V(A). Planned Program (Summary)

Program # 9

1. Name of the Planned Program

Sustainable Energy

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms	0%	0%	9%	0%
204	Plant Product Quality and Utility (Preharvest)	15%	3%	24%	0%
205	Plant Management Systems	0%	0%	19%	0%
206	Basic Plant Biology	0%	0%	14%	0%
402	Engineering Systems and Equipment	34%	0%	0%	0%
511	New and Improved Non-Food Products and Processes	0%	0%	30%	0%
512	Quality Maintenance in Storing and Marketing Non-Food Products	0%	0%	4%	0%
723	Hazards to Human Health and Safety	51%	97%	0%	0%
	Total	100%	100%	100%	0%

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2012	Extension		Research	
	1862	1890	1862	1890
Plan	5.4	0.0	5.0	0.0
Actual Paid Professional	4.0	0.0	6.4	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
85697	4102	415720	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
91229	3174	2401422	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	0	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Sustainable energy research continues to be an important component of plant science and biosystems engineering research programs at the University of Kentucky. Research in energy science included both basic studies in plant biology for developing improved feedstocks and applied, pilot-scale demonstrations of bio-based production processes. The production and utilization of switchgrass as a feedstock continues to be an area of emphasis for our researxh and extension programs. Another important area of research for UK's programs is the improvement of oilseeds for energy applications and other bio-based chemical development.

2. Brief description of the target audience

-producers
-extension agents
-electric company representatives
-other researchers and extension specialists

3. How was eXtension used?

online resources/publications used

V(E). Planned Program (Outputs)

1. Standard output measures

2012	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	32820	32820	19036	19036

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2012
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2012	Extension	Research	Total
Actual	0	16	16

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Peer reviewed journal articles

Year	Actual
2012	14

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	The number of individuals who will become knowledgeable in the production of switchgrass as a biofuel
2	Availability of sustainable oilseed crops that can enable sustainable bioenergy production

Outcome #1

1. Outcome Measures

The number of individuals who will become knowledgeable in the production of switchgrass as a biofuel

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	1723

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The production and utilization of biomass energy, such as through switchgrass, continues to be explored due to a need to acquire additional sources of energy.

What has been done
The Bracken County Ag Advancement Council received a $50,000 grant from GOAP to study the potential of Biomass production and its conversion to a usable energy as an alternative crop.

UK College of Engineering worked with the 4-H area agent for SET to establish a hands-on bio-fuel research opportunity for local high school students. This program focused on the bio-fuel research being conducted and how this research could benefit programs in the community.

Kentucky State University (KSU) has designed a study to assess biomass production.

Results
Over 175 sixth to eighth grade students have learn how various types of biomass can be converted into usable fuel for transportation, industrial and home use.

The KSU study assessed non-agricultural land for its biomass production potential for land maintained by the Kentucky Transportation Cabinet (KTC). KSU, in conjunction with KTC, digitized and quantified land areas that are mowed and maintained.

4. Associated Knowledge Areas

KA Code	Knowledge Area

402 Engineering Systems and Equipment

Outcome #2

1. Outcome Measures

Availability of sustainable oilseed crops that can enable sustainable bioenergy production

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2012	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Plant oils are mainly composed of triacylglycerol (TAG) which represent an important edible and industrial resource. Oil from crops such as soybeans is the main substrate for biodiesel and can be an important source of renewable chemicals for the future. The basis of selective accumulation of specific fatty acids and the final synthesis of TAG in seed oil are not fully understood. An improved understanding of seed oil biosynthesis will lead to improved breeding and bioengineering methods for developing crops with optimal oil content. One target of our work on triacylglycerol biosynthesis and higher oil levels in soybeans is for renewable lubricant applications with branch-chain fatty acids (BCFAs). This will increase the profitability of agricultural production, enhance rural economic opportunities. A considerable market currently exists for lubricants with worldwide demand ~ 36 Mt with motor oils accounting for a little over half of this market, most of which is currently derived from petroleum.

What has been done
A detailed analysis was conducted of the expression of the primary enzyme responsible for most oilseed triacylglycerol, diacylglycerol acyltransferase (DGAT), during soybean and Arabidopsis seed development. Studies looked at the effect of blocking expression of the enzyme on oil accumulation in seed. Insight achieved through this work was used to engineer soybean lines with higher oil content. We grew out higher oil + protein soybean lines we developed for additional generations in the field and greenhouse in 2012 and further verified development of soybean lines with 4% or higher oil contents with no reductions in protein content. We also obtained high oil seed from two collaborating breeding programs and crossed these lines with our high oil lines developed by metabolic engineering. In addition, soybean somatic embryos have been transformed with BCFA gene constructs and progeny plants are being screened for the presence of the gene(s). Plants confirmed to have the BCFA genes were grown out in the greenhouse and additional lines analyzed for BCFA genes.

Results

Significant progress was made toward the goal of metabolically engineering soybean oils as a source of renewable lubricants such as motor oils. Genes have been cloned for conversion of soybean oil into BCFA as a new use of soybean oil as a lubricant source. Some of the new soybean lines with 4% or greater oil levels and total oil + protein levels have been further characterized and found to exhibit higher oil + protein levels for another generation in the greenhouse and in field trials. Further chemical analyses are consistent with the other prior work indicating higher oil and protein levels than soybeans previously developed. Additional yield trials were conducted in 2012 of some of our new high oil + protein lines for which sufficient seed was available and no significant reduction in yield is seen with some of the high oil lines. As much as 20% more oil per acre may be possible with some of our soybean lines with protein yield per acre as conventional lines. This increased oil production could make more than $2 billion of renewable oil produced by US soybean growers per year and increase this renewable resource for edible, fuel and renewable chemical applications without requiring more land for the production.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
204	Plant Product Quality and Utility (Preharvest)
206	Basic Plant Biology

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Government Regulations
- Competing Programmatic Challenges

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

See outcome 1; increased awareness; pilot study

Key Items of Evaluation

Feedback from participants, preliminary findings