The Use of Sunn Hemp as Forage in Florida

João M. B. Vendramini
University of Florida

J. E. Garzon Alfonso
University of Florida

H. M. da Silva
University of Florida

Maria L. Silveira
University of Florida

J. C. B. Dubeux Jr.
NARO, Japan

See next page for additional authors

The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress

Published by the Kenya Agricultural and Livestock Research Organization

Presenter Information

João M. B. Vendramini, J. E. Garzon Alfonso, H. M. da Silva, Maria L. Silveira, J. C. B. Dubeux Jr., and M. Kaneko

The use of sunn hemp as forage in Florida

Vendramini, J.M.B.*, Garzon Alfonso, J.E.*, da Silva, H.M.*, Silveira, M.L.*, Dubeux Jr., J.C.B.†, and Kaneko, M. †

*University of Florida, Range Cattle Research and Education Center, Ona, FL, USA, † University of Florida, North Florida Research and Education Center, Marianna, FL, USA, † Kyusyu Okinawa Agricultural Research Center, NARO, Kumamoto, Japan

Key words: sunn hemp, nutritive value, herbage accumulation

Abstract

Sunn hemp (*Crotalaria juncea* L.) is a warm-season annual legume that has been widely used as cover crop; however, there is potential to use sunn hemp as forage in subtropical regions. The objective of this study was to evaluate management practices to improve the efficiency of using sunn hemp as a forage crop. The study was conducted in Ona, Florida, USA from 2016 to 2018 and tested the factorial arrangement of five sunn hemp genotypes (Crescent Sunn, Ubon, Blue Leaf, and AU Golden) and two harvest times (60 d after seeding or flowering) with four replicates. There was a cultivar × harvest period effect on HA, crude protein (CP), and in vitro digestible organic matter (IVDOM) concentrations. Herbage accumulation was greater at flowering than 60 d harvest for all cultivars; however, the magnitude of increase was greater for Blue Leaf and Crescent Sun than AU Golden and Ubon. AU Golden and Ubon flowered at 83 and 92 d after seeding, while Blue Leaf and Crescent Sun flowered or were harvested at 166 d after seeding. AU Golden and Crescent Sunn had the greatest CP at 60 d harvest, and Blue Leaf and Ubon had the least CP concentrations. AU Golden and Crescent Sun had the greatest IVDOM at 60-d harvest; however, AU Golden and Ubon had greater IVDOM than Blue Leaf and Crescent Sun at flowering. Sunn hemp may be a feasible warm-season annual legume to be used in forage systems in Florida and harvest 60 d after seeding would results in forage with greater nutritive value.

Introduction

Warm-season perennial grasses are the predominant forages in tropical and subtropical regions; however, there is a possibility of using warm-season legumes in pure stands or overseeded into warm-season perennial grass pastures to increase herbage accumulation and forage nutritive value and supply biologically fixed N to grazing systems. Warm-season legumes can fix from 130 to 300 kg N yr^{-1} (Thomas et al, 1992),

Sunn hemp is a warm-season annual legume and has been used primarily as a cover crop due to the rapid growth. Sunn hemp HA varies depending on its management and climatic conditions, being reported a range from 1 to 9 Mg DM ha^{-1} (Finney et al, 2016; Mahama et al, 2016; Young-Mathews, 2017). Some articles reported superior CP concentrations, ranging from 110 to 180 g kg^{-1} (Foster et al, 2017). Additionally, La Guardia and Dereck (2018) showed concentrations from 520 to 620 g kg^{-1} of neutral detergent fiber (NDF) and 620 to 710 g kg^{-1} of in vitro DM digestibility (IVDMD), using this legume as forage crop intercropped with corn (*Zea mays* L.). Similarly to many forages, it has been observed an inverse correlation between maturity and nutritive value in sunn hemp. Lepcha et al, (2019) observed decreasing values of 178, 143 and 117 g kg^{-1} of CP and 798, 678 and 508 g kg^{-1} DM of in vitro true dry matter digestibility (IVTD) at 35, 45 and 55 d after seeding, with an increase of 399, 573 and 615 g kg^{-1} in NDF during the same period of time.

Sunn hemp seeds and pods may contain pyrrolizidine alkaloids; however, several studies have shown a safe animal consumption of this legume without adverse effects, if consumed in the vegetative stages with no seedheads (Burke et al, 2011; Purseglove, 1981; Strickland et al, 1987).

Therefore, the objective of this study was to evaluate forage characteristics of different genotypes of sunn hemp harvested at different physiological stages.

Methods and Study Site

The experiment was conducted at the University of Florida Range Cattle Research and Education Center, Ona, FL, USA (27°23 18"N lat; 81°56'38"W long) from April to November 2016 and 2017.

The soil in the study area was a Smyrna sand (sandy, siliceous, hyperthermic Aeric Alaquods), Before the initiation of the study, soil pH (in water) was 6.5 and Mehlich-3 P, K, Mg, and Ca concentrations in the surface horizon (0–15-cm depth) were 49, 24, 116, and 1151 mg kg^{-1} respectively.

Treatments were a factorial arrangement of four sunn hemp genotypes (AU Golden, Crescent Sunn, Ubon, and Blue Leaf) and two harvesting times (60 d after seeding or flowering) distributed in a randomized complete block design with 4 replicates. As some sunn hemp entries may not flower, the harvested for these genotypes occurred at the end of the growing season. Plots were 5 × 5 m with 2 m between plots. Sunn hemp was seeded in a prepared seedbed with a no-till drill (Pasture Pleaser, Agco-Tye, Batavia, IL) with a seeding rate of 16 kg ha^{-1} in April 2016 and 2017. Plots were fertilized with 30 kg ha^{-1} of N, 13.2 kg ha^{-1} of P and 25 kg ha^{-1} of K two weeks after germination.

An area of 2 × 2 m was harvested at ground level in the center of the plot and used to calculate HA. A subsample was dried at 60°C for 48 h and ground to pass a 1 mm screen in a Wiley mill (Udy Corporation, Fort Collins, CO) and used for nutritive value analysis. Samples were analyzed for N concentration using a micro-Kjeldahl method, a modification of the aluminum block digestion technique described by Gallaher et al, (1975). Crude protein was determined by multiplying nitrogen (N) concentration by 6.25. The IVDOM was determined using the two-stage technique described by Tilley and Terry (1963) and modified by Moore and Mott (1974).

Twelve Angus × Brahman crossbred heifers [(*Bos.* spp.); 388 ± 27 kg bodyweight (BW)] were allocated to individual pens (5 × 3 m) for voluntary DM intake and in vivo DM digestibility for a 17-d evaluation period. Treatments were proportions of sunn hemp and bermudagrass hay fed to beef heifers. Treatments consisted of 100% bermudagrass, 50% sunn hemp - 50% bermudagrass, and 100% sunn hemp, distributed in a complete randomized design with four replicates.

The data were analyzed using PROC MIXED of SAS (SAS Institute Inc, 2006). Response variables were HA, CP, and IVDOM. Genotype and harvest time were considered fixed effects. Block and year, and their interactions, were considered random effects. Treatments were considered different when $p<0.05$. Interactions not discussed were not significant ($p>0.05$). Data are reported as least squares means and were compared using PDIFF (SAS Institute Inc, 2006).

Results

There was a genotype × harvesting time interaction on HA. The interaction occurred because all genotypes harvested at flowering had greater HA than 60 d, but Crescent Sunn and Blue Leaf increased at a greater magnitude. Crescent Sunn had the greatest HA at 60 d (3.3 Mg ha^{-1}) and flowering (15.0 Mg ha^{-1}). AU Golden and Ubon had similar HA (mean = 1.9 Mg ha^{-1}) and Blue Leaf had the least HA (1.5 Mg ha^{-1}) when harvested at 60 d. When harvested at flowering, Blue Leaf and Crescent Sunn had the greatest HA (mean = 15.0 Mg ha^{-1}), followed by Ubon (5.0 Mg ha^{-1}) and AU Golden (3.9 Mg ha^{-1}). In 2016, Crescent Sunn and Blue Leaf did not flower and were harvested at the end of the growing season. In 2017, Crescent Sunn and Blue Leaf were harvest in late September, without flowering, due to hurricane Irma. Crescent Sunn and Blue Leaf had the greatest time between seeding and flowering or termination of the growing season (mean = 166 d); while Ubon and AU Golden flowered at similar times (mean = 87 d).

There was a genotype × harvesting time interaction for CP and IVDOM. The CP interaction occurred because AU Golden (160 g kg^{-1}) and Crescent Sunn (115 g kg^{-1}) did not decrease CP concentration from 60 d to flowering; however, Ubon and Blue Leaf had greater CP concentration at 60 d than flowering (from 140 to 120 g kg^{-1}, from 130 to 110 g kg^{-1}, for Ubon and Blue Leaf, respectively). AU Golden had the greatest CP concentration at both harvest times. Crescent Sunn had the least CP concentration at 60 d (110 g kg^{-1}) but there was no difference among Blue Leaf, Ubon, and AU Golden at flowering (mean = 117 g kg^{-1}).

The IVDOM was greater for AU Golden (580 g kg^{-1}) and Crescent Sunn (600 g kg^{-1}) at 60 d and did not differ among the other genotypes (mean = 530 g kg^{-1}). However, AU Golden and Ubon had the greatest IVDOM at flowering (mean = 540 g kg^{-1}), while Blue Leaf and Crescent Sunn had lesser IVDOM (mean = 430 g kg^{-1}). AU Golden and Ubon maintained the IVDOM from 60 d to flowering and there was a decrease in Crescent Sunn (from 600 to 430 g kg^{-1}) and Blue Leaf (from 530 to 410 g kg^{-1}).

Heifers receiving 100% bermudagrass had greater forage DM intake than 100% sunn hemp (1.6 vs. 1.2% BW). Additionally, the intake of 50% sunn hemp – 50% bermudagrass treatment did not differ from those with 100% inclusion. Heifers consuming 100% sunn hemp had lesser in vivo digestibility than those consuming 50% sunn hemp – 50% bermudagrass and 100% bermudagrass (480 vs. 520 g kg^{-1}).

Discussion

Crescent Sunn and Blue Leaf had the greatest HA at the end of the growing season likely because they did not flower during the experimental period. However, the long period decreased the nutritive value, possibly by the deposition of structural tissues with greater height of the plant (Mosjidis and Wang, 2011). Harvesting sunn hemp at 60 d after seeding decreased HA but resulted in forage with greater nutritive value. Schomberg et al, (2007), evaluated HA of sunn hemp in two locations in Georgia (United States), harvesting at 30, 60, 90 and 120 d after seeding and observed a location x harvesting time interaction and the HA at 60 and 120 d after seeding was 4,800 vs. 11,000 kg DM ha^{-1}.

The decrease in CP happened likely due to increase in cell wall concentration and dilution of CP in the greater HA (Juarez-Hernandez and Bolaños-Aguilar, 2007). An exception was the AU Golden genotype and it is hypothesized that AU Golden may have a greater leaf:stem ratio that may have caused the greater CP at longer maturity (Mosjidis et al, 2013). This hypothesis may be supported to the greater IVDOM of AU Golden at 60 d and flowering. The Ubon and AU Golden did not decrease IVDOM from 60 d to flowering; however, they flowered shortly after the 60 d and have a limited increase in HA. Conversely, Blue Leaf and Crescent Sunn had significant increase in HA due to the longer growth period with decrease in CP and IVDOM. The decrease in CP concentration with greater maturity was observed by Lepcha et al, (2019), which observed a decrease from 131 to 178 and from 106 to 117 g kg^{-1} N at 35 and 55 d of maturity respectively.

Cattle receiving the 100% sunn hemp diet had lesser digestibility that likely decreased the forage DM intake. Consequently, greater in vivo DM digestibility of the diet with 50% sunn hemp – 50% bermudagrass or 100% bermudagrass may have led to greater intake. It is important to mention that the sunn hemp and bermudagrass had similar IVTD and the reason for the differences in the in vivo DM digestibility is unknown. It may be hypothesized that negligible concentrations of alkaloids in the sunn hemp leaves may have affected the in vivo DM digestibility or forage DM intake.

In conclusion, the relatively early flowering characteristics of Ubon and AU Golden may be a desirable trait due to superior nutritive value and potential seed production, which decreases the cost of seed in the USA. Conversely, genotypes that did not flower has greater potential to produce greater HA with limited nutritive value.

Acknowledgements

Tropical Seeds LLC. for funding the research project.

References

Burke, J., Mosjidis, J., Miller, J., & Casey, P. (2011). Sunn hemp with chicory or pearl millet to minimize gastrointestinal nematode infection in weaned goats. In *American Society of Animal Science Southern Section Meeting* (pp. 17–18). United States. https://www.ars.usda.gov/research/publications/publication/?seqNo115=261064

Finney, D. M., White, C. M., & Kaye, J. P. (2016). Biomass Production and Carbon/Nitrogen Ratio Influence Ecosystem Services from Cover Crop Mixtures. *Agronomy Journal*, 108(1), 39. https://doi.org/10.2134/agronj15.0182

Foster, J. L., Muir, J. P., Bow, J. R., & Valencia, E. (2017). Biomass and nitrogen content of fifteen annual warm-season legumes grown in a semi-arid environment. *Biomass and Bioenergy*, 106, 38–42. https://doi.org/10.1016/J.BIOMBIOE.2017.08.016

Gallaher, R. N., Weldon, C. O., & Futral, J. G. (1975). An Aluminum Block Digester for Plant and Soil Analysis. *Soil Science Society of America Journal*, 39, 803–806. https://doi.org/10.2136/sssaj1975.03615995003900040052x

Jaramillo, D. M., Dubeux Jr, J. C. B., Vendramini, J. M. B., Quiroz, L. M. D., Santos, E. R. S., Ruiz-Moreno, M., … de Siqueira, M. C. F. (2020). Establishment techniques affect productivity, nutritive value and atmospheric N_2 fixation of two sunn hemp genotypes. *Grass and Forage Science*, 0(0), 1–6. https://doi.org/10.1111/gfs.12472

Juarez-Hernandez, J., & Bolaños-Aguilar, E. D. (2007). Las curvas de dilución de la proteína como alternativa para la evaluación de pastos tropicales. *Universidad y Ciencia*, 23(1), 81–90. https://www.redalyc.org/articulo.oa?idp=1&id=15423109&cid=35205

La Guardia, R., & Dereck, M. (2018). Forage Warm-Season Legumes and Grasses Intercropped with Corn as an Alternative for Corn Silage Production. *Agronomy*, 8(199), 1–9. https://doi.org/10.3390/agronomy8100199

Lepcha, I., Naumann, H. D., Fritschi, F. B., & Kallenbach, R. L. (2019). Herbage Accumulation, Nutritive

Value, and Regrowth Potential of Sunn Hemp at Different Harvest Regimens and Maturity. *Crop Science*, 59(1), 413–421. https://doi.org/10.2135/cropsci2017.09.0589

Mahama, G. Y., Vara Prasad, P. V, Roozeboom, K. L., Nippert, J. B., & Rice, C. W. (2016). Response of Maize to Cover Crops, Fertilizer Nitrogen Rates, and Economic Return. *Agronomy Journal*, 108, 17–31. https://doi.org/10.2134/agronj15.0136

Mosjidis, J. A., Balkcom, K., Burke, J., Casey, P., Hess, J., & Wehtje, G. (2013). *Production of the Sunn Hemp Cultivars 'AU Golden' and 'AU Durbin' Developed by Auburn University*. Auburn, United States. http://hdl.handle.net/11200/44129

Mosjidis, J., & Wang, M. (2011). Crotalaria. In C. Kole (Ed.), *Wild Crop Relatives: Genomic and Breeding Resources* (pp. 63–69). Berlin, Germany: Springer. https://doi.org/10.1007/978-3-642-21102-7_3

Purseglove, J. (1981). Leguminosae. In J. Purseglove (Ed.), *Tropical crops: Dicotyledons* (pp. 250–254). Essex, UK: Longman Group.

SAS Institute Inc. (2006). SAS statistics user´s guide. Cary (United States): SAS Institute Inc.

Schomberg, H. H., Martini, N. L., Diaz-Perez, J. C., Phatak, S. C., Balkcom, K. S., & Bhardwaj, H. L. (2007). Potential for Using Sunn Hemp as a Source of Biomass and Nitrogen for the Piedmont and Coastal Plain Regions of the Southeastern USA. *Agronomy Journal*, 99, 1448–1457. https://doi.org/10.2134/agronj2006.0294

Strickland, R., Lambourne, L., & Ratcliff, D. (1987). A rat bioassay for screening tropical legume forages and seeds for palatability and toxicity. *Australian Journal of Experimental Agriculture*, 27(1), 45. https://doi.org/10.1071/EA9870045

Thomas, R., Lascano, C., Sanz, J., Ara, M., Spain, J., Vera, R., & Fisher, M. (1992). The role of pastures in production systems. In *Pastures for the Tropical Lowlands: CIAT Contribution* (p. 240). Cali, Colombia: CIAT.

Young-Mathews, A. (2017). *Irrigated Warm Season Cover Crops from Western Oregon*. Corvallis, United States: https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/orpmcsr13158.pdf