Productivity, Fossil Fuel Replacement Potentiality and GHG Emission Reduction Ability from Lignocellulosic Bioenergy Crops Grown on Marginal Land

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ABSTRACT

The aim of this investigation was to study the production system of perennial and annual bioenergy crops on marginal lands. The perennial crops were Napier grass (*Pennisetum purpureum* (L.) Schum.), and Energy cane (*Saccharum spp*), while annuals were sorghum (*Sorghum bicolor* L. Moench) (biomass- ES5200, sweet-EJ7281). Three nitrogen fertilization rates (0, 100 and 200 kg N/ha) and two cover crops (no cover and clover) were used with the perennials while two nitrogen fertilization rates (0, 90 kg/ha) and four cover crops treatments (no cover, annual rye, vetch, and rye+vetch) were used with the annuals. Field experiments were conducted at the Agricultural Research Farm, Fort Valley, GA, from 2011-2015. The results showed Napier grass produced higher biomass (30.4 Mg/ha) in comparison to Energy cane (20.1 Mg/ha). Cover crop and different fertilizer rates did not show any significant difference in crop biomass production. In case of annuals, sweet sorghum produced significantly higher biomass. The dry matter yield of biomass sorghum ranged from 10.9 – 48.6 Mg/ha (Mean =30.8±10.9) while 9.9-51.7 Mg/ha (Mean=33.1±11.8) for sweet sorghum. No significant difference was observed in dry matter yield of biomass and sweet sorghum in response to nitrogen rates or cover crops treatments. The calculated calorific value for Energy cane and Napier grass was 34.5% and 35.8 % of commercial motor gasoline respectively. The net greenhouse gas (GHG) emission from combustion of bioethanol produced from biomass of one hectare of Energy cane and Napier grass was found to be lower (32% and 34% respectively) when compared to GHGs emitted from equivalent amount of motor gasoline combustion. We conclude that these lignocellulosic bioenergy crops can be highly suitable for producing lignocellulosic biomass on marginal lands with limited inputs and can put significant amount of unutilized farm resources to productive use.

INTRODUCTION

- The world total reserve to production (R/P) ratios for the main conventional fuels are oil - 46 years, natural gas - 58 years, coal - 118 years (BPstat,2016).
- Emission of greenhouse gases (CO_2, N_2O & CH_4) from conventional fuels.
- The U.S. Energy Policy Act 2005 mandates replacing 30% of liquid fuel from fossil to renewable source by 2030 (DOE,2006).
- Fuel from bioenergy crops is identified as one of the best renewable source to provide alternative.
- Production of biofuels from food crops (e.g. corn) is seriously criticized (Ajanovic, 2011)
- C4 perennial lignocellulosic crops are identified as possible alternative.
- Perennial crops like Energy cane (*Saccharum spp*.) and Napier grass (also called as Napier grass) (*Pennisetum purpureum* (L.) Schum.) which produces cellulosic bio-ethanol are prioritized as renewable source of Energy.
- These can be grown in marginal lands with minimum inputs.

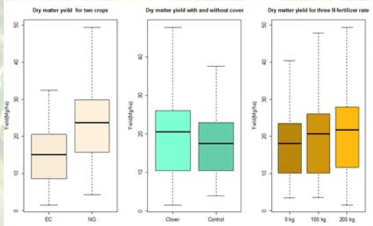
MATERIALS AND METHODS

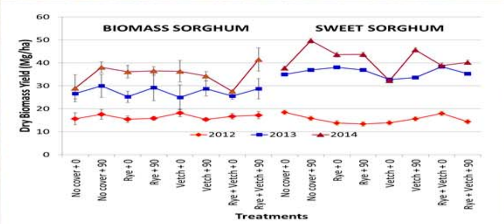
Perennial Crops: Energy cane (*Saccharum spp*.) and Napier grass (*Pennisetum purpureum* (L.) Schum.)
Cover Crop : Clover (*Trifolium incarnatum*)
Treatment and design: 8 , randomly complete block design.
T1 =Energy cane control ,T2 = Energy cane + cover + 0 KgN/ha,
T3 = Energy cane+ cover + 100 kg N/ha, T4 = Energy cane + cover + 200 Kg N/ha, T5 = Napier grass control , T6 = Napier grass + cover+ 0 kg N/ha, T7 = Napier grass + cover + 100 Kg N/ha, T8 = Napier grass + cover + 200 kg N/ha
Annual Crops
Sorghum varieties EJ7281 (sweet sorghum) and ES5200 (biomass sorghum) (Blade energy Crops)
Cover Crop: Annual rye, hairy vetch, nd annual rye plus hairy vetch
Treatment and design: 8 , split plot. No cover + 0, No cover + 90, Rye + 0, Rye + 90, Vetch + 0, Vetch + 90, Rye + Vetch + 0, Rye + Vetch + 90

Fossil Fuel Replacement and GHG emission

- Total ethanol = Yield x Calorific value x ethanol per unit of biomass
- Ethanol production per metric ton of dry biomass was used as 300 L /mt for both EC and NG.
- Calorific values of biomass samples for EC and NG was 16.32 and 16.47 MJ/kg respectively and was were determined experimentally and calculated from both ultimate and proximate analyses.
- The equivalent fossil fuel required to produce same energy as of total bioethanol per hectare of biomass was calculated using total ethanol of biomass x ratio of calorific value of biomass to motor oil fuel.
- The calorific value of motor oil was used as 45.5 MJ/kg.
- Carbon dioxide emission equivalent (CO_2 Kg/L) was calculated using emission factor of GHGs (IPCC, 2007) and "Emission Factors for Greenhouse Gas Inventories" (EPA, 2014).
- The CO_2 e for motor oil was compared with biomass . The CO_2 e of motor oil was calculated as 11.12 Kg CO_2 /L , whereas 2.90 Kg CO_2 /L for bioethanol.

RESULTS

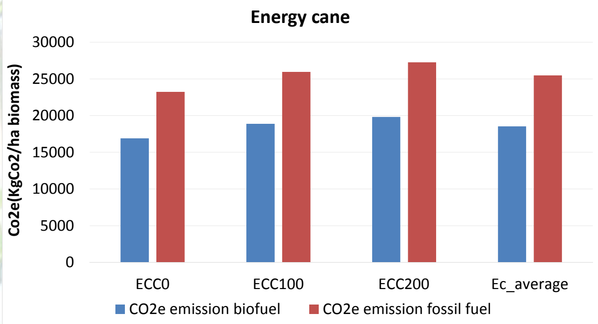




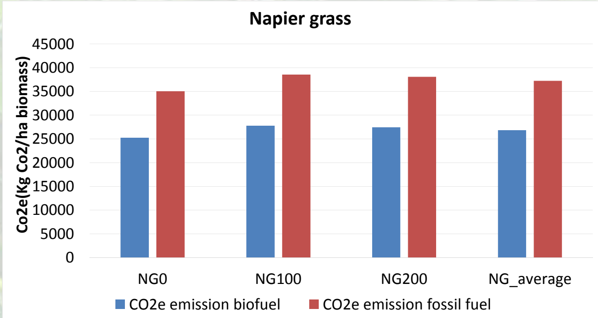
Biomass yield of energy cane and napier grass over time

CROPS	2011	2012	2013	2014	2015
Energycane	[B]4.57±0.25[c]	[B]11.17±0.4[b]	[B]19.62±0.52[a]	[B]20.25±0.47[a]	[B]20.35±0.56[a]
Napier grass	[A] 6.87±0.29[d]	[A]19.93±0.53[c]	[A]30.44±0.5[b]	[A]23.84±0.36[c]	[A]36.96±0.77[a]

(Letters with uppercase denotes the significance difference of yield of two crops at 0.05 level LSD; Letters with lower case denotes the significance difference of different years yield for particular crop at 0.05 level LSD)



CO_2e emission of biofuel from per hectare energy cane production and equivalent fossil fuel



CO_2e emission of biofuel from per hectare napier grass production and equivalent fossil fuel

CONCLUSIONS

- Yield of perennial and annual grasses is high enough for bioethanol production from marginal land.
- The bioethanol production from these crops are not only useful in terms of using marginal land but also for replacing fossil fuel. The total greenhouse gas emission can be reduced significantly if we replace bioethanol with fossil fuel usage.

REFERENCES

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