From:	Anna Nguyen
To:	Bill Rooney
Subject:	Re: Permission for publication
Date:	Wednesday, November 04, 2009 1:16:44 PM
Attachments:	Annual Hybrid Energy Crops.pdf

Dear Dr. Rooney;

Most certainly. I have attached the PDF file. Please let me know if you have trouble opening it.

Sincerely,
Anna Nguyen

----- Original Message -----
From: "Bill Rooney" <wlr@tamu.edu>
To: "Anna Nguyen" <annan@ncat.org>
Sent: Saturday, October 31, 2009 6:13:21 AM GMT -06:00 US/Canada Central
Subject: RE: Permission for publication

Anna:

Can you provide me with a copy of the material that I developed that you plan to distribute? I'm not exactly sure which publication it is and I would like to review it to make sure that it is current and accurate.

Regards,

Bill

-----Original Message-----
From: Anna Nguyen [mailto:annan@ncat.org]
Sent: Friday, October 30, 2009 3:04 PM
To: wlr@tamu.edu
Subject: Permission for publication

Dear Dr. William L. Rooney,

I would like to request permission to provide the publication of your article, "Annual Hybrid Energy Crops: Sorghums", to a group of energy professionals who participated in the training program called Energy Training for Agriculture Professionals www.entap.org. The ENTAP program is an education program designed to give USDA extension agents the tools to work with their clients on farm-scale energy technologies and issues. All use of your materials will be cited as belonging to you. Feel free to provide us with specific guidance on citing your materials.

If you have any questions feel free to get in touch with me at annan@ncat.org.

Thank you,

Anna Nguyen

TRANSITION TO A BIO ECONOMY
The Role of Extension in Energy

Annual Hybrid Energy Crops: Sorghums

Dr. William L. Rooney, Texas A&M University
wlr@tamu.edu

Second generation biofuel production will be based on crops grown specifically for the purpose of biofuel production. These dedicated energy crops provide the only economic and logical means for the production of biofuel on a commercial scale. Most of the research emphasis has focused on perennial grass species such as switchgrass and miscanthus, and these perennial crops will be critical for second generation bioenergy fuel production.

Regardless of which perennial bioenergy crops are grown in each location, there will be a need for annual lignocellulosic bioenergy crops for several reasons. First, they are needed to fill production gaps due to establishment lags in perennial crops. Second, they are the only means available to rapidly replace lost production due to weather or other unpredicted factors. Finally, in many productions systems, annual crops are required for the crop rotation patterns practiced by producers.

For lignocellulosic biomass production, sorghum is the logical annual bioenergy crop. In describing sorghum as a dedicated bioenergy, there are two distinct types to consider. Sweet sorghums are tall sorghums that accumulate sugar in the stalk as well as lignocellulosic biomass. Photoperiod sensitive energy sorghums are types that do not flower in temperate climates; they are tall and accumulate large amounts of lignocellulosic biomass.

Energy sorghums have high yield potential in favorable environments. Studies in Iowa, compare perennial grasses with annual row crops and found that sorghum had the highest yield potential, averaging over 35 Mg ha^{-1} (dry weight basis), and also performed well when intercropping with legume species. More recent data in multiple locations across the country have demonstrated that sorghum will consistently produce between 18 to 35 Mg ha^{-1} (dry weight basis) in rain-fed environments in the Eastern United States, with total yield directly correlated with available moisture. The potential to increase these yields through genetic improvement is high; adopting hybrids (sweet sorghum) and selection for highly heritable traits such as height, maturity and disease resistance. Longer term gains from marker-assisted breeding and transgenic approaches can be expected as well.

The biochemical composition of sorghum is highly dependent on the type that is produced; i.e., grain sorghum, sweet sorghum, forage and cellulosic (high biomass) sorghum. Sorghum grain is high in starch, with lower levels of protein, fat and ash. Juice extracted from sweet sorghum stalks is high in fermentable sugars, predominantly sucrose with variable levels of glucose and fructose, and in some genotypes, small amounts of starch. In photoperiod sensitive energy sorghums, the predominant compounds that are produced are structural carbohydrates (lignin, cellulose and hemi-cellulose). Our lab recently screened an array of different sorghum types, glucan content ranged from 20-40 percent; xylan content ranged from 8-21 percent; lignin content ranged from 9-20 percent and soluble extractive content ranged from 17-43 percent. The range in variation indicates that sorghum has substantial variation within the species from which to

either increase or decrease a component, depending on the end-users desired raw material. There remains a need to assess the relative magnitude of environment in composition.

Of all the potential bioenergy crops, sorghum is unique in that is has been cultivated in many regions of the United States as either a grain or forage crop. Producers are familiar with the crop and the agronomic infrastructure for growing the crop is essentially identical to other row crops such as corn. This reduces the need for additional equipment or the development of alternative production practices. There remains the need to develop agronomic management plans for energy sorghum production (as opposed to forage or grain sorghum production), but there are several groups actively researching the topic now. Production of sorghum as an energy crop will be initially similar to that of forage sorghum; the crop will required a good seed bed, early season weed control and suitable moisture to establish the crop.

While nitrogen fertilization requirements are not yet established, the crop will require nitrogen for maximum productivity and it is expected to be at a level somewhat lower than that required for optimum forage production, primarily because forage crops require and remove higher levels of nitrogen at harvest. It is our assertion that irrigation of bioenergy crops will be very limited; primarily to those that will produce a sugar component: i.e., sugar or energycane or sweet sorghum. In these situations, the water requirements of sweet sorghum are approximately 1/2 to 3/4 that of sugarcane. For photoperiod sensitive energy sorghums, they have been bred specifically for rainfall production and the absence of reproductive growth allows them a much greater level of drought tolerance than seen in other crops where reproduction is a required phase of growth. Consequently, these crops will be rain-fed; yields will be a function of available moisture.

Because of its history as cultivated crop in the United States, much of the infrastructure to establish sorghum as a viable energy crop already exists. There remains an active sorghum improvement industry that is producing new grain, and forage sorghum hybrid seed. These production and processing facilities have been used for over fifty years and are completely adaptable to the production of energy sorghum hybrid seed. Commercially acceptable sorghum hybrids are available for energy sorghum production at this time; new hybrids developed specifically for energy production will be available in the next couple of years. Sweet sorghum cultivars are currently available, but sweet sorghum hybrids are needed to provide seed quantities at scale; these should be available within two years.

With excessive storage, it is unrealistic to expect a single crop species to supply biomass to a large (>30MGY) throughout the year. Sorghum is one crop in a portfolio that will be used to provide biomass to the plant across a wide range of the United States. Energy sorghums can be harvested as early as two to three months after planting, if planting in staggered schedules it can be continuously harvested until past a killing frost. Composition over that time will change depending on hybrid and environment so management is important. If storage is required there is the potential to dry on ensile it. For sweet sorghum, like sugarcane, processing immediately is critical, so production in most of the United States is limited by available growing season. Application of sweet sorghum in initial development will be limited to regions that also produce sugarcane and can use the crop in a complementary fashion.