

Production, Management and the Environment: Environmental Quality

W236 Using dietary saponin extracts to reduce methane emissions from steers. W. Li* and W. Powers, *Michigan State University, East Lansing.*

A total of 3 experiments (Exp), in vitro and in vivo, were conducted to investigate the effects of saponin extracts from *Quillaja saponaria* (QS), *Yucca schidigera* (YS) and *Camellia sinensis* (TS) on CH₄ emissions from steers. The in vitro Exp was carried out to determine the effects of saponin inclusion on ruminal methanogenesis and fermentation parameters. Two doses (0.5% and 2.0% of substrate DM) of each saponin were added to the mixture of rumen fluid and buffer for 0, 4, 8, 12 and 24 h incubation. During the in vivo experiments (Exp 1 and 2), concentrations of saponin extracts added to the diets were determined based on the actual saponin content in the extract to provide 0.54 g/kg DM saponin in the diets. Exp 1 used a 3 × 3 Latin Square design with 4 replicates for each treatment, to compare the effects of saponin containing diets, QS (LQS, 1.5% DM) and YS (LYS, 0.64% DM), to a corn and corn silage based control (C1) treatment on enteric CH₄ emissions. Exp 2 used a 2 × 2 Latin Square design with 6 replicates to evaluate the effect of TS (LTS, 0.25%) on enteric CH₄ emissions, by comparing it to a corn and corn silage based control diet (C2). For each study, 12 Holstein steers were individually housed in environmental rooms for 14 d per period. Methane concentrations were monitored in room exhaust air. In the in vitro experiment, both inclusion rates reduced in vitro CH₄ production in all saponin treatments at 24 h incubation ($P < 0.01$), while gas production and pH were not affected ($P > 0.05$). Acetate concentration was reduced in all treatments except 0.5% QS and 0.5% YS ($P < 0.01$). With the exception of the QS 0.5% treatment, all saponin treatments reduced A:P ratio and the NH₄-N concentration compared with the control treatment, at 24hr time point ($P < 0.01$). During both in vivo Exp, feeding saponins to steers did not change ADG or manure excretion characteristics ($P > 0.05$), but decreased DMI with TS saponin supplementation ($P < 0.01$). Methane emission mass, emission factors and manure excretions were not affected by dietary saponin inclusion. Results indicated that dietary supplementation of 0.54 g/kg DM saponin did not decrease ruminal CH₄ emissions.

Key Words: saponin extracts, CH₄ emissions, Holstein steer

W237 Does total condensed tannin concentration predict rumen methane production in vitro? H. D. Naumann*¹, L. O. Tedeschi¹, J. P. Muir², B. D. Lambert^{2,3}, D. K. Andrade Silva⁴, and M. A. Fonseca⁵, ¹Texas A&M University, College Station, ²Texas AgriLife Research, Stephenville, ³Tarleton State University, Stephenville, TX, ⁴Federal Rural University of Pernambuco, Garanhuns, Pernambuco, Brazil, ⁵Federal University of Viçosa, Viçosa, Minas Gerais, Brazil.

The US EPA has indicated that 20% of total CH₄ emissions in the US are the result of enteric fermentation in domestic ruminants. Previous studies have indicated that forages containing biologically active condensed tannins (CT) may reduce the amount of CH₄ produced during rumen fermentation. The objective of this work was to verify if the concentration of total CT (TCT) from warm season perennial herbaceous legumes affects CH₄ production in vitro. Five forages commonly fed to ruminants were evaluated, including *Desmanthus illinoensis* (Illinois bundleflower), *Lespedeza cuneata* (sericea lespedeza), *Acacia angustissima* (prairie acacia), *Desmodium paniculatum* (panicked tickclover), and *Arachis glabrata* (rhizoma perennial peanut). Each of these forages was fermented for 48 h under anaerobic conditions. Perennial peanut had the least TCT at 5.69 g/kg DM and produced 110.62 mM CH₄/g DM, which was greater ($P < 0.05$) than the other species surveyed. There

was no difference in CH₄ production between Illinois bundleflower and sericea lespedeza ($P > 0.05$), which produced 66.17 and 46.73 mM CH₄/g DM and had TCT concentrations of 81.49 and 82.95 g/kg DM, respectively. There was no difference in CH₄ production between sericea lespedeza and panicked tickclover ($P > 0.05$), which produced 46.73 and 23.26 mM CH₄/g DM, respectively, even though panicked tickclover had the greatest TCT concentration of all plants surveyed at 124.63 g/kg DM, suggesting the type, but not necessarily the amount, of CT might have affected CH₄ production. Prairie acacia had a TCT concentration of 84.66 g/kg DM and produced 6.93 mM CH₄/g DM. Prairie acacia suppressed CH₄ to a greater degree than sericea lespedeza, Illinois bundleflower, and perennial peanut but not panicked tickclover ($P < 0.05$). Results indicated that feeding native warm season perennial herbaceous legumes containing CT is a promising alternative to feeding introduced and potentially invasive species sericea lespedeza as it relates to reducing CH₄ production during fermentation in vitro. In addition, it appears that TCT concentration alone is not a reliable predictor of the CT biological activity relative to CH₄ production by rumen liquid in vitro.

Key Words: condensed tannins, legumes, greenhouse gas

W238 Methane production from novel oat varieties measured by gas production. J. M. Moorby,* A. A. Cowan, D. K. Leemans, and A. H. Marshall, *Institute of Biological, Environmental and Rural Sciences, Aberystwyth University, Aberystwyth, UK.*

Methane emissions from sheep fed naked oats has been shown previously to be lower than from sheep fed husked oats or barley, offering the potential of this crop as a potential mitigation option. However, the price of naked oats is significantly higher than that of husked oats, which limits their use. To improve the digestibility of husked oats, a breeding program aimed at producing low-lignin oats with a high oil content has generated several new breeding lines. The methane production potential of these lines was compared with commercial naked oat varieties using the gas production technique. Triplicate ground samples of 1 g DM of each oat whole grain (including the husk, if present) were incubated in dairy cow rumen fluid at 39°C in gas-tight bottles. Gas was removed from the bottles to equalize pressure at 3, 6, 10, 14, 20, 26, 31, 47, 71 and 81 h from the start of incubation, and the methane concentration in the recorded volume was measured. Dry matter residues were weighed to determine apparent digestion. Methane production varied from 28.3 to 46.1 (mean = 35.4, SD = 4.73) ml per g grain DM incubated, and 39.7 and 52.2 (mean = 46.3, SD = 3.68) ml per g of apparently digested DM (adDM). Methane production was negatively related to grain ADL content ($r = -0.86$; $P < 0.001$) but was positively related to DM loss ($r = 0.78$; $P < 0.001$). Methane production per g adDM was also negatively related to grain total fatty acid (FA) content ($r = -0.77$; $P < 0.001$). As the relative proportion (g FA/100g total FA) of some of the unsaturated FA increased, methane production per g adDM decreased (e.g., C18:1, $r = -0.76$; $P < 0.001$). However, because the relative proportions of individual FA did not vary greatly among the different oat lines, the relationships with methane emissions were similar to those of total FA, particularly for those FA in greatest abundance (C16:0, C18:1, C18:2 n-6). In conclusion, breeding husked oats for reduced lignin concentrations and increased FA concentrations to produce more digestible oat with a high oil content offers potential as a ruminant dietary ingredient that could help mitigate methane emissions.

Key Words: oats, methane, gas production

W239 Effect of crude glycerin on methane emissions of male beef calves finished in feedlot. J. F. Lage^{*1}, T. T. Berchielli¹, I. P. C. Carvalho¹, A. Berndt², R. T. S. Frighetto³, E. San Vito¹, R. A. Silva¹, A. F. Ribeiro¹, L. M. Delevatti¹, E. E. Dallantonia¹, L. R. Simonetti¹, and R. A. Reis¹, ¹Universidade Estadual Paulista, Jaboticabal, São Paulo, Brazil, ²Embrapa Pecuária Sudeste, São Carlos, São Paulo, Brazil, ³Embrapa Meio Ambiente, Jaguariúna, São Paulo, Brazil.

The objective of this study was to evaluate the effects of feeding crude glycerin (CG; 80% glycerol) included as 10% of diet DM to replace corn or soybean hulls in 2 concentrate:roughage ratios (60:40 or 40:60) on enteric methane (CH₄) production of young bulls finished in feedlot. Thirty 6 young bulls (Nelore breed) with 374.11 ± 24.77 initial BW, were randomly assigned to 6 treatments, with 6 replicates. The diets were: 1- corn, no CG; 2- CG and corn, 3- CG and soybean hulls. These 3 diets were formulated with 2 concentrate:roughage ratios (60:40 or 40:60), resulting in 6 treatment diets in a 2 × 3 factorial arrangement. The diets were isonitrogenous. Animals were slaughtered at 495.50 kg BW. The CH₄ emissions were evaluated using the SF₆ tracer gas technique. Five consecutive gas samples were collected in 24-h intervals from each animal. Data were analyzed using the GLM procedure of SAS. Characteristics evaluated in the study were daily carcass gain (CrG, kg.d⁻¹), and CH₄ emission expressed in kg of CH₄ emitted per year (kg CH₄.yr⁻¹), gram of CH₄ emitted per day (g CH₄.d⁻¹), gram of CH₄ emitted per day per kg of metabolic BW (g CH₄.d.MBW⁻¹) and kg of CH₄ emitted per kg of carcass produced (kg CH₄.kg CAR⁻¹). The CrG was not different ($P > 0.05$) among the treatments, with mean values of 0.94 kg.d⁻¹. The CH₄ emission was also not different ($P > 0.05$) among the treatments in any unit expressed, with mean values of 62.5 kg.yr⁻¹, 171.2 g.d⁻¹, 1.62 g.d.MBW⁻¹, 0.22 kg.kg CAR⁻¹, respectively. Interaction between concentrate:roughage ratios and feeding regimens was not significant ($P > 0.05$). The evaluated variables did not change ($P > 0.05$) in response to the ratio of roughage utilized (60:40 or 40:60). Animals fed with CG in diet with low or high level of concentrate showed similar enteric methane production.

Key Words: beef cattle, greenhouse, glycerol

W240 Prediction of methane emission from enteric fermentation of growing-finishing Hanwoo steers using IPCC methodology. N. C. Jo^{*1}, S. Y. Jeong¹, K. H. Park², and S. Seo¹, ¹Chungnam National University, Daejeon, Republic of Korea, ²National Institute of Animal Science, R.D.A., Suwon, Republic of Korea.

The objectives of this study were 1) to predict methane (CH₄) emissions from enteric fermentation of Hanwoo steers using the Intergovernmental Panel on Climate Change (IPCC) Tier 2 equations and 2) to evaluate and compare the adequacy of the use of the IPCC Tier 2 and the Japanese Tier 3 equations for predicting enteric methane emissions from Hanwoo steers. The values of animal and feed characteristics required for the equations (e.g., BW, ADG, and energy content of feeds) were obtained from Kim et al. (2005). CH₄ emission was calculated by multiplying gross energy (GE) intake with constant CH₄ conversion factor as suggested by IPCC. Methane emission from enteric fermentation of Hanwoo steers was estimated to be 116.3, 93.6, and 99.1 g CH₄/head/day for the growing, finishing, and overall, respectively. These resulted in an estimated enteric methane emission factor of 36.2 kg CH₄/head/year for growing-finishing Hanwoo operation. The value was lower than the one estimated using IPCC Tier 1 (53 kg CH₄/head/year) which is being used for the national inventory report of Korea. When GE intakes were replaced by the values estimated from actual feed intake, estimated enteric methane emission was significantly lower ($P < 0.01$) in the finishing period (80.3 g CH₄/head/day) and overall (91.7 g CH₄/head/day). Consequently, enteric

methane emission factor was estimated to be 33.5 kg CH₄/head/year. This implies the IPCC Tier 2 method may overestimate enteric methane emission from Hanwoo especially during the finishing period, which is primarily due to overestimation of GE intake. On the contrary, the Japanese Tier 3 predicted DMI of Hanwoo steers surprisingly well ($R^2 = 0.88$, root mean squared prediction error = 0.4). However, it estimated enteric methane emission factor of 69.1 kg CH₄/head/year, which is even larger than the default value based on IPCC Tier 1. The discrepancy was due to over-prediction of a percentage of feed energy converted to methane. We concluded that either the IPCC Tier 2 or the Japanese Tier 3 method overestimated methane emissions from enteric fermentation of growing-finishing Hanwoo steers and further research to develop Korean-specific equations and parameter estimates is warranted.

Key Words: Hanwoo steers, enteric fermentation, methane emission factor

W241 Enteric methane emissions by dairy cows grazing temperate pastures. N. Nelson^{*1}, K. Steensma¹, S. Utsumi¹, D. K. Beede¹, S. Zimmerman², and P. Zimmerman², ¹Michigan State University, East Lansing, ²C-Lock Technology Inc., Rapid City, SD.

Effects of grazing ryegrass (RG) or orchardgrass (OG) pasture on milk production, enteric methane (CH₄) flux and CH₄ per unit of milk by United States Holstein (USH; 552 ± 6 kg BW; n = 24) and New Zealand Friesian (NZF; 342 ± 11 kg BW; n = 6) cows managed with an automatic milking system (AMS) was quantified. Rotational grazing of RG and OR pastures was applied at conservative stocking rates (2.5 cow/ha) using pre- and post-grazing pasture biomass targets of 2400 ± 200 and 1500 ± 200 kg/ha, respectively. Voluntary milking with one single-stall AMS was applied at variable rates of 4 to 2 milkings/day based on DIM and milk yield (MY). In addition to pasture, cows received 1 kg of concentrate per 6 kg of MY. Concentrate was fed in the AMS unit. Mass flux of eructed and expired CH₄ during individual milkings (n = 1,151) was automatically recorded using nondispersive infrared sensors and tracer gas (Greenfeed system, C-Lock Technology Inc., Rapid City, SD). Repeated measures analysis of daily CH₄ fluxes and Pearson correlation of calculated CH₄ fluxes and milk production for a completely randomized design were conducted ($\alpha = 0.05$). Enteric CH₄ flux (g/d) was greater ($P < 0.001$) for USH (384 ± 8) than NZF (281 ± 22) cows, but CH₄ flux per unit of metabolic BW was not different ($P = 0.68$) between the 2 breeds (average: 3.43 ± 0.14 g/kg BW^{0.75}). Daily CH₄ flux was affected by a pasture by day interaction ($P = 0.002$), likely influenced by daily decreases in CH₄ flux in RG pastures. Milk yield was not different ($P = 0.84$) between RG and OG pastures (average: 20.5 ± 1.5 kg/cow per d), but MY was greater ($P < 0.001$) for USH (27.2 ± 1.0 kg) than NZF (14.1 ± 1.9 kg) cows. Differences in MY between breeds explained the diluted ($P = 0.05$) CH₄ per unit of milk in USH compared with NZF cows (15.8 ± 0.9 vs. 21.2 ± 2.5 g CH₄/kg milk). There was a positive correlation ($P < 0.001$) between MY and CH₄ flux ($r = 0.20$) and a significant negative correlation ($P < 0.001$) between CH₄ emissions per unit of milk and MY ($r = -0.75$), highlighting the importance of high milk production levels as a management strategy to mitigate CH₄ emissions in pasture-based dairy systems.

Key Words: methane, pasture-based dairy, automatic milking

W242 Estimation of greenhouse gas emissions from beef cattle production systems using whole-farm models. A. W. Alemu^{*1}, K. H. Ominski¹, M. Tenuta¹, and E. Kebreab², ¹University of Manitoba, Winnipeg, MB, Canada, ²University of California, California, Davis.

Measuring greenhouse gas (GHG) emissions from beef cattle operations is challenging as these are complex systems, composed of multiple

interacting components. Whole-farm modeling integrates these components and can be used to determine the effects of change in management practices on net emissions and to develop cost-effective mitigation options. The objectives of this study were to: 1) integrate process-based models into a whole-farm GHG model and 2) compare the outputs from the integrated model with outputs from other whole-farm models under different management practices. Input data for the models were obtained from published literature including a 3-year study which examined GHG emissions associated with the following management practices: no application of liquid hog manure on pasture (baseline), application of manure in fall and spring (split) and single application of manure in spring only (single). An integrated whole-farm model (IM) was developed by integrating the process-based models, COWPOLL and manure-DNDC, as well as aspects of IPPC. Emission estimates from IM were examined along with those generated from HOLOS and the Integrated Farm System Model (IFSM). It was assumed that the simulated cow-calf operation was self-sufficient with regard to feed and bedding. Estimated whole-farm emissions were 13, 15 and 14 kg CO₂ eq/kg animal live weight for the baseline scenario using IM, HOLOS and IFSM, respectively. However, whole-farm emission estimates were higher for split (24 and 19 kg CO₂ eq/kg animal live weight) and single (29 and 19 kg CO₂ eq/kg animal live weight) application using IM and IFSM, respectively. Estimates from all models indicated enteric methane was the major contributor in the baseline scenario (68–74%) whereas enteric methane (36–54%) and soil nitrous oxide (34–51%) were the major contributors for the split and single application. In general, variation was observed among models, not only in estimating whole-farm emissions, but also in the proportion of methane and nitrous oxide produced from the different farm components.

Key Words: greenhouse gas emissions, whole-farm model, beef cattle production

W243 Isotope ratio mass spectrometry monitoring of nitrogen volatilization from cattle feces and ¹⁵N-labeled synthetic urine. F. Y. Ayadi,* E. L. Cortus, and D. E. Clay, *South Dakota State University, Brookings.*

Losses in the nitrogen cycle from manure, to fertilizer, to crops fed to the animal and back to manure are losses of valuable nutrients to the environment in form of gaseous emission or runoff. To minimize these losses, we must first understand the nitrogen source. The objective of this study was to verify the ¹⁵N-labeled urea tracer method to determine the fate and origin of nitrogen in manure. A bench-scale manure storage experiment with beef feces and synthetic urine was conducted to monitor the movement of nitrogen (N) via ¹⁵N-labeled urea through the system. Isotope ratio mass spectrometry (IRMS) was used to determine the ratio of fecal material vs. urine contribution to loss of ¹⁵N and total nitrogen from a manure mixture. Feces were collected from beef cattle and mixed in a 1:2.2 ratio with 10 atom % ¹⁵N-labeled synthetic urine. Fresh urine and feces were added daily for 4 d to jars that were connected to a vacuum pump which pulled the exhaust through a sulfuric acid trap solution. Acid traps were exchanged daily and exhausted ammonia was collected for 15 d. All samples (initial urine and feces, acid trap, and final manure mixture) were analyzed for total N and ¹⁵N using IRMS. Results showed that nitrogen loss of the manure mix was highest during the first 2 to 3 d of monitoring. The majority of N loss (92.2%, SE = 0.3) occurred from the urine portion of the manure mixture on d 2. On d 15 only 68.6% (SE = 1.1) of the volatilized N was derived from urine. The average N volatilization from urine from d 1 to 15 was 83.7% (SE = 0.1). Nitrogen losses from feces were more variable, being high on d 1 (24.5%, SE = 0.5), decreased to 9.0% (SE = 0.3) on d 5 and gradually

increased to 31.4% (SE = 1.2) on the last day of sampling (d 15). This study verified the applicability of IRMS measurements for beef manure mixtures that has previously been verified for dairy systems. The results suggest that further research to explain and model the ammonia/nitrogen release from fecal material is warranted.

Key Words: ammonia volatilization, gas emission, beef cattle manure

W244 Identifying ammonia hotspots on a Colorado dairy using conditional passive samplers and inverse modeling. C. Williams,* J. Ham, and K. Shonkwiler, *Colorado State University, Fort Collins.*

Increasing pressure is being placed on concentrated animal feeding operations to reduce NH₃ emissions as the public becomes more concerned over effects on environmental and human health. The purpose of this study was to identify and monitor strong NH₃ emission zones on a northern Colorado dairy farm using a newly developed conditional sampling system. Passive samplers can be used to measure spatial variations of NH₃ near livestock operations, but results are often confounded by changing weather conditions during extended deployment periods (e.g., 1 to 2 weeks). A new type of conditional sampler was developed that only exposes the passive samplers when a user-defined set of wind and weather conditions are met. Several sampling stations were deployed on a northern Colorado dairy for an 8-wk period during late summer. Stations were placed on the downwind side of potential NH₃ sources, including: the composting area (S1, S2, and S3), lagoon and open-sided freestall barns. Each station contained 2 passive samplers. One sampler deployed whenever weather conditions were met (Full-day), while the other deployed when weather conditions were met between 1000 and 1600 h (Mid-day). Passive samplers were exchanged every 2 wk during the sampling period. Background NH₃ concentrations averaged 19.9 ppb NH₃ over the course of the study. Full-day samplers averaged 430.9, 637.0, and 588.9 ppb NH₃ for S1, S2 and S3, respectively. The sampler downwind of the 4 open-sided freestall barns averaged 321.5 ppb, while the lagoon averaged 1126.5 ppb NH₃. Analysis of all 4 sampling periods yielded similar patterns, with the lagoon consistently producing the highest NH₃ concentrations of the sources measured (*P* = 0.02). An inverse dispersion model also was used to estimate NH₃ emissions from each zone where the samplers were deployed. Deployment of the conditional sampling system on dairies or other livestock operations will help producers identify hotspots of NH₃ emissions, as well as monitor any subsequent changes in emissions resulting from implementation of best management practices. Data will also help quantify farm-specific NH₃ losses for mandatory reporting requirements.

Key Words: environment, emissions, ammonia

W245 Effects of alum and aluminum chloride on volatile fatty acid concentration and pathogen populations in Hanwoo (Korean native cattle) manure. C. M. Kim¹, S. C. Kim², S. M. Amanullah², H. J. Lee³, J. H. Choi⁴, and I. H. Choi^{*5}, ¹*Department of Chemistry, Sookmyung Women's University, Seoul, South Korea,* ²*Department of Animal Science (Inst. Agric. Life Sci.), Gyeongsang National University, Jinju, South Korea,* ³*Division of Applied Life Science (BK 21), Gyeongsang National University, Jinju, South Korea,* ⁴*Department of Chemistry, Hanyang University, Seoul, South Korea,* ⁵*Department of Companion Animal & Animal Resources Science, Joongbu University, Kumsan, South Korea.*

Several recent studies have shown that treating animal manure with alum (aluminum sulfate) and aluminum chloride is one of the most effective methods of reducing odor and inhibiting microbial growth.

Of all treatments tested, alum has been intensively used in the poultry industry, but there is little information available on the effects of alum and aluminum chloride on odor and pathogen populations from Hanwoo manure. The objective of this study was to evaluate the effect of applying alum and aluminum chloride on VFA concentration and pathogen populations of Hanwoo manure. A total of 36 steers (8 mo old and averaging 300 kg in weight) were used in this trial and allotted to 9 pens (3 replication pens per group with 4 steers per experimental unit, 5 × 8 m). Chemical additives were applied as a top dressing with garden rake to a depth of 1 cm of manure with wood shavings in each treatment. The treatments were control (without chemical amendments) or 50 g of alum and 50 g of aluminum chloride/kg of Hanwoo manure. The experiment was carried out for 6 weeks. The addition of alum and aluminum chloride reduced ($P < 0.05$) volatile fatty acid concentration (6.2 mM/100 g compared with 9.7 mM/100 g for control) during the 6-wk period. Manure pH was lower ($P < 0.05$) in alum and aluminum chloride treatments (7.5 to 8.4) compared with the controls (9.2 to 9.3) during the 6-wk period. Both levels of the alum and aluminum chloride treatments tested decreased ($P < 0.05$) *Escherichia coli* and *Salmonella enterica* populations (average 4–5.7 log 10 cfu/g manure compared with average 7–7.5 log 10 cfu/g manure in untreated controls) in Hanwoo manure during the 6-wk period. It appeared that the reduction in VFA concentration and pathogen populations was primarily associated with the lower manure pH. If more strict environmental regulations are put into effect regarding VFA concentration and pathogen populations from Hanwoo facilities, treating Hanwoo manure with alum and aluminum chloride may be a good management practice.

Key Words: alum, aluminum chloride, Hanwoo manure

W246 Whole-farm balances of phosphorus and potassium on dairy farms. D. Fulawka, T. L. Garner, K. H. Ominski, D. Flaten, and J. C. Plaizier,* *University of Manitoba, Winnipeg, MB, Canada.*

Imports and exports of phosphorus (P) and potassium (K) were monitored during a 12-mo period on 10 commercial dairy farms in Manitoba. Balances were expressed per kg of milk shipped, milking cow, and ha. The farms differed in housing, feeding, manure management systems, and in the production and purchase of feeds. Imports included feed, bedding, animals, inorganic fertilizer, and manure. Exports included milk, animals, feed, and manure. A farm included the milking herd, the replacement herd, and the fields used to produce feed for these herds. Two farms purchased all their feed and exported all their manure. Results show that P and K balances varied substantially among farms. Based on these balances, P accumulated on all farms and K accumulated all but one farm. On average, the imports of P through feed, inorganic fertilizer, animals, bedding, and manure were 47.8, 47.7, 2.6, 1.7, and 0.2% of total P imports, respectively. The imports of K through feed, inorganic fertilizer, animals, bedding, and manure were, on average, 78.4, 0, 1.4, 20.1, and 0.2% of total K imports, respectively. On average, the exports of P through feed, animals, and milk were 5.4, 9.1, and 85.5% of total P exports respectively. The exports of K through feed, animals, milk, and manure were, on average, 15.3, 3.5, 78.6, and 2.6% of total K exports, respectively. The coefficients of variation (CV) for the import of P through feed, inorganic fertilizer, animals, and manure were 28, 168, 97, and 101%, respectively. The CV for the export of P through feed, animals, milk, and manure were 170, 53, 3, and 262%, respectively. The CV for the import of K through feed, animals, bedding and manure were 74, 112, 128, and 217%, respectively. The CV for the export of K through feed, animals, milk, and manure were 165, 83, 10, and 265%, respectively. This shows that the greatest opportunity to reduce the P balance is through management of inorganic fertilizer

and to reduce the K balance is through the reduction of the import of bedding and increasing the export of feed that is not needed. As the largest imports of P and K occur through feed, ensuring that dietary P and K do not exceed requirements is critical in avoiding whole farm surpluses of these minerals.

Table 1.

	Minimum	Median	Maximum	SD
Milking cows	46	82	634	237
Total cows, heifers and calves	64	213	1027	332
Landbase, ha ¹	65	432	1272	446
P balance, g/kg of milk	0.3	2.4	16.8	5.1
P balance, kg/cow yr	4.2	29.1	159.1	48.7
P balance, kg/ha year ¹	1.1	10.5	112.6	37.8
K balance, g/kg of milk	-1.3	3.6	17.6	5.3
K balance, kg/cow yr	-16.9	40.5	156.3	52.1
K balance, kg/ha yr ¹	-4.2	22.7	118.0	38.8

¹Excluding 2 farms that purchased all feed.

Key Words: phosphorus, potassium, dairy

W247 Foliar uptake and utilization of phosphorus by grazing cattle as influenced by nitrogen fertilization regime. S. L. Dillard,* W. F. Owsley, C. W. Wood, B. H. Wood, and R. B. Muntifering, *Auburn University, Auburn, AL.*

Accumulation of soil nutrients potentially restricts production and land-use options available to resource managers. Efficiency of nutrient utilization may be increased by implementation of management practices that facilitate phytoextraction of nutrients from nutrient-enriched soils. An experiment was conducted to determine the effect of different N-fertilization regimens on foliar P uptake and P utilization by grazing cattle in plots with high soil-test P. In October 2010, 6 0.28-ha plots were overseeded with triticale (*Triticum secale*) and crimson clover (*Trifolium incarnatum*) into a tall fescue (*Lolium arundinacea*)/bermudagrass (*Cynodon dactylon*) sod and assigned randomly to 1 of 3 treatments (trts) (n = 2): 100% of N recommendation for tall fescue in a split application (100N), 50% of N recommendation (50N), and 0% of N recommendation (0N). In February 2011, 6 cattle (339 ± 11 kg; 4 steers, 2 heifers) were randomly assigned to plots (1 animal/plot) until May. In June, plots were overseeded with cowpea (*Vigna unguiculata*) and maintained on the same N-fertilizer regimens, based on N recommendation for bermudagrass. In August, 6 steers (361 ± 23 kg) were randomly assigned to plots (1 steer/plot) until September. Forages were sampled biweekly, and intake and fecal excretion of P was determined for each animal in mid- and late season using Cr dilution technique by reference to forage IVDMD. Data were analyzed as a completely randomized design using a mixed-model in which intake and fecal excretion of P were treated as repeated measures. Forage DM availability ($P = 0.002$) and uptake of P ($P = 0.01$) were greater for cool- than warm-season forage (4,441 vs. 2,311 kg/ha and 8.44 vs. 5.30 kg P/ha, respectively), but were not different among trts. Foliar P concentrations were not different among trts. Daily P intake and excretion were not different among trts (12.2, 11.3 and 13.3 g/d, and 14.8, 15.0 and 11.9 g/d for 0N, 50N and 100N, respectively). Results indicate manipulation of N-fertilization regimen did not affect P removal from plots with high soil P beyond that from overseeded small-grain and annual legumes, and seasonal differences in P removal were not reflected in patterns of P utilization by grazing cattle.

Key Words: phosphorus, cattle, nitrogen

W248 Soil CO₂ emission during the dry season under different grazing intensities in Southern Brazil. L. de Figueiredo Brito, M. Vieira Azenha,* A. R. Panosso, F. H. M. de Souza, A. A. Oliveira, S. S. Santana, R. A. Reis, N. La Scala, and A. C. Ruggieri, *Sao Paulo State University, Jaboticabal, Sao Paulo, Brazil.*

Greenhouse gas emissions have been considered in sustainable livestock production, and the objective of this study was to monitor the soil CO₂ emission in Marandu-grass pasture submitted to continuous stocking with different grazing intensities during the drought period of the year. Three grazing intensities, defined by heights of 15, 25 and 35 cm, were studied in 6 plots (2 plots for each treatment) with 6 replications in each. Soil CO₂ emission and soil temperature were evaluated in 20 d between May 3rd and September 29th, 2011, in all plots, by using a LI-8100 portable Flux System. Data were submitted to variance analysis and Tukey test for mean comparison ($P < 0.05$). Daily soil CO₂ means varied from 0.90 to 5.58 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ with significant reductions probably due to reductions in soil moisture. Higher values were observed at the beginning of the dry season reflecting the importance of soil moisture to biological processes, such as biological activity and root respiration. In the last days of the study, soil respiration reached a minimum, similar to what was observed in relation to plant's growth. Accumulated monthly precipitation along the wet period before these evaluations were 267, 202, 495 and 92 mm (January to April 2011), and in the drought period the total precipitation was 59 mm (May to September, 2011). On the other hand, while soil CO₂ emission and soil moisture declined, soil temperature increased (18.4°C in May to 22.1°C in September, 2011), indicating that soil moisture was a limiting factor to soil CO₂ production. Total mean values indicate higher grazing intensities (15 and 25 cm) resulted in higher CO₂ emissions, 2.64 and 2.59 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$, respectively, when compared with the lower grazing intensity (35 cm), 2.30 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ ($P < 0.001$). Total CO₂ emission for the period was estimated as being 4.10, 3.93 and 3.48 Mg C ha⁻¹, respectively, for heights of 15, 25 and 35 cm.

Key Words: *Brachiaria brizantha*, carbon cycle, greenhouse gases

W249 Using a batch culture system to measure volatile organic compounds as the primary substrates for methanogenesis in anaerobic digestion of dairy waste. C. L. Ross,* K. C. Das, and M. A. Froetschel, *University of Georgia, Athens.*

Cost effective anaerobic digestion of dairy excrement is limited by its relatively low energy content. As a result, anaerobic digestion of dairy waste requires a greater reactor volume and retention time for stable and efficient methane production. Processing dairy waste to concentrate its volatile organic compound (VOC) content as substrate for methanogenesis could improve digester efficiency and reduce costs associated with volume and retention time. Dairy excrement was processed using different methods to alter its concentration of VOC's. Bio-conversion of processed dairy excrement into methane was studied in a one-way factorial designed experiment. Processing methods included: A) oven-dried (55°C for 72 h) and ground through a 1mm screen, B) freeze-dried, C) fresh whole manure in a 1:1 water dilution (with solids present), D) a water extract of fresh whole manure from a 1:1 dilution (without solids), or E) dairy excrement processed through an on-farm solid separator. All waste substrates were fermented in batch cultures for 48 h after being inoculated with a mixed culture of rumen microorganisms. Gas production was analyzed for volume and concentrations of methane (CH₄) and carbon dioxide, pH, volatile fatty acid concentration, in vitro dry matter digestion, and free-ammonia. All data were analyzed with SAS 9.2 using PROC GLM. Caloric values of volatile fatty acids and CH₄ were calculated. Process C produced the greatest volume of CH₄ gas, 33–179% more than the other methods ($P < 0.01$). Process C, D, and E had higher concentrations (mM) of acetate ($P < 0.01$) than A or B (C = 43.5, D = 22.3, E = 20.8 vs. A = 1, C = 3.5). C and D both contained more acetate calories (70% and 7%, respectively) than E ($P < 0.01$). Calories of CH₄ were also higher for the C (23.1) and D (17.1) than A (4.4), B (4.9), or E (0.8) ($P < 0.01$). Energetic data implies that substrate processed to contain more VOC's increasingly fuels methanogenesis. The liquid fraction of dairy excrement contains the VOC's that may be concentrated to enhance methane production during anaerobic digestion.

Key Words: volatile organic compounds, methanogenesis, anaerobic digestion