

Forages and Pastures: Alternative Forages and Improving Forage Quality and Characterization

215 Gain from selection for 16- and 96-h in vitro ndf digestibility of alfalfa stems. H. G. Jung* and J. F. S. Lamb, *USDA-Agricultural Research Service, St. Paul, MN.*

Alfalfa is a high quality forage, but stems are high in NDF and of limited digestibility. A gain from selection study with alfalfa populations selected for divergent in vitro NDF digestibility (IVNDFD) was planted at St. Paul and Becker, MN. Two cycles of selection were conducted starting with a base population created by mixing seed from 6 commercial varieties. Individual plants ($n = 2000$) were harvested twice (spring and first regrowth) at late flower for 2 years. Plants consistently low or high for 16- or 96-h IVNDFD were crossed to create 4 cycle one IVNDFD populations: low 16-h/low 96-h (LL), low 16-h/high 96-h (LH), high 16-h/low 96-h (HL), and high 16-h/high 96-h (HH). Cycle one populations were planted and harvested twice annually for 2 years to identify plants with appropriate IVNDFD combinations and crossed to create cycle 2 populations. Near-infrared reflectance spectroscopy calibrations were developed for NDF, ADL, Klason lignin, cell wall polysaccharide components, and 16- and 96-h IVNDFD based on 470 samples from the base population, cycle 2, and other experiments. Data were analyzed as a randomized complete block with 4 replicates, 2 locations and 9 populations, and 2 harvests arranged as repeated measures. The least significant difference test ($P < 0.05$) was used to compare population means when the F-test was significant. After 2 cycles of selection, 16-h IVNDFD increased from 19.3% for the base population to 20.1% for the HH population. The LL population (19.0% 16-h IVNDFD) differed from the HH population after 2 cycles, but not from the base. Both LL (50.3%) and HH (55.8%) differed for 96-h IVNDFD from the base (52.4%) after 2 cycles. The LH and HL populations did not differ significantly from the base; however, means shifted in the direction of the positive selection criterion. Selection for greater IVNDFD resulted in less NDF, cell wall, and lignin (ADL and Klason) in the cycle 2 HH than the base and cycle 2 LL populations. Cellulose and pectin increased for HH cycle 2 and hemicellulose declined in cycle 2 LL compared with the base. Genetic selection in alfalfa was successful in improving IVNDFD of stems.

Key words: alfalfa, fiber, digestibility

216 The nutritive value of mature corn silage from BMR, non-BMR and a 50:50 mix ensiled for varying lengths of time. J. M. Lim*¹, M. C. Santos¹, J. P. Riguera¹, M. C. Der Bedrosian¹, K. E. Nestor Jr.², and L. Kung, Jr.¹, ¹*University of Delaware, Newark, 2**Mycogen Seeds, Indianapolis, IN.*

The effects of hybrid type (H) and storage length (LEN) on the nutrient value of corn silage were studied. Hybrids were 1) brown midrib (BMR, Mycogen F2F700, Dow AgroScience, Indianapolis, IN), 2) non-BMR (NML, Mycogen TMF2W726) and 3) a 50:50 mixture (MIX). The BMR and NML were planted separately whereas MIX was produced by planting alternate rows of each H. Five replicated rows of plants (at about 40% DM) for each H were chopped (~20 mm length) and processed. Forage was ensiled (25°C) in vacuum-sealed bags and 5 replicates were opened after 200 and 400 d. All silages fermented well (pH < 3.7). Ammonia-N increased for all treatments from d 0 to 200 but did not change between 200 to 400 d. Lignin content was lowest for BMR, highest for NML and intermediate for MIX and the difference ($P < 0.01$) was greater after 400 vs. 200 d of ensiling.

The NDF content of BMR (42.5%) was higher ($P < 0.01$) than the NML (34.6%) and MIX (37.74%) at d 0 but this difference diminished over ensiling time. Over time, silage NDF-D did not change but was different ($P < 0.01$) among the treatments and was highest for BMR (63.7%), intermediate for MIX (59.8%) and lowest for NML (51.7%). Starch content was lower ($P < 0.01$) for BMR (36.8%) than NML (40.7%) and MIX (42.3%) from 0 to 200 d but not on 400 d of ensiling. Starch digestibility (Str-D) was lower ($P < 0.01$) for BMR (65.3%) than NML (68.5%) and MIX (68.5%) for 0 and 200 d but was not different on 400 d of storage. Str-D increased by 6% for all treatments from d 0 to 200. From d 200 to 400 of ensiling, Str-D did not change for the NML but increased by 6 and 20% more for MIX and BMR, respectively. This study showed that NDF-D of silage was influenced by hybrid type but not length of storage. Length of storage increased Str-D, which proved that prolonged storage enhanced the nutritive value of corn silage. Planting NML yielded more ($P < 0.01$) DM than BMR (22.6 vs. 17.3 t/ha). Interplanting and harvesting BMR and NML together was not detrimental to silage quality and produced an acceptable DM yield (19.3 t/ha).

Key words: silage, BMR

217 Concentrations and apparent digestibility of lignin and carbohydrate fractions in cell walls of whole-crop cereal silages. J. Wallsten* and R. Hatfield, *US Dairy Forage Research Center, Madison, WI.*

Whole-crop cereal silage (WCCS) of oats generally have lower fiber digestibility than WCCS of barley. When investigated more closely the difference seems to mainly be in the digestibility of the hemicellulosic fraction (HC), where HC is calculated as neutral detergent fiber (NDF) minus acid detergent fiber (ADF). The objective of this study was to see if the difference is true or a result of losses during analysis. A set of 27 WCCS samples of barley, wheat and oats harvested at 3 different maturity stages and 54 corresponding fecal samples (from dairy heifers fed the respective silages) were analyzed for cell wall (CW) composition. Analysis included NDF, ADF and total CW, recovered by washing the samples in different aqueous and organic solvents. The CW residues were used to analyze ash, acetyl bromide lignin and neutral sugar composition. The data were analyzed with proc reg and proc mixed in SAS. The CW concentration was higher than the NDF concentration in both forages and feces. The correlation between the 2 fiber fractions was lower in forages ($R = 0.63$) than in feces ($R = 0.94$), possibly due to soluble fiber fractions that were included in forage CW, but not in the forage NDF. The lignin concentration in the silages was higher ($P < 0.001$) in oats (111 g/kg DM) than in barley (88 g/kg DM) and wheat (91 g/kg DM). Also in the feces oats (190 g/kg DM) had higher lignin concentration ($P < 0.001$) than barley (168 g/kg DM) and wheat (168 g/kg DM). There was an apparent loss of 20–40% of the lignin during digestion and the losses were higher in more immature silages. The correlation between xylose and HC concentrations was lower than expected in both forages ($R = 0.63$) and feces ($R = 0.65$). However, the correlation between xylose and HC digestibilities was high ($R = 0.91$). The high apparent digestion of lignin is probably a result of losses from the feces during analysis rather than actual digestion in the animal. The trend with higher losses for more immature silages is of concern as that will overestimate fiber and possibly in vitro DM digestibility for these silages.

Key words: neutral detergent fiber, xylose, acetyl bromide lignin

218 Construction of a recombinant *Pichia pastoris* integrating a two-copy xylanase gene from *Thermomonospora fusca* and characterization of its secreted protein. Q. Wang*¹, M. Z. Ma¹, X. Y. Weng², J. Y. Sun¹, and J. X. Liu¹, ¹MOE Key Laboratory of Molecular Animal Nutrition, College of Animal Sciences, Zhejiang University, Hangzhou, P.R. China, ²College of Life Science, Zhejiang University, Hangzhou, P.R. China.

Endo- β -1, 4-xylanases are key glycosidases in the degradation of xylan, the most abundant natural polysaccharide after cellulose. The study was designed to construct a recombinant strain expressing thermostable xylanases. Due to its good thermostability, a gene from *Thermomonospora fusca* xylanase (txf) was employed to generate a yeast expression vector pGAPZaA-txf. Then, the resulting vector was linearized with AvrII and inserted into *Pichia pastoris* GS115 at the locus of GAP promoter by electroporation (1500V, 5.2 ms). Transformants were spread onto YPD plates (1% yeast extract, 2% peptone, 2% dextrose, 2% agar) with 500–2000 μ g/ml Zeocin. Seven putative multi-copy recombinants exhibiting high resistance to Zeocin were selected to determine gene copy number. The strain GS115/33 was identified as a 2-copy recombinant by Southern blotting and real-time PCR, and used for protein expression. Subsequently, scale-up expression was achieved for 96 h in a 2-L baffled shaking flask containing 100 mL YPD medium. The recombinant xylanase TFX, driven by the GAP promoter and *Saccharomyces cerevisiae* α -mating factor, was constitutively secreted into culture medium. The specific xylanase activity in culture supernatant reached 89.8 U/mg, and purification by 6 \times His tagged Ni-NTA agarose resulted in 10-fold increase in specific activity (932.5 U/mg). After being incubated at 70°C for 5 min, the residual activity retained more than 70%. SDS-PAGE analysis revealed that the molecular weight of TFX was about 43 kDa, while the unglycosylated protein was 32 kDa after treatment with Endoglycosidase H. Three potential N-glycosylation sites (N5, N183 and N230) may contribute to the extra molecular weight. A weak protein interaction was observed between TFX and rice xylanase inhibitor (RIXI), a main xylanase inhibitor in cereals, by using yeast 2-hybrid. Because of its high specific activity and good tolerance to temperature and xylanase inhibitor, TFX produced by GS115/33 would be an attractive candidate for the feed and biofuel industries.

Key words: xylanase, *Pichia pastoris*, protein expression

219 Screening exogenous fibrolytic enzyme products for improved in vitro ruminal fiber digestibility of bermudagrass. J. J. Romero*, K. G. Arriola, M. A. Zarate, and A. T. Adesogan, Department of Animal Sciences, IFAS, University of Florida, Gainesville.

Eighteen exogenous fibrolytic enzyme products (EFE) from 5 companies were evaluated for their effect on digestibility of a 4-week regrowth of Tifton 85 bermudagrass haylage (68.1, 34.2, 3.7 and 18.7% NDF, ADF, ADL, and CP, respectively). All EFE were evaluated with a 24-h in vitro ruminal digestibility assay using bermudagrass haylage as substrate. EFE were diluted in citrate-phosphate buffer (pH 6) and applied in quadruplicate to the substrate at the manufacturer-recommended rates. The suspensions were incubated at 25°C for 24 h before addition of buffered rumen fluid (39°C) and further incubation for 24 h. The run was repeated once (Experiment 1). Compared with the Control (buffer and substrate alone), 6 EFE had greater DMD

(%) (54.2 \pm 0.4 vs. 52.4 \pm 0.4; $P < 0.05$), 6 EFE had greater NDFD (%) (40.8 \pm 0.6 vs. 38 \pm 0.6; $P < 0.05$), 4 had greater ADFD (%) (43.3 \pm 0.3 vs. 40.8 \pm 0.7; $P < 0.05$), 8 had greater hemicellulose digestibility (%) (38.1 \pm 1.3 vs. 35.1 \pm 0.6; $P < 0.05$), 5 had greater cellulose digestibility (%) (46.3 \pm 0.3 vs. 44.3 \pm 0.6; $P < 0.05$), 2 had lower pH (7.33 \pm 0.01 vs. 7.40 \pm 0.02; $P < 0.01$) and 11 had greater pH (7.5 \pm 0.03 vs. 7.4 \pm 0.02; $P < 0.05$). In Experiment 2, the 12 EFE with the greatest NDFD from Experiment 1 were tested using similar procedures. Compared with the Control, 5 EFE had greater DMD (55.2 \pm 0.7 vs. 51.2 \pm 0.8; $P < 0.05$), 10 had greater NDFD (36.4 \pm 2.0 vs. 30 \pm 0.9; $P < 0.05$), 8 had greater ADFD (39.3 \pm 1.3 vs. 34.4 \pm 1.0; $P < 0.05$), 10 had greater hemicellulose digestibility (34.8 \pm 2.2 vs. 28.9 \pm 0.9; $P < 0.05$), 9 had greater cellulose digestibility (42.9 \pm 0.9 vs. 36.8 \pm 1.2; $P < 0.05$), 11 had lower pH (6.97 \pm 0.03 vs. 7.05 \pm 0.01; $P < 0.05$), and 1 had lower ruminal NH₃ (mg/dl; 42.1 \pm 0.76 vs. 44.1 \pm 0.66; $P < 0.05$). Several promising EFE candidates to improve the digestibility of bermudagrass haylage were identified in this experiment.

Key words: forage, enzyme, screening

220 Relationships between exogenous fibrolytic enzyme product activities and in vitro ruminal digestibility of bermudagrass. J. J. Romero*, K. G. Arriola, M. A. Zarate, and A. T. Adesogan, University of Florida, IFAS, Department of Animal Sciences, Gainesville.

The objective was to examine relationships between exogenous fibrolytic enzyme activities (EFE) and digestibility values of bermudagrass haylage treated with the enzymes. The protein concentration (PR) and endoglucanase (EN), exoglucanase (EX), β -glucosidase (BG), and xylanase (XY) activities of 18 EFE from 5 companies were measured using carboxymethylcellulose, avicel, cellobiose, and oat spelt xylan, as substrates, respectively. The EFE were diluted in citrate-phosphate buffer (pH 6) and applied in quadruplicate at manufacturer-recommended rates to ground (1 mm) Tifton 85 bermudagrass haylage (4-week regrowth; 68.1, 34.2, 3.7 and 18.7% NDF, ADF, ADL, and CP, respectively). Suspensions were incubated for 24 h at 25°C and for a further 24 h at 39°C after addition of buffered-rumen fluid. The run was repeated once (Experiment 1). A similar second experiment was conducted with the 12 EFE with the greatest NDFD in Experiment 1. Stepwise regressions of digestibility of DM, NDF, ADF, hemicellulose (HEM) and cellulose (CELL) on enzyme activities and protein content of 18 (Experiment 1) and 12 (Experiment 2) EFE were conducted. Experiment 1 did not yield any accurate relationships ($R^2 < 0.07$; $P < 0.01$). In Experiment 2, PR (mg/g EFE) and enzyme activities (μ mol/min/mg EFE) explained ($P < 0.01$) 56, 81, 68, 82, and 47% of the variation in DMD, NDFD, ADFD, and HEM and CELL digestibility, respectively. Prediction equations were as follows: DMD = 51.2 - 0.001XY - 3.37EX - 1.28BG + 0.32PR + 0.00000204EN² + 0.0000000130XY² + 0.05BG² - 0.00197PR²; NDFD = 30.7 + 0.00853EN - 0.0009448XY - 5.76EX - 2.32BG + 0.43PR + 0.00000167EN² + 0.05612BG² - 0.00280PR²; ADFD = 34.7 + 0.01594EN - 0.00093598XY - 11.66EX - 2.6BG + 0.41PR + 1.53EX² + 0.06BG² - 0.00267PR²; HEM digestibility = 29.0 + 0.01067EN² - 0.00113XY - 6.73EX - 3.07BG + 0.51137PR + 0.00000205EN² + 0.07819BG² - 0.00343PR²; CELL digestibility = 38.2 - 0.00067827XY - 2.5EX - 0.66BG + 0.27PR + 0.00000218EN² - 0.00161PR². Important relationships between enzymatic activities and PR concentration and enzyme effects on in vitro digestibility were developed.

Key words: enzyme, forage, regression

221 Effect of rate of application of various exogenous fibrolytic enzyme products on in vitro ruminal fiber digestibility of bermudagrass. J. J. Romero*, K. G. Arriola, M. A. Zarate, and A. T. Adesogan, *Department of Animal Sciences, IFAS, University of Florida, Gainesville.*

The objective was to examine the effects of the dose rate of 5 exogenous fibrolytic enzyme products (EFE; E1, E2, E3, E4, and E5) from 3 companies on the digestibility of a 4-wk regrowth of Tifton 85 bermudagrass haylage (66.8, 33.2, 3.7 and 18.7% NDF, ADF, ADL, and CP, respectively). Application rates were 0x (Control), 0.5x, 1x, 2x and 3x; where 1x was the respective manufacturer-recommended dose (10, 15, 2.25, 2.25, and 15 g/kg substrate). Enzymes were diluted in citrate-phosphate buffer (pH 6) and applied in quadruplicate to ground (1 mm) bermudagrass haylage. The suspension was incubated for 24 h at 25°C and for a further 24 h at 39°C after addition of buffered rumen fluid. The run was repeated once. Data for each enzyme were analyzed separately as a completely randomized block design. The model included effects of dose, run, and the interaction. Polynomial contrasts were used to determine dose rate effects and the Fisher's LSD test was used to compare EFE means. Increasing the dose rate had the following effects: produced non-linear increases in DMD (%) of E2 and E4 (cubic; $P < 0.01$) and E1 and E3 (quadratic; $P < 0.01$); increased NDFD (%) of E1, E2 and E4 (cubic; $P < 0.01$) and E3 (quadratic; $P < 0.01$); increased ADFD (%) of E2, E4 and E5 (cubic, $P < 0.05$), E3 (quadratic, $P < 0.05$), and E1 (linear, $P < 0.01$); increased hemicellulose digestibility (%) of E1 and E2 (cubic, $P < 0.01$), E3 and E5 (quadratic, $P < 0.01$), and E4 (linear, $P < 0.01$); increased cellulose digestibility (%) of E2, E3, E4 and E5 (cubic, $P < 0.05$), and E1 (linear, $P < 0.01$) and increased pH of E2 and E4 (cubic, $P < 0.01$), E1 (quadratic, $P < 0.01$) and E3 (linear, $P < 0.05$). The optimal doses (and % increases compared with the control) for improving the DMD of E1, E2, E3 and E4 were 1x (2.8), 0.5x (2.5), 1x (1.5) and 2x (1.1), respectively. Optimal doses (and % increases compared with the control) for improving NDFD were 1x (5.7), 0.5x (4.7), 1x (2.9) and 2x (2.6), respectively. Enzyme application increased the DMD and NDFD of bermudagrass haylage but the optimal application rate varied with the enzyme.

Key words: forage, enzyme, dose

222 Alternative approaches of replication for estimating in vitro starch disappearance. D. R. Mertens*¹ and R. Ward², ¹Mertens Innovation & Research LLC, Belleville, WI, ²Cumberland Valley Analytical Services Inc., Maugansville, MD.

Measuring disappearance kinetics of starch and other substrates as they ferment is expensive and labor intensive because replicated serial measurements are needed. Assuming starch is 100% digested, rates of disappearance could be calculated theoretically from measurements at a single time by assuming that disappearance is zero at a fixed and assumed lag time. However this approach is dependent on removal of outliers and high precision in the measurement of in vitro starch digestion (IVSD). Our objective was to evaluate alternative strategies for minimizing the number of IVSD needed to measure starch disappearance rate. The IVSD of 6 samples of corn grain or silage (4-mm grind) were measured in quadruplicate on 3 consecutive days by Cumberland Valley Analytical Services, Inc. using a composite inoculum from 3 donors fed TMR. Measurements were made at 2, 4, 6, 12, 18, and 24 h. Local regression (Proc LOESS in SAS) was used to detect outliers. LOESS has the advantage that not only the observations replicated within day, but also those from repeated days and serial times can be used to detect outliers. Proc NLIN of SAS was used to fit a model

with a single exponential pool with discrete lag to the results. Rate and lag estimates were generated for each replicate within day. Proc MIXED of SAS was used to test day effects with random replicates. There was no difference among consecutive days for rates ($P = 0.13$) but a 1 h difference in lags ($P = 0.04$). All 72 measurements for each feed were used to estimate the overall rate of starch disappearance, which varied from 0.114 to 0.168/h for the 6 corn sources. Deviations from the overall rate for each source were calculated by using 4 replicates within each day or 2 replicates from each of 2 d. There was no difference in deviations, absolute deviations or squared deviation for within-day or among-day rate estimates. When 2 replicates within day were compared with 1 replicate from 2 d there was no difference in replication approach. For consecutive-day in vitro, it appears that replications within day are as accurate as between day replicates for estimating rate.

Key words: in vitro, starch, kinetics

223 Microbial protein synthesis and partitioning of nutrients of native species from semiarid regions of North Mexico. M. Guerrero-Cervantes^{1,3}, M. A. Cerrillo-Soto*^{1,3}, A. S. Juárez-Reyes^{1,3}, H. Bernal-Barragán^{2,3}, and R. G. Ramírez², ¹Universidad Juárez del Estado de Durango, Durango, México, ²Universidad Autónoma de Nuevo León, Nuevo León, México, ³Red Internacional de Nutrición y Alimentación en Rumiantes.

The aim of this study was to determine the partitioning of nutrients and microbial protein synthesis of fruits and foliage of 3 cacti: (*Opuntia imbricata*, *O. leptocaulis* and *O. leucotricha*), fruits of 3 browse: (*Acacia shaffneri*, *Prosopis leavigata* and *Atriplex canescens*), and foliage of 4 forbs: (*Coldenia greggii*, *Dalea bicolor*, *Jatropha dioica* and *Panthenium incanum*), which are commonly consumed by range small ruminants in semiarid regions of Mexico. Foliage was obtained from 10 distinct plants at early stages of growth, dried and milled (1 mm). Triplicate samples (500 mg) were incubated in 100 mL glass syringes, using buffered rumen fluid. Gas production was recorded at 0,3,6,9,12 and 24 h. After incubation, contents of syringes were centrifuged. An aliquot from the supernatant (5 mL) was utilized for determination of volatile fatty acids (VFA = mmol/40 mL incubation medium) using gas chromatography. The solid residue was lyophilized and subjected to the determination of purine content (μmol) using spectrophotometry. Efficiency of microbial protein synthesis (EMPS) was calculated as μmol purines/mmol VFA. Incubation residues from a separate set of syringes were refluxed with neutral detergent fiber solution and the partitioning factor (PF) was calculated as the ratio of mg substrate truly degraded/ml gas produced_{24h} in vitro. Data were analyzed by ANOVA using PROC GLM. Mean differences were separated using Tukey's test. The PF and purine values were similar among groups of feedstuffs ($P > 0.05$). Total VFA were in average higher ($P < 0.05$) for the foliage of cacti (930 mmol/40 mL) and lower for forbs (657 mmol/40 mL). The EMPS for fruits of browse (9.30) was almost twice the value for *Opuntia* foliage (4.67; $P < 0.05$), while values for fruits and foliage of forbs were similar. These data support the potential of native species as feed resources in harsh environments. The data obtained might be utilized for the establishment of feeding systems for small ruminants in semiarid regions.

Table 1. Efficiency of microbial protein synthesis and partitioning of nutrients of native plants

Species	PF	Purines (µmol)	Total VFA	EMPS (µmol purine/mmol VFA)
Fruits of Opuntia	2.89 ^a	6.25 ^a	805 ^{ab}	7.48 ^{ab}
Foliage of Opuntia	2.98 ^a	4.68 ^a	930 ^a	4.67 ^b
Fruits of browse	3.02 ^a	6.01 ^a	739 ^{ab}	9.30 ^a
Foliage of forbs	2.90 ^a	4.31 ^a	657 ^b	7.05 ^{ab}
Mean	2.95	5.31	783	7.12
sem	0.28	2.55	245	3.01

^{a,b} Means in columns with unlike letter differ ($P < 0.05$); PF=Partitioning factor; VFA=Volatile fatty acids; EMPS=Efficiency of microbial protein synthesis

Key words: native plants, microbial protein synthesis, in vitro gas production

224 Effects of species and season on chemical composition and ruminal crude protein and organic matter degradability of some multi-purpose tree species by West African Dwarf rams. O. M. Arigbede*^{1,2}, U. Y. Anele^{1,2}, K.-H. Südekum², J. Hummel², A. O. Oni¹, J. A. Olanite¹, and A. O. Isah¹, ¹University of Agriculture, Abeokuta, Nigeria, ²University of Bonn, Bonn, Germany.

Seasonal chemical composition and ruminal organic matter (OM) and crude protein (CP) degradabilities were determined in 4 tropical multipurpose tree species (MPTS), namely *Pterocarpus santalinoides*, *Grewia pubescens*, *Enterolobium cyclocarpum*, and *Leucaena leucocephala*. Three West African Dwarf rams fitted with permanent rumen cannula were used for the degradability trials. Foliage samples were randomly collected from 6 plants per MPTS 4 times to represent seasonal variations: January – mid dry; April – late dry; July – mid rainy, and October – late rainy seasons. Samples were analyzed for oven DM at 60°C for 96 h, milled (2.5 mm) and weighed (5 g) into 9 × 18 cm nylon bags. Bags were incubated in triplicate for 6, 12, 24, 48, 72 and 96 h in the rumen of 3 West African dwarf rams (35 kg body weight). Another portion of the dried foliage samples and residues after in sacco incubation were milled through a 1 mm sieve and stored until required for chemical analysis and ruminal in situ OM and CP degradability estimation. All samples had high CP (161 - 259 g/kg DM) and moderate fiber concentrations (neutral detergent fiber (ash-free), 300 - 501 g/kg DM; acid detergent fiber (ash-free), 225 - 409 g/kg DM and acid detergent lignin, 87 - 179 g/kg DM as well as low contents of secondary metabolites (13.5 to 33.5, 0.8 to 11.5 and 3.0 to 17.4 g/kg DM for tannins, trypsin inhibitors, and phytic acid respectively). Interaction effects between species and season were observed for DM, CP and secondary metabolite contents except for trypsin inhibitor ($P =$

0.614). Ruminal degradability of OM and CP showed that more than 50% were degraded at 24 h and the undegraded fraction varied from 17.5 to 47.6%. This implied that the MPTS were highly degradable and their incorporation into ruminant feeding systems as dry season forage supplement is recommended.

Key words: multi-purpose tree species, chemical composition, ruminal degradation

225 Effect of land clearing and tillage methods on growth and yield of maize-cassava intercrop. A. H. Ekeocha*, University of Ibadan, Ibadan, Oyo, Nigeria.

One of the prevailing problems facing developing countries today is that of producing enough food to meet their ever increasing population. It is in view of this that this work was carried out to evaluate the effect of land clearing and tillage methods on growth and yield of a maize-cassava intercrop. The experiment was carried out at the International Board for Soil Research and Management, Epemakinde, Nigeria. (4° 45' 0" E, 6° 45' 0" N) after 3 cropping years. The experimental design was a split-split plot in a randomized complete block design with 3 replicates. Three land clearing methods namely manual slash and burn (SB), bulldozed not windrowed (BNW) and bulldozed windrowed (BW) constituted the main treatments while 4 tillage methods namely (zero, conventional, traditional and minimum tillage) constituted the sub-treatments. There were a total of 12 treatment combinations per block. The plot size for each land clearing treatment was 20m × 30m each. Data were subjected to ANOVA and significant means separated using the least significant difference. The results indicate that maize grain yield was not different ($P > 0.05$) among land clearing and tillage methods. Traditional and minimum tillage had more grain (2.94 and 2.59 t ha⁻¹) on average, representing 22.5% and 7.9% increase in yield above conventional tillage (2.40 t/ha). Cassava fresh weight was significantly ($P < 0.05$) affected by the land clearing method, SB and BNW (21.94 and 21.20 t ha⁻¹) having higher yields than BW representing 44.1% and 39.2% increase in cassava fresh weight above BW (15.23 t ha⁻¹). Similar results were obtained under tillage practices where there were differences ($P < 0.05$) among the tillage practices and minimum tillage and zero tillage had higher fresh weight (21.31 t/ha) and (20.61 t/ha) on average representing 28.6% and 24.4% increase in fresh weight above traditional tillage (16.57 t/ha). In conclusion, SB under minimum tillage treatment and BNW under zero tillage treatment gave better maize and cassava yield and appear to be the better options.

Key words: land clearing, tillage methods, growth and yield