activity can also be enhanced by the trees, due to the respiration of tree roots and soil microorganisms, as more labile C are expected from root exudation and litter decomposition (Pavinato & Rosolem, 2008).

The mineral fertilization of grassland forages is usually recommended to increase the supply of food for the cattle. However, if the amount of fertilizer exceed the nutritional demand of species, large increases in the soil contents of mineral N can occur, favoring the N_2O fluxes to the atmosphere, as quoted previously. In agricultural areas the elevation of the levels of N-mineral in soil is very sensitive to nitrogen fertilization (Rambo et al., 2007). The availability of NO_3^- and NH_4^+ in the soil occurs shortly after fertilization and can result in N_2O emission peaks (Zanatta et al., 2010). Piva et al. (2014) also found high levels of mineral N in soil after application of urea in grazing areas of cultivated forage. However, these authors mention that on these sites there is a rapid absorption of N by plants stimulated by the grazing of animals. Yet, in areas of planted pasture, fertilization may have greater efficiency of utilization than in agricultural areas (Neill et al., 1997). In this case, mineral N fertilization might not raise significantly the soil mineral N content, reflecting in lowering GHG emissions to the atmosphere. In a SPS system with native grassland, the high absorption capacity of forage plants can also hinder large contents of mineral N in the soil, inclusively in a more efficient way than in agricultural areas and planted pastures, but few studies have evaluated these processes up to now. Therefore, to understand the behavior of the SPSs with native species of the Pampa biome in relation to emissions of CH_4 and N_2O is of paramount importance, in view of the great international concern in finding mitigating GHG emissions strategies.

In this context, the study aimed to evaluate the fluxes of CH_4 and N_2O from soil in the field area of native grassland at the Pampa biome with introduction of the native legume tree species *Parapiptadenia rigida* (Benth.) Brenan (Angico-vermelho) and identify the factors of soil that more interfere in these fluxes. In addition, we aimed to assess the contribution of mineral fertilization on GHG fluxes in this system, in order to find an emission factor for areas of native grassland in a consortium with leguminous trees, since the data is based on studies carried out in other conditions of climate and soil that may not represent the reality of our region with natural pastures under subtropical climate.

2 MATERIAL AND METHODS

2.1 Characterization of the region

The study was based on an experiment established at the Experimental Station of Agricultural Research Foundation (FEPAGRO), in São Gabriel, Rio Grande do Sul State, southern Brazil (30°20'59"S and 54°15'82"W). The region belongs to the Brazilian Pampa biome (Roesch et al., 2009). Local climate is subtropical with hot summers and cold winters, classified as Cfa according to Köeppen classification system. The average annual temperature is 19°C, with maximum of 40°C in summer and minimum of -3°C in winter and with average annual rainfall of 1400 mm. The site features a soft and homogeneous slope, with an average altitude of 137 m. The soil is classified as Umbric-Rhodic Acrisol according to FAO classification or Argissolo Vermelho Distrófico latossólico to the Brazilian system of soil classification.

2.2 Experiment

The study consisted in the implementation of a silvopastoral system (SPS) on a native grassland representative of the Pampa biome, in which the tree component was based on the native leguminous species *Parapiptadenia rigida* (Benth.) Brenan (red Angico). *P. rigida* seedlings were obtained from seeds of selected tree reproducers in the central region of the Rio Grande do Sul State. Seedlings were planted in the field in September 2012.

The experimental design for the SPS was the split-plot randomized blocks with three field replications. In the main plots, measuring 36 m wide and 30 m long, tree plantation was performed as following: T1 - native grassland without tree plantation (reference); T2 - *P. rigida* trees planted in 2x4 m spacing; T3 - *P. rigida* trees planted in double rows of 2x2 m separated by 6m of native pasture alley. The subplots (15x36m) consisted of the presence or absence of annual mineral fertilization of native forages.

Land preparation for planting of *P. rigida* was based on minimum tillage system. The soil was mechanically tilled, only in the tree rows, with a subsoiling at 0-40 cm depth with a ripper composed of three stems spaced by 40 cm between each stem.

The planting of seedlings was carried out manually in pits of 30x30x30 cm. immediately before planting, the initial fertilization of seedlings was applied to the pit soil and was homogenized. Mineral fertilizer was applied at a rate of 25 g N, 84 g P_2O_5 and 87 g K_2O per pit, based on the official recommendation (Comissão, 2004), adapted from the nutrient requirements of the *Mimosa scabrella* due to the absence of specific recommendation for the *P. rigida.* Where necessary, re-planting of seedlings was performed after two and four months of the planting event.

Until the end of the evaluation period of this study, in December 2014, annual fertilization of forages in the fertilized subplots was performed in three occasions: 17/01/2013, 16/01/2014 and 15/11/2014. In each event, mineral fertilization was applied at the same rate: 100 kg ha^{-1} of N, 40 kg ha^{-1} P_2O_5 and 70 kg ha^{-1} of K_2O as urea, triple superphosphate and potassium chloride, respectively. Fertilization rate was established according to Comissão (2004).

The size of *P. rigida* plants did not provide enough height and diameter for allowing the presence of animals grazing in the plots up to the end period of the study, in December 2014. Thus, throughout the period of the experiment, weeds were controlled by hoeing circularly to the seedlings when necessary, to avoid the effect of competition and stuffiness by native grass. Forage shoot height was sporadically controlled by mechanized mower.

2.3 Installation of lysimeters and soil sampling

In September 2013, one year after planting of the *P. rigida*, trenches of 1.5x1.5x1.0 m were opened for the installation of lysimeters of free drainage (zero tension). The trenches were placed exactly in the middle of the main plot, in such a way that each sub-plot (with and without forage fertilization) had half of the trench. The lysimeters were built up and installed according to Basso (2005), with some adjustments. Each lysimeter was composed by a tray made of polyvinyl chloride (PVC) plates, on the dimensions of 60 cm long by 40 cm wide. They were positioned on the sides of the trenches, 40 cm below the soil surface, being allocated four trays for trench, two in the sub-plot with presence of fertilization and two in the subplot without fertilization. For placing the trays, galleries were excavated in the lateral of the trenches, so that the soil above each lysimeter had its structure unchanged. The trays were filled with a layer of pre-washed coarse gravel, followed by a layer of fine gravel and covered with synthetic fibre filter, who came in contact with the ground. Below each lysimeter, a vessel made of plastic of five dm^3 capacity was positioned for storing the leachate solution.

Soil sampling for chemical and physical analyses was performed in the lateral of the trenches at the depths of 0-5, 5-10, 10-20, 20-40, 40-60, 60-80 and 80-100 cm.

Immediately after the lysimeters installation and soil sampling, the trench was filled up with soil according to the same sequence of original horizons of the soil profile. The vessel of soil solution was connected to the surface by a pipe, closed in its upper part by a cap. The area above each lysimeter and its neighborhood were kept isolated from compaction by soil deposition or transit of people during the lysimeter installation and soil sampling tasks.

2.4 Analysis of soil chemical and physical attributes

Soil samples were submitted to analysis of texture (pipette method), soil bulk density (volumetric ring method), and the total porosity, macro porosity, micro porosity (method of tension table) according to Embrapa (1997). Samples for chemical analysis were air dried at room temperature, ground in hammer mill and sieved (sieve of 2 mm). Total organic carbon (TOC) contents were determined by colorimetry after oxidation with potassium dichromate (Nelson & Sommers, 1996). Labile organic C was separated by physical granulometric fractionation method (particulate organic C, POC) following the methodology described by Vieira et al. (2007), ground with ceramic mortar and its content of C was analyzed similarly to the TOC above cited. Labile C was determined only up to 40 cm depth, in the same layers used for analysis of the other attributes. The total nitrogen content (TN) of the soil was determined by wet digestion, followed by distillation in semi-micro Kjeldahl distiller drag, according to the methodology described by Tedesco et al. (1995). Stocks of TOC, TN and POC were calculated using the soil bulk density.

The levels of clay, silt, sand, bulk density, total porosity, macro and micro porosity of the soil are shown in table 1.

Tab. 1 Soil physical attributes of texture, bulk density and porosity in the beginning of the period of study. São Gabriel, RS, Brazil, October, 2013

Depth (cm)	Soil Texture			Bd	Soil Porosity		
	Clay	Silt	Sand		Total	Macro	Micro
	--------- g kg^{-1} --------			Mg m^{-3}	------- m^3 m^{-3} --------		
0-5	198	455	347	1.26	0.50	0.11	0.39
5-10	216	456	328	1.45	0.45	0.08	0.37
10-20	235	449	316	1.44	0.45	0.09	0.36
20-40	304	423	273	1.43	0.45	0.08	0.37
40-60	438	355	207	1.39	_	_	_
60-80	430	373	197	1.42	_	_	_
80-100	378	417	205	1.48	_	_	_

Bd = bulk density

2.5 Fluxes of N_2O and CH_4

Air samplings for analysis of N_2O and CH_4 fluxes in the soil were taken through the method of static cameras, with six repetitions (Costa et al., 2006). During the period of one year, of Dez/2013 to Dez/2014 samples were obtained every fifteen days or immediately after fertilization events. Chambers were made of PVC, with 25 cm diameter by 25 cm high. Each chamber was equipped inside with a fan to perform homogenization of air and a digital thermometer, and contained in its upper part a three way valve. Two chambers were allocated per sub-plot, in the vicinity of where the lysimeters were installed. In the treatments containing tree seedlings, one chamber was settled on the tilled row while the other was placed in the untilled inter-row.

The chambers were positioned on bases made of galvanized steel with an inner ring inserted in the soil 5 cm deep. At the top of each base, a channel filled with water prevented the exchange of gases between the interior and the exterior of the chamber. The bases remained on the ground throughout the period of the experiment. Each air sampling event began at nine o'clock in the morning and air samples were taken at the times 0, 20 and 40 minutes after the chamber closure. For the sampling of air, 20 mL polypropylene syringes and three-way valves were utilized, attached at the top of the chamber. Air samples were stored in vials of 12 mL Exetainer® (Labco Ltd, High Wycombe, United Kingdom).

The quantification of N_2O and CH_4 was performed by gas chromatography with Shimadzu GC 2014 Model "Greenhouse".

The streams of CH_4 and N_2O emissions were estimated based on the following equation:

$$f = \frac{\Delta Q}{\Delta t} \frac{PV}{RT} \frac{1}{A}$$

Where f is the flux of gases (µg m^{-2} h^{-1} CH_4 or N_2O), Q is the quantity of each gas in the Chamber (µg CH_4 or N_2O), P is the atmospheric pressure in the Chamber (1 atm), V is the volume of the Chamber (L), t is the time (h), R is the ideal gas constant (0.08205 atm. L mol^{-1} K^{-1}), T is the internal temperature of the chamber at the instant of sampling (°K) and A is the area of the Chamber (m^2).

The rate of increase in the concentration of the gases inside the Chamber was estimated using the angular coefficient obtained from the relationship between the concentration of the gas and the time after the lock Chamber. Daily emissions of CH_4 and N_2O, expressed in μg CH_4 –C m^{-2} h^{-1} and μg N_2O–N m^{-2} h^{-1}, were calculated from the variation of the concentrations of methane and nitrous oxide. The cumulated emission in the period was calculated by integrating the daily emissions (Zanatta et al., 2010; Gomes et al., 2009).

Simultaneously to each air sampling, soil samples were taken from 0-10 cm depth, in six replicates, through a soil auger, for the analyses of NH_4^+ and NO_3^-, gravimetric moisture and determination of water filled porous space (WFPS). The levels of NH_4^+ and NO_3^- in soil and gravimetric moisture were analyzed using semi-micro Kjeldahl distillation and drying at 105ºC until constant weight, respectively (Tedesco et al., 1995). The WFPS was estimated using the gravimetric moisture values and total soil porosity.

In addition, the air temperature monitoring inside the chambers and soil around the same (0.05 m), with thermometers. Data of rainfall occurring in the study area were monitored through gauges installed at the same location.

2.6 Statistical analysis

The relationships among gas flux rates and climate and soil variables were evaluated by Pearson's correlation (P < 0.10). The significance of the effect of the treatments was assessed using analysis of variance considering the randomized blocks design with split plots, through software SAS and the comparison between the averages by Tukey test were carried out at the level of 10%.

3 RESULTS AND DISCUSSION

3.1 Soil N_2O fluxes

Daily fluxes of N_2O have remained relatively low during most of the evaluated period. Neither the mineral fertilization nor the insertion of *P. rigida* promoted significant differences on N_2O flux rates, but a few isolated peaks of emission before long after fertilization can be observed (Fig. 1a, b).

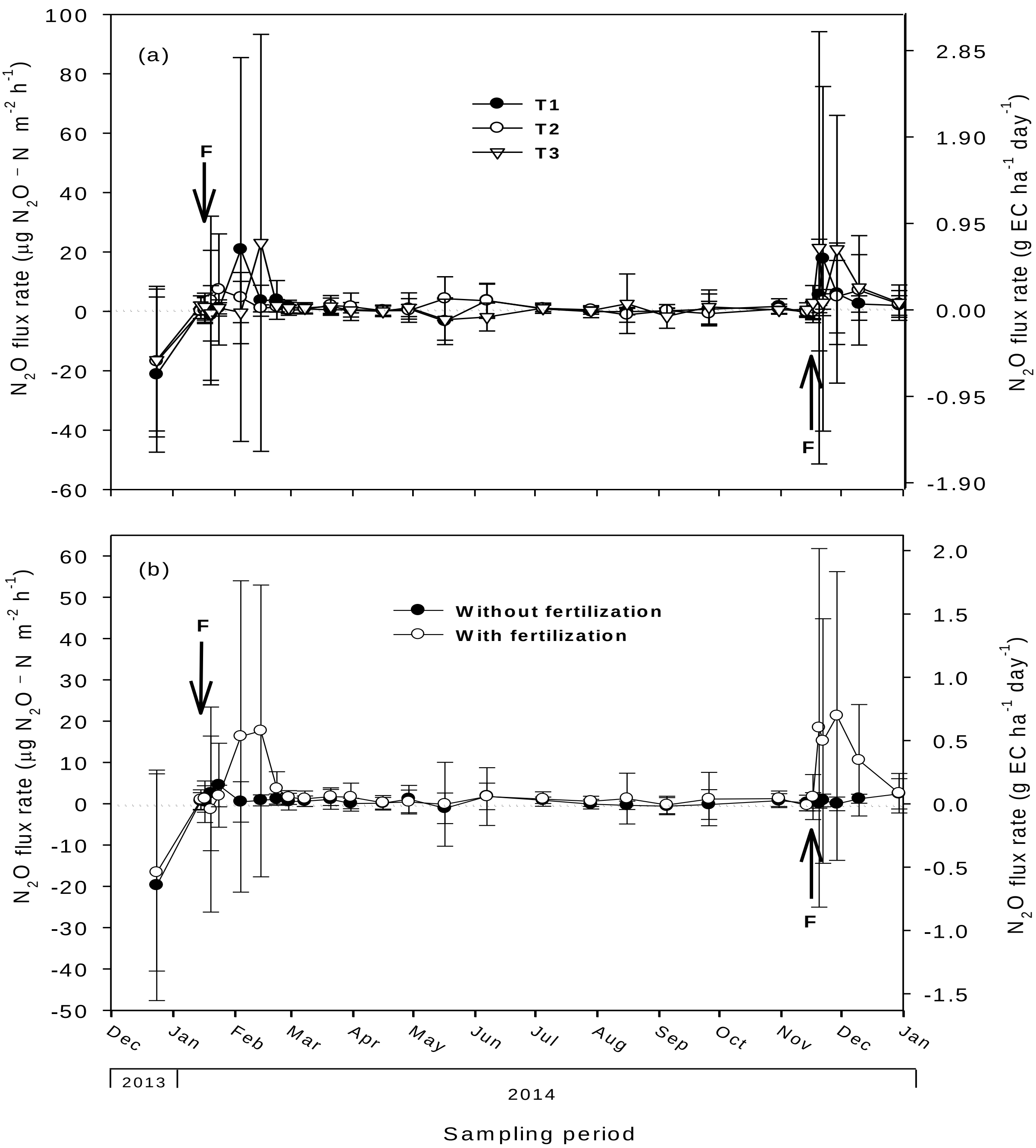

Fig.1 Flux rates of N_2O in an Acrisol under silvopastoral systems over one year period. São Gabriel, RS, Brazil, 2015. (a) effect of mineral fertilization of the forage; (b) effect of the plantation of *Parapiptadenia rigida* in two spatial distributions. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. F: mineral fertilization event. Vertical bars indicate standard deviation of the average.

Between March and November, most of the observed rates ranged between -5 and +5 µg N_2O–N m^{-2} h^{-1}, being that the negative flux indicates the gas absorption by soil. Peak of emission of N_2O occurred 20 days after the first application of fertilizers, which increased the daily emission rate of 0.45 to 16.3 µg N_2O–N m^{-2} h^{-1}, remaining elevated until 35 days after fertilization. In the second fertilizer application event the emission peak occurred 5 days after the application of fertilizer, increasing the daily emission rate from 0.07 to 18.37 µg N_2O–N m^{-2} h^{-1}, remaining elevated until 35 days after fertilization.

The introduction of legume species could increase N_2O emissions from soil, the elevation of the levels of mineral N (NO_3^- and NH_4^+) in the soil, provided by waste disposal of trees, rich in N (Rochette & Janzen, 2005; Verchot et al., 2008). However, there was an increase of the levels of mineral N in only a few sampling events (Fig. 2a, c), probably because the plants were still in early stages of development (less than 2 m in height), generating little litter deposition.

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Treatment T3 (planting spacing 6 x (2 x 2) m) presented tree emission peaks in late November of 21.41 e 20.92 µg N_2O–N m^{-2} h^{-1}, shortly after a 48 mm precipitation (Fig. 3a), at four and nine days after fertilization, respectively. This increased soil moisture following the fertilization elevated the soil contents of NH_4^+ and NO_3^- (Fig. 2a, c), and this may have contributed to increase nitrification and denitrification mainly in anaerobic soil microsites.

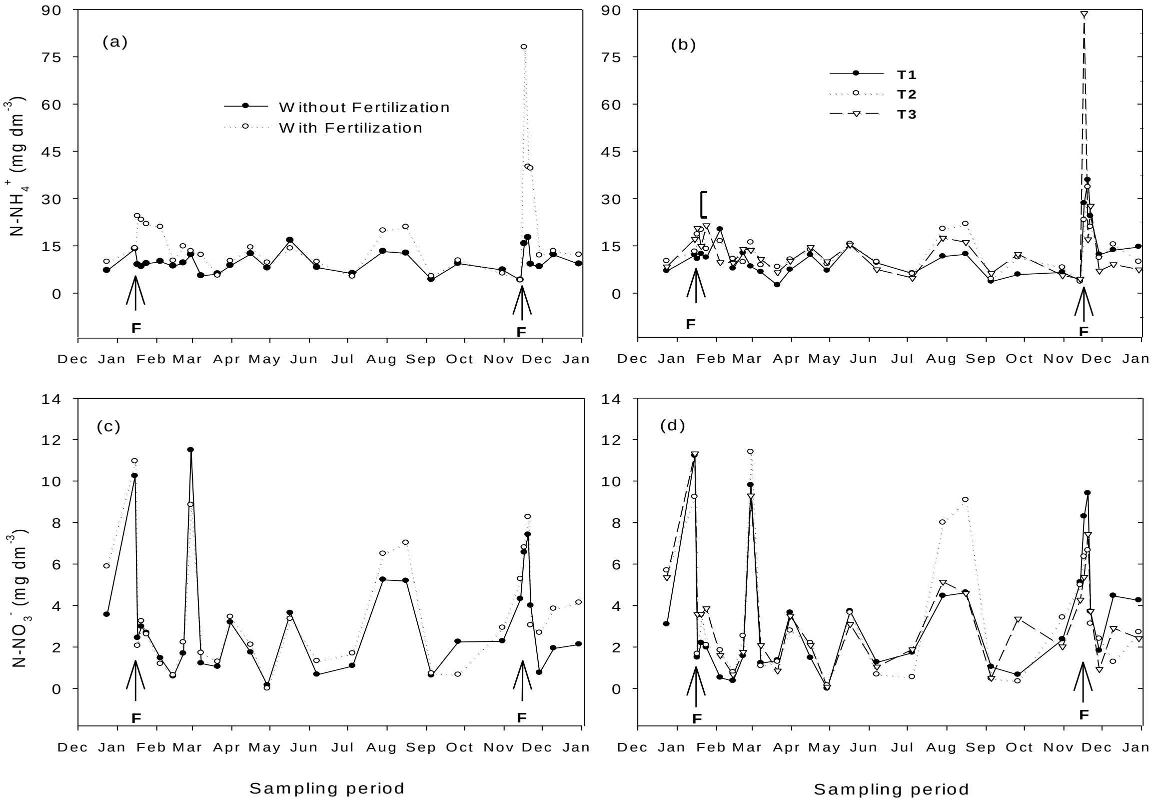

Fig. 2 Content of NH_4^+-N (a, b) and NO_3^--N (c, d) in the soil at 0-10 cm depth over one year. (a) and (c) refers to the effect of mineral fertilization of the forage, while (b) and (d) refers to the effect of the plantation of *Parapiptadenia rigida* in two spatial distributions in the period of one year. São Gabriel, RS, Brazil 2015. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. Vertical bars indicate the minimum significant difference (MSD) by Tukey test (*P* <0.10) between the treatments, within the respective date of sampling. F: mineral fertilization event.

Treatment T1 (native grassland) also had isolated peak of emission of N_2O 20.83 µg N_2O–N m^{-2} h^{-1} in the month of February (Fig. 1b). This emission peak occurred between 15 days after application of N fertilizers in treatment T1. This result is similar to those found by Piva et al. (2014) and Zanatta et al. (2010), which also found peaks of emission of N_2O, soon after application of nitrogen fertilizer.

Native non-degraded grasslands usually present a high quality of soil structure, promoted mainly by the renewal of the dense root system of grass species which cover the surface of this environment (Vezzani & Mielniczuk, 2011; Bayer et al., 2004). This plant-soil system has a rapid and more close cycling of nutrients in comparison to agriculture and planted forage systems. In our study, the mineral fertilization stimulated the development of shoot pasture plants, causing a rapid absorption of nutrients and maintaining low NO_3^- contents in soil in the surface layer (Fig. 2 c, d). This evidence was likely crucial to prevent the raise in N_2O emission rates, as lower incidence of denitrification process is expected (Fig. 1a, b). A similar result was found for Godoi (2012) in native grassland area of the Pampa biome, where low emission of N_2O to the atmosphere was reported when the N-mineral content was low (<10 mg NO_3^-–N dm^{-3} of soil).

It is noteworthy that a rainfall of 1576 mm was recorded in the study site in the period from early March to late October, which was well above the expected average for these months in the region, which is approximately 900 mm (ANA, 2014). This high rainfall kept the WFPS above the value of 60% (Fig. 3b). In such conditions of high soil humidity for an extended period, larger fluxes of N_2O from the soil would be expected (Khalil et al., 2002; Khalil & Baggs, 2005). However, N_2O flux remained low, near to 0 μg N_2O–N m^{-2} h^{-1} in all treatments (Fig. 1b). This fact may have been favored by good soil structure, by the high C/N ratio of the litter and high N uptake by plants that are distinctive this environment. The high rainfall may also favored an increase in the leaching, enhancing loss of DOC and NO_3 (Fig. 4g,i). However, NO_3^- contents in the soil solution from the lysimeters were low (<7 mg NO_3^- –N dm^{-3}). Besides, high levels of WFPS (> 80%) can also encourage the complete process of denitrification with a very small N_2O/N_2 ratio.

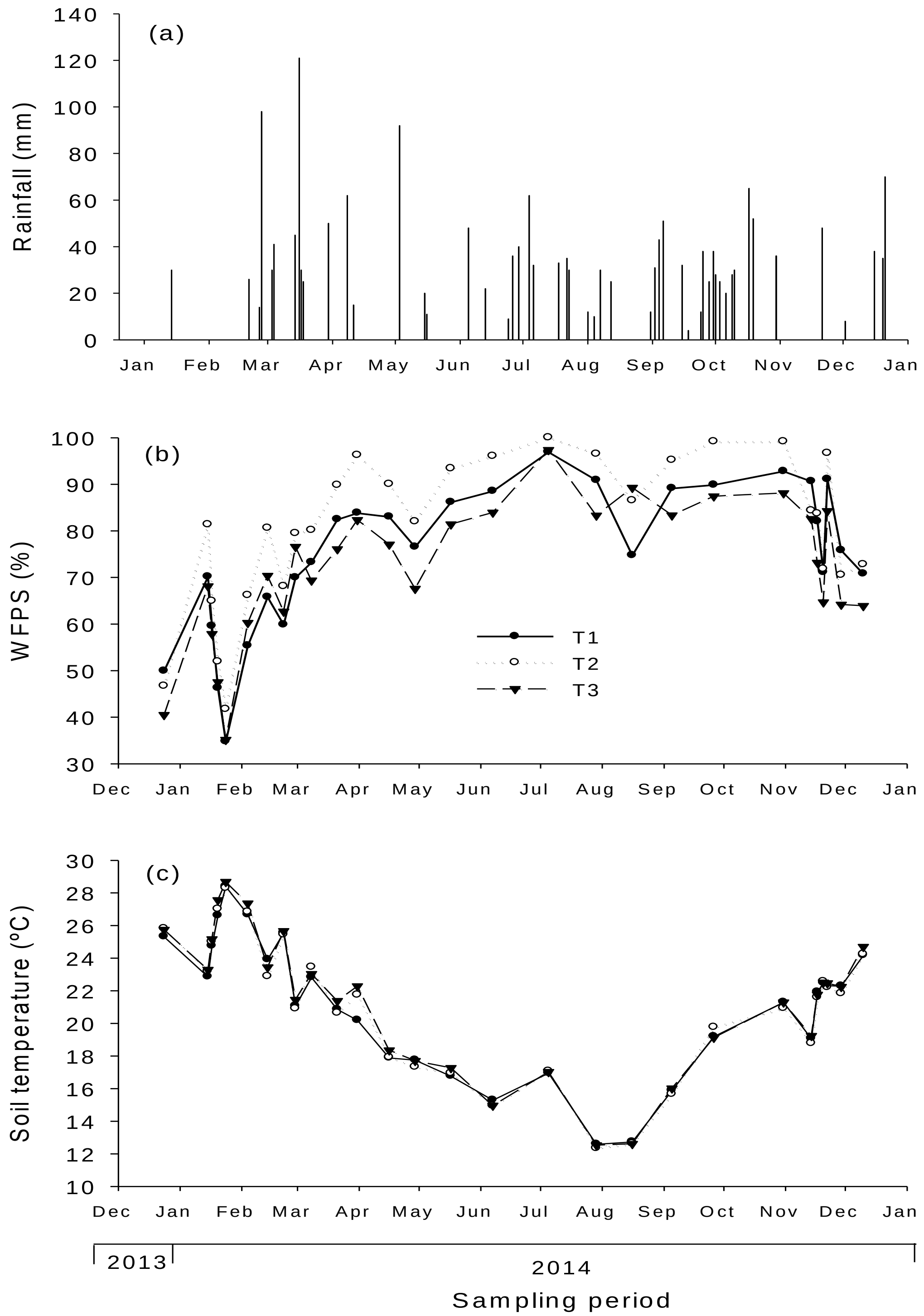

Fig. 3 Rainfall (a), water-filled pore spaces (WFPS) (b) and soil temperature (c) at 0-5 cm depth. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. São Gabriel, RS, Brazil 2015.

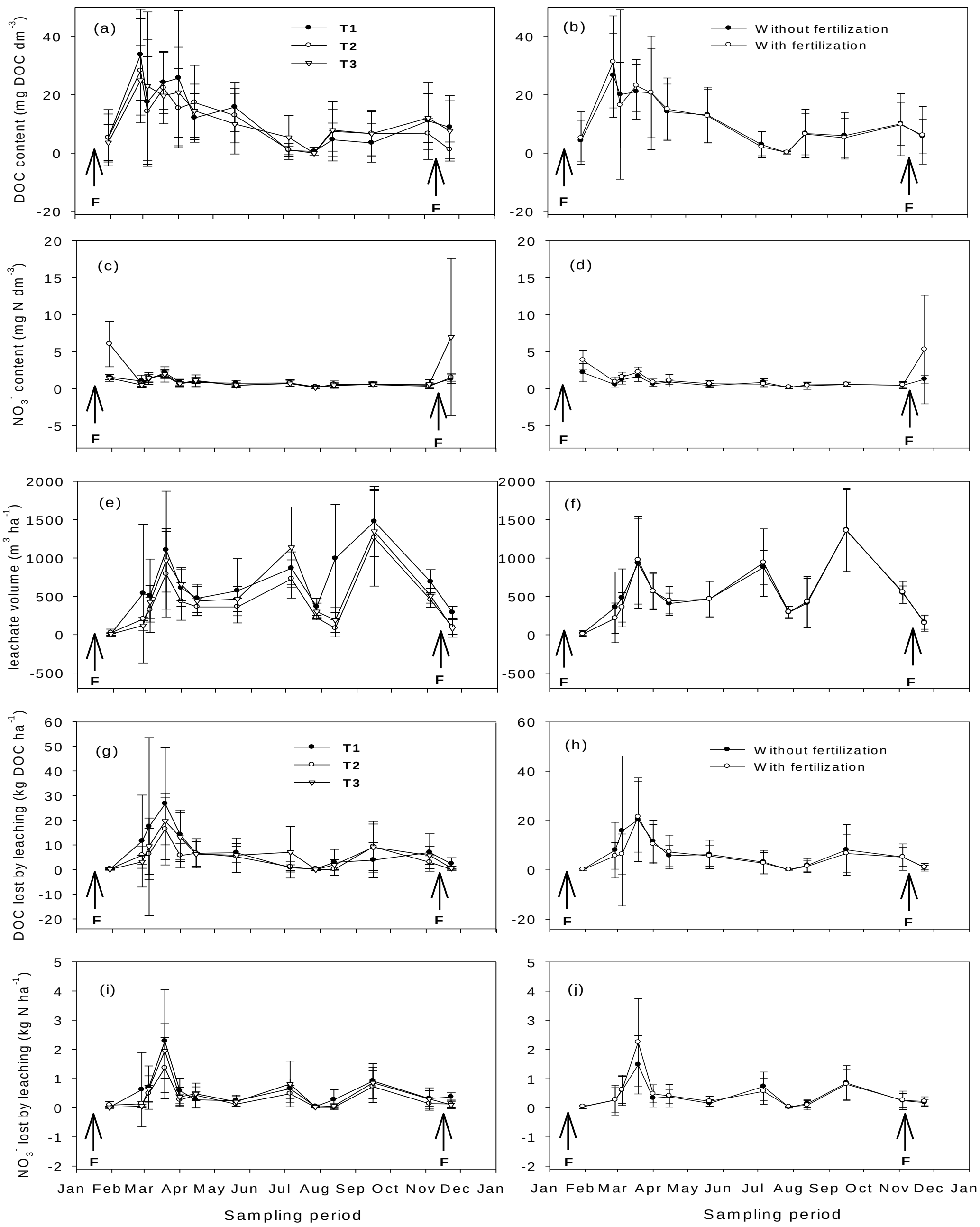

Fig. 4 Content of dissolved organic carbon (DOC; a and b) and mineral N (c and d) in soil solution from the lysimeters; leachate volume (e and f); losses of DOC (g and h) and mineral N (I and j) by leaching in an Acrisol over one year period. F: mineral fertilization event. São Gabriel, RS, Brazil, 2015.

It has been found that the evaluated soil has the capacity to consume N_2O when the soil is WFPS low (<50%). Possible contributing factors to this occurrence were the low values of N-mineral in soil, COD and soil solution NO_3^- (Fig. 3a, 3c, 4a, 4c) when soil was drier (Zhu, 2005). This can be observed at the beginning of the evaluations, where there was an influx of N_2O, in all treatments, with values of -

21.28, -16.91 and -16.39 μg N_2O–N m^{-2} h^{-1}, for the treatments T1, T2 and T3, respectively (Fig. 1b).

The N_2O fluxes were positively correlated with NH_4^+, NO_3^- and WFPS ($P < 0.10$; Table 2). However, the closest relation was found for NH_4^+, suggesting that the nitrification process may have been the main driving factor responsible for the emission of this gas (Konda et al., 2010), although the emission was low, as above discussed. These results are in agreement with those obtained by Werner et al. (2006). The authors found out close relation between N_2O fluxes and soil humidity in a tropical seasonal rainforest, but they also concluded that substrate availability ultimately controlled the N_2O emissions.

Table 2 Pearson correlation among N_2O and CH_4 soil fluxes and variable NH_4^+, NO_3^-, soil temperature and WFPS in an Acrisol under silvopastoral systems over one year period. São Gabriel, RS, Brazil, 2015.

Flux of gases		NH_4^+	NO_3^-	WFPS[1]	Soil temperature
N_2O	R	0.342	0.0583	0.0567	0.0241
	P	4.63×10^{-30}	0.0597	0.0669	0.437
CH_4	R	0.00972	-0.00783	0.278	-0.108
	P	0.754	0.800	5.63×10^{-20}	0.000492

[1] = water-filled pore spaces

3.2 Soil CH_4 fluxes

The daily fluxes of methane were low in the whole period, ranging from - 40 μg CH_4–C m^{-2} h^{-1} to 104 μg CH_4–C m^{-2} h^{-1} (Fig. 5b).

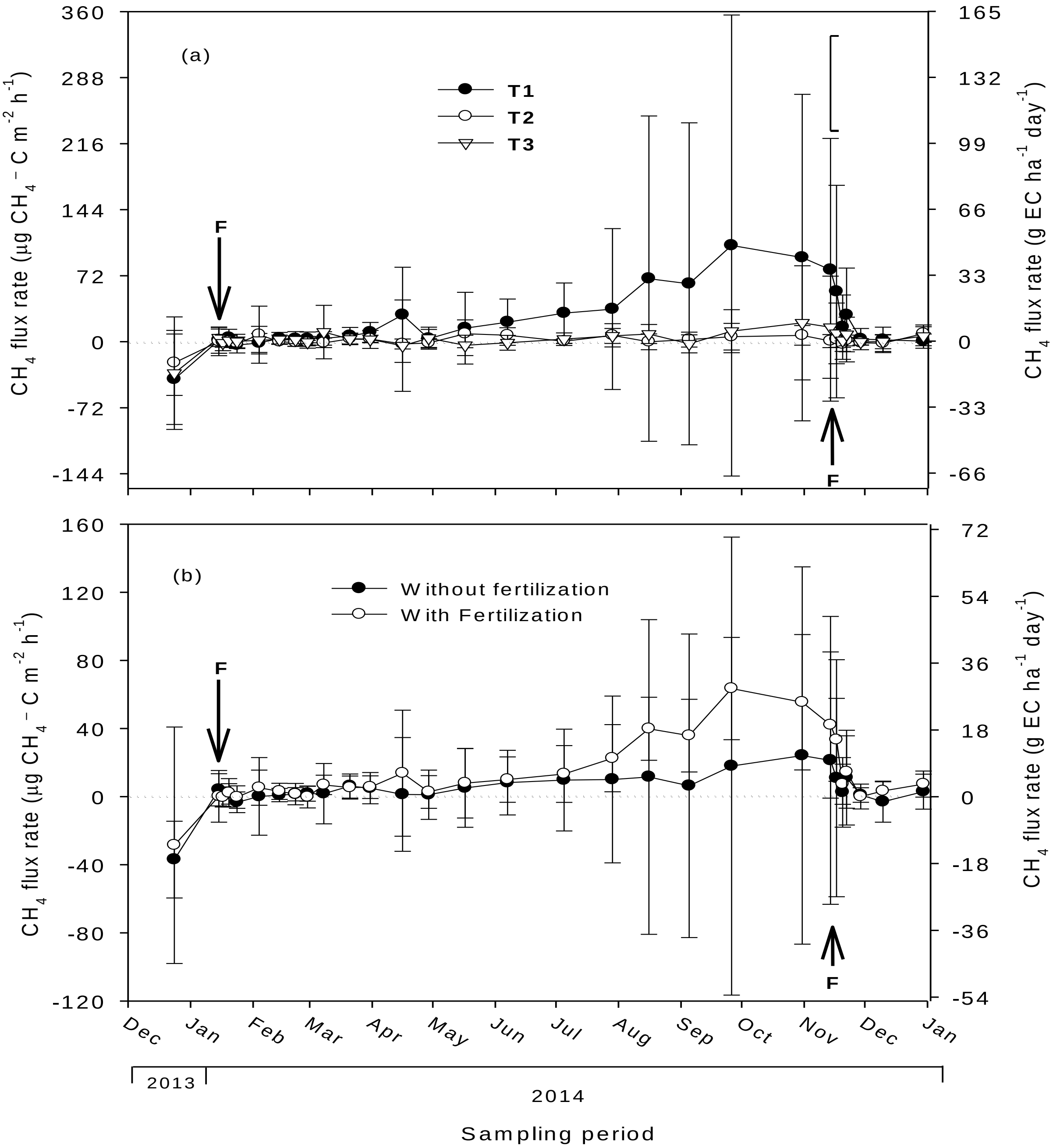

Fig. 5 Flux rates of CH_4 in an Acrisol under silvopastoral systems over one year period. São Gabriel, RS, Brazil 2015. (a) effect of mineral fertilization of the forage; (b) effect of the plantation of *Parapiptadenia rigida* in two spatial distributions. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. F: mineral fertilization event. Vertical bar indicate the minimum difference significantly the soil fluxe of CH_4 by Tukey test ($P < 0.10$) between the treatments, within the respective date of collect.

Similar CH_4 fluxes were found by Piva et al. (2014) analyzing crop-livestock integration systems in southern Brazil. These authors verified methane fluxes between -50 µg CH_4–C m^{-2} h^{-1} and 140 µg CH_4-C m^{-2} h^{-1}.

The soil under conditions of anaerobiosis impairs the methanogenic bacteria, promoting net CH_4 emission (Hüstch, 1998). Thus, among the factors of soil, the WFPS is critical to the role of the soil acting as source or sink of CH_4 to the atmosphere (Liu et al., 2006; Piva et al., 2014; Tate et al., 2007). Soil humidity conditions coupled with the elevation of soil temperature favor the biological activity of microorganisms, which in other words implies a largest consumption of O_2 in the soil and, concomitantly, an increase in anaerobic conditions. There is degradation of organic compounds that serve as a substrate for methanogenic bacteria to emit CH_4. Thus, CH_4 emission is expected to be proportional to the labile C availability in the soil. In our study, even with the high soil moisture and temperature in most of the evaluations (Fig. 3b, c), T2 and T3 treatments presented low CH_4 fluxes, with average value of 0.95 and 2.54 µg CH_4–C m^{-2} h^{-1}, respectively (Fig. 5a). This low emission of CH_4 may be linked to the contents of dissolved organic carbon (DOC) in soil solution, which remained relatively low during the period of evaluations (Fig. 4a) since, to degrade organic compounds the microorganisms need low C/N ratio. High quality of soil structure under native grassland may have contributed to prevent even more anaerobic conditions in the soil. The large amount of macropores (Tab. 1) and their continuity along the soil profile (not evaluated) improved soil aeration in such a way that the critical threshold of 60-70% of WFPS for more methane emissions (Konda et al., 2010; Khalil & Baggs, 2005) seems to be not valid for the natural field under study. However, CH_4 flux rates were closely related with WFPS (Table 2), suggesting that soil moisture was the main driving factor for soil CH_4 fluxes.

Treatment T1 (native grassland) from June to November presented higher CH_4 fluxes than the other treatments. This result was markedly affected by a difference in the slope position of the blocks in the field. Block III was settled in a lower position than blocks II and I. Specifically on the fertilized sub-plot of T1 in Block III, water table was observed on the soil surface in several occasions, promoting greater emissions of CH_4, raising the average of this treatment. If this outlier replicate is neglected, the mean CH_4 flux rate of T1 decreases from 29.35 µg CH_4–C m^{-2} h^{-1} to 12.7 µg CH_4–C m^{-2} h^{-1}.

In a recent study regarding the fluxes of CH_4 in soil with native grassland at the Brazilian Pampa, in a year of below average rainfall, Godoi (2012) found consumption of CH_4 for most days evaluated. In the present study, when the soil had low humidity (WFPS <50%; Fig. 3b), along with low levels of DOC and N-mineral in soil solution (Fig. 4a, c), there was an influx of methane -40.9, -23.0, and -34.3 μg CH_4–C m^{-2} h^{-1}, for the treatments T1, T2 and T3 respectively. These results clearly indicate that the soil has the potential for CH_4 oxidation and that, in drier conditions, oxidizers will probably surpass the activity of methanogenic bacteria. The absence of tillage and of heavy inputs of mineral N fertilizers preserves the soil capacity for CH_4 oxidation (Bayer et al., 2012). However, it is necessary to evaluate the behavior of CH_4 emissions in years with normal rainfall, low or above average, since the moisture interferes decisively in the variables that contribute to the fluxes of CH_4.

3.3 Effect of fertilization in N_2O and CH_4 fluxes from soil

Emission rates of N_2O in the soil from fertilized subplots were slightly higher than from non-fertilized ones in periods following the input of fertilizer (Fig. 1a). However, fertilized subplots had significantly larger rates of N_2O than those who have not received mineral fertilization (P< 0.10) only on the 26th sampling event, seven days after the second application of fertilizer. For CH_4 fluxes, fertilization promoted significantly larger flows (P < 0.10) of this gas in only two sampling events. However, for the methane, fertilization had a more pronounced and extended effect, from May, when soil moisture increased, up to November (Fig. 5b).

An increase in the CH_4 emission from the soil after the mineral fertilization was expected, as the raise of NH_4^+ contents in soil can promote competition between the ions NH_4^+ and CH_4 by monoxygenase enzyme (Mosier & Delgado, Konda et al., 2010). However, such behavior was not evidenced in our study. Emission peaks occurring shortly after fertilization were observed only for N_2O (Fig. 1a, b). Fertilization was done when the soil was with low humidity, mainly in the first fertilization event (Fig. 3b), which probably has conditioned a high soil aeration and may have retarded microbial transformations of mineral nitrogen fertilizer in the soil.

3.4 Cumulative emissions of N_2O-N and CH_4-C

The accumulated emissions of N_2O appeared low in the evaluated period for all treatments, and only the fertilization treatment promoted significant difference in this variable (Fig. 6a and 6b). In the average of fertilized and non-fertilized soils (Fig. 6a), T3 treatment issued 200.6 g N_2O–N ha^{-1} $year^{-1}$, twice as much as the T1 and T2 treatments, which had virtually the same emission rates (98.3 and 94.8 g N_2O–N ha^{-1} $year^{-1}$, respectively; Fig. 6a). These results represent low emissions of N_2O in equivalent carbon (EC) per year, with values of 59.8, 29.3 and 28.2 kg EC ha^{-1} $year^{-1}$ for the treatments T3, T1 and T2, respectively. The greater accumulated emission in the T3 treatment may be related to emission peak registered at the 26^{th} sampling event (Fig. 1b), whereas during the period of evaluations, the daily fluxes of N_2O between treatments remained practically similar (Fig. 1b).

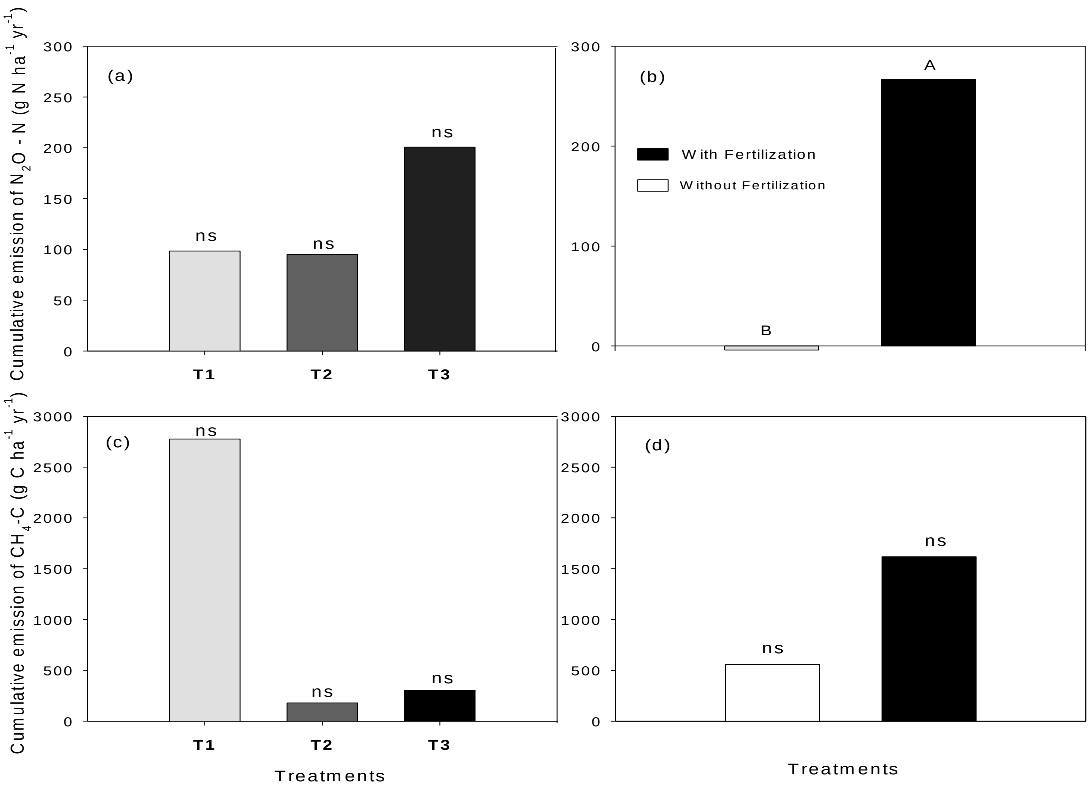

Fig. 6 Cumulative emissions of N_2O-N (a and b) and CH_4-C (c and d) in an Acrisol under silvopastoral systems. São Gabriel, RS, 2015. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with double lines spatial arrangement of 6 x (2 x 2) m. Capital letters above the columns represent significant difference by Tukey test (*P* <0.10). ns: no significant difference by Tukey test (P <0.10) among the averages.

These results are very similar to those found by Godoi (2012). Evaluating the fluxes of N_2O in a soil with native grassland and eucalyptus planting near about 50 km from our study, the author found emission of 221 and 99 g N_2O-N ha^{-1} $year^{-1}$ for these treatments, respectively. Yet, the results of this article are superior to those found for agriculture soils in the region, in which annual accumulated emissions up to 1.4 kg N_2O-N ha^{-1} $year^{-1}$have been reported(Bayer et al., 2015; Gomes et al., 2009)

The fertilization promoted net emissions of N_2O while the plots that have not received fertilization (mean of T1, T2 and T3) had N_2O consumption (Fig. 6b). This is probably due to the increase in the levels of NH_4^+ in soil (Fig. 2a) resulting in intense nitrification and denitrification processes (Inagaki & Ishizuka, 2011).

Taking into account that the fertilized soil received 100 kg N ha^{-1} $year^{-1}$ as urea, the average accumulated emission for the fertilized subplots (266.5 g N ha^{-1} yr^{-1}) in the present study represents an emission factor (EF) of 0.26%. Such value is smaller than that indicated for the practice of N fertilization on pastures by the IPCC (2006), which is 1%, indicating that soil under native field in a consortium with *P. rigida* has a closer N cycle of this nutrient and can be further explored to practices of SPSs.

The total emission of CH_4-C within one year showed positive values, i.e. all treatments evaluated in this study showed a net emission of CH_4 (Fig. 6 c). These results were probably exacerbated by above-average precipitation in the evaluated year (Fig. 3a). The treatment T1 (native grassland) had the largest CH_4 emission, with 2775 g CH_4-C ha^{-1} $year^{-1}$ (Fig. 6 c), representing 69.3 kg EC-C ha^{-1} $year^{-1}$. This result is probably due to the reason cited previously, in which part of the soil in Block III site was occasionally waterlogged in the evaluation period. Our results are distinct from those obtained by Godoi (2012) in a year of below-average precipitation. In native grassland for the same region of our study, the author reported methane influx of 699 g CH_4 –C ha^{-1} $year^{-1}$ in native grassland, in which WFPS < 60% predominated along the sampling events. In fact, the author only had net CH_4 emission from grassland soil when WFPS was larger than 80%. In our study, WFPS remained above 60% in practically all the evaluated period (Fig. 3b) favoring the predominance of CH_4 production in detriment of its consumption in the anaerobic conditions (Garcia et al., 2000). The remaining treatments T2 (planting in native grassland with spatial arrangement of 2 x 4 m) and T3 (planting in native grassland with spatial arrangement of double lines of 6 x (2 x 2) m) presented low emission of accumulated CH_4, with 179 and 304 g CH_4-C ha^{-1} $year^{-1}$ treatments T2 and T3, respectively (Fig.

6c), representing 4.5 and 7.6 kg EC-C ha^{-1} $year^{-1}$, T2 and T3 treatments, respectively. These results are similar to those found by Bayer et al. (2012), for the cultivation of grasses (*Avena strigosa* Schreb. and *Zea mays* L.) under no-tillage, without application of fertilizer and without the insertion of leguminous coverage crops in long-term experiments.

Although fertilization has promoted no statistical difference for the cumulative emissions of CH_4, fertilized soils emitted about three times more than those without fertilization (1617.9 and 555.3 g CH_4-C ha^{-1} $year^{-1}$, respectively; Fig. 6d). This behavior is probably linked to the increase in the soil contents of NH_4^+ due to the fertilization (Fig. 2a, b), promoting competition between the ions NH_4^+ and CH_4 for the monoxygenase enzyme (Acton & Baggs, 2011).

3.5 Total organic carbon (TOC), total nitrogen (TN) and particulate organic carbon (POC) in soil

The soil carbon and nitrogen contents in the soil (TOC, TN and POC) were neither affected by the insertion of *P. rigida* nor by the mineral fertilization (Fig. 7) after eleven months of the tree plantation. The short period of the field experiment was likely not enough to induce effective changes in these attributes. The insertion of *P. rigida* in native grassland presented trend of increased levels of TOC and TN (Fig. 7a, e), but not being significant ($P< 0.10$), probably as a function of the early stages of the tree plants development, causing little waste disposal. Their contents, however, were significantly different among the soil layers, as consequence of the absence of soil disturbance in the previous years of native grassland use.

The largest TOC levels occurred in the topsoil (0-5 cm), but did not differ significantly between treatments. The TOC content in this layer in the treatments T1, T2 and T3 were 22.6, 21.4 and 24.1 g C kg^{-1} soil, respectively (Fig. 7a).

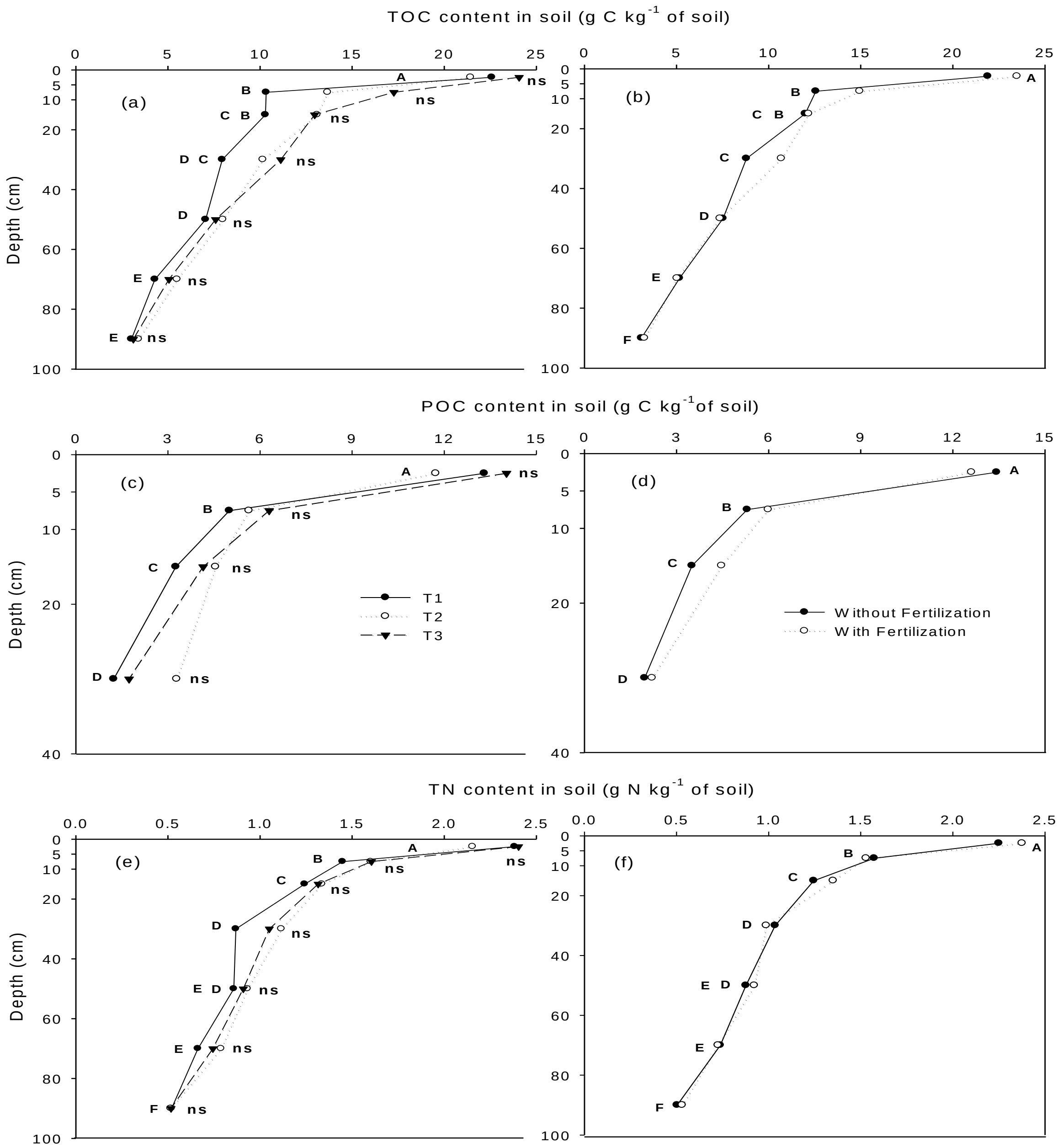

Fig. 7 Total organic C content (TOC; a and b), particulate organic C (POC; c and d) and total nitrogen (TN; e and f) in an Acrisol under silvopastoral systems. São Gabriel, RS, 2015. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. Uppercase letters indicate the minimum significant difference by Tukey test (P <0.10) between the layers of soil (averages for each layer). ns: no significant difference by Tukey test (P <0.10) between the treatments within each soil layer.

TOC results found in this work are slightly higher than those reported by Vezzani & Mielniczuk (2009), where they found 18 g C kg^{-1} soil layer (0-7.5 cm) on natural grassland under Acrisol (253 g kg^{-1} clay) with more than 30 years without disturbance). On another hand, Godoi (2012) evaluating the levels of TOC as well in an Acrisol, with sandy texture (830 g kg^{-1} sand) in the surface layer, found 8 g C kg^{-1} soil layer (0-5 cm) in the Pampa biome's natural field. However, in Cambisol with native grassland in Pampa biome, with less sand content in the surface layer (600 g kg^{-1} sand), the author found 38.2 g C kg^{-1} soil layer 0-5, slightly higher than the values of the present study. These results are expected, because the interaction between OM and clay, gives greater physical stability of OM (Bayer et al., 2001). As a result, the greater stability of this component helps to keep the TOC content in the soil, as at average 58% of OM is carbon (Nelson & Sommers, 1996).

With regard to levels of TN in the soil, the highest values were found in layer 0-5 cm, influenced by the higher TOC content in this layer (Fig. 7a and 7e). The contents of TN in the first 5 cm of soil were similar for all treatments, with values of 2.4, 2.1 and 2.4 g N kg^{-1} of soil treatments T1, T2 and T3, respectively (Fig. 7e).

In the study of Godoi (2012) in Cambisol, the author found average levels of TN 4.1 g N kg^{-1} soil at 0-5 cm layer in native field. However, in this same study, another type of soil (Acrisol) was verified content of 1.0 g N kg^{-1} soil in this layer. These results indicate that the contents of TOC and TN are extremely dependent on the clay content and the higher the clay content, more C and N soil can store (Lima et al., 2008). The treatments where they were inserted the plants of *P. rigida* presented trend of larger stocks of TOC, POC and TN than the nature grassland without trees (Fig. 8). In the surface layer (0-5 cm), the largest TOC stock (16.1 Mg C ha^{-1}) was found in T3 treatment. TN stocks in topsoil presented practically similar values (1.5 Mg N ha^{-1}) for all treatments (Fig. 8 c). Therefore, the presence of *P. rigida* seems to have provided a slight increase in stocks of TOC, but it did not occur for TN stocks in the superficial layer. The trend is more pronounced in surface soil layers than in deep subsoil.

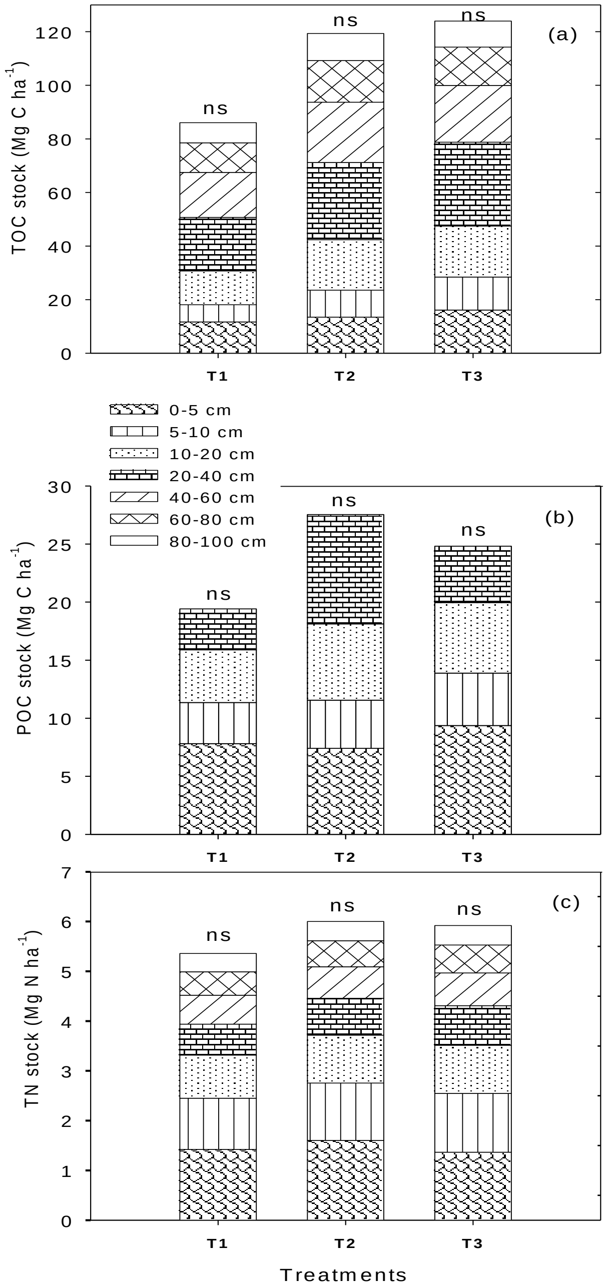

Fig. 8 Stocks of Total organic C (TOC; a), particulate organic C (POC; b) and total N (TN; c) in the 0-100 cm depth of an Acrisol under silvopastoral systems. São Gabriel, RS, Brazil, 2015. T1: native grassland (NG); T2: NG + *P. rigida* with spatial arrangement of 2 x 4 m; and T3: NG + *P. rigida* with spatial arrangement of double lines 6 x (2 x 2) m. ns: no significant difference by Tukey test (P <0.10) between the treatments.

With respect to the stock of C in the soil, approximately 60% of the total of C stored in the soil is in labile fraction (POC) (Fig. 8 c). This percentage of POC in the topsoil (0-5 cm) is larger than results for a soil under native grassland found by Vieira et al. (2007) in the south of Brazil, suggesting that the native grassland of the present study has promoted favorable conditions to accumulate labile C fractions and, consequently, to promote soil quality.

Although the fertilizer has increased the fluxes of nitrous oxide from soil, the greater contribution of C to the soil and growth of plants can surpass the CH_4 and N_2O from the soil in the approaching years, but this hypothesis must be tested in future studies. In the year of this study, mineral fertilization increased the input rate of shoot dry biomass of the forage in 89% for the annual average (data not showed). This increase will probably raise the C sequestration in soil organic matter in the following years.

Therefore, the silvopastoral system has low emission of CH_4 and N_2O to the atmosphere, showing themselves to be efficient for the mitigation of GHG emissions, by having the ability to sequester C in the biomass of trees that make up this system and thus increase C stocks in the soil. However, the follow-up of evaluations in these systems is necessary to assess the effect with larger trees and with the introduction of cattle, in order to obtain a more complete view of the implications that occur when the insertion of trees in nature grasslands of the Pampa biome, in relation to GHG mitigation potential.

4 CONCLUSIONS

a. The native grassland in a consortium with *Parapiptadenia rigida* (Benth.) Brenan (red Angico) presented low emission of nitrous oxide and methane from the soil, even with application of nitrogen fertilizer and high soil moisture. However, in the present study we found an emission factor (EF) of 0.26%, smaller than that indicated for the practice of N fertilization on pastures by the IPCC which is 1%.
b. The intro*duction of the spec*ies *Parapitadenia rigida* (Benth.) Brenan (red Angico) in native grassland did not influenced significantly the fluxes of N_2O and CH_4 from the soil. However, it is necessary to longer follow-up of air fluxes from the soil at this location in order to have a better understanding of the dynamics of GHG emissions.

c. Elevated soil moisture (WFPS) was the factor that most contributed to methane emissions, mainly when associated with the presence of fertilization. Nitrous oxide emission, in turn, was driven mainly by the fertilization, while soil moisture had small effect in the fluxes of this gas in the soil.

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APÊNDICES

Apêndice. 1. Atributos físicos de um Argissolo Vermelho sob sistema silvipastoril no bioma Pampa. São Gabriel-RS, 2015.

Trat	Bloco	0-5	5-10	10-20	20-40	40-60	60-80	80-100
		------------------	------------	------------	cm	------------	------------	------------
					Sand (g kg^{-1})			
	1	341.2	317.6	304.8	270.8	191.5	159.0	175.6
T1	2	362.3	308.2	344.5	231.2	191.9	216.3	212.4
	3	336.7	312.7	299.0	302.6	169.0	180.0	63.6
	Média	**346.8**	**312.8**	**316.1**	**268.2**	**184.1**	**185.1**	**150.5**
	1	334.3	335.5	300.3	266.4	206.5	176.7	228.8
T2	2	315.4	298.3	274.1	268.3	199.8		262.9
	3	367.5	329.6	338.8	297.2	244.2	254.6	177.6
	Média	**339.1**	**321.1**	**304.4**	**277.3**	**216.8**	**215.6**	**223.1**
	1	327.8	337.3	340.2	279.7	202.4	187.0	230.7
T3	2	362.2	365.2	315.3	260.1	221.8	203.3	263.3
	3	378.1	345.7	327.0	278.2	234.6	201.6	235.1
	Média	**356.0**	**349.4**	**327.5**	**272.7**	**219.6**	**197.3**	**243.0**
					Silt (g kg^{-1})			
	1	435.6	439.2	450.9	404.7	324.5	324.5	363.5
T1	2	429.9	473.7	444.5	431.9	394.4	294.9	719.2
	3	510.9	502.8	502.8	522.4	404.9	446.4	452.7
	Média	**458.8**	**471.9**	**466.1**	**452.1**	**374.6**	**355.3**	**511.8**
	1	473.2	429.5	446.9	410.1	309.5	325.6	331.0
T2	2	476.4	479.0	448.6	414.2	341.5		362.1
	3	429.5	461.1	472.1	442.5	379.7	347.8	413.8
	Média	**459.7**	**456.5**	**455.9**	**422.3**	**343.6**	**336.7**	**369.0**
	1	442.9	423.6	369.3	370.6	283.7	407.5	405.5
T3	2	463.4	440.2	438.0	398.3	382.3	366.1	321.4
	3	428.0	459.3	471.5	416.6	375.1	469.4	389.7
	Média	**444.7**	**441.0**	**426.2**	**395.1**	**347.0**	**414.3**	**372.2**
					Clay (g kg^{-1})			
	1	223.1	243.3	244.3	324.5	484.1	516.5	461.0
T1	2	207.7	218.0	211.0	336.9	413.7	488.7	068.4
	3	152.3	184.5	198.2	175.1	426.1	373.6	483.7
	Média	**194.4**	**215.3**	**217.8**	**278.8**	**441.3**	**459.6**	**337.7**
	1	192.6	234.9	252.8	323.5	483.9	497.7	440.1
T2	2	208.2	222.7	277.3	317.4	458.7		375.0
	3	203.0	209.3	189.1	260.2	376.1	397.6	408.6
	Média	**201.26**	**222.3**	**239.7**	**300.4**	**439.6**	**298.4**	**407.9**
	1	229.3	239.1	290.5	349.8	513.9	405.5	363.7
T3	2	174.4	194.6	246.8	341.6	395.9	430.6	415.3
	3	193.9	194.9	201.5	305.2	390.3	329.0	375.2
	Média	**199.2**	**209.5**	**246.3**	**332.2**	**433.4**	**388.4**	**384.7**

Apêndice 2. Fluxo de óxido nitroso (N_2O) em Argissolo Vermelho sob sistema silvipastoril no bioma Pampa. São Gabriel-RS, 2015.

			Bloco 1				Bloco 2			
Data	Trat	Col	sem	com	sem	com	sem	com	sem	com
	T1		12.89	-5.18	14.58	-2.27	12.46	-17.94	-7.97	5.35
24/12/13	**T3**	**1**	-1.17	-3.61	-2.85	3.00	-0.76	19.47	-9.49	-12.82
	T2		-6.96	-1.22	-6.77	-3.30	-6.36	-14.76	37.44	-12.70
	T1		-3.04	-1.81	-0.62	11.90	-3.13	3.28	0.92	3.94
15/01/14	**T3**	**2**	12.36	0.61	10.14	2.32	2.33	-2.88	0.01	2.59
	T2		-0.87	-1.71	1.59	-1.81	2.69	-1.01	0.20	0.30
	T1		-4.95	0.47	-6.60	7.30	5.62	1.36	-4.24	0.63
17/01/14	**T3**	**3**	0.02	8.66	-3.77	2.90	12.60	4.46	-4.05	17.09
	T2		10.54	-2.76	-5.72	2.53	10.17	3.66	5.02	-7.95
	T1		-0.08	-96.64	28.76	31.68	-2.22	11.73	-24.00	10.47
20/01/14	**T3**	**4**	-0.82	-8.48	16.59	14.69	-0.78	-1.63	-13.23	23.82
	T2		-9.55	-1.10	10.40	12.95	78.41	105.88	5.86	-16.96
	T1		2.48	0.90	4.19	0.53	2.53	2.64	0.90	7.46
24/01/14	**T3**	**5**	-0.72	0.55	1.09	1.48	2.97	6.83	2.87	10.35
	T2		1.85	4.15	-1.14	3.33	0.91	-1.01	104.18	1.30
	T1		-2.08	17.01	-5.65	17.33	11.07	6.09	2.86	353.81
04/02/14	**T3**	**6**	1.93	11.74	0.01	-48.62	7.97	-3.64	-3.01	0.87
	T2		5.52	25.22	18.33	27.31	3.87	-2.59	1.81	4.62
	T1		4.84	3.55	-1.44	4.49	0.15	23.41	1.87	10.15
14/02/14	**T3**	**7**	2.78	0.12	2.23	2.57	7.16	2.16	4.07	8.08
	T2		2.38	3.28	-0.01	0.41	-0.55	2.94	-0.07	3.85
	T1		1.64	1.57	2.71	3.86	4.12	8.44	2.05	33.35
22/02/14	**T3**	**8**	2.31	0.93	1.82	7.47	7.88	3.62	1.67	8.79
	T2		1.08	-2.60	-0.31	2.57	2.39	4.48	1.04	3.21
	T1		0.61	3.17	6.08	1.81	5.41	2.69	-1.77	5.72
28/02/14	**T3**	**9**	1.09	-1.22	3.00	1.96	2.15	-0.20	-3.46	8.32
	T2		-2.98	1.52	0.07	3.42	-0.94	-1.41	4.86	-1.17
	T1		-2.49	0.76	1.97	-1.70	-0.30	-0.80	-0.03	5.87
08/03/14	**T3**	**10**	0.66	-1.29	2.01	2.47	2.18	-0.09	-1.11	-0.53
	T2		-2.45	4.28	1.09	3.87	-0.03	1.43	-0.19	-4.01
	T1		1.39	4.07	1.02	1.77	0.59	-0.29	-1.63	0.00
16/03/14	**T3**	**11**	1.40	0.74	0.44	1.02	13.94	-1.52	-0.31	2.46
	T2		8.70	1.20	0.73	5.12	-0.30	15.34	-0.77	4.29
	T1		-0.05	5.47	2.74	1.58	-1.81	-2.21	-0.43	-5.94
24/03/14	**T3**	**12**	-1.18	1.38	1.71	1.47	1.62	-1.12	-1.40	1.51
	T2		3.91	1.84	-3.68	24.65	0.52	0.66	0.06	1.88
	T1		1.04	2.67	0.11	1.83	0.63	-2.82	-0.37	-4.36
01/04/14	**T3**	**13**	-4.93	-0.35	-3.01	1.97	-2.47	-1.24	-0.17	0.55
	T2		-0.04	-2.43	4.09	5.11	1.51	1.96	0.35	-1.24
	T1		2.81	11.85	2.34	-3.57	2.38	-0.45	-4.21	-8.74
09/04/14	**T3**	**14**	-3.07	-4.37	-0.19	0.69	25.10	0.24	6.80	1.35
	T2		-0.69	-2.09	-4.26	3.01	1.83	3.34	-2.14	-5.42
	T1		35.81	0.75	-0.18	-2.06	0.57	0.26	1.13	2.06
17/04/14	**T3**	**15**	2.52	-2.03	1.05	-1.40	-1.15	-29.74	0.86	0.35

	T2		0.68	1.22	1.94	18.67	-0.55	26.58	0.55	0.28
	T1		3.07	19.22	21.12	1.99	1.75	1.34	-0.92	-0.16
25/04/14	**T3**	**16**	0.89	0.83	3.06	-16.61	0.36	-18.47	2.31	1.24
	T2		1.45	2.91	0.19	13.97	-0.07	21.98	1.30	0.22
	T1		0.72	1.33	1.17	4.29	0.26	6.76	0.69	3.23
03/05/14	**T3**	**17**	0.61	7.23	4.45	5.41	0.71	-0.94	-1.11	-0.27
	T2		3.23	0.24	3.47	1.98	2.39	3.36	3.97	0.73
	T1		-6.45	1.81	-2.90	6.07	0.13	-2.72	1.53	0.67
11/05/14	**T3**	**18**	0.41	-0.23	2.07	0.20	1.29	-0.20	0.38	0.77
	T2		-0.37	-0.98	-0.67	3.09	0.74	0.12	1.83	1.16
	T1		-0.79	0.65	1.20	1.47	0.31	2.94	0.38	0.09
19/05/14	**T3**	**19**	0.04	-1.67	-5.11	53.67	0.66	-1.22	-1.54	0.70
	T2		-1.91	-12.48	-0.25	-6.22	0.04	-1.74	-0.73	-2.19
	T1		0.40	2.18	1.33	0.51	0.62	-2.18	2.47	0.45
27/05/14	**T3**	**20**	0.42	3.04	-1.38	-0.37	-0.20	-10.82	0.78	1.81
	T2		0.73	1.30	1.14	1.48	-0.56	2.86	-1.41	0.35
	T1		3.16	20.58	-2.69	-2.39	1.69	-0.45	7.74	6.08
04/06/14	**T3**	**21**	10.35	0.80	2.12	-9.98	1.24	-5.90	-3.59	21.59
	T2		-12.54	8.82	4.14	-0.52	-8.82	3.71	5.07	-9.95
	T1		0.10	1.14	0.78	-1.23	-1.06	1.11	5.12	0.61
12/06/14	**T3**	**22**	-1.08	2.89	1.53	1.18	-2.04	3.43	3.17	-0.66
	T2		2.82	-0.13	-0.72	3.54	7.38	1.68	-0.69	2.14
	T1		-3.49	0.52	2.23	-0.28	0.47	-0.72	-1.46	-4.47
20/06/14	**T3**	**23**	-1.44	-0.83	1.18	1.62	0.79	-0.24	2.09	-0.48
	T2		1.16	-1.86	1.67	2.81	-4.50	0.68	0.45	-0.19
	T1		-0.12	13.10	0.87	3.73	-1.06	0.84	-3.04	1.59
28/06/14	**T3**	**24**	-2.61	1.39	2.72	-2.11	0.37	4.03	-0.49	29.06
	T2		4.66	-17.17	-2.51	4.24	2.77	0.98	-0.57	1.19
	T1		0.35	102.18	1.50	2.26	-0.75	1.13	0.89	0.75
06/07/14	**T3**	**25**	-0.92	2.70	2.27	-1.67	0.12	0.97	1.41	396.82
	T2		-1.08	1.87	-0.57	4.62	0.50	1.58	0.35	-0.47
	T1		-0.03	317.21	1.82	9.33	0.29	1.23	1.86	2.28
14/07/14	**T3**	**26**	-0.07	23.75	2.21	6.06	0.12	1.21	2.62	1156.64
	T2		6.20	7.32	-2.46	9.35	4.76	6.16	0.56	7.15
	T1		1.25	93.22	0.11	3.11	-3.16	12.54	-0.74	4.63
22/07/14	**T3**	**27**	-0.59	32.21	2.07	39.42	-1.33	-0.39	0.55	246.78
	T2		6.89	9.31	-2.86	67.63	-2.23	1.71	0.48	3.71
	T1		1.48	10.35	-0.03	2.77	3.32	7.16	3.76	12.67
12/10/14	**T3**	**28**	0.80	42.05	3.88	36.90	3.04	3.44	1.93	3.30
	T2		2.63	-0.90	3.66	102.66	2.61	7.52	3.87	6.78
	T1		0.02	3.79	5.46	-0.78	2.43	0.56	1.99	1.20
30/12/2014	**T3**	**29**	1.84	32.24	-0.55	4.83	0.50	3.78	8.33	-1.84
	T2		3.45	3.46	-0.13	8.63	5.51	4.74	19.72	10.34

Data	TRAT	Col	sem	com	sem	com
			Bloco 3			
	T1		-103.93	-93.66	101.06	-34.77
24/12/13	T2	1	-73.25	-54.62	-96.12	-80.32
	T3		-64.71	-82.64	-74.88	-78.61
	T1		-1.24	1.67	-3.65	-1.26
15/01/14	T2	2	0.77	0.74	0.00	-1.06
	T3		-2.65	9.93	3.10	0.54
	T1		10.73	-2.23	12.58	-8.30
17/01/14	T2	3	-6.33	8.14	6.75	0.74
	T3		-6.24	-2.18	2.10	-1.65
	T1		20.10	-22.30	9.57	7.68
20/01/14	T2	4	0.00	60.56	14.83	19.30
	T3		-9.84	23.76	-19.71	-3.54
	T1		-5.50	0.54	1.29	1.44
24/01/14	T2	5	5.43	14.10	3.51	2.39
	T3		2.12	3.24	-1.88	-7.11
	T1		-0.58	-5.76	-13.31	12.02
04/02/14	T2	6	14.12	23.24	6.24	-3.34
	T3		0.64	19.22	-0.27	6.16
	T1		-2.35	17.43	-3.76	9.32
14/02/14	T2	7	2.36	-1.64	2.44	3.93
	T3		-0.50	18.44	1.69	386.25
	T1		0.32	-1.22	-2.75	18.97
22/02/14	T2	8	1.91	2.11	3.61	8.67
	T3		1.07			
	T1		-1.81	7.39	-2.79	3.53
28/02/14	T2	9	-2.60	0.06	0.88	3.62
	T3		3.78	0.05	2.80	3.88
	T1		1.12	2.27	4.92	3.62
08/03/14	T2	10	3.51	2.48	1.72	2.71
	T3		2.76	8.77	2.07	4.21
	T1		0.39	4.12	0.77	-2.28
16/03/14	T2	11	3.97	-2.50	-3.23	5.11
	T3		5.81	5.31	-2.44	4.81
	T1		-1.23	8.13	-0.13	4.39
24/03/14	T2	12	0.81	1.08	-2.76	0.50
	T3		0.41	-0.73	2.58	0.73
	T1		-1.20	0.27	5.33	2.38
01/04/14	T2	13	-3.87	-0.35	3.11	-4.12
	T3		1.64	5.88	1.76	0.85
	T1		-0.87	7.01	5.01	2.14
09/04/14	T2	14	2.55	3.56	1.55	3.56
	T3		-2.55			
	T1		-0.11	-1.55	-1.13	-26.63
17/04/14	T2	15	1.74	-0.12	-0.81	30.92
	T3		-0.53	-24.72	-1.96	3.65

25/04/14	**T1**	**16**	19.66	0.46	1.60	-0.47
	T2		2.46	-1.48	-0.92	24.92
	T3		1.49	-0.99	-8.10	-1.65
03/05/14	**T1**	**17**	0.75	-0.65	-0.68	-1.74
	T2		0.92	-0.53	-0.87	0.14
	T3		1.86	2.34	1.30	-0.95
11/05/14	**T1**	**18**	-1.40	0.10	-1.25	2.56
	T2		1.82	-0.13	3.19	0.39
	T3		-3.02	5.21	-0.02	-1.49
19/05/14	**T1**	**19**	-1.94	-2.11	-3.01	-0.84
	T2		-0.51	1.25	1.58	1.01
	T3		0.30	3.04	0.74	-1.11
27/05/14	**T1**	**20**	0.65	-2.05	-2.16	0.74
	T2		-0.18	-0.40	-0.19	-0.67
	T3		-0.38	0.28	-18.56	-6.48
04/06/14	**T1**	**21**	-7.14	-0.10	-1.52	-11.87
	T2		-1.06	-2.49	0.18	-0.71
	T3		-0.32	14.97	-3.40	0.02
12/06/14	**T1**	**22**	5.01	13.53	1.14	4.80
	T2		1.64	-2.10	-0.72	0.72
	T3		0.59	1.93	-1.91	0.00
20/06/14	**T1**	**23**	-1.24	-4.58	-0.41	0.69
	T2		0.06	-0.11	-3.01	-1.77
	T3		0.06	1.10	11.08	-4.17
28/06/14	**T1**	**24**	-4.87	-0.79	-0.04	-2.34
	T2		2.02	1.13	-0.08	-0.24
	T3		0.67	0.62	15.12	6.63
06/07/14	**T1**	**25**	-6.76	0.38	0.70	0.49
	T2		2.10	4.93	1.65	-0.61
	T3		-1.30	1.11	1.68	0.55
14/07/14	**T1**	**26**	-4.13	4.27	0.11	-0.35
	T2		5.14	12.63	0.84	5.10
	T3		0.88	11.99	2.02	5.13
22/07/14	**T1**	**27**	-3.18	8.94	-3.15	-1.47
	T2		4.88	4.38	-0.96	0.31
	T3		-0.52	6.59	1.40	68.46
12/10/14	**T1**	**28**	-0.64	5.59	0.65	-0.36
	T2		2.88	1.84	-1.14	1.10
	T3		-0.33	10.96	2.09	43.85
30/12/2014	**T1**	**29**	16.67	8.06	-3.26	1.29
	T2		1.00	-1.44	1.20	-9.23
	T3		0.96	-3.89	2.88	6.22

Apêndice 3. Fluxo de metano (CH_4) em Argissolo Vermelho sob sistema silvipastoril no bioma Pampa. São Gabriel-RS, 2015.

			Bloco 1				Bloco 2			
Data	**TRAT**	**Coleta**	**sem**	**com**	**sem**	**com**	**sem**	**com**	**sem**	**com**
	T1		29.5	-34.2	-54.1	-8.3	38.1	-59.7	-32.1	-28.0
24/12/13	T3	1	-92.4	-15.2	117.5	2.0	-37.5	-16.5	-80.5	24.6
	T2		68.1	-22.1	-32.2	-36.2	9.6	-98.3	20.6	-22.0
	T1		14.1	4.9	49.9	20.9	-4.1	-4.4	0.5	-16.2
15/01/14	T3	2	28.7	6.9	17.9	12.6	-5.9	-15.5	-6.7	14.3
	T2		-0.2	-30.4	8.6	6.0	2.7	2.3	-7.0	-11.6
	T1		9.1	-10.0	0.3	6.5	1.3	13.7	-1.2	-11.2
17/01/14	T3	3	10.7	22.5	-16.5	-2.6	-5.6	6.7	-9.3	8.7
	T2		13.8	-0.5	-5.6	-9.0	6.4	-6.1	2.1	-6.4
	T1		16.2	-3.3	-2.9	7.9	37.7	9.7	-7.0	-2.9
20/01/14	T3	4	12.9	12.5	-1.6	5.9	-4.6	12.2	-13.3	-4.7
	T2		-7.8	-0.2	-1.1	-19.2	9.8	5.5	10.0	-1.6
	T1		-4.3	-8.0	-6.2	-5.3	22.7	-1.9	-10.6	-2.8
24/01/14	T3	5	7.4	18.5	1.7	-6.8	-5.1	17.1	-3.3	-16.4
	T2		-5.1	-7.2	-14.2	4.5	-2.6	9.6	-2.0	-7.5
	T1		8.6	0.6	-17.1	-10.4	27.7	-27.7	-3.5	-6.6
04/02/14	T3	6	4.4	20.4	16.2	42.9	-12.5	16.5	-23.6	-23.6
	T2		-14.5	-2.4	-5.5	-5.7	5.7	132.3	-5.6	-1.3
	T1		5.8	9.0	-2.1	7.4	21.5	1.3	-3.9	11.7
14/02/14	T3	7	4.7	7.0	-2.6	6.1	15.2	1.6	0.2	-2.1
	T2		-0.3	-0.6	-2.6	2.3	0.8	-0.1	-5.9	-0.7
	T1		1.3	0.0	1.6	10.0	33.9	1.7	-1.5	7.7
22/02/14	T3	8	6.2	11.3	-4.0	-1.0	7.2	14.4	1.6	-3.2
	T2		-0.2	-1.9	-7.2	-5.5	2.9	-5.9	-9.1	5.1
	T1		2.4	-5.9	1.8	7.0	31.8	3.1	7.8	-7.0
28/02/14	T3	9	15.6	8.1	-1.2	-12.5	-6.0	9.1	-8.2	-4.4
	T2		-4.8	-0.8	-3.4	1.9	0.0	-3.6	3.5	-6.1
	T1		-0.5	-7.1	-3.3	-2.0	18.6	-3.9	4.4	0.1
08/03/14	T3	10	6.8	13.5	-2.2	3.1	-2.8	15.4	-3.4	-1.4
	T2		-15.1	-7.6	-1.6	-8.0	-5.7	-2.1	2.4	-2.6
	T1		13.4	0.3	16.8	4.5	36.7	0.3	-1.3	1.7
16/03/14	T3	11	7.5	24.6	16.1	1.5	2.9	5.2	5.1	1.3
	T2		7.1	7.6	-5.3	-2.2	10.4	17.8	-7.7	17.7
	T1		10.1	2.4	-6.4	5.2	28.0	5.6	3.8	-0.2
24/03/14	T3	12	8.3	17.2	-9.8	-7.7	0.8	34.0	2.5	7.0
	T2		-3.6	5.8	8.2	-0.5	6.1	6.3	7.2	-6.7
	T1		3.0	-7.3	12.0	6.2	4.2	-5.7	-6.7	-0.2
01/04/14	T3	13	-19.4	3.8	0.3	4.4	-6.6	132.8	-3.2	3.2
	T2		-0.8	-6.3	0.7	1.0	0.2	-5.3	-1.2	-6.1
	T1		-6.9	5.2	-13.0	-9.3	-2.9	2.4	-18.3	-14.2
09/04/14	T3	14	0.2	-19.0	6.5	-20.9	37.9	18.4	12.9	10.7
	T2		-6.2	-11.2	-11.9	-1.3	0.8	-7.1	-13.1	-7.0
	T1		-64.3	-9.5	2.8	4.8	-5.4	4.2	-0.7	-15.8

17/04/14	T3	15	-15.6	26.7	5.9	5.3		-7.1	-30.2	-8.1	-5.3
	T2		2.2	-10.0	-3.3	20.4		8.3	42.9	-2.1	-2.4
	T1		-1.1	28.2	-0.8	1.9		-1.3	5.9	-3.3	-0.7
25/04/14	T3	16	-1.2	8.4	-2.2	-28.1		0.4	-15.3	2.6	-1.8
	T2		1.0	-1.0	1.0	19.0		1.4	33.2	13.2	1.4
	T1		0.7	-0.5	0.2	4.0		2.9	-0.5	-0.1	-2.8
03/05/14	T3	17	0.9	22.9	-1.1	5.8		-4.9	19.8	3.6	-1.8
	T2		8.5	1.2	-2.1	1.0		-1.1	0.9	4.8	2.3
	T1		-17.8	4.5	-5.6	12.9		-3.2	-5.7	0.3	-0.6
11/05/14	T3	18	0.2	2.9	0.9	3.0		1.3	12.8	4.4	1.8
	T2		-2.5	-1.1	-6.1	-3.0		2.5	-1.0	22.0	1.0
	T1		-8.4	1.7	-4.1	-0.5		1.6	8.1	12.4	5.4
19/05/14	T3	19	1.1	0.2	-11.5	33.6		8.6	32.6	7.8	0.0
	T2		-5.4	-13.5	-6.4	-23.8		9.2	-1.3	18.6	-0.5
	T1		-2.2	3.1	-2.2	-5.7		-6.0	-6.9	-15.2	-1.5
27/05/14	T3	20	-8.6	8.4	-12.0	-2.4		-6.6	28.1	4.2	2.5
	T2		-1.9	-4.9	-3.5	13.4		16.6	4.3	9.8	12.0
	T1		6.5	38.3	5.2	2.2		3.6	-7.5	0.3	1.0
04/06/14	T3	21	13.7	13.7	0.7	-2.7		7.8	104.9	-2.4	23.5
	T2		-12.8	13.3	-2.3	-3.5		-8.0	0.4	7.1	61.8
	T1		1.4	63.3	-5.4	-3.1		-4.3	-11.2	11.3	6.8
12/06/14	T3	22	11.6	12.9	-5.0	3.0		4.4	290.5	11.1	0.2
	T2		5.4	-2.8	-4.9	-1.6		6.3	0.0	25.8	16.1
	T1		-2.0	15.8	-3.7	0.9		-0.6	-0.6	-4.5	-6.5
20/06/14	T3	23	-4.2	-1.1	-1.3	0.4		2.6	246.8	0.4	-0.1
	T2		1.1	-5.9	-5.5	-5.1		-0.6	0.7	-5.3	-3.0
	T1		-0.8	11.1	-7.7	-0.9		-9.1	-2.5	-9.2	-2.1
28/06/14	T3	24	-5.9	-1.7	1.5	0.0		1.7	152.0	1.0	4.5
	T2		7.7	-7.3	-7.9	0.2		-2.3	16.0	-3.6	-6.5
	T1		0.1	0.1	-6.3	-5.7		-6.9	-5.7	-10.1	-6.6
06/07/14	T3	25	-9.6	-2.0	-1.0	0.1		3.4	50.8	-0.6	-2.6
	T2		-9.2	-10.2	-12.3	-3.1		-2.1	-1.3	-0.6	-2.0
	T1		-4.3	5.2	-8.6	7.1		0.0	-6.5	4.4	-6.1
14/07/14	T3	26	3.1	-2.4	7.6	0.9		8.1	89.4	-2.9	8.1
	T2		16.8	-0.2	-3.9	2.9		-3.0	2.0	-13.7	-4.6
	T1		-2.2	-4.2	-8.0	-7.1		-2.7	-3.1	-11.3	-1.4
22/07/14	T3	27	-4.8	-4.1	-1.9	-4.4		10.8	4.0	-2.5	0.1
	T2		1.1	-3.2	-5.1	-4.6		0.4	5.8	-4.5	0.0
	T1		-10.6	-0.2	7.0	-3.5		10.7	57.3	-11.1	1.5
12/10/14	T3	28	-5.1	-0.5	-15.2	-2.2		1.4	-1.2	-17.2	17.5
	T2		-6.5	-17.3	-0.3	-0.2		-3.0	-2.7	-5.9	-13.3
	T1		-14.0	-2.0	8.3	-3.8		3.4	-10.3	-9.0	9.0
30/12/14	T3	29	14.6	-2.2	0.0	8.1		1.0	25.8	5.5	41.4
	T2		22.1	3.4	-1.1	13.3		21.4	28.3	23.5	27.9

			Bloco 3			
Data	TRAT	Coleta	**sem**	**com**	**sem**	**com**
	T1		-160.0	-88.9	-177.7	-79.9
24/12/13	T2	1	-56.1	-47.5	-95.6	-56.8
	T3		-190.4	-47.7	-162.2	-50.7
	T1		-19.1	-9.5	-12.1	2.7
15/01/14	T2	2	45.1	10.2	-29.2	6.8
	T3		-3.8	0.3	16.7	3.3
	T1		-0.5	-3.6	9.9	-10.6
17/01/14	T2	3	-3.9	9.0	-6.5	-0.4
	T3		-10.5	-5.3	6.2	-10.0
	T1		10.3	12.0	-3.7	-5.0
20/01/14	T2	4	-0.9	7.6	-6.7	8.8
	T3		-3.7	11.0	-5.9	-2.1
	T1		-28.9	2.6	-8.1	-6.3
24/01/14	T2	5	-1.4	-1.1	-5.5	-1.9
	T3		-10.5	5.1	-3.3	0.9
	T1		-5.6	4.1	5.6	2.1
04/02/14	T2	6	-5.8	-4.9	25.5	5.1
	T3		-3.4	4.1	5.8	-19.6
	T1		-6.0	16.2	-4.9	2.9
14/02/14	T2	7	5.6	-3.0	2.3	0.3
	T3		-3.1	-0.2	-3.3	14.6
	T1		-1.8	3.6	-11.5	3.1
22/02/14	T2	8	3.7	-1.0	9.6	-3.3
	T3		1.0			
	T1		5.3	0.3	-4.0	6.0
28/02/14	T2	9	-5.4	-2.0	2.3	0.2
	T3		5.8	-3.8	-0.9	3.9
	T1		7.9	8.1	25.7	9.6
06/03/14	T2	10	3.1	2.4	3.0	11.8
	T3		-1.1		5.9	135.9
	T1		25.5	7.1	1.7	-4.4
12/03/14	T2	11	4.5	-5.0	3.6	1.4
	T3		10.5	8.9	1.6	39.9
	T1		26.2	17.7	33.0	38.0
18/03/14	T2	12	0.2	8.8	4.2	11.7
	T3		-1.8	-16.0	3.2	3.5
	T1		87.3	24.3	162.5	189.5
24/03/14	T2	13	-20.2	9.0	0.2	-9.6
	T3		-5.6		-175.5	-3.7
	T1		-4.1	17.7	20.9	74.2
30/03/14	T2	14	-1.2	-3.9	9.0	31.2
	T3		15.9			
	T1		75.9	33.2	124.8	
05/04/14	T2	15	6.7	11.8	4.9	
	T3		-6.2	-23.9	3.2	
11/04/14	T2	16	-0.6	0.7	2.6	42.8

	T3		3.7	9.5	9.4	-3.8
17/04/14	T1	17	75.0	17.1	142.8	260.4
	T2		-0.8	-1.7	-3.1	-1.1
	T3		5.3	-6.4	2.2	-1.6
23/04/14	T1	18	66.6	15.7	100.0	403.0
	T2		4.0	-0.3	52.4	44.4
	T3		12.2	39.3	10.0	12.0
29/04/14	T1	19	94.7	44.9	112.9	831.8
	T2		9.3	-2.1	10.3	3.8
	T3		5.8	10.6	20.7	25.5
05/05/14	T1	20	124.9	11.9	96.9	813.9
	T2		-14.9	-13.8	9.1	11.1
	T3		-13.0	-1.4	-22.6	-12.8
11/05/14	T1	21	250.2	58.7	145.9	1175.4
	T2		1.5	-0.4	17.9	13.3
	T3		-2.7	28.7	-2.6	1.6
17/05/14	T1	22	308.2	119.0	172.9	809.9
	T2		2.0	12.2	42.5	9.9
	T3		-1.1	6.4	-3.0	-1.7
23/05/14	T1	23	382.0	168.5	119.9	586.1
	T2		2.0	2.7	28.8	6.0
	T3		-0.2	3.0	6.3	0.5
29/05/14	T1	24	187.4	109.5	76.3	522.6
	T2		4.6	0.9	30.0	7.7
	T3		-3.0	-3.5	-1.5	0.2
04/06/14	T1	25	82.0	25.4	48.9	139.2
	T2		0.0	0.9	-3.6	2.0
	T3		-5.1	-3.0	-6.8	-2.3
10/06/14	T1	26	168.2	53.2	74.3	179.8
	T2		6.0	3.6	8.9	7.1
	T3		3.2	4.9	3.5	2.9
16/06/14	T1	27	42.6	6.4	18.7	18.0
	T2		-3.6	-3.3	-0.9	0.4
	T3		-3.6	5.0	0.9	-3.4
12/10/14	T1	28	-7.5	-7.1	2.0	-5.5
	T2		-6.2	20.7	-12.7	21.3
	T3		6.5	16.1	2.1	0.0
30/12/14	T1	29	10.5	4.4	-7.7	21.0
	T2		-5.0	-5.6	4.8	8.2
	T3		-2.6	11.3	-5.4	-1.4

Apêndice 4. Temperatura (ºC) de um Argissolo Vermelho (0-5 cm) sob sistema silvipastoril no bioma Pampa. São Gabriel, RS, 2015.

		Bloco 1								
Data	**Coleta**	**T1**			**T3**			**T2**		
24/12/13	1	23.3	24.6	24.6	24.9	24.9	25.2	25.1	24.4	24.6
15/01/14	2	22.1	22.9	22.7	22.3	22.9	22.9	22.5	23.0	23.0
17/01/14	3	24.4	24.5	24.6	24.2	24.3	24.4	24.9	24.9	24.9
20/01/14	4	25.7	25.7	25.8	25.7	26.1	26.6	26.4	26.6	26.8
24/01/14	5	27.4	27.5	27.6	27.7	27.7	27.9	28.0	28.5	28.2
04/02/14	6	26.3	26.3	26.4	26.5	26.4	26.5	26.8	26.4	26.8
14/02/14	7	24.0	24.0	24.0	22.6	22.6	22.5	23.8	23.8	23.8
22/02/14	8	24.9	24.9	25.0	24.3	24.3	24.6	24.7	24.7	24.8
28/02/14	9	21.1	21.1	21.2	20.6	20.6	20.7	21.2	21.3	21.4
06/03/14	10	21.9	22.0	22.2	21.3	21.5	21.7	22.4	22.5	22.6
12/03/14	11	20.3	20.3	20.4	20.4	20.4	20.4	21.0	21.0	21.1
18/03/14	12	20.7	20.2	20.1	21.7	21.6	21.6	22.3	22.3	22.3
24/03/14	13	17.1	17.1	17.1	17.4	17.5	17.5	17.4	17.5	17.5
30/03/14	14	17.6	17.6	17.6	17.2	17.3	17.3	17.3	17.3	17.3
05/04/14	15	16.5	16.5	16.6	17.1	17.1	17.2	16.5	16.5	16.5
11/04/14	16	15.1	15.1	15.1	14.7	14.7	14.8	14.7	14.7	14.7
17/04/14	17	16.7	16.6	16.6	16.8	16.8	16.8	16.6	16.6	16.6
23/04/14	18	12.1	12.1	12.1	12.1	12.1	12.1	12.5	12.5	12.5
29/04/14	19	12.1	12.1	12.1	12.5	12.4	12.4	12.2	12.1	12.2
05/05/14	20	15.8	15.8	15.8	15.3	15.3	15.3	15.9	15.8	15.8
11/05/14	21	18.6	18.6	18.6	18.3	18.3	18.5	18.8	18.8	18.8
17/05/14	22	21.0	21.0	21.0	20.4	20.4	20.5	21.0	21.0	21.0
23/05/14	23	17.8	18.1	18.2	17.8	17.8	18.0	19.1	19.2	19.3
29/05/14	24	21.3	21.3	21.3	21.0	20.9	21.0	20.8	20.8	20.8
04/06/14	25	22.0	22.0	21.1	22.0	22.0	22.0	21.6	21.6	21.6
10/06/14	26	22.0	22.0	21.9	21.8	21.8	21.8	21.9	21.9	22.0
16/06/14	27	21.6	21.6	21.7	21.1	21.1	21.2	21.6	21.6	21.7
12/10/14	28	23.6	23.6	23.7	23.6	23.6	23.8	24.1	24.1	24.2
30/12/14	29	24.0	24.0	24.0	24.0	24.0	24.1	24.1	23.6	24.1

Bloco 2

Data	Coletas	T1			T3			T2		
24/12/13	1	26.8	26.8	26.8	24.6	25.0	25.3	28.5	26.0	25.3
15/01/14	2	22.7	22.5	22.9	22.9	22.8	23.0	23.0	23.0	23.3
17/01/14	3	24.5	24.6	25.0	24.7	25.5	25.1	24.8	25.7	25.2
20/01/14	4	26.2	26.5	26.8	26.8	27.1	27.5	26.6	26.7	26.8
24/01/14	5	28.1	28.4	28.6	28.6	28.8	29.2	28.2	28.2	28.4
04/02/14	6	26.2	26.4	26.6	26.4	26.8	26.9	26.6	27.6	27.8
14/02/14	7	23.0	23.2	23.3	22.3	22.3	22.5	22.7	22.8	22.9
22/02/14	8	24.7	24.9	25.2	25.4	25.7	26.1	25.1	25.3	25.4
28/02/14	9	19.7	19.9	20.2	20.1	20.2	20.4	21.5	21.5	21.6
06/03/14	10	22.8	23.1	23.3	23.4	24.2	24.8	22.7	22.9	23.1
12/03/14	11	20.8	20.9	20.9	20.3	20.4	20.4	21.4	21.4	21.4
18/03/14	12	20.1	20.1	20.1	21.2	21.3	21.3	22.5	22.5	22.5
24/03/14	13	17.9	18.0	18.1	17.5	17.6	17.8	18.3	18.3	18.5
30/03/14	14	17.6	17.6	17.7	16.5	16.7	17.0	17.9	18.0	18.0
05/04/14	15	16.6	16.7	16.8	16.4	16.6	16.7	17.5	17.6	17.7
11/04/14	16	15.2	15.2	15.3	14.9	14.9	15.0	15.0	15.0	15.0
17/04/14	17	17.1	17.2	17.2	17.1	17.2	17.3	16.8	16.8	16.9
23/04/14	18	12.2	12.2	12.2	12.1	12.3	12.3	12.7	12.7	12.8
29/04/14	19	12.3	12.4	12.6	12.1	12.3	12.5	12.1	12.2	12.5
05/05/14	20	15.8	15.8	15.8	15.6	15.6	15.6	16.0	16.0	16.0
11/05/14	21	18.9	19.0	19.2	19.5	19.7	21.3	19.0	19.1	19.4
17/05/14	22	21.1	21.2	21.2	20.8	20.9	20.9	21.0	21.1	21.2
23/05/14	23	18.7	18.8	19.1	18.7	18.9	19.3	19.2	19.3	19.5
29/05/14	24	21.3	21.4	21.5	21.8	22.0	22.3	21.6	21.6	21.7
04/06/14	25	22.3	22.3	22.5	22.9	22.9	23.1	22.4	22.5	22.5
10/06/14	26	22.0	21.1	22.2	22.5	22.6	22.8	22.4	22.4	22.6
16/06/14	27	22.0	22.0	22.1	22.1	22.1	22.1	22.0	22.0	22.1
12/10/14	28	23.7	23.7	23.8	24.3	24.1	24.5	25.7	24.4	24.4
30/12/14	29	24.1	24.3	24.3	24.1	24.1	24.1	24.0	24.0	24.0

Bloco 3

Data	Coleta	T1			T2			T3		
24/12/13	1	24.7	25.1	25.1	25.7	26.0	26.1	27.1	27.5	27.8
15/01/14	2	23.4	23.6	22.9	23.6	24.0	24.2	23.9	24.3	23.6
17/01/14	3	25.0	25.3	24.8	25.2	25.6	25.3	25.4	26.1	25.3
20/01/14	4	27.4	27.6	27.7	28.4	29.9	29.9	27.5	27.7	28.0
24/01/14	5	28.9	29.3	29.7	29.6	29.5	29.6	28.3	28.1	28.3
04/02/14	6	27.2	27.3	27.4	27.8	28.0	28.5	27.2	27.3	27.4
14/02/14	7	24.5	24.6	24.7	23.6	23.7	23.9	23.6	23.7	23.8
22/02/14	8	26.5	26.8	27.0	26.7	27.0	27.3	25.7	26.2	26.6
28/02/14	9	21.9	22.1	22.3	21.3	21.5	21.8	21.6	21.8	22.0
06/03/14	10	23.0	23.4	23.6	23.1	23.4	24.6	24.6	24.3	25.2
12/03/14	11	21.3	21.4	21.4	21.5	21.7	21.9	21.1	21.3	21.0
18/03/14	12	20.1	20.1	20.2	22.0	22.1	22.1	22.3	22.3	22.3
24/03/14	13	18.3	18.5	18.8	18.9	19.2	19.6	18.5	18.6	18.8
30/03/14	14	17.6	18.0	18.4	17.6	17.8	18.1	17.8	18.0	18.1
05/04/14	15	17.0	17.0	17.1	17.6	17.7	17.8	16.9	17.1	17.3
11/04/14	16	15.5	15.5	15.6	15.1	15.2	15.3	15.0	15.3	15.1
17/04/14	17	17.0	17.0	17.1	17.6	17.6	17.7	17.1	17.2	17.3
23/04/14	18	13.5	13.5	13.4	12.3	12.3	12.5	12.6	12.6	12.8
29/04/14	19	13.5	13.6	13.8	13.1	13.4	13.7	12.9	13.2	13.2
05/05/14	20	16.0	16.0	16.1	16.1	16.2	16.4	16.0	16.1	16.2
11/05/14	21	19.7	19.9	20.2	19.3	19.4	19.5	20.5	20.7	21.0
17/05/14	22	22.0	22.0	21.1	21.5	21.8	22.0	21.3	21.5	21.6
23/05/14	23	20.0	20.3	20.5	19.0	19.2	19.3	19.3	19.5	19.6
29/05/14	24	22.7	23.0	23.5	22.4	22.9	23.3	21.6	21.8	21.9
04/06/14	25	23.1	23.2	23.8	23.3	23.4	23.7	22.5	22.5	23.1
10/06/14	26	23.1	23.2	23.3	22.8	23.1	23.1	22.1	22.2	22.2
12/10/14	28	25.1	25.1	25.2	25.1	25.1	25.2	24.8	24.7	24.7
30/12/14	29	24.3	24.4	24.5	24.8	24.8	24.9	24.5	24.6	24.7

Apêndice 5. Teor de N-mineral (NH_4^+ + NO_3^-) de um Argissolo Vermelho sob sistema silvipastoril em campo nativo

Bloco 1

		T1				T2				T3			
Data	**N**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
24/12/13	NH_4^+	-0.1	5.1	1.9	6.0	5.9	4.7	5.4	2.7	12.5	7.1	10.1	8.4
	NO_3^-	1.8	2.1	1.6	1.5	2.0	1.1	1.2	1.6	10.0	2.4	3.2	2.3
15/1/14	NH_4^+	8.4	6.5	10.4	19.0	22.2	5.1	5.8	12.8	6.0	5.6	26.3	8.2
	NO_3^-	7.9	8.6	8.0	12.3	8.5	7.2	6.7	4.6	7.8	3.4	12.1	7.5
17/1/14	NH_4^+	2.8	9.9	6.2	14.9	20.6	11.	8.6	32.1	10.6	17.1	10.8	7.5
	NO_3^-	1.0	3.5	1.1	3.0	3.2	7.8	8.4	8.4	2.2	0.3	5.5	6.3
20/1/14	NH_4^+	6.9	16.3	0.4	21.0	8.0	7.9	12.8	5.1	6.3	22.7	8.5	22.3
	NO_3^-	5.0	7.2	-1.2	0.9	6.6	5.4	2.7	2.4	-2.0	1.3	0.3	-2.5
24/1/14	NH_4^+	4.4	5.6	14.3	9.3	13.0	57	8.9	14.2	11.4	14.0	15.2	40.0
	NO_3^-	0.8	0.0	0.1	-0.4	2.2	4.7	2.1	1.4	12.5	1.3	2.2	3.3
4/2/14	NH_4^+	3.9	17.7	11.2	14.2	24.0	-0.6	-5.4	2.1	4.8	30.0	4.1	11.1
	NO_3^-	6.2	0.0	0.0	0.0	3.3	0.0	8.1	0.0	0.0	5.1	0.0	0.0
14/2/14	NH_4^+	4.5	1.9	2.8	5.9	1.5	11	3.8	7.2	3.5	36.6	5.6	1.0
	NO_3^-	4.3	0.0	0.0	0.0	0.7	0.2	2.4	0.0	0.0	1.2	0.0	0.0
22/2/14	NH_4^+	6.6	1.5	2.7	8.4	5.6	4.5	5.6	7.3	17.4	10.1	9.0	7.3
	NO_3^-	0.0	0.0	1.7	0.0	0.0	0.2	0.0	1.7	2.6	1.9	0.0	2.1
28/2/14	NH_4^+	4.1	3.8	5.3	8.6	4.2	10	9.6	7.5	9.9	13.7	19.6	9.3
	NO_3^-	4.4	1.1	2.7	13.2	7.4	4.8	4.0	2.1	3.5	7.0	23.6	5.0
8/3/14	NH_4^+	1.4	8.5	0.9	9.0	3.1	5.8	1.7	6.4	6.5	31.4	0.6	11.1
	NO_3^-	4.0	0.0	0.0	4.1	0.0	6.0	0.0	2.3	1.4	7.1	0.5	0.0
21/3/14	NH_4^+	3.4	0.0	3.7	0.0	8.5	7.5	7.6	5.1	12.2	16.2	8.2	6.5
	NO_3^-	0.0	2.0	0.0	2.5	0.2	0.0	1.0	1.3	4.7	2.1	1.1	1.5
31/3/14	NH_4^+	8.5	13.9	7.7	12.2	1.5	6.1	5.6	8.0	4.9	19.6	11.5	7.5
	NO_3^-	4.1	8.4	3.3	2.2	2.7	2.3	1.6	1.5	1.6	0.8	1.9	2.7
16/4/14	NH_4^+	14.3	7.1	8.6	13.2	13.0	15	12.1	12.2	12.2	18.4	14.5	10.0
	NO_3^-	0.0	0.0	0.4	0.0	1.6	0.0	0.8	0.2	0.6	2.9	0.0	1.2
29/4/14	NH_4^+	4.5	6.5	4.3	7.9	5.5	5.6	6.0	3.1	8.2	18.0	6.3	9.8
	NO_3^-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0
17/5/14	NH_4^+	12.5	15.1	14.2	11.3	12.2	15.0	20.1	7.9	36.8	18.3	14.9	19.6
	NO_3^-	1.4	2.8	3.4	2.1	2.3	4.5	4.5	1.4	3.2	2.6	2.2	1.2
7/6/14	NH_4^+	17.2	12.5	10.7	13.2	4.5	7.7	3.2	7.7	13.0	8.6	7.5	11.0
	NO_3^-	1.7	2.9	0.9	1.6	0.8	0.7	0.2	2.7	1.1	1.0	0.0	0.4
5/7/14	NH_4^+	0.8	12.9	10.9	1.5	0.0	2.2	14.5	0.0	3.1	14.2	2.8	9.8
	NO_3^-	0.3	4.6	0.9	7.0	1.6	0.0	0.8	0.0	0.9	0.0	0.0	0.0
29/7/14	NH_4^+	12.7	11.4	7.1	12.4	14.1	24.5	0.0	34.7	24.0	39.0	16.9	26.9
	NO_3^-	6.2	2.1	2.0	3.4	2.1	9.4	0.0	13.1	4.6	8.9	9.4	10.3
16/8/14	NH_4^+	6.9	12.3	4.9	6.2	5.3	8.9	0.0	7.9	19.7	28.2	7.3	20.7
	NO_3^-	3.4	2.2	1.4	1.7	0.8	3.4	0.0	3.0	3.8	6.4	4.0	8.0
5/9/14	NH_4^+	2.1	4.4	12.7	0.6	12.0	5.2	4.5	1.1	1.5	5.1	4.0	4.8
	NO_3^-	1.6	1.4	0.4	3.3	1.0	0.6	0.9	0.3	0.1	0.2	0.0	2.0
26/9/14	NH_4^+	7.9	0.3	4.6	0.3	10.3	21.1	12.6	1.8	5.1	3.1	8.4	4.0
	NO_3^-	0.0	0.0	0.0	0.0	0.0	0.0	5.2	2.5	0.0	0.0	0.0	1.1
31/10/14	NH_4^+	9.2	5.6	5.5	5.9	3.7	4.3	3.0	6.1	16.1	8.2	12.6	8.2
	NO_3^-	0.0	3.8	1.7	1.0	0.3	0.2	3.1	5.1	5.0	4.9	5.2	7.3
14/11/14	NH_4^+	5.1	6.9	4.2	5.8	5.0	3.9	8.8	2.6	4.1	0.8	2.5	2.8
	NO_3^-	5.7	6.1	0.7	6.8	2.8	4.7	4.5	4.4	8.3	9.2	6.2	7.5
17/11/14	NH_4^+	16	13.7	17.5	25.8	14.9	59.1	20.9	411	15.5	30.9	12.2	12.8
	NO_3^-	12	9.7	5.9	8.5	7.4	9.1	6.7	7.5	2.6	3.5	4.6	14.2
20/11/14	NH_4^+	4.0	9.6	14.0	10.0	10.4	11.4	14.2	12.4	38.3	17.6	8.7	20.2
	NO_3^-	7.3	11.4	6.9	1.6	4.2	10.6	4.7	1.9	10.9	8.2	3.4	6.4
22/11/14	NH_4^+	14	8.7	10.0	57.4	6.9	7.4	7.5	14.2	8.0	6.9	10.4	3.5
	NO_3^-	19	5.4	4.5	2.3	2.5	6.3	6.3	2.1	0.8	2.0	0.9	3.7
29/11/14	NH_4^+	0.0	17.7	8.5	9.7	15.0	9.3	7.0	5.6	15.8	13.0	6.8	8.8
	NO_3^-	4.2	3.1	0.0	1.5	0.0	1.9	0.0	0.0	0.0	1.9	0.0	0.0
10/12/14	NH_4^+	4.4	15.4	6.9	12.4	5.3	11.1	6.1	6.4	5.1	6.9	5.0	11.6
	NO_3^-	0.7	15.0	1.9	-0.7	1.0	3.0	2.6	9.4	-2.3	-2.8	-0.8	-0.9
30/12/14	NH_4^+	4.7	3.3	3.4	4.0	0.5	-0.2	-2.3	1.5	3.8	10.5	9.8	7.0
	NO_3^-	2.7	3.4	1.0	-0.1	3.0	1.3	1.8	2.4	0.5	5.0	2.6	4.3

Bloco 2

Coleta	Data	N-mineral	T1 Rep 1	T1 Rep 2	T1 Rep 3	T1 Rep 4	T2 Rep 1	T2 Rep 2	T2 Rep 3	T2	T3 Rep 1	T3 Rep 2	T3 Rep 3	T3 Rep 4
1	24/12/13	NH_4^+	0.0	8.0	16.0	3.5	10.6	8.2	11.5	12.3	14.9	23.9	16.1	10.6
		NO_3^-	0.0	2.7	1.6	3.1	8.6	4.1	5.4	12.5	7.9	15.1	12.6	6.4
2	15/1/14	NH_4^+	9.2	14.0	11.9	13.8	19.0	19.6	15.8	27.5	10.9	8.0	12.9	11.2
		NO_3^-	6.4	11.1	13.4	19.1	17.0	19.0	13.2	19.8	12.9	5.8	4.6	4.3
3	17/1/14	NH_4^+	4.8	15.0	7.7	27.2	16.4	29.0	8.7	34.3	17.9	24.7	7.7	32.1
		NO_3^-	0.6	0.1	2.3	2.6	8.7	2.7	1.7	0.7	-0.3	-1.4	-0.9	0.3
4	20/1/14	NH_4^+	9.0	16.8	4.2	13.4	9.2	34.4	5.7	46.4	17.6	58.6	6.8	32.2
		NO_3^-	-2.0	6.2	-0.5	-0.1	5.3	-0.3	7.3	4.4	8.5	17.7	8.4	3.4
5	24/1/14	NH_4^+	7.7	12.7	8.6	10.8	13.3	37.9	6.5	57.8	6.8	8.8	15.9	21.4
		NO_3^-	1.2	3.0	0.2	-0.6	24.3	0.9	-0.5	3.3	1.6	4.4	1.5	3.6
6	4/2/14	NH_4^+	15.1	17.5	4.7	15.2	6.6	16.6	3.5	4.8	7.7	27.2	26.7	10.2
		NO_3^-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0	2.1	0.0	0.0
7	14/2/14	NH_4^+	10.5	8.2	14.6	12.6	4.3	11.9	19.0	11.6	7.1	17.1	6.8	10.1
		NO_3^-	0.0	0.0	0.0	0.0	0.0	1.8	0.0	2.9	0.0	1.4	0.0	0.0
8	22/2/14	NH_4^+	5.9	6.3	9.7	24.3	40.1	9.5	3.6	50.0	10.6	13.4	15.9	12.3
		NO_3^-	0.0	6.0	0.0	0.0	1.0	0.0	0.0	1.4	4.2	2.4	4.1	4.2
9	28/2/14	NH_4^+	8.1	0.0	10.1	15.8	13.6	18.5	12.9	22.8	14.8	15.5	9.5	15.2
		NO_3^-	16.5	0.0	4.8	14.3	14.5	8.4	5.1	21.8	11.3	11.8	7.6	8.9
10	8/3/14	NH_4^+	8.8	26.6	3.2	5.0	3.9	1.0	10.1	4.6	3.2	4.6	6.9	7.1
		NO_3^-	0.0	1.3	1.2	0.0	0.0	0.0	0.0	2.7	1.5	0.0	0.0	0.0
11	21/3/14	NH_4^+	0.5	0.5	0.0	1.4	0.9	2.1	6.4	4.8	8.5	9.8	9.9	6.1
		NO_3^-	0.0	1.9	2.5	3.2	0.9	0.5	1.6	2.2	1.5	1.4	0.0	0.2
12	31/3/14	NH_4^+	7.4	8.3	4.4	0.0	10.2	8.7	9.8	8.9	17.8	9.8	15.1	9.7
		NO_3^-	1.8	1.9	3.4	3.1	3.4	9.7	2.1	3.2	1.9	2.2	3.0	1.2
13	16/4/14	NH_4^+	17.4	8.7	9.1	8.9	7.7	13.2	7.8	5.7	15.4	18.8	13.0	20.0
		NO_3^-	0.4	1.0	0.2	4.2	0.0	2.2	3.5	3.1	2.8	2.9	2.6	4.4
14	29/4/14	NH_4^+	7.1	8.7	10.5	7.1	5.3	4.5	2.9	4.5	12.0	15.1	10.2	10.1
		NO_3^-	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	17/5/14	NH_4^+	21.3	16.6	17.6	22.3	14.9	12.6	11.5	10.0	15.2	8.1	15.7	10.8
		NO_3^-	2.3	2.8	1.3	3.0	2.2	2.9	2.7	2.6	5.6	6.4	3.9	4.0
16	7/6/14	NH_4^+	0.0	10.6	11.7	9.6	6.1	10.8	6.1	11.8	7.6	12.9	11.0	16.1
		NO_3^-	0.0	0.6	1.2	1.2	0.0	1.3	0.0	1.1	0.0	0.3	0.0	0.2
17	5/7/14	NH_4^+	9.0	6.1	17.4	8.4	2.3	0.2	0.1	2.6	2.3	2.0	12.0	5.1
		NO_3^-	0.0	1.3	0.0	0.2	4.3	1.4	0.0	0.0	0.7	0.0	0.0	0.0
18	29/7/14	NH_4^+	6.8	16.8	14.7	14.0	16.8	14.1	7.8	13.4	12.8	24.0	32.2	18.9
		NO_3^-	4.5	2.9	6.0	9.4	11.3	4.6	2.7	3.1	4.1	6.4	5.1	6.9
19	16/8/14	NH_4^+	8.1	18.7	7.9	10.0	19.7	16.0	15.4	31.7	12.6	46.3	29.2	15.2
		NO_3^-	5.4	3.3	3.3	6.7	13.3	5.2	5.4	7.3	4.0	12.4	4.6	5.5
20	5/9/14	NH_4^+	0.8	5.6	3.6	5.0	2.8	5.4	4.2	7.2	6.2	4.7	4.0	10.1
		NO_3^-	0.7	2.1	3.0	0.0	0.2	0.6	0.0	0.0	0.9	0.4	0.4	0.2
21	26/9/14	NH_4^+	6.7	5.2	2.0	-4.3	26.1	23.5	6.5	8.2	15.3	17.1	7.3	26.0
		NO_3^-	0.0	0.0	2.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0
22	31/10/14	NH_4^+	12.3	8.0	3.3	4.9	7.3	7.6	7.0	5.2	5.6	6.0	5.9	10.3
		NO_3^-	4.0	6.0	3.1	5.0	2.1	3.0	2.4	1.3	3.2	4.1	3.3	2.5
23	14/11/14	NH_4^+	2.0	1.5	3.4	3.5	2.3	1.6	4.2	4.3	4.0	5.1	3.0	3.8
		NO_3^-	5.7	9.5	4.8	5.9	4.7	2.3	2.7	4.1	2.4	2.3	2.4	6.6
24	17/11/14	NH_4^+	14.8	75.0	17.9	20.5	13.5	24.4	17.2	157.6	20.0	16.6	12.9	79.1
		NO_3^-	5.1	6.4	9.3	5.2	5.8	0.9	12.1	3.6	8.9	5.7	13.4	8.6
25	20/11/14	NH_4^+	14.3	10.5	14.5	16.8	15.6	16.4	26.0	24.0	7.8	13.5	18.9	26.3
		NO_3^-	8.8	2.7	7.4	1.5	4.2	3.2	21.6	17.4	8.0	3.9	5.1	13.9
26	22/11/14	NH_4^+	6.7	8.8	9.4	14.0	16.9	10.2	9.6	159.2	6.3	32.4	7.1	61.3
		NO_3^-	0.1	3.4	2.7	1.0	3.6	0.6	2.2	18.3	7.1	1.5	6.0	2.1
27	29/11/14	NH_4^+	11.0	25.1	2.2	10.3	7.4	2.4	7.8	0.8	7.9	4.6	12.6	12.5
		NO_3^-	0.0	5.8	0.0	0.8	0.1	0.8	0.5	0.9	0.6	0.0	0.5	18.2
28	10/12/14	NH_4^+	10.2	18.0	18.9	11.3	5.5	12.4	7.1	13.0	14.3	29.7	12.4	10.6
		NO_3^-	4.2	13.6	-3.7	-0.6	1.5	1.7	7.4	2.8	0.0	3.3	-0.8	3.8
29	30/12/14	NH_4^+	13.0	10.1	13.5	62.9	12.6	10.7	11.9	8.4	9.7	5.5	9.7	14.1
		NO_3^-	1.8	1.3	9.4	18.9	5.3	12.4	2.3	1.9	-0.1	5.9	1.6	1.6

Bloco 3

			T1				T2				T3			
Coleta	Data	N-mineral	Rep 1	Rep 2	Rep 3	Rep 4	Rep 1	Rep 2	Rep 3	Rep 4	Rep 1	Rep 2	Rep 3	Rep 4
1	24/12/13	NH_4^+	10.3	11.3	9.9	11.9	12.4	13.2	6.4	10.5	8.9	14.7	0.0	15.8
		NO_3^-	5.4	7.2	4.4	5.6	4.3	3.8	9.4	10.7	4.3	10.3	0.0	13.2
2	15/1/14	NH_4^+	12.2	12.1	13.6	12.9	21.7	21.0	9.5	15.5	19.4	21.1	16.4	21.3
		NO_3^-	12.3	12.3	13.0	10.1	20.3	11.4	3.7	17.0	7.9	10.9	8.4	12.7
3	17/1/14	NH_4^+	7.9	18.7	4.8	9.3	6.1	65.3	10.2	12.9	6.5	36.9	3.1	39.9
		NO_3^-	2.0	0.7	1.0	-0.2	1.8	1.9	4.1	0.1	0.8	-0.7	0.8	0.5
4	20/1/14	NH_4^+	4.9	22.4	7.7	25.3	13.0	20.1	10.2	22.2	8.0	6.5	11.3	23.6
		NO_3^-	2.6	0.9	4.7	2.4	1.5	2.4	2.0	1.4	2.5	3.7	1.7	1.5
5	24/1/14	NH_4^+	8.5	18.6	10.0	24.3	16.6	16.0	9.0	15.2	9.4	12.2	10.7	16.2
		NO_3^-	0.9	4.2	7.4	6.8	10.0	4.4	3.1	2.2	2.9	2.3	0.7	2.1
6	4/2/14	NH_4^+	-2.2	93.3	11.5	39.8	24.9	18.1	11.1	21.3	11.1	23.7	16.4	14.5
		NO_3^-	0.0	0.0	0.0	0.0	5.7	1.0	2.8	5.3	0.0	0.0	0.0	0.0
7	14/2/14	NH_4^+	7.1	4.4	10.0	10.5	17.2	7.7	7.5	9.3	22.4	5.5	5.0	11.2
		NO_3^-	0.0	0.0	0.0	0.0	1.4	0.5	1.5	3.3	0.0	0.0	0.0	0.0
8	22/2/14	NH_4^+	1.7	3.8	4.1	76.7	5.7	1.5	6.4	8.1	11.6	3.2	9.0	17.5
		NO_3^-	3.1	0.6	4.0	3.4	1.7	0.0	2.4	4.6	3.7	4.2	1.7	7.1
9	28/2/14	NH_4^+	8.6	14.4	15.0	7.0	19.0	26.5	17.8	21.5	17.5	11.8	18.5	16.1
		NO_3^-	28.1	10.0	11.1	11.3	15.7	12.3	25.3	4.9	8.2	7.3	13.0	15.1
10	8/3/14	NH_4^+	0.6	1.6	6.3	8.2	0.0	13.1	8.6	12.4	0.0	48.5	32.1	12.1
		NO_3^-	1.7	0.0	0.8	1.4	0.0	0.0	2.3	0.0	0.0	0.0	8.3	5.7
11	21/3/14	NH_4^+	15.1	3.3	0.0	1.9	3.3	5.2	5.9	7.0	9.9	17.3	4.8	3.8
		NO_3^-	1.4	0.0	0.8	1.9	1.1	0.5	0.4	0.9	0.6	0.2	1.0	0.7
12	31/3/14	NH_4^+	5.1	10.8	2.9	7.5	4.7	6.9	10.8	8.7	12.9	18.9	15.6	16.4
		NO_3^-	3.5	2.4	5.9	3.7	3.5	5.5	6.0	3.2	3.1	3.5	4.2	4.6
13	16/4/14	NH_4^+	8.5	13.4	17.6	18.2	8.7	12.7	11.2	9.3	17.8	37.1	14.6	17.6
		NO_3^-	2.7	2.0	4.5	2.1	1.1	4.8	1.7	1.1	5.6	2.9	2.4	2.8
14	29/4/14	NH_4^+	5.1	8.4	8.5	6.1	4.8	3.5	6.1	5.9	13.7	23.5	20.9	24.4
		NO_3^-	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.2	0.0	0.0	0.0
15	17/5/14	NH_4^+	23.7	7.5	7.9	14.6	13.1	7.9	12.0	14.2	20.3	19.0	16.9	23.8
		NO_3^-	12.5	4.6	4.1	4.5	2.1	5.0	5.3	2.4	4.8	3.9	1.6	3.7
16	7/6/14	NH_4^+	10.1	9.6	4.7	5.0	7.7	8.2	6.8	7.5	7.6	4.5	10.1	9.7
		NO_3^-	0.5	2.7	1.2	0.6	1.5	2.2	0.0	1.3	0.7	1.1	2.1	1.8
17	5/7/14	NH_4^+	2.0	2.5	0.0	3.3	0.0	4.7	17.0	0.0	8.4	7.6	8.8	10.7
		NO_3^-	1.3	0.9	0.0	4.2	0.0	0.0	4.9	0.0	2.6	5.5	1.3	5.1
18	29/7/14	NH_4^+	9.9	10.9	10.4	12.2	14.8	13.7	2.4	18.2	18.5	20.0	15.1	31.1
		NO_3^-	2.2	3.6	6.7	4.5	12.4	9.6	7.1	11.0	3.4	3.5	4.6	3.9
19	16/8/14	NH_4^+	17.1	17.1	16.3	22.4	18.8	14.7	1.8	47.8	18.2	27.4	17.8	25.1
		NO_3^-	3.7	5.7	10.4	8.3	15.7	10.4	5.3	28.8	3.4	4.8	5.4	3.2
20	5/9/14	NH_4^+	2.8	3.3	2.0	1.0	0.0	7.4	1.0	3.8	9.4	15.0	2.6	6.0
		NO_3^-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.3	0.0	1.6	0.6
21	26/9/14	NH_4^+	8.6	23.0	8.1	7.9	15.9	18.6	4.7	10.5	17.1	4.6	1.5	14.4
		NO_3^-	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.8	25.8	6.0
22	31/10/14	NH_4^+	6.5	0.0	10.0	7.5	6.9	6.8	5.2	5.1	3.9	6.1	7.5	5.0
		NO_3^-	3.1	0.0	-0.1	0.8	0.5	0.2	2.4	2.4	0.3	3.2	1.4	1.9
23	14/11/14	NH_4^+	5.8	3.8	1.2	4.9	4.9	3.7	4.8	4.3	3.5	7.5	4.6	5.8
		NO_3^-	3.3	4.5	4.5	3.9	6.1	2.1	2.8	3.9	2.7	4.7	7.2	6.4
24	17/11/14	NH_4^+	12.9	15.5	12.8	98.5	15.0	21.5	17.1	24.3	12.2	277.5	17.6	39.9
		NO_3^-	8.7	6.5	4.7	16.6	3.9	5.9	1.5	3.2	1.2	4.2	3.3	2.7
25	20/11/14	NH_4^+	34.4	181.4	14.7	105.7	12.0	101.5	33.2	105.1	11.8	25.1	23.6	13.1
		NO_3^-	12.6	14.8	13.7	24.2	2.3	5.2	7.4	5.2	2.7	14.3	2.0	2.4
26	22/11/14	NH_4^+	6.5	139.1	10.4	6.3	8.3	59.1	7.4	40.7	9.5	69.5	8.5	12.8
		NO_3^-	4.5	0.9	0.4	0.0	8.4	2.4	2.5	0.1	0.0	0.1	0.1	2.6
27	29/11/14	NH_4^+	12.8	31.5	7.9	9.2	10.8	5.2	1.2	34.2	6.9	9.7	8.5	4.6
		NO_3^-	0.9	0.0	0.1	5.3	1.5	1.4	2.8	1.6	0.0	4.3	2.0	0.7
28	10/12/14	NH_4^+	27.0	0.0	17.6	21.5	25.6	16.4	24.7	22.3	11.5	5.8	11.1	13.9
		NO_3^-	3.2	0.0	9.9	10.2	9.0	1.6	-3.8	9.0	1.3	0.7	3.5	0.0
29	30/12/14	NH_4^+	12.3	21.3	17.4	9.4	7.3	11.9	9.0	20.9	19.2	7.0	10.0	9.8
		NO_3^-	0.7	4.8	2.3	4.7	1.5	2.6	3.8	3.3	-2.6	0.2	0.6	0.4

NH_4^+ = Amônio NO_3^- = Nitrato

Apêndice 6. Espaço de poros do solo preenchido por água (EPPA).

Bloco 1

Coleta	**Data**	**T1**			**T2**			**T3**		
1	12/24/2013	34	34	34	31	36	33	39	39	38
2	1/15/2014	75	64	60	78	76	75	58	76	72
3	1/17/2014	49	70	52	58	60	62	62	60	61
4	1/20/2014	42	39	38	47	46	51	55	53	50
5	1/24/2014	38	34	33	36	34	38	37	39	18
6	2/4/2014	52	50	53	58	60	61	65	67	59
7	2/14/2014	61	56	62	75	79	75	72	74	72
8	2/22/2014	53	54	53	67	66	63	65	57	72
9	2/28/2014	63	62	63	73	76	70	85	86	81
10	3/8/2014	58	60	63	68	68	68	71	76	42
11	3/21/2014	80	81	71	75	78	86	74	70	71
12	3/31/2014	72	75	81	81	82	84	84	87	82
13	4/16/2014	75	80	80	74	79	74	79	74	74
14	4/29/2014	76	70	73	68	58	62	61	58	60
15	5/17/2014	76	74	74	85	80	82	81	83	84
16	6/7/2014	76	75	76	79	83	82	82	88	84
17	7/5/2014	88	88	93	101	96	106	93	94	92
18	7/29/2014	80	91	71	88	83	89	82	85	74
19	8/16/2014	77	78	84	15	81	90	90	101	84
20	9/5/2014	76	78	77	72	85	83	79	81	79
21	9/26/2014	83	79	76	84	87	83	89	78	73
22	10/31/2014	75	94	91	89	83	90	85	88	92
23	11/14/2014	74	80	82	76	81	80	82	79	81
24	11/17/2014	70	70	63	62	61	67	67	64	68
25	11/20/2014	57	55	51	44	51	47	56	53	53
26	11/22/2014	85	76	85	82	87	81	82	88	85
27	11/29/2014	43	47	45	50	64	64	59	54	56
28	12/10/2014	59	52	55	59	70	69	63	52	71
29	29/12/14	67	68	66	73	73	76	81	80	86

					Bloco 2					
Coleta	**Data**	**T1**			**T3**			**T2**		
1	12/24/2013	39	40	40	65	61	66	35	34	33
2	1/15/2014	70	66	68	77	87	79	64	70	70
3	1/17/2014	53	51	55	62	69	64	54	58	54
4	1/20/2014	46	45	42	55	54	49	44	43	44
5	1/24/2014	34	35	8	46	50	35	34	39	39
6	2/4/2014	60	56	55	71	72	66	58	48	57
7	2/14/2014	70	70	65	83	79	78	68	72	67
8	2/22/2014	63	55	64	62	69	65	75	59	62
9	2/28/2014	68	72	70	87	84	81	74	69	65
10	3/8/2014	66	72	64	80	85	89	62	63	64
11	3/21/2014	83	86	88	98	90	92	74	69	68
12	3/31/2014	81	83	60	101	107	102	79	72	74
13	4/16/2014	81	74	75	98	105	95	67	70	66
14	4/29/2014	63	66	64	100	99	94	53	59	60
15	5/17/2014	77	82	85	98	102	107	74	74	73
16	6/7/2014	88	81	81	111	106	103	74	71	76
17	7/5/2014	91	97	95	94	93	92	106	95	93
18	7/29/2014	76	85	86	104	102	100	79	75	76
19	8/16/2014	85	73	0	103	100	94	82	84	98
20	9/5/2014	80	77	87	101	104	105	75	75	73
21	9/26/2014	82	93	84	115	107	101	98	77	75
22	10/31/2014	81	81	82	103	109	113	81	83	78
23	11/14/2014	78	92	82	100	109	101	72	73	73
24	11/17/2014	69	69	78	106	109	102	62	63	71
25	11/20/2014	63	59	60	102	89	98	51	50	53
26	11/22/2014	81	80	77	106	110	103	73	73	81
27	11/29/2014	66	77	65	84	79	101	59	51	50
28	12/10/2014	60	60	63	85	80	90	57	50	48
29	29/12/14	80	76	77	109	104	91	70	78	74

Bloco 3

coleta	Data	T1			T2			T3		
1	12/24/2013	78	75	75	45	44	58	45	34	50
2	1/15/2014	72	81	76	66	68	68	85	86	88
3	1/17/2014	67	68	70	58	55	58	65	73	70
4	1/20/2014	48	63	52	40	49	50	64	46	55
5	1/24/2014	44	42	43	39	40	32	42	50	43
6	2/4/2014	58	60	52	62	66	60	68	73	67
7	2/14/2014	64	75	67	69	69	69	95	85	77
8	2/22/2014	62	71	64	59	57	57	72	82	66
9	2/28/2014	76	86	70	77	77	74	83	76	85
10	3/8/2014	94	88	95	80	81	87	90	87	87
11	3/21/2014	80	84	89	90	87	81	95	95	100
12	3/31/2014	95	106	102	82	85	95	100	102	96
13	4/16/2014	98	90	94	85	92	88	94	93	98
14	4/29/2014	96	89	92	86	90	82	95	84	77
15	5/17/2014	108	96	103	84	88	91	89	94	102
16	6/7/2014	107	105	108	93	97	92	93	95	111
17	7/5/2014	111	111	98	100	99	97	103	109	103
18	7/29/2014	116	108	105	92	00	87	107	99	95
19	8/16/2014	93	98	85	84	98	81	96	102	98
20	9/5/2014	115	107	106	96	93	98	104	100	93
21	9/26/2014	101	102	109	100	09	87	109	108	100
22	10/31/2014	107	110	114	97	98	92	98	105	101
23	11/14/2014	103	107	115	101	94	89	0	94	108
24	11/17/2014	102	112	105	86	89	89	80	82	82
25	11/20/2014	102	98	95	88	88	90	75	74	66
26	11/22/2014	109	112	115	92	93	91	97	95	99
27	11/29/2014	112	107	119	85	80	84	57	64	73
28	12/10/2014	105	90	93	81	81	72	71	65	67
29	29/12/14	107	104	109	86	**79**	**77**	89	95	96

Apêndice 7. Teor de N na solução lixiviada (NH_4^+ + NO_3^-) dos lisimetros.

		Bloco 1											
		T1				**T3**				**T2**			
		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Coleta	Data	sem	com	sem	com	sem	com	sem	com	sem	com	sem	com
1	30/1/14	-	-	-	-	2.35	-	1.88	-	-	10.22	6.57	-
2	27/2/14	0.64	3.22	0.68	1.38	0.88	0.29	0.25	0.41	0.29	0.29	0.45	1.11
3	5/3/14	1.69	0.55	0.85	0.68	0.65	0.98	1.49	1.05	0.92	1.69	1.08	0.98
4	19/3/14	1.76	2.19	1.49	2.27	1.96	2.47	1.22	2.19	1.49	1.65	1.34	1.22
5	01/4/14	0.44	0.95	0.75	0.28	0.48	1.76	0.71	0.63	0.95	0.71	0.28	0.71
6	15/4/14	0.09	1.53	0.75	-	1.30	0.48	1.30	0.67	0.44	0.48	0.79	0.05
7	20/5/14	-	-	0.30	0.59	0.41	0.66	0.66	1.02	0.44	0.73	0.73	1.20
8	6/7/14	0.19	0.55	0.55	0.73	0.55	0.77	1.31	1.02	0.80	1.42	1.67	1.20
9	28/7/14	0.35	-	-	-		0.06	-	0.28	0.03	0.32		0.24
10	13/8/14	0.27	0.84	1.00	0.35	0.52	0.27	0.27	1.20	-	-	1.37	-
11	16/9/14	0.16	0.29	0.29	0.33	0.29	0.16	0.33	0.57	0.41	0.57	0.49	0.45
12	4/11/14	-	0.07	0.77	0.07	0.28	-	1.42	0.48	0.40	-	-	0.11
13	23/11/14	1.11	1.03	0.62	1.44	1.31	-	2.67	36.24	1.68	-	1.27	1.93

		Bloco 2											
Nº Coleta	Data	T1				T3				T2			
1	30/1/14	1.51	-	-	1.14		0.64	-	-	0.97	5.70	-	-
2	27/2/14	-	0.06	-	0.25		0.02	0.10	0.53	0.06	1.11	0.33	0.57
3	5/3/14	0.71	1.79	0.65	1.15	1.95	1.92	0.92	1.49	0.41	2.83	2.72	1.55
4	19/3/14	2.04	4.85	1.30	2.31	1.88	2.08	1.49	3.29	4.34	1.92	1.84	0.75
5	01/4/14	0.59	0.91	0.36	1.37	0.13	0.59	1.30	0.75	0.24	1.14	1.06	0.83
6	15/4/14	-	0.95	0.67	1.10	0.87	1.06	1.37	1.14	0.91	0.83	0.75	3.91
7	20/5/14	1.06	0.84	0.55	1.63	0.26	0.98	0.66	0.16	0.05	0.26	0.44	0.30
8	6/7/14	0.98	1.38	1.56	1.09	1.31	0.62	1.20	0.30	0.77	0.16	0.77	0.37
9	28/7/14	0.14	0.39	0.57	0.03	0.10	0.06	-	-	0.14	-	-	-
10	13/8/14	0.44	-	0.56	0.03	0.52	-	0.15	0.07	0.52	-	0.31	-
11	16/9/14	0.25	0.74	1.44	0.49	0.82	0.66	0.62	0.45	0.33	0.37	0.45	0.45
12	4/11/14	0.65	0.97	0.19	0.56	0.60	1.59	0.03	1.26	0.19	0.85	0.03	0.60
13	23/11/14	1.15	1.52	1.80	3.28	1.07	0.49	1.27	0.82	0.94	-	1.76	-

Bloco 3

Nº Coleta	Data	T1 L1 sem	T1 L2 com	T1 L3 sem	T1 L4 com	T2 L5 sem	T2 L6 com	T2 L7 sem	T2 L8 com	T3 L9 sem	T3 L10 com	T3 L11 sem	T3 L12 com
1	30/1/14	1.81	2.04	-	1.27	1.37	-	-	11.46	-	1.34	1.54	-
2	27/2/14	0.33	2.79	1.03	0.64	1.03	0.99	0.53	1.19	0.45	0.57	1.07	1.07
3	5/3/14	1.69	1.99	0.75	2.52	1.08	1.85	1.49	1.65	1.32	1.49	1.59	2.52
4	19/3/14	0.79	3.05	2.12	1.96	1.53	2.19	1.30	1.49	1.37	2.58	0.98	2.08
5	01/4/14	0.98	1.73	0.71	1.69	0.87	0.40	0.52	0.17	-	0.48	-	0.32
6	15/4/14	1.26	-	1.22	0.05	0.67	1.41	1.34	0.95	1.34	1.92	0.71	1.34
7	20/5/14	0.84	0.84	0.19	0.66	0.08	-	0.16	0.55	0.12	0.23	0.26	0.12
8	6/7/14	0.48	0.26	0.98	0.66	0.44	0.01	0.95	0.30	-	0.19	0.08	0.30
9	28/7/14	-	0.14	-	0.14	-	-	-	0.14	-	0.21	-	0.46
10	13/8/14	0.44	-	-	0.03	0.56	-	0.23	-	0.68	-	-	-
11	16/9/14	0.90	0.82	1.03	0.78	0.74	0.45	0.86	0.98	0.66	0.74	0.70	1.03
12	4/11/14	0.52	0.32	0.69	-	0.81	0.07	0.07	0.19	-	0.11	0.32	0.15
13	23/11/14	0.98	1.19	1.23	0.74	0.70	1.27	0.78	2.34	1.11	-	-	-

L= Lisímetro

Sem = sem adubação da pastagem

Com = com adubação da pastagem

Apêndice 8. Massa de N em (kg de NH_4^+ + NO_3^- ha^{-1}) perdida por lixiviação nos lisímetros.

						Bloco1						
Lisímet	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Trat		T1					T2			T3		
Adub	sem	com	sem	com	sem	com	sem	com	Sem	Com	Sem	Com
30/1/14	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.0
27/2/14	0.1	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.2
5/3/14	0.4	0.1	0.2	0.2	0.1	0.2	0.3	0.2	0.2	0.4	0.2	0.2
19/3/14	2.1	1.6	0.8	1.7	1.8	1.2	0.7	1.2	0.7	0.7	0.6	0.5
01/4/14	0.3	0.4	0.3	0.1	0.2	0.8	0.3	0.2	0.2	0.2	0.0	0.2
15/4/14	0.0	0.7	0.4	0.0	0.4	0.2	0.6	0.3	0.1	0.1	0.4	0.0
20/5/14	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.1	0.3
6/7/14	0.1	0.4	0.5	0.6	0.6	2.2	2.0	0.9	0.5	0.8	0.8	0.6
28/7/14	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1
13/8/14	0.4	1.0	0.6	0.3	0.1	0.1	0.1	0.3	0.0	0.0	0.0	0.0
16/9/14	0.4	0.6	0.2	0.3	0.2	0.1	0.3	0.3	0.2	0.3	0.2	0.2
4/11/14	0.0	0.0	0.4	0.0	0.1	0.0	0.7	0.2	0.1	0.0	0.0	0.0
23/11/1	0.3	0.3	0.1	0.3	0.1	0.0	0.0	0.3	0.2	0.0	0.2	0.2
						Bloco 2						
Data	sem	com	sem	com	sem	com	sem	com	sem	com	sem	
30/1/14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
27/2/14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1
5/3/14	0.2	0.4	0.1	0.2	1.8	1.0	0.6	0.7	0.1	0.6	0.6	0.3
19/3/14	0.9	2.2	0.6	1.0	1.0	2.8	0.9	4.9	1.9	0.9	0.8	0.3
1/4/14	0.3	0.4	0.2	0.6	0.1	0.5	1.1	0.7	0.1	0.5	0.5	0.4
5/4/14	0.0	0.3	0.2	0.4	0.6	0.7	0.7	0.8	0.3	0.4	0.3	1.8
20/5/14	0.2	0.2	0.1	0.4	0.2	0.6	0.4	0.1	0.0	0.1	0.2	0.1
6/7/14	0.7	0.8	1.1	0.9	1.5	0.6	1.3	0.3	0.5	0.1	0.5	0.3
28/7/14	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13/8/14	0.1	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16/9/14	0.3	1.0	1.6	0.6	1.4	1.1	1.1	0.8	0.6	0.6	0.6	0.7
4/11/14	0.3	0.5	0.1	0.3	0.3	1.3	0.0	0.7	0.1	0.6	0.0	0.3
23/11/1	0.3	0.3	0.4	0.7	0.3	0.1	0.3	0.2	0.0	0.0	0.0	0.0
						Bloco 3						
Data	sem	com	sem	com	sem	com	sem	com	com	sem	com	sem
30/1/14	0.1	0.1	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0
27/2/14	0.2	2.9	3.5	0.6	0.2	0.2	0.1	0.3	0.0	0.1	0.1	0.0
5/3/14	1.6	1.7	1.3	1.9	0.7	0.8	0.9	0.8	0.6	0.7	0.7	0.6
19/3/14	1.5	6.0	5.1	3.8	2.7	3.6	1.4	2.1	1.9	3.1	1.3	2.7
01/4/14	0.9	1.4	0.8	1.5	0.6	0.3	0.3	0.1	0.0	0.3	0.0	0.2
15/4/14	0.5	0.0	0.8	0.0	0.2	0.6	0.6	0.4	0.6	0.5	0.2	0.3
20/5/14	0.5	0.5	0.1	0.4	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1
6/7/14	0.5	0.3	1.2	0.8	0.3	0.0	1.0	0.2	0.0	0.2	0.1	0.3
28/7/14	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
13/8/14	0.8	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
16/9/14	1.6	1.4	1.8	1.4	1.3	0.8	1.5	1.7	1.1	1.3	1.1	1.5
4/11/14	0.7	0.4	0.9	0.0	0.4	0.0	0.0	0.1	0.0	0.1	0.2	0.1
23/11/1	0.3	0.5	0.4	0.3	0.1	0.3	0.2	0.4	0.0	0.0	0.0	0.0

L= Lisímetro

Apêndice 9. Massa de COD em (kg COD ha^{-1}) perdido por lixiviação nos lisímetros.

	Lisímetros	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Nº col	TRAT/DATA	T1				T3				T2			
1	30/1/14	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.4	0.1	0.0
2	27/2/14	3.4	0.4	2.2	0.8	4.0	5.6	7.5	7.4	9.7	11.8	8.9	10.7
3	5/3/14	3.2	1.4	2.0	3.6	0.0	1.0	2.8	2.7	1.0	1.0	0.7	0.7
4	19/3/14	32.6	12.4	2.5	27.2	22.1	12.0	7.3	6.1	8.0	7.8	7.9	13.6
5	01/4/14	8.7	2.3	2.3	34.1	8.1	27.8	4.6	6.9	5.1	2.6	0.4	7.5
6	15/4/14	5.5	0.9	2.1	5.8	3.3	4.9	1.9	4.6	0.7	1.9	1.9	1.2
7	20/5/14	3.5	5.3	6.3	8.6	4.8	0.0	1.3	2.2	0.0	0.0	0.9	4.0
8	6/7/14	1.0	2.7	1.1	4.1	0.0	21.5	7.8	1.1	3.3	0.0	0.0	0.0
9	28/7/14	1.2	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	13/8/14	15.8	10.9	0.0	0.0	0.5	0.3	4.4	0.6	0.0	0.0	0.0	0.4
11	16/9/14	0.0	0.0	0.0	10.4	13.1	0.0	0.0	0.0	0.0	9.3	0.0	0.0
12	4/11/14	8.8	0.0	8.3	29.3	7.8	8.0	15.5	3.8	0.0	5.3	2.2	0.9
13	23/11/14	1.9	5.8	2.4	7.4	0.8	0.0	0.1	0.3	0.0	0.0	0.4	0.0
								Bloco 2					
Nº col	TRAT/DATA	T1				T3				T2			
1	30/1/14	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	27/2/14	3.9	0.3	4.4	1.0	1.7	2.1	1.3	0.5	2.7	3.2	2.4	8.6
3	5/3/14	2.3	3.6	0.0	2.9	0.0	4.8	7.7	4.5	1.8	3.1	0.4	4.9
4	19/3/14	16.1	13.8	8.4	11.5	10.5	27.1	10.0	32.9	19.0	6.2	9.5	17.1
5	01/4/14	24.3	15.0	15.0	2.9	33.1	5.8	18.9	14.6	3.4	3.0	21.9	6.4
6	15/4/14	2.6	1.5	1.5	5.7	10.6	2.3	6.1	15.3	6.3	12.3	9.5	13.3
7	20/5/14	3.5	3.5	3.1	7.0	15.7	11.3	17.4	13.9	7.0	2.9	2.9	7.0
8	6/7/14	0.0	0.0	0.0	0.0	32.4	0.0	9.7	1.3	0.0	0.0	0.0	0.0
9	28/7/14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	13/8/14	0.6	2.3	3.8	1.8	3.5	5.3	4.2	3.8	0.0	0.3	0.0	0.2
11	16/9/14	0.0	14.1	19.5	0.0	0.0	12.5	0.0	7.8	36.9	15.6	10.2	0.0
12	4/11/14	7.1	1.1	0.0	6.7	3.5	2.6	0.5	1.8	4.8	0.0	1.8	0.0
13	23/11/14	4.8	0.0	0.0	0.0	1.9	2.1	1.0	0.7	0.0	0.0	0.0	0.0
								Bloco 3					
Nº col	TRAT/DATA	T1				T2				T3			
1	30/1/14	0.5	0.4	0.0	0.1	2.0	0.0	0.0	0.7	0.0	0.5	0.1	0.0
2	27/2/14	12.3	22.4	72.3	15.1	0.9	5.5	1.2	3.8	2.0	1.9	3.1	0.4
3	5/3/14	5.8	26.2	155.8	2.2	7.6	11.9	41.9	0.0	28.7	29.5	22.2	9.7
4	19/3/14	45.6	18.7	63.4	68.4	55.3	19.3	1.2	31.9	25.1	34.8	22.1	26.3
5	01/4/14	15.5	24.0	16.1	9.5	4.5	5.1	1.0	6.9	8.2	1.3	16.1	12.2
6	15/4/14	3.9	17.4	5.9	26.4	10.4	0.9	13.5	7.5	15.6	5.4	2.0	3.4
7	20/5/14	10.4	11.3	14.8	4.3	10.4	6.4	10.4	10.4	0.0	0.0	0.0	2.9
8	6/7/14	0.0	0.0	0.0	0.0	0.0	6.7	0.0	3.0	1.9	0.0	0.0	8.7
9	28/7/14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	13/8/14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.0
11	16/9/14	1.9	0.0	0.0	0.0	11.7	0.0	15.6	11.7	21.4	13.6	15.3	24.8
12	4/11/14	9.2	4.6	0.0	8.2	4.4	3.5	5.5	7.4	7.1	4.7	7.7	5.3
13	23/11/14	0.4	0.0	3.2	1.5	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0

Apêndice 10. Produção total e diária de massa seca de forragens e incremento de altura do pasto no período de 2013 a 2014.

Piquete	Tratamento	Bloco	Subparcela	Período	Ptotal	Prod	Hacum	Hacdia
1	3	1	1	1	808.1	11.5	23.5	0.3
1	3	1	2	1	539.7	7.7	17.0	0.2
2	1	1	1	1	1059.0	15.1	15.7	0.2
2	1	1	2	1	471.0	6.7	13.8	0.2
3	4	1	1	1	340.3	4.9	9.1	0.1
3	4	1	2	1	539.1	7.7	13.5	0.2
4	2	1	1	1	383.4	5.5	10.3	0.1
4	2	1	2	1	700.0	10.0	6.1	0.1
5	1	2	1	1	674.0	9.6	22.5	0.3
5	1	2	2	1	583.6	8.3	12.1	0.2
6	4	2	1	1	1226.6	17.5	23.9	0.3
6	4	2	2	1	996.8	14.2	21.4	0.3
7	3	2	1	1	1427.5	20.4	22.8	0.3
7	3	2	2	1	705.3	10.1	25.3	0.4
8	2	2	1	1	739.6	10.6	15.4	0.2
8	2	2	2	1	1125.8	16.1	18.8	0.3
9	3	3	1	1	103.5	1.5	11.0	0.2
9	3	3	2	1	-612.9	-8.8	12.9	0.2
10	1	3	1	1	624.4	8.9	12.2	0.2
10	1	3	2	1	770.6	11.0	18.3	0.3
11	2	3	1	1	828.0	11.8	12.7	0.2
11	2	3	2	1	905.8	12.9	16.7	0.2
12	4	3	1	1	261.4	3.7	16.1	0.2
12	4	3	2	1	628.0	9.0	15.9	0.2
1	3	1	1	2	736.8	10.7	21.8	0.3
1	3	1	2	2	1684.0	24.4	30.2	0.4
2	1	1	1	2	1270.4	18.4	16.2	0.2
2	1	1	2	2	1572.6	22.8	25.8	0.4
3	4	1	1	2	358.8	5.2	11.9	0.2
3	4	1	2	2	947.7	13.7	27.1	0.4
4	2	1	1	2	956.8	13.9	16.5	0.2
4	2	1	2	2	2002.6	29.0	25.8	0.4
5	1	2	1	2	755.4	10.9	16.4	0.2
5	1	2	2	2	2751.4	39.9	34.6	0.5
6	4	2	1	2	916.5	13.3	20.2	0.3
6	4	2	2	2	2220.0	32.2	32.2	0.5
7	3	2	1	2	1360.9	19.7	25.4	0.4
7	3	2	2	2	2289.8	33.2	28.2	0.4
8	2	2	1	2	1873.8	27.2	17.2	0.2
8	2	2	2	2	2552.2	37.0	37.1	0.5
9	3	3	1	2	118.6	1.7	12.4	0.2
10	1	3	1	2	461.8	6.7	13.1	0.2
10	1	3	2	2	1844.2	26.7	31.5	0.5
11	2	3	1	2	1106.8	16.0	17.6	0.3
11	2	3	2	2	1643.0	23.8	31.9	0.5

12	4	3	1	2	1480.2	21.5	22.4	0.3
12	4	3	2	2	1499.7	21.7	25.2	0.4
1	3	1	1	3	384.6	4.8	2.2	0.0
1	3	1	2	3	1497.0	18.7	12.0	0.2
2	1	1	1	3	463.2	5.8	7.6	0.1
2	1	1	2	3	1471.2	18.4	11.1	0.1
3	4	1	1	3	420.4	5.3	6.8	0.1
3	4	1	2	3	1750.2	21.9	17.8	0.2
4	2	1	1	3	288.2	3.6	9.1	0.1
4	2	1	2	3	815.6	10.2	18.8	0.2
5	1	2	1	3	258.6	3.2	5.3	0.1
5	1	2	2	3	430.2	5.4	7.6	0.1
6	4	2	1	3	947.6	11.8	7.2	0.1
6	4	2	2	3	1073.0	13.4	14.3	0.2
7	3	2	1	3	183.6	2.3	5.5	0.1
7	3	2	2	3	2136.6	26.7	23.8	0.3
8	2	2	1	3	398.0	5.0	8.0	0.1
8	2	2	2	3	1692.2	21.2	18.4	0.2
9	3	3	1	3	289.6	3.6	7.1	0.1
9	3	3	2	3	1478.2	18.5	20.2	0.3
10	1	3	1	3	204.4	2.6	10.7	0.1
10	1	3	2	3	495.6	6.2	14.1	0.2
11	2	3	1	3	408.0	5.1	10.0	0.1
11	2	3	2	3	1096.4	13.7	12.8	0.2
12	4	3	1	3	-701.8	-8.8	-0.8	0.0
12	4	3	2	3	722.6	9.0	13.5	0.2

Apêndice 11. Produção de massa seca e altura diária e total de forragens em sistema silvipastoril**.**

Outubro à Dezembro de 2013

Intervalo dias: 70

Piquetes	SubPar.	Amostra	H total (cm)	H diária (cm)	MF total (Kg MS/ha)	diária(Kg MS/ha)
1	1	**não Adub.**	23.5	0.34	808.1	11.5
1	2	**Adubado**	17.0	0.24	539.7	7.7
2	1	**não Adub.**	15.7	0.22	1059.0	15.1
2	2	**Adubado**	13.8	0.20	471.0	6.7
3	1	**não Adub.**	9.1	0.13	340.3	4.9
3	2	**Adubado**	13.5	0.19	539.1	7.7
4	1	**não Adub.**	10.3	0.15	383.4	5.5
4	2	**Adubado**	6.1	0.09	700.0	10.0
5	1	**não Adub.**	22.5	0.32	674.0	9.6
5	2	**Adubado**	12.1	0.17	583.6	8.3
6	1	**não Adub.**	23.9	0.34	1226.6	17.5
6	2	**Adubado**	21.4	0.31	996.8	14.2
7	1	**não Adub.**	22.8	0.33	1427.5	20.4
7	2	**Adubado**	25.3	0.36	705.3	10.1
8	1	**não Adub.**	15.4	0.22	739.6	10.6
8	2	**Adubado**	18.8	0.27	1125.8	16.1
9	1	**não Adub.**	11.0	0.16	103.5	1.5
9	2	**Adubado**	12.9	0.18	-612.9	-8.8
10	1	**não Adub.**	12.2	0.17	624.4	8.9
10	2	**Adubado**	18.3	0.26	770.6	11.0
11	1	**não Adub.**	12.7	0.18	828.0	11.8
11	2	**Adubado**	16.7	0.24	905.8	12.9
12	1	**não Adub.**	16.1	0.23	261.4	3.7
12	2	**Adubado**	15.9	0.23	628.0	9.0

Dezembro de 2013 à Fevereiro de 2014

Intervalo dias: 69

Piquetes	SubPar.	Amostras	H total / (cm)	Diária (cm)	MF Total(Kg MS/ha)	diária(Kg MS/ha)
1	1	**não Adub.**	21.8	0.32	736.8	10.7
1	2	**Adubado**	30.2	0.44	1684.0	24.4
2	1	**não Adub.**	16.2	0.23	1270.4	18.4
2	2	**Adubado**	25.8	0.37	1572.6	22.8
3	1	**não Adub.**	11.9	0.17	358.8	5.2
3	2	**Adubado**	27.1	0.39	947.7	13.7
4	1	**não Adub.**	16.5	0.24	956.8	13.9
4	2	**Adubado**	25.8	0.37	2002.6	29.0
5	1	**não Adub.**	16.4	0.24	755.4	10.9
5	2	**Adubado**	34.6	0.50	2751.4	39.9
6	1	**não Adub.**	20.2	0.29	916.5	13.3
6	2	**Adubado**	32.2	0.47	2220.0	32.2
7	1	**não Adub.**	25.4	0.37	1360.9	19.7
7	2	**Adubado**	28.2	0.41	2289.8	33.2
8	1	**não Adub.**	17.2	0.25	1873.8	27.2
8	2	**Adubado**	37.1	0.54	2552.2	37.0
9	1	**não Adub.**	12.4	0.18	118.6	1.7
9	2	**Adubado**	20.4	0.30	876.0	12.7
10	1	**não Adub.**	13.1	0.19	461.8	6.7
10	2	**Adubado**	31.5	0.46	1844.2	26.7
11	1	**não Adub.**	17.6	0.26	1106.8	16.0
11	2	**Adubado**	31.9	0.46	1643.0	23.8
12	1	**não Adub.**	22.4	0.32	1480.2	21.5
12	2	**Adubado**	25.2	0.37	1499.7	21.7

Fevereiro à Maio de 2014

Intervalo dias: 80

Piquetes	SubPar.	Amostra	H total (cm)	Diária (cm)	MF total (Kg MS/ha)	Diária(Kg MS/ha)
1	1	**não Adub.**	2.2	0.03	384.6	4.8
1	2	**Adubado**	12.0	0.15	1497.0	18.7
2	1	**não Adub.**	7.6	0.10	463.2	5.8
2	2	**Adubado**	11.1	0.14	1471.2	18.4
3	1	**não Adub.**	6.8	0.09	420.4	5.3
3	2	**Adubado**	17.8	0.22	1750.2	21.9
4	1	**não Adub.**	9.1	0.11	288.2	3.6
4	2	**Adubado**	18.8	0.24	815.6	10.2
5	1	**não Adub.**	5.3	0.07	258.6	3.2
5	2	**Adubado**	7.6	0.10	430.2	5.4
6	1	**não Adub.**	7.2	0.09	947.6	11.8
6	2	**Adubado**	14.3	0.18	1073.0	13.4
7	1	**não Adub.**	5.5	0.07	183.6	2.3
7	2	**Adubado**	23.8	0.30	2136.6	26.7
8	1	**não Adub.**	8.0	0.10	398.0	5.0
8	2	**Adubado**	18.4	0.23	1692.2	21.2
9	1	**não Adub.**	7.1	0.09	289.6	3.6
9	2	**Adubado**	20.2	0.25	1478.2	18.5
10	1	**não Adub.**	10.7	0.13	204.4	2.6
10	2	**Adubado**	14.1	0.18	495.6	6.2
11	1	**não Adub.**	10.0	0.13	408.0	5.1
11	2	**Adubado**	12.8	0.16	1096.4	13.7
12	1	**não Adub.**	-0.8	-0.01	-701.8	-8.8
12	2	**Adubado**	13.5	0.17	722.6	9.0

LEGENDA:

Piquete = 1 a 12

Tratamento 1 = pastagem pura; 2 = 4x2; 3 = 10(2x2); 4 = 6(2x2)

Bloco = 1 a 3

Subparcela 1 = não adubada; 2 = adubada

Período = 1 = out-dez; 2 = dez-fev; 3 = fev-mai

Ptotal = Produção total de biomassa no período (kg MS ha^{-1})

Prod = Produtividade de biomassa no período (kg MS ha^{-1} dia^{-1})

Hacum = Incremento de altura do pasto no quadro de corte (cm) no período

Hacdia = Incremento diário de altura do pasto no quadro de corte (cm dia^{-1}) no período