Impact of Synthetic Nitrogen Rates on Fresh and Dry Weight Biomass Yield, Above Ground Plant Components, Physiological Parameters of Three Perennial Feedstock Bio-Fuel Grass Species

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Introduction

Perennial feedstock bio-fuel grasses produces more biomass and bioethanol. Compared with the first generation biofuels based on annual grain crops, perennial biomass crops require fewer inputs, produce more energy, and reduce greenhouse gas (GHG) emissions (Adler et al., 2007).

Napier grass, also known as elephant grass, is a perennial warm season grass native to Africa. It is grown for forage in tropical and subtropical regions of the world, including plant hardiness zones 8 and 9 of the southeastern U.S. It grows to a height of 2-4.5m (sometimes up to 7.5 m) and has leaves 30-120 cm long and 1-5 cm broad. Napiergrass has a cane-like growth and utilizes the efficient C4 carbon fixation path, resulting in high biomass productivity. According to Hanna *et al.* (2004), napier grass has the potential to produce more dry matter per unit time than most other grasses in the southeast.

Energycane is a hybrid of commercial sugarcane (*Saccharum officinarum* L.) with wild sugarcanes and related grassy species (*Saccharum spontaneum* L., *Saccharum robustum* Brandes & Jesw ex. Grassl., Erianthus sp., etc.) selected for high tonnage on a dry matter basis rather than for high sucrose content as in commercial sugarcane. Due to high fiber and biomass yield, energycane emerged as a potential lignocellulosic crop for second generation ethanol production (Matsuoka et al., 2009)

Giant reed (*Arundo donax* L.) is a perennial, herbaceous plant, graminaceous family of grasslands and wetlands occurring over a wide range of climatic habitats. It has a C3 photosynthetic cycle, but it has high rates of photosynthesis and productivity similar to those of C4 species (Christou, 2001). An average yields of 22.1 t ha^{-1} dry matter was obtained in the second year of plantation of giant reed in Italy (Cosentino et al., 2006).

Crop plants have a fundamental dependence on inorganic nitrogenous fertilizers, principally in the form of NO_3^- and NH_4^+ (Lam et.al, 1996) .Nitrogen has a significant role on plant growth through cell division (Saraswathy et al., 2007). High level of soil nitrogen stimulate tiller formation and leaf growth, which results in an increase of shoot dry weight and leaf area index (Spiertz and de Vos,1983). Present study was aimed to analyze the role of different rates of nitrogen fertilizer on biomass yield, above ground plant components and physiological parameters of three bio-fuel perennial grass species.

Materials and Methods:

Experimental site and design

Site: Fort valley State University: Agricultural Research Station Farm
Year: 2013-2014
Soil Type: Dothan sandy loam(fine-loamy, siliceous, thermic, plinthic and paleudult)
Soil pH: 6.5-6.7
Design: Randomized complete block design with four replications (plots comprise of three rows 9 m each with inter-row spacing of 1.8 m)

Treatments: (1)Energy cane zero(0kg N/ha) (2) Energy cane Half(100 kg N/ha) (3) Energy cane Full (200 kg N/ha) (4) Giant reed zero(0 kg N/ha) (5) Giant reed Half (100 kg N/ha) (6) Giant reed Full (200 kg N/ha) (7) Napier grass Zero(0 kg N/ha) (8) Napier grass Half(100 Kg N/ha) (9) Napier grass Full (200 kg N/ha)

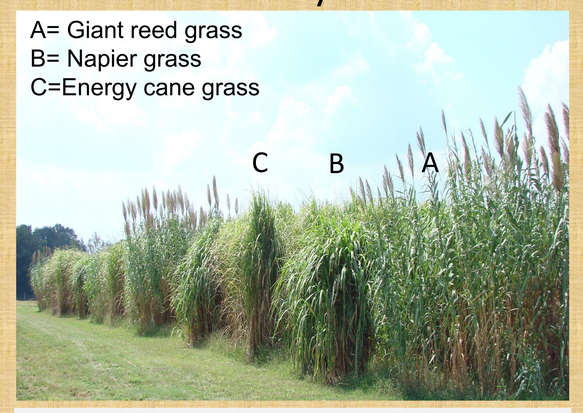
Site Management and Environment

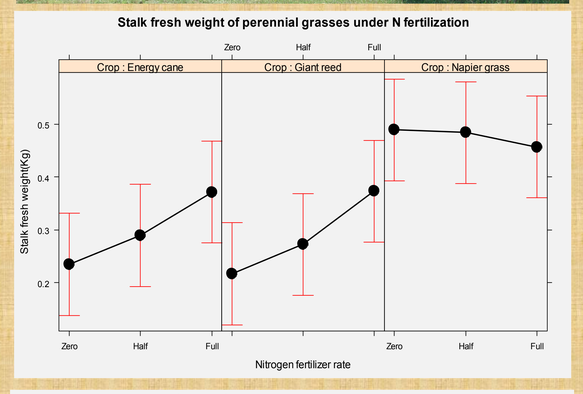
Crop Types: C4- Napier grass and Energy grass, C3- Giant reed grass
Plant Dates: Oct,2008
Fertilizer: Zero(0:20:20 NPK /ha), Half(100:20:20 NPK/ha), Full (200:20:20 NPK/ha)
Fertilizer Application Date: 3/31/14 and 5/16/14
Harvest Date:9/25/14
PAR range: 228.6-1674.65 $\mu molm^2s^{-1}$ (on 7/28/2014)

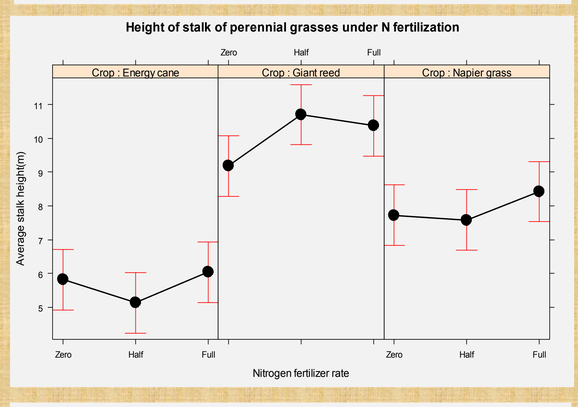
Data collection and Analysis:

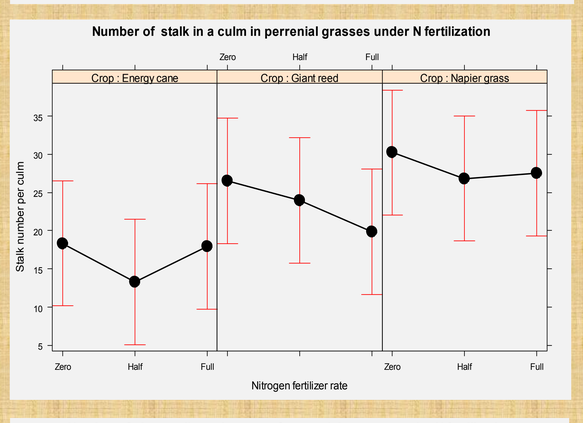
Observations: Biomass yield(fresh and dry weight), above ground plant component (height of stalk, stalk fresh weight, stalk no./ha, stalk no./culm, and culm fresh weight) and physiological parameter (photosynthesis, conductance, transpiration) and leaf area index
Procedure: Physiological parameters during vegetative growth, others during harvesting time and after harvest

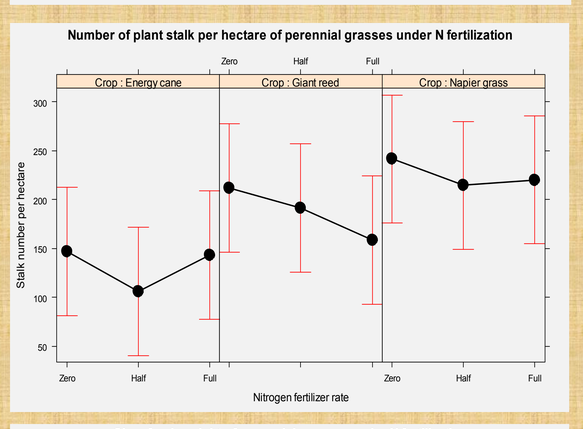
Data Analysis: Descriptive statistics; Analysis of variance using general linear model; and mean difference by Duncan's multiple range test using R (Version 3.3.0, R Foundation for Statistical Computing, Vienna, Austria

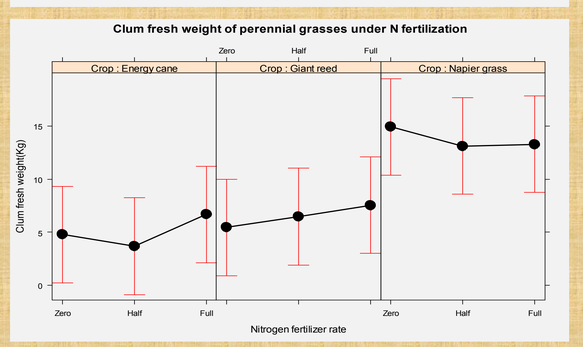


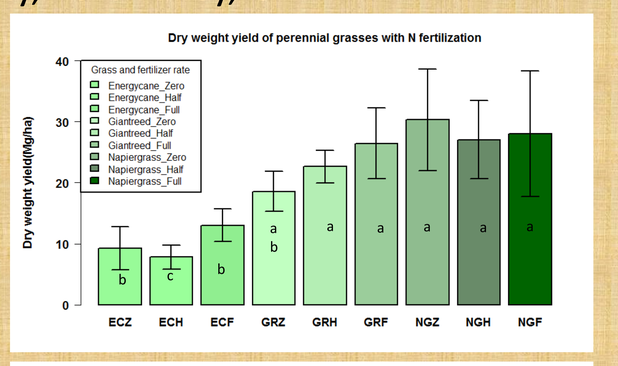


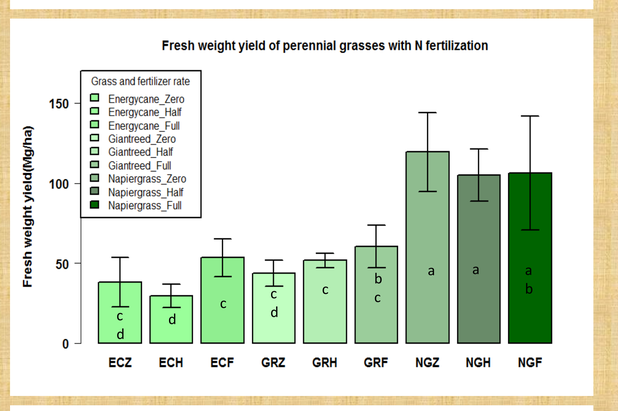


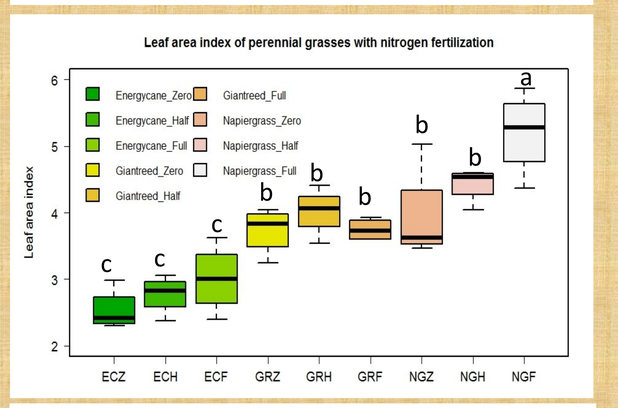


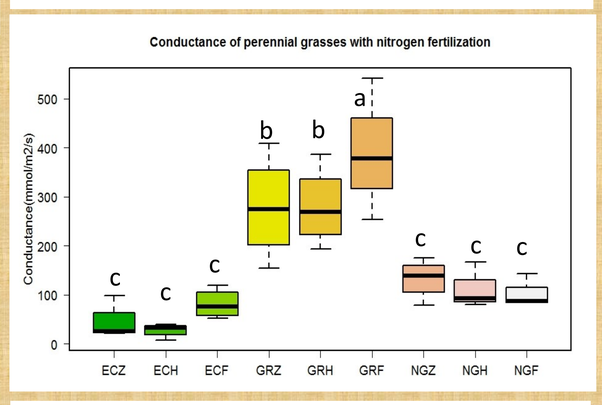


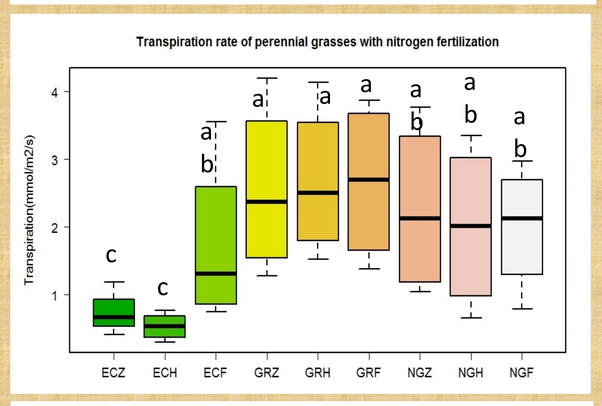


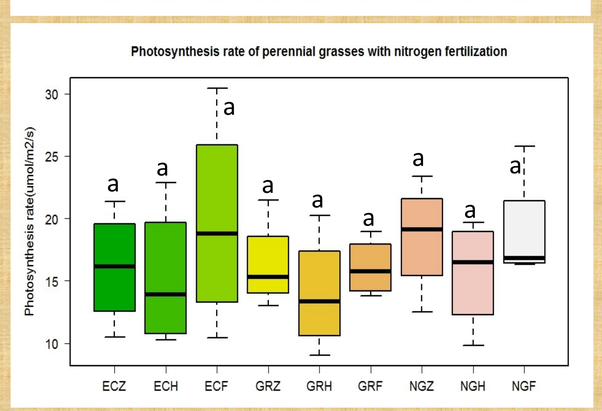












Results

There were significant variation among treatments for biomass yield, above ground plant components and physiological parameters. Napier grass with 0 kg N/ha produced highest fresh weight yield and dry weight yield (238.1and 60.5 Mg/ha) while lowest fresh weight yield and dry weight yield by energy cane with 100 kg N/ha (58.4 and 15.6 Mg/ha respectively). Napier grass with 0 kg N/ha produced maximum (481793) stalk no./ha while with energy cane with 100 kg N/ha produced minimum stalk no./ha (211969). Napier grass with 0 kg N/ha produced highest culm fresh wt. (14.94 kg) and stalk no./culm (30.2) while lowest culm fresh wt. (3.67 kg) and stalk no./culm (13.30) was produced by energy cane with 100 kg N/ha. Napier grass with 100 kg N/ha produced highest stalk ht./culm (356.7 cm) were by and energy cane with 100 kg N/ha produced the least (171.0 cm). Maximum fresh wt. / stalk (489.1 g) was produced by napier with 0 kg N/ha with energy cane with 0 kg N /ha producing minimum (217.4 g) fresh wt. per stalk. Leaf Area Index was highest (5.2) for giant reed grass with 200 kg N/ha and lowest (2.5) for energy cane with 0 kg N/ha. Physiological parameters were examined with napier grass with 200 kg N/ha, energy cane with 100 kg N/ha and energy cane with 200 kg N/ha producing highest rate of photosynthesis (19.6 umol/m^2/s), transpiration (2.7 mmol/m^2/s) and conductance (388.0 mmol/m^2/s).

Conclusions

- Napier grass produces higher biomass followed by giant reed and energy cane.
- Application of half and full doses of nitrogen fertilizer (100 and 200 kg N/ha) showed no significant difference in biomass production.
- Plants with higher above ground plant components (like height of stalk, stalk fresh weight, number of stalk per hectare and culm fresh weight) resulted into higher biomass yield.

References

- Adler, P. R., Grosso, S. J. D. and Parton, W. J., 2007. Life-cycle assessment of net greenhouse-gas flux for bioenergy cropping systems. Ecological Applications, 17: 675–691. doi:10.1890/05-2018
- Cosentino et al. 2006, First results on evaluation of *Arundo donax* (L.) clones collected in Southern Italy, Industrial Crops and Products 23 (2006) 212–222
- Christou, M., 2001. Giant reed in Europe. In: Proceedings of the First World Conference on Biomass for Energy and Industry, Sevilla, Spain, 5–9 June 2000, pp. 2089–2091.
- Eggleston, G., T. Tew, L. Panella, and T. Klasson. 2010. Ethanol from sugar crops. p. 60-83. In: B.P. Singh (ed.) Industrial Crops and Uses. CABI, Wallingford, U.K.
- Hanna, W.W., C.J. Chaparro, B.W. Mathews, J.C. Bums, and L.E. Sollenberger. 2004. Perennial *Pennisetums.* In: L.E. Moser, B.L. Burson and L.E. Sollenberger (eds.) Warm-season (C4) Grasses. American Society of Agronomy Monograph series no. 45, Madison, pp.503-535
- Kikas, T, Tutt, M, Raud, M, Alaru, M, Lauk, R, & Olt, J ,2016. Basis of energy crop selection for biofuel production: Cellulose vs. lignin', International Journal Of Green Energy, 13, 1, pp. 49-54, viewed 28 March 2016
- Lam, H.M. et al. (1996) The molecular-genetics of nitrogen assimilation into amino acids in higher plants. Annu. Rev. Plant Physiol. Plant Mol. Biol. 47, 569–593
- Saraswathy, R., S. Suganya and P. Singaram: Environmental impact of nitrogen fertilization in tea eco-system. J. Environ. Biol., 28, 779-788 (2007)

Acknowledgements:

This research was supported from USDA-NIFA-AFRI (2011-67010-20075) grant to Fort Valley State University.