

Energy Crop Analysis & Planning (ENCAP)

User Manual
2015

Version 1

By

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I. Introduction

With current mandates for renewable fuels production from cellulosic feedstocks, producers are increasingly interested in growing energy crops such as switchgrass, miscanthus, or energy sorghum. In addition to resources for growing these crops, producers need information on how production practices affect cost and thereby management decisions. Given volatile fertilizer prices and the potential for extended drought stress, producers need to be able to evaluate tradeoffs associated with fertilizer use, irrigation, expected yield, and optimal harvest time.

Energy Crop Analysis and Planning (ENCAP) software was developed to compare user-specified production practices for growing switchgrass on cropland or pasture, irrigated or dryland energy sorghum, and miscanthus against default production budgets. The user may specify:

- different machinery complements for performing tasks by specifying tractor horsepower, equipment width, purchase price, salvage value, annual use hours, fuel consumption, and allocate acres across multiple implements and/or crop enterprises;
- amount and type of fertilizers, herbicides, and other chemicals applied;
- the expected yield by production year and stand life by crop; and
- other input prices.

Also provided is a summary sheet for comparisons of outcomes associated with different production practices and/or price scenarios. Modifying production practices to fit the circumstances of the user-specific operation allows the opportunity to conduct meaningful sensitivity analysis when comparing to default values for production practices. Also included are weather data and a tool that provides weather- and location-specific recommendations for switchgrass production in terms of needed nutrient replacement which, in turn, is dependent on harvest date, which may be either user-specified or estimated using profit-maximizing fertilizer needs driven by switchgrass price and nutrient replacement costs. This section of the tool is based on experimental switchgrass trials conducted across OK, AR, MO and LA. A brief description of each energy crop is provided below to ensure a basic understanding of similarities and differences across these biomass crops.

Switchgrass

Switchgrass is a perennial, warm-season crop that, unlike corn or soybeans, does not need to be reseeded annually (Gibson et al., 2007). Growth generally begins each spring in March and continues through the warm months of the year, generally June through September. Leaf shedding occurs throughout the year, but increases after first frost. Fall frost stops active growth and initiates the translocation of nutrients contained in the leaf tissue to the crown and roots. The concentration of nutrients in the harvested material is thus affected by timing of harvest. This makes switchgrass very efficient at nutrient use because it requires little nitrogen, phosphorus, and potassium for the amount of cellulose produced.

Once established, varieties of switchgrass adapted for the northern United States are very winter hardy (Gibson et al., 2007) and are not susceptible to lodging, even with snowfall. A producer can expect a typical stand life of ten years with annual harvests except for the establishment year.

Foregoing harvest in the establishment year helps to ensure adequate root growth. While weed control can be problematic during the establishment year, the vigorous growth of the plant usually shades out weeds starting in the second year. First year growth contributes to the yield potential in the second and subsequent years.

The second year of production generally leads to two-thirds of the full yield potential achieved in the third year. Analysis of the yield data used for developing the economic modeling as presented herein showed a statistically significant 1-ton yield shortfall for 2nd year yields compared 3rd to 6th year yields. Very old stands, with a 16th and 17th year harvest, showed nearly a 3-ton penalty compared to 3rd through 6th year yields, but part of those yield shortfalls may also be attributed to that soil and weather conditions at that study site. Yields for the first harvest period, occurring in the 2nd year, range from three to five dry tons per acre per year, whereas full yield potential in the third year onward typically ranges from 5 to 10 dry tons per acre and varies with nutrient availability, soil quality, and rainfall. Adding a second harvest early in the year to harvest higher quality forage for feed adds to fertilizer requirements and has little consequence on total annual yield. Nonetheless, since more nutrients are removed in the harvested material, cost of production increases. The focus of the tool is on harvests of biomass as an energy crop with a single harvest recommendation.

Miscanthus

Miscanthus, like switchgrass, is a perennial, warm-season crop that may grow from 8 to 12 feet in height. Annual growth generally begins in April and ends when temperatures decline in the fall. With maximum attainable yields occurring during late summer, harvest can again be delayed until winter or early spring after senescence has occurred (Heaton et al., 2010). *Miscanthus* is less drought hardy than switchgrass. Given its height and yield, the lodging potential for *miscanthus* is most likely intermediate between energy sorghum and switchgrass.

Similar to switchgrass, harvest is forgone in the establishment year to allow the crop to establish a strong root system. In contrast to switchgrass that is planted using seed, *miscanthus* is propagated using plugs or rhizomes. A stand life of 15 years is typical for *miscanthus*. Dryland yields for the first harvest period (2nd year) are estimated at three to seven dry tons per acre. A harvest of up to 12 dry tons per acre is not unusual for the remainder of the stand life.

Energy Sorghum

Energy Sorghum is a warm-season, annual grass similar to forage sorghum, except these varieties are bred for biomass accumulation rather than feed quality. It grows best during high temperatures and can reach up to approximately 12 feet tall. Seeding of sorghum typically occurs during mid-May and extends to early June with harvest occurring in mid-to-late August or early September (Undersander et al., 1990). Yields can range from crop failures in arid production regions with drought to slightly over 13 dry tons per acre as demonstrated in field trials performed in the study region over the period 2011 to 2013. Under irrigated conditions, 10 to 15 dry tons per acre are not unusual. Given the range of yield observations described, a yield of seven dry tons per acre may be a reasonable expectation without irrigation while 12 dry tons per acre are expected under irrigated conditions.

Energy sorghum stems are not hollow, but pithy, which allows for good moisture retention and drought tolerance, but increases drying time after cutting. It is not unusual for the drying period to last up to 10 days after cutting, before the moisture content is sufficiently low for safe baling (Rocateli, 2010). When shorter in-field drying periods are used to allow easier coordination for a custom harvesting crew, a period of two days for drying between cutting and baling, leads to moisture content expectations between 30 and 50% of the harvested material (Popp et al., 2015). Furthermore, the stalks do not rake well for enhanced dry down. Hence, this crop is likely best managed with a forage harvester.

Use Caveats

This model uses default values that are based on some experimental observations as well as a review of the existing literature. Estimates using these parameters lead to results that are the result of a set of complex calculations performed in this model. These calculations are described in greater detail in the appendix section of this manual.

Changes in parameter values and its implications on returns are estimates and the user should use their own reasonable judgment to reflect whether the direction of change in returns is appropriate before changing their operation on the basis of the results. *As such, this software is provided 'as is' and without warranties as to performance or merchantability. Further, statements may have been made to you about this software. Any such statements do not constitute warranties and shall not be relied on by the user in deciding whether to use the program or act on its results. This program is provided without any expressed or implied warranties whatsoever. Because the diversity of conditions and hardware under which this program may be used, no warranty of merchantability or warranty of fitness for a particular purpose is offered. The user is advised to test the program thoroughly before relying on it. The user assumes the entire risk of using the program. The University of Arkansas will not be liable for any claim or damage brought against the user by any third party, nor will the University of Arkansas be liable for any consequential, indirect or special damages suffered by the user as a result of the software.*

II. Purpose

ENCAP was designed to provide producers and researchers with a planning tool to allow specific analysis of varying production inputs as they relate to the cost of energy crop production. This decision aide allows the user to enter values for average costs of production to compare 'Benchmark' values with user-specified values from their own operation for a side-by-side comparison. This program is divided into several worksheets so information pertaining to a particular energy crop and operation is viewable on-screen and can be printed on one page. These worksheets are navigable by left-mouse clicking the command buttons at the top of each screen or by clicking on the names of the tabs at the bottom of the spreadsheet and are discussed in greater detail in later sections of this user manual.


Given the multi-year nature of the perennial energy grasses and the potential need to compare to annual crop returns, this spreadsheet calculates the average, prorated, and annual equivalent breakeven cost of production. This allows for comparison of costs and returns as if production

occurred within an annual time step. In reality, producers may have several fields at varying points in their stand life. For example, one field might be established, whereas the next is three years old and another seven years old. The intention is to make the cost and return data presented comparable to an average of several fields, at varying ages by discounting future cash flows to the present and weighting those cash flows according to their occurrence over the stand life making the discounted total of cash flows comparable to those of an annual crop enterprise.

This tool also contains a worksheet, Switchgrass Harvest Date, Yield and Nutrient Concentration Evaluation (SHYNE), which utilizes the user-specified switchgrass price, nutrient costs, and weather- and location-dependent yield responses to nitrogen applications to determine a profit-maximizing harvest date. Cost implications of deviating from that profit-maximizing harvest date are also calculated by calculating an alternative switchgrass price that would leave the producer with the same level of profitability, but with different nutrient concentrations in the harvested biomass.

III. Installation and General Use Instructions

Installation

This software was developed as a macro-enabled workbook in a 2007 – 2013 compatible file format of Excel® using a Windows 7 working environment. Its file extension is **‘.xlsm’** and the name of the file is **‘ENCAP.xlsm’**. *Note: displayed next to file name is an icon, , showing an image of an Excel® spreadsheet with an exclamation mark in the bottom right corner. This icon is normal for all macro-enabled workbooks and does **not** indicate errors within the program.*

The user may download and save the file to any directory or file folder on their computer; however the user should **not** use a flash drive for this directory. This practice may lead to many problems, including slow read/write speeds as well as loss of data if the flash drive becomes damaged, corrupted, or fails to integrate when files are backed-up to the computer’s hard drive. In addition, if this file is received via email, please first save the file to the computer instead of opening the file directly from the email. This will ensure ease of access to the file at a later time.

Several warning messages may appear when opening the file (Figs. 1 to 3). These messages will differ depending on the version of Excel®, operating system and the user’s security settings. Please complete the following screen instructions in Excel® to set the appropriate security settings to enable macros.

Saving Files



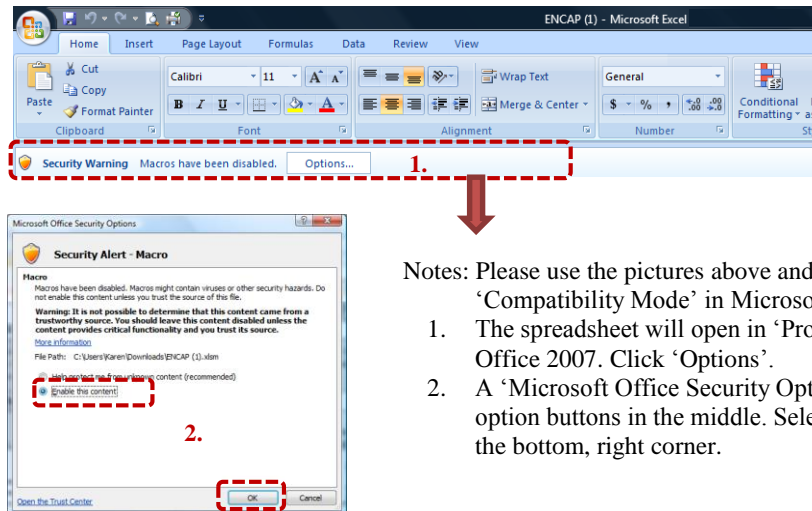
ENCAP is an Excel® program compatible with Excel® 2007 – 2013 with an **‘.xlsm’** file extension. As the user enters data into ENCAP, changes may be saved in the current workbook by either clicking on the **‘Save’** icon,  **Save**, to overwrite the original file or by choosing **‘Save As’**,  **Save As**, from the **‘File’** menu so the original version of this spreadsheet is maintained. Figure 4 shows the steps needed to save a file in this manner.

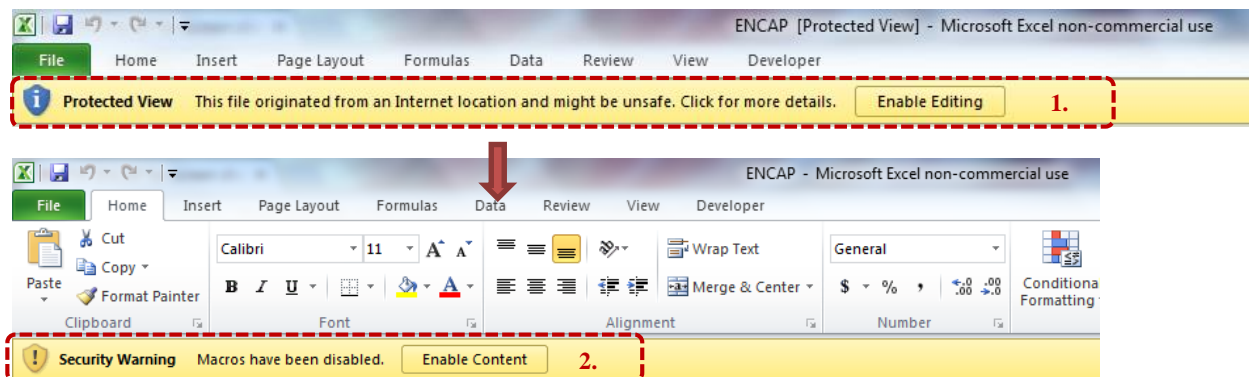
Figure 1. Initial File Installation Message for Excel 2007



Notes: Please use the pictures above and left and instructions below to get to 'Compatibility Mode' in Microsoft Office 2007.

1. The spreadsheet will open in 'Protected View' when installed in Microsoft Office 2007. Click 'Options'.
2. A 'Microsoft Office Security Options' dialog box will appear with two option buttons in the middle. Select 'Enable this content', then click 'OK' in the bottom, right corner.

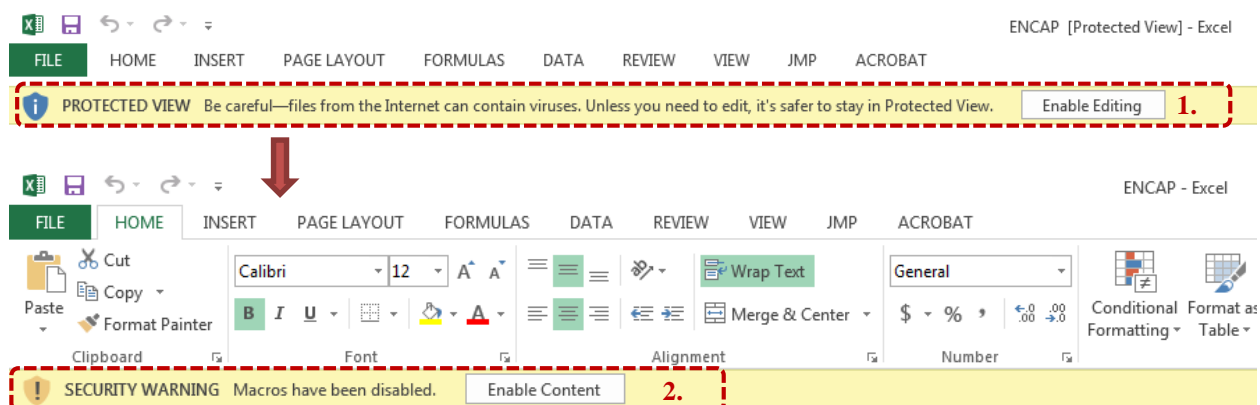
Figure 2. Initial File Installation Message for Excel 2010



Notes: Please use the pictures above and instructions below to get to 'Compatibility Mode' in Microsoft Office 2010.

1. The spreadsheet will open in 'Protected View' when installed in Microsoft Office 2010. Click 'Enable Editing'.
2. Enable macro content when first installing the software by pressing the 'Enable Content' button, if prompted.

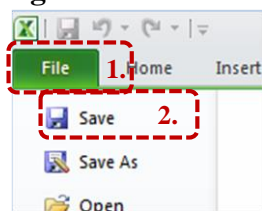
Figure 3. Initial File Installation Message for Excel 2013




Notes: Please use the pictures above and instructions below to get to 'Compatibility Mode' in Microsoft Office 2013.

1. The spreadsheet will open in 'Protected View' when installed in Microsoft Office 2013. Click 'Enable Editing'.
2. Enable macro content when first installing the software by pressing the 'Enable Content' button, if prompted.


Figure 4. Save



Notes:

1. Click 'File' at the top right hand corner of the screen.
2. Click 'Save As', , to rename the file. This allows an unaltered file to be maintained for later use.

Copy and Paste Restriction and Other Highlighting

Please do not copy and paste values from one location or cell in the spreadsheet to another because special formatting (bold, italic numbers with a sky blue background color) has been applied to all cells the user is allowed to change. This ensures easy, subsequent identification of any modifications from default values. Should the user use the copy and paste feature, ENCAP's integrity cannot be ensured and the user is therefore advised to use the 'Undo' feature, , or revert to downloading another copy of the program.




Navigating Worksheets

To simplify the use of the software, ENCAP is divided into different worksheets that can be accessed by clicking on the appropriate tabs at the bottom of the screen or by left-clicking the command buttons located at the top of each sheet. Note: this user manual and its accompanying spreadsheet use the terms "worksheet," "sheet," and "tab" interchangeably.

The 'Main Menu' sheet provides a brief overview of the layout of this program and includes links to other sheets within the spreadsheet. The 'Inputs' sheet also allows the producer to enter the cost of production inputs in comparison to the default 'Benchmark' production inputs typically used for energy crop production using prices common in 2012 – 2015 production years.


The 'Machinery' sheet permits the user to specify equipment complements by selecting an implement with an associated tractor. The 'Switchgrass', 'Miscanthus', and 'Energy Sorghum' sheets contain the crop budgets for each enterprise and allow the user to specify:

- stand life and yield expectations for the second and subsequent years for perennials;
- fertilizer use for year of establishment and harvesting years;
- yield losses associated with baling, staging, loading/unloading, storage, and processing;
- number of passes with a rake, if needed; and
- production practices performed using a host of equipment choices linked to default production practices for switchgrass on crop land or pasture, irrigated or dryland energy sorghum, and miscanthus against their respective benchmark values.

The 'Results' worksheet provides side-by-side comparisons of crop production practices established by clicking on the save buttons (, , or ) in the aforementioned crop budget worksheets. The 'Weather' sheet allows analysis of weather and location impacts for optimal harvest date calculations for switchgrass as shown in the 'Inputs' sheet. Lastly, the 'SHYNE' worksheet calculates optimal harvest date to maximize partial returns by calculating appropriate fertilizer application for *switchgrass only*.

ENCAP contains many different working parts on each worksheet known as ‘controls’. These controls include command buttons, drop-down lists, check boxes, comment boxes, cell shading, and userforms that are briefly discussed below:


Command Buttons

Command buttons are gray, square boxes containing bold, red text. These buttons contain macros that allow the user to move among worksheets, access userforms, select desired land type (cropland or pasture for switchgrass and irrigated or dryland for energy sorghum) in the crop budget worksheets, save scenarios for comparison, reset user information to default data from the ‘Benchmark’ case, or print worksheet data. These command buttons provide easy access to different tabs and an easy way to revert to program defaults. ***Warning: macro commands cannot be reversed using the ‘Undo’ button, , to return to a condition before the command button was clicked.*** For this reason, the user may be prompted to continue when clicking on a command button. Clicking the ‘Cancel’ button allows the user to stop before losing data.

Drop-Down Lists

Drop-down lists are located in the light blue cells and can be accessed by left-clicking on the cell. After clicking the cell, a downward pointing arrow will appear to the right of the cell. Clicking on this arrow will display the options contained in the drop-down list. The user may select a desired option by scrolling up or down the list using the mouse cursor and left-clicking on the desired option. Once the desired option is selected, the selection will appear in the cell.

Check Boxes

Check boxes allow the user to utilize a defined set of data. Check boxes, , are used by clicking within the box provided. A check mark within the box indicates a ‘yes’ response and a blank indicates a ‘no’ response.

Comment Boxes

Comment boxes may be accessed by moving the cursor over the small red triangles located in the top right corner of a cell containing a comment. These comment boxes contain information to better explain contents of a cell, or range of cells, and aids in the selection of data entered by the user. Comment boxes will disappear when the mouse is moved away from the cell. They do not affect the operation of the spreadsheet, but add information for the ENCAP user.


Cell Shading

Throughout the spreadsheet, cells are color coded for ease of identification. Cells shaded in yellow are provided for user input. Green cells provide ‘Benchmark’ or default information to compare against user input. Light blue cells contain drop-down lists for the user to make appropriate selections as previously discussed. Cells without shading are protected so the user cannot modify the contents of the cell, thus ensuring proper functioning of the program.

Note: if an option is not available that directly describes the user’s situation, the option that *most closely* describes the user’s operation should be selected to provide a reasonable estimate of the cost of production or equipment performance.

Userforms

Machine selection userforms may be accessed in the ‘Machinery’ selection worksheet by left-clicking on the command buttons located on the left of the sheet. These userforms allow the user to specify various settings, including the size (width in feet or horsepower), purchase price, salvage value, annual use and useful life hours, and fuel consumption as well as assign tractors to implements and allocate acres across multiple implements and/or crop enterprises. Figure 5 is an example of the ‘Fertilizer/Lime Applicator’ userform, which allows the user to assign a tractor and specify fuel consumption. Section VI provides the user with greater detail on properly entering data in the userforms.

After selecting the desired options within the userform, the user must click the ‘**Save**’ button in the upper right corner of the userform to apply the desired changes to the workbook. **Warning:** *clicking ‘Save’ in the userform will not result in saving the workbook in its entirety; in order to save changes made in the userform, the user must save the workbook as described in the previous section of this manual. Note: changes made in a userform, like command button macros, **cannot be reversed** using the ‘Undo’ button, .*

Userforms contain many options similar to the controls discussed previously, such as drop-down lists, check boxes, and command buttons. In addition, userforms contain text boxes and option buttons. These additional controls are briefly discussed below.

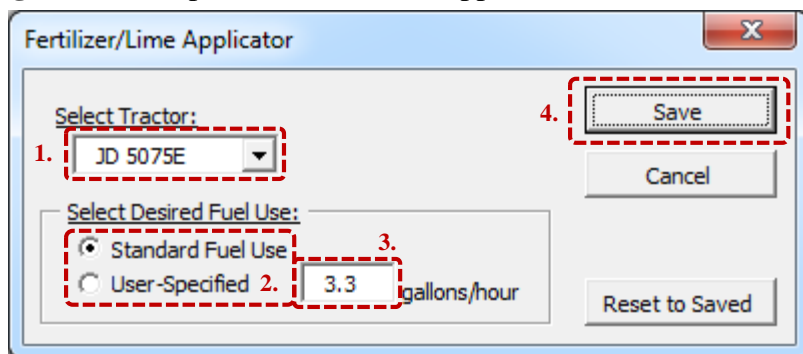
Text Boxes

Text Boxes allow the user to input customized data into the userform by typing the data directly into the text box provided. This data may be entered in alphanumeric format.

Option Buttons

Option Buttons allow the user to choose between a set of options within the userform. Unlike check boxes, which allow the user to make multiple selections, option buttons limit the user to only one selection.

Figure 5. Example Fertilizer/Lime Applicator Selection Userform



Notes:


1. The drop-down list allows the user to assign a tractor to the fertilizer/lime applicator by clicking the arrow to the right and choosing from a pre-selected list of tractor options.
2. Selecting between the two option buttons allows the user to choose between the standard fuel use rate and specifying their own fuel use rate.
3. Descriptions of each worksheet are provided to the right of their corresponding command buttons.
4. The column to the right of the sheet provides a basic introduction to the spreadsheet.

IV. Main Menu

After installation, the user is immediately directed to the 'Main Menu' tab (Fig. 6). The 'Main Menu' provides an overview of the program as well as command buttons linking the user to each of the worksheets provided along with a brief description. The user may click on the command buttons to the left to go directly to the indicated worksheet. These same command buttons are also located at the top of each worksheet for easy navigation.

While ENCAP is designed for the user to move along the tabs in the order of 'Inputs', 'Machinery', production budget desired ('Switchgrass', 'Energy Sorghum', or 'Miscanthus'), 'Results', 'Weather' and ending with 'SHYNE'; the user may access any worksheet, at any time. Moving from tab to tab does not save the spreadsheet. It will also not alter previously entered data.


Figure 6. 'Main Menu' Worksheet



Division of Agriculture
Research & Extension
University of Arkansas System

Energy Crop Analysis & Planning (ENCAP)

Main Menu



ENCAP
ENERGY CROP
ANALYSIS & PLANNING

1. Enter farm name: **Circle C**

2.

Sheet	Description
Inputs	Enter prices for inputs of fuel, labor, application costs, seed, weed and pest control, fertilizer, and interest rates. Shows fertilizer recommendations for trial data.
Machinery	Specify the size, purchase price, salvage value, annual use and useful life hours, fuel consumption for tractors and implements, assign tractors to implements, and allocate acres across multiple implements and/or crop enterprise. Specify the price of custom operations or use the average benchmark prices. Provides key performance statistics.
Switchgrass	Calculate the cost for pasture or cropland switchgrass production. Specify field operations, application amounts, percentage of yield loss with harvest, and stand life.
Energy Sorghum	Calculate the cost for dryland or irrigated energy sorghum production. Specify field operations, application amounts, percentage of yield loss with harvest, and stand life.
Miscanthus	Calculate the cost for miscanthus production. Specify field operations, application amounts, percentage of yield loss with harvest, and stand life.
Results	Compare production costs for Circle C to the benchmark on a per acre basis.
Weather	Compare weather patterns for estimates of switchgrass production performance from several experimental trials.
SHYNE	Calculate switchgrass optimal harvest date to maximize partial returns by calculating appropriate urea and litter application rates to meet nitrogen needs in the spring and estimate the cost of replacing nutrients that are removed in the biomass harvested.

3.

A spreadsheet format was chosen to allow producers to vary prices and equipment used for operation-specific comparisons to a flexible benchmark. The benchmark default values are a result of a collection of expert opinion and results of experimental trials across a range of weather and soil conditions.

Drop-down lists are provided for selecting among options. The user should select options most compatible with their operation in terms of specified fertilizer and machinery used for a particular piece of equipment. This information is summarized in the enterprise budget tabs which allow the user to select among different options for the operation and aid in benchmarking.

Each worksheet has dedicated links near the top to aid navigation of ENCAP. These links will look like the command buttons in the left column of this sheet. Information entered will not change as a result of moving to other sheets. Cells requiring user input are highlighted in light yellow throughout this spreadsheet. Other cells contain formulas and cannot be modified. Each sheet contains a command button to print with automated

Comment boxes have also been added to help the user better understand the contents of input cells or calculations throughout the spreadsheet. The user may hover the cursor over the red triangle at the top right corner of a cell or heading to read a comment.

Enterprise budgets feature estimated costs for switchgrass on cropland or pasture, irrigated and dryland energy sorghum, and miscanthus for comparison against benchmark values and provide helpful information to the following intended audience for this tool:

- 1) Entrants are provided with an approximation of capital requirements and annual costs, and
- 2) Producers and researchers are provided with a tool performance evaluation and sensitivity analyses

The main purpose for these enterprise budgets is to provide benchmark estimates of the input requirements and costs of producing different forages for renewable energy in the South Central US. Economic analyses provide a critical guide to investment, continued growth, and prosperity of biomass production for renewable energy. Please use Excel's Save and SaveAs options.

Please do not use the copy button when modifying information across a range of cells. Special formatting was applied throughout this spreadsheet to allow for at least some error checking and is voided if using copy and paste.

4.

Disclaimer: The information provided within represents estimates that are a result of a set of complex calculations that are described in more detail in the user manual. Changes in parameter values and its implications on returns are estimates and the user should use their own reasonable judgment to reflect whether the direction of change in returns is appropriate before acting on the results. As such, this software is provided 'as is' and without warranties as to performance of merchantability. Further, statements may have been made to you about this software. Any such statements do not constitute warranties and shall not be relied on by the user in deciding whether to use the program or act on its results. This program is provided without any expressed or implied warranties whatsoever. Because the diversity of conditions and hardware under which this program may be used, no warranty of merchantability or warranty of fitness for a particular purpose is offered. The user is advised to test the program thoroughly before relying on it. The user assumes the entire risk of using the program. The University of Arkansas will not be liable for any claim or damage brought against the user by any third party, nor will the University of Arkansas be liable for any consequential, indirect or special damages suffered by the user as a result of the software.

Notes:

5. Enter the operation's name in the cell highlighted in yellow near the top left corner of the sheet.
6. Use the command buttons in the left column of the sheet to navigate between the spreadsheet's worksheets.
7. Descriptions of each worksheet are provided to the right of their corresponding command buttons.
8. The column to the right of the sheet provides a basic introduction to the spreadsheet.


V. Price Information and Other User Inputs

Setting Costs for Inputs and Prices for Outputs

The purpose of the 'Inputs' worksheet (Fig. 7) is to allow the user to enter prices for various inputs that are categorized into fuel, labor, application costs, seed, weed and pest control, fertilizer, biomass value, and interest rate categories. Yellow cells are for user input values while

the average default prices are provided in the green cells and based on production year prices collected for 2014 and 2015. The 'Benchmark' average prices can be accepted for all inputs by clicking the 'Defaults' command button highlighted in red font near the top right (Fig 7 (1)).
Note: these prices automatically update the enterprise budgets for all crops.

Figure 7. 'Inputs' Worksheet



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University of Arkansas System

Print

Main Menu


Machinery

Switchgrass

Energy Sorghum

Miscanthus

Results



ENCAP
ENERGY CROP
ANALYSIS & PLANNING

Variable Input Prices for Circle C

The cells highlighted in yellow are for the producer to enter their own values for their farm. Cells highlighted in light blue are drop-downs for the producer to choose different harvest date, location, and year. The "Benchmark" prices, highlighted in light green, are the updated prices for 2014 and are used to calculate the costs for the "Benchmark" farm. Cells highlighted in sky blue with bold and italicized font are used to highlight amounts that are different from the "Benchmark" data. In the "Custom Fertilizer" section, specific blends of fertilizer are converted to their Urea, Triple Super Phosphate and potash equivalents in terms of cost. This helps track nutrient replacement, particularly in switchgrass where nutrient use trials were used to calculate profit-maximizing fertilizer recommendations and harvest dates.

1. Click "Defaults" to accept the average benchmark prices: **Defaults**

	Benchmark	Producer
Fuel	\$/gallon	\$/gallon
Diesel	\$2.48	\$2.48
Labor	\$/hr	\$/hr
Operator Labor	\$9.25	\$9.25
Hired Labor	\$8.00	\$8.00

2. Labor Multiplier by Operation

	Labor Multiplier	Labor Multiplier
Field Preparation	1.5	1.5
Planting	1.5	1.5
Veggie Planting	3	3
Fertilizer	1.5	1.5
Post-Plant Field Work	1.5	1.5
Harvest	1.5	1.5
Seed	\$/lb	\$/lb
Switchgrass	\$10.00	\$10.00
Energy Sorghum	\$10.58	\$10.58
Miscanthus (per plug)	\$0.25	\$0.25

3. Weed & Pest Control

	Unit	\$/unit	\$/unit
Glyphosate	pt	\$4.75	\$4.75
Quinclorac	lb a.i.	\$55.00	\$55.00
Ally (Cimarron)	oz a.i.	\$29.50	\$29.50
Atrazine	lb a.i.	\$3.94	\$3.94
Dual II Magnum	pt	\$13.63	\$13.63
Paraquat	pt	\$4.13	\$4.13
Grazon P+D	pt	\$4.38	\$4.38
Bayerbroad XL LFC	oz	\$1.53	\$1.53

4. Enter Your Own

Enter Your Own	Enter Your Own	
Enter Your Own	Enter Your Own	

Please do not use copy and paste when modifying information across a range of cells. Special formatting was applied to allow for at least some error checking and is voided if using copy and paste.

Item Value	Benchmark	Producer
Switchgrass	\$50.00	\$50.00
Energy Sorghum	\$50.00	\$50.00
Miscanthus	\$50.00	\$50.00

5. Interest Rates

	Benchmark	Producer
Discount Factor	6.00%	6.00%
Operating Interest	7.75%	7.75%

6. Application Costs

	\$/acre	\$/acre
Custom Fertilizer	\$6.00	\$6.00
Custom Air Herbicide	\$7.00	\$7.00
Custom Ground Herbicide	\$6.00	\$6.00
Custom Air Insecticide	\$7.00	\$7.00

7. Fertilizer, N-P₂O₅-K₂O

	\$/ton	\$/ton
Urea, 46-0-0	\$571.00	\$571.00
Triple Super Phosphate, 0-45-0	\$621.00	\$621.00
Potash Fertilizer, 0-0-60	\$601.00	\$601.00
Poultry Litter	\$22.50	\$22.50
Lime	\$56.60	\$56.60

8. Custom Fertilizer

Please check the box to convert custom blend fertilizers specified below to urea, phosphate and potash price equivalents: ☐

Custom Fertilizer	N	P ₂ O ₅	K ₂ O	Amount (lbs/acre)	\$/ton
Ammonium Nitrate	34	0	0	50	\$560.00
DAP	18	46	0	100	\$611.00
Custom Blend	13	13	13	25	\$390.00

8. Harvest Conditions

	User Defined	Alternate Date
Post-Harvest Storage Loss Rate	10%	10%
Harvest Date	25-Nov	25-Nov 24-Feb
Harvest Location	Fayetteville	
Harvest Year	2012	
Please check to use poultry litter on switchgrass:	<input type="checkbox"/> Weather	SHYNE
Fertilizer (Litter is limited to phosphate needs)	Fertilizer Needs (lbs/acre)	Yield (qt/acre) & Moisture (%)
Urea, 46-0-0	166	166
Triple Super Phosphate, 0-45-0	56.28	56.28 26.46
Potash Fertilizer, 0-0-60	140	140 39
Expected Yield	6.0	6.0 4.5
Moisture Content at Cutting (w.b.)	40	40 14

Notes:

- Click 'Defaults' to accept the average benchmark prices for producer values. Choosing a different price than the 'Benchmark' causes cell formatting in the 'Producer' column to change.
- Specify a labor multiplier to indicate how many hired laborers are needed for a particular field operation.
- Specify a labor multiplier that applies to the planting of plugs using a veggie planter. This operation may require owner operator labor and two additional hired laborers for the handling and planting of plugs for miscanthus.
- Enter up to two additional Weed & Pest Control options along with unit of measure and cost per unit (optional).
- Specify discount and operating interest rates to determine the present value of future cash flows for perennial crops and equipment ownership charges as well as operating loan interest payments.
- Enter up to three custom fertilizer options along with desired application amounts in pounds per acre and cost in dollars (\$) per ton for the computer to calculate Urea, Triple Super Phosphate, and potash fertilizer equivalents.
- Check the check box provided to convert the user-specified custom blend fertilizers to Urea, Phosphate and potash price and quantity equivalents. Uncheck to use benchmark fertilizer prices.
- Specify year location and production year to see calculations for profit-maximizing time of harvest, yield, and amount of urea, triple super phosphate, and potash fertilizer to apply. The user may also change the harvest date and post-harvest storage loss rates that apply over a six-month period. The 'Weather' and 'SHYNE' buttons are provided in this section to easily move from this section to relevant additional screens. Output from these sections may provide the user with guidance about fertilizer application rates they wish to apply to their switchgrass stand during harvest years.

Wage Rates and Labor Multipliers

While most price data is applied to operations or input application rates by multiplying quantity with cost, labor cost calculations depend on the number of hired labor used. The user may specify labor multipliers to indicate how many hired laborers are needed for a particular field operation (Fig. 7 (2)), such as using hired labor to help with filling a planter. If no hired labor is utilized, the user should specify a labor multiplier of one so the owner operator rate is used to accurately estimate the cost (Table 1). Miscanthus is likely to require several hired laborers for planting plugs of miscanthus, as the operator may ride the tractor and have two employees handling and planting plugs. Therefore, the ‘Veggie Planting’ labor multiplier (Fig. 7 (3)) allows the user to specify a labor multiplier that applies *only* to this field operation.

The example field operation provided in Table 1 displays a labor cost per acre of ½ hour per acre of operator labor at the operator labor rate of \$9.25 per hour and ½ hour per acre of hired labor at the hired labor wage rate for two additional employees.

Table 1. Example of Labor Cost Calculations when Operator Labor is Charged at \$9.25/hr and Hired Labor at \$8.00/hr at a Field Speed of Two Acres per Hour.

Number of Workers (including Owner Operator)	Labor Multiplier	Labor Cost Calculations	Labor Cost \$/acre
1	1	1 x \$9.25 @ ½ hr/acre	\$4.63
2	1.5	(1 x \$9.25 + 0.5 x \$8) @ ½ hr/acre	\$6.63
2	1.75	(1 x \$9.25 + 0.75 x \$8) @ ½ hr/acre	\$7.63
3	3	(1 x \$9.25 + 2 x \$8) @ ½ hr/acre	\$12.63

Default Chemicals and User Defined Options

Under the ‘Weed & Pest Control’ category, the user may choose from default chemicals and has the option to enter up to two additional chemicals to use for their operation (Fig. 7 (4)). These additional options are entered into the cells highlighted in yellow directly below the default options. The user should add the chemical name, units of quantity for measuring the amount applied, and cost per unit in dollars (\$). These additional chemicals will now appear in the drop-down boxes available for use in the crop budgets describing field operations. *Note: user-defined chemicals may be added and selected by the user, however, the ‘Benchmark’ only uses the default chemicals and amounts for its cost calculations.* ‘Benchmark’ herbicide amounts and prices paid are based on recommendations provided by University of Arkansas Cooperative Extension Service publications (Flanders et al., 2015 and Scott et al., 2015). Recommendations for energy sorghum are based on Haankuku et al. (2014).

Interest Rates

The ‘Interest Rates’ category includes the discount and operating interest rates (Fig. 7 (5)). The discount rate is used to determine the present value of future cash flows for perennial crops and also represents the opportunity cost of capital for capital recovery or ownership cost calculations for equipment. This allows ENCAP to properly adjust for inflation and risk. Using a relatively

low rate, such as 2 to 3%, implies low risk to cash flow estimates. Using a higher rate would account for greater uncertainty associated with yield and/or account for potential price fluctuations. The default is 6% to reflect somewhat risky cash flows.

The operating interest rate represents interest payments a producer is charged on an operating credit line from a bank for other financing operations during the course of the production year. As such, ENCAP calculates operating interest for six months on all cash input expenditures, to estimate interest expense paid to lenders for operating costs during an annual production cycle.

Fertilizers and Lime

The fertilizer section uses five different types of fertilizers (Fig 7 (6)). Urea (46-0-0), Triple Super Phosphate (0-45-0), potash fertilizer (0-0-60), poultry litter and custom blends (discussed further below). Urea, Triple Super Phosphate, and potash fertilizer are utilized as ‘Benchmark’ defaults because of their focus on a single nutrient (Nitrogen (N) – Phosphate (P₂O₅) – Potassium Oxide (K₂O)) as specified on fertilizer labels. Lime is available as an input so the user may adjust for soil pH.

The N fertilizer recommendation for switchgrass during the year of establishment is zero (0) to avoid stimulating excessive weed growth. Nutrient application rates for P and K are provided by the Arkansas Fertilizer and Lime Recommendations (Espinoza et al., 2015) for native warm-season grass production and based on ‘Medium’ P and K soil tests as shown in Figure 8. These application rates apply to switchgrass only. For miscanthus, recommendations for the establishment year are to bring P and K levels to adequate levels for corn production or approximately 70 lbs of P₂O₅ and K₂O with a ‘Medium’ P and K soil test (Espinoza et al., 2015; Arundale et al., 2013; Strullu et al., 2011; Shield et al., 2014; and Cadoux et al., 2012) and approximately 70 lbs of N.

For the second harvest year and beyond, the user may choose fertilizer application levels in the switchgrass and miscanthus budget tabs (Figs. 19 and 20) by either adopting the default fertilizer recommendation or entering their own rate. For switchgrass, the user may form an opinion about fertilizer needs by looking at estimated fertilizer needs across years and locations as discussed in the ‘Harvest Conditions’ section below. For miscanthus, fertilizer recommendations are based on a rule of thumb of applying 1-2 lbs of elemental P and 10 lbs of elemental N and K per ton of harvested material, assuming a single fall harvest (Arundale et al., 2013; Strullu et al., 2011; Shield et al., 2014; and Cadoux et al., 2012). *Note: there is considerable on-going discussion about these recommendation and ENCAP does not provide detail about fertilizer and harvest date recommendations for miscanthus.*

Similar fertilizer recommendations are provided for energy sorghum (Fig 21) and based on research in Oklahoma as a repeated single production year recommendation as reported in Haankuku (2014). Default fertilizer prices paid are the national 2014 prices as provided by United States Department of Agriculture, National Agricultural Statistics Service (NASS 2015).

Figure 8. Fertilizer Recommendations for Switchgrass**NATIVE WARM-SEASON GRASS PRODUCTION RECOMMENDATIONS**

PHOSPHORUS (P ₂ O ₅) AND POTASSIUM (K ₂ O) RECOMMENDATIONS							
Crop Code	Soil-Test P		Soil Test K Level and Concentration Range (ppm)				
			V. Low	Low	Medium	Optimum	Above Opt
			< 61	61 - 90	91 - 130	131 - 175	>175
	Level	ppm	----- lb N-P ₂ O ₅ -K ₂ O/acre -----				
	V. Low	<16	60-60-120	60-60-80	60-60-40	60-60-0	60-60-0
	Low	16 - 25	60-40-120	60-40-80	60-40-40	60-40-0	60-40-0
211	Medium	26 - 35	60-30-120	60-30-80	60-30-40	60-30-0	60-30-0
	Optimum	36 - 50	60-0-120	60-0-80	60-0-40	60-0-0	60-0-0
	Above Opt	>50	60-0-120	60-0-80	60-0-40	60-0-0	60-0-0

Note: ‘Benchmark’ fertilizer recommendations for switchgrass will depend on soil test results. If soil test for P and K are optimum or higher, no nitrogen, phosphate, or potash fertilizers are required, regardless of crop or pasture land.

Custom Blend Fertilizers

Since producers are often quoted prices on blended fertilizers, the user may enter up to three custom fertilizer options along with desired application amounts in pounds per acre and cost in dollars (\$) per ton (Fig. 7 (6) and (7)). Clicking the check box (Fig. 7 (7) and Fig. 9) calculates the equivalent amount of Urea, Triple Super Phosphate and potash fertilizer at equivalent cost to allow the program to determine nutrient specific cost for fertilizer and harvest date needs.

Figure 9. Example of Fertilizer Inputs when Custom Blend Fertilizers are applied

Fertilizer, N-P ₂ O ₅ -K ₂ O	Amount	\$/ton	\$/ton		
Urea, 46-0-0	83	\$571.00	\$582.48		
Triple Super Phosphate, 0-45-0	109	\$621.00	\$430.95		
Potash Fertilizer, 0-0-60	5	\$601.00	\$600.00		
Poultry Litter		\$22.50	\$22.50		
Lime		\$56.60	\$56.60		
Please check the box to convert custom blend fertilizers specified below to urea, phosphate and potash price equivalents: <input checked="" type="checkbox"/>					
Custom Fertilizer	N	P ₂ O ₅	K ₂ O	Amount (lbs/acre)	\$/ton
Ammonium Nitrate	34	0	0	50	\$560.00
DAP	18	46	0	100	\$611.00
Custom Blend	13	13	13	25	\$390.00

Harvest Conditions

The ‘Harvest Conditions’ section of the ‘Inputs’ tab (Fig. 10) provides profit-maximizing fertilizer and harvest date analyses for *switchgrass only*. The user may enter several parameters that affect yield and optimal harvest date. Benchmark optimal harvest date is calculated on the basis of yield expectation by harvest date, nitrogen, phosphorus, and potassium costs and switchgrass price. Considered are i) operating interest expenses associated with delayed harvest

as cash receipts occur later; ii) the change in nutrients removed as a function of harvest date; iii) changes in post-harvest storage losses as a function of harvest date; and iv) yield implications of alternative harvest dates. This information is based on field experiments performed from 2009 to 2014 at Fayetteville, AR; Pine Tree, AR; Jonesboro, AR; Haskell, OK; Stillwater, OK; Woodward, OK; New Franklin, MO; and Winnsboro, LA (Fig. 10 (1)). Not all locations had the same trials and experimental years and hence the drop-down menu choices are limited to years when trials were performed. Note: N-P-K needs may also be supplied by poultry litter applications that may be more economical than commercial fertilizers (Fig. 10 (4)). Poultry litter applications are limited to P nutrient requirements to avoid excess application of P. Litter application alters the cost of commercial N, P, and K prices used to determine profit-maximizing harvest date and yield, as lower nutrient cost for N leads to greater N application in the spring and thereby greater yield potential. Lower nutrient cost for P and K also lessens cost savings attainable with delayed harvest.

Figure 10. Alternative Harvest Date Analysis on Fertilizer Needs Specific to Year and Location as Available in ‘Inputs’

Harvest Conditions		User Defined	Alternate Date
Post-Harvest Storage Loss Rate	10%	10%	
Harvest Date	25-Nov	25-Nov	24-Feb
Harvest Location	Fayetteville		
Harvest Year	2012		
Please check to use poultry litter on switchgrass:	<input type="checkbox"/>	4. Weather	5. SHYNE
Fertilizer (Litter is limited to phosphate needs)	Fertilizer Needs (lbs/acre), Yield (dt/acre) & Moisture (%)		
Urea, 46-0-0	166	166	166
Triple Super Phosphate, 0-45-0	56.28	56.28	26.46
Potash Fertilizer, 0-0-60	140		
Expected Yield	6.0		
Moisture Content at Cutting (w.b.)	40		

Harvest Conditions		User Defined	Alternate Date
Post-Harvest Storage Loss Rate	10%	10%	
Harvest Date	24-Feb	24-Feb	24-Feb
Harvest Location	Jonesboro		
Harvest Year	2010		
Please check to use poultry litter on switchgrass:	<input type="checkbox"/>	Weather	SHYNE
Fertilizer (Litter is limited to phosphate needs)	Fertilizer Needs (lbs/acre), Yield (dt/acre) & Moisture (%)		
Urea, 46-0-0	166	166	166
Triple Super Phosphate, 0-45-0	nd	nd	nd
Potash Fertilizer, 0-0-60	nd	nd	nd
Expected Yield	5.9	5.9	5.9
Moisture Content at Cutting (w.b.)	37	37	37

Notes:

- Users may choose between eight locations and a range of years between 2009 and 2013, depending on location selected.
- Calculated harvest dates for the benchmark (green) and the user (clear) are based on respective input for switchgrass price, fertilizer cost, interest rate, and post-harvest storage losses. For the user-specified harvest date (blue cell) alternative nutrient removal estimates for P and K are shown below. For all N, P and K estimates, N and K removal will differ if poultry litter is applied as poultry litter will supply all of needed P plus some of N and K (see note 3).
- Check the check box if the user wishes to apply poultry litter to switchgrass. Poultry litter application is limited to meet P needs.
- The ‘Weather’ tab allows the user to determine how a particular year at each of the experimental sites deviated from the most recent 10-year weather pattern. The user may analyze the weather data to decide whether a year had extreme moisture or temperature deviations from the 10-year pattern shown.
- The ‘SHYNE’ tab shows more detail about changes in yield by harvest date, nutrient removal rates, and timing of profit-maximizing harvest date relative to a yield-maximizing harvest date for the different locations and years analyzed. The interested reader is referred to Cahill et al. (2014) and Lindsay et al. (2015) for further reading on this topic.
- Estimated fertilizer needs in lbs/acre, yield in dry tons per acre, and moisture content at cutting in wet weight basis are provided for harvest dates above (see note 2).
- nd = no data.
- Conditional formatting (italicized font) has been applied to indicate when estimated fertilizer needs, yield, or moisture content at cutting is using data that is “out-of-sample.”

The profit-maximizing harvest date for the benchmark (green cell) and user (white cell) is shown in Figure 10 (2), but may be altered by the user (light blue cell) to evaluate harvest-date dependent yield and fertilizer estimations (Fig. 10 (6)).

Warning: *The user-specified and ‘Benchmark’ calculations for fertilizer requirements and expected yield are estimates and should be treated as such. An average fertilizer recommendation is provided by the program in the switchgrass budget (Fig. 19) for the ‘Benchmark’ and is based on experimental results and expert opinion. The user is expected to specify fertilizer use and yield in the crop budgets as discussed in section VII of this manual. The ‘Harvest Conditions’ section in Figure 10 is for informational purposes only. The soils used at the experiment site in Fayetteville, AR contained rocky, shallow soils with relatively poor water holding capacity and are considered to have lower soil quality compared to Haskell, OK where soils were of higher quality with better water holding capacity and hence better yield potential. More details on soil conditions across experimental sites are reported below:*

Soil Conditions


In order to better understand the differences among estimated nutrient needs, yields, and moisture content at cutting (Fig. 10 (6)), it is important to understand the differences in soil conditions across each location analyzed. Trials in **Fayetteville, AR** for harvest date and N rate occurred on eroded Pickwick gravelly loam at 3-8% slope and on Captina silt loam at 1-3% slope with silt-loam texture in the top 20 inches and a clay fragipan (root-restrictive layer) at 20-24 inches for litter application trials. The **Pine Tree, AR** site had yield, N, P, and K rate, and moisture content trials conducted on soils with 0-3% slope consisting of 75% Calloway silt loam (Fine-silty, mixed, active, thermic Aquic Fraglossudalfs) and 25% Henry silt loam (Course-silty, mixed, active, thermic Typic Fragiqualfs) with a root-restrictive layer at 30 inches. The **Jonesboro, AR** site had harvest date, litter, and N rate trials on a Collins silt loam (course-silty, mixed, active, acid, thermic Aquic Udifluvents with a 0-2% slope and no root restrictive layer within the top 48 inches. Litter application, yield, and moisture content trials for **Haskell, OK** occurred on Taloka silt loam at 1-3% slope with silt-loam texture in the upper 20 inches and no root restrictive layer until 80 inches. The harvest date, yield, and moisture content trials for the **Stillwater, OK** location were conducted on Easpor Loam with 0-1% slope and a restrictive layer at 80 inches from the surface. The harvest date and yield trials for **Woodward, OK** took place on Carey silt loam soils with 1-3% slope with a densic bedrock at 50-56 inches below the surface. The **Winnsboro, LA** harvest date, yield, and moisture content trials were conducted on Gigger silt loam (fine silty, mixed, thermic, Typic Fragiudalf) with 1-3% slope. The subsoil typically has a depth of 12-15 inches with a pH of 4.5 to 4.7. The fragipan usually occurs somewhere between 30-48 inches and represents a barrier to root growth. Lastly, the **New Franklin, MO** harvest date, yield, and moisture content trials were conducted on well-drained Sibley silt loam (fine-silty, mixed superactive, mesic Typic Argiudolls) on a ridge top to back slope of 2-9% with a mean pH of 6.7.

VI. Machinery Selection


The ‘Machinery’ worksheet (Fig. 11) allows the user to select various tractor and implement specifications by left-clicking on the command buttons to the left of the worksheet to display userforms as discussed previously in section III of this manual, under ‘Userforms’. These userforms allow the user to select the default values or specify the size (width in feet or

horsepower), purchase price, salvage value, hours of annual use, useful life (in hours), and fuel consumption. In addition, the user may assign tractors to implements and allocate acres across multiple implements and/or crop enterprises. Default values for purchase prices are based on values from John Deere, Williams Tractor (personal communication, April 15, 2015), and the Mississippi State Budget Generator (v. 6). Ownership calculations are based on formulae and information provided by the American Society of Agricultural and Biological Engineers (ASABE, 2011a and 2011b) and described in greater detail in the appendix section of this manual. The following sub-sections as well as notes provided in Figures 12 and 14 provide instruction on how to specify details in the tractor and implement selection userforms.

Figure 11. 'Machinery' Worksheet



Print **Main Menu** **Inputs** **Switchgrass** **Energy Sorghum** **Miscanthus** **Results** **Weather** **SHYNE**



Machinery Selection for Circle C

The equipment buttons for tractors, tillage, planting, fertilizer application and harvesting equipment, found on the left-hand column of this sheet, allow the producer to choose the quantity, size, purchase price and salvage value for their operation's equipment. The user may specify annual use hours and fuel use as well as cost allocation across crop enterprise. The user may also specify which tractor to use to power an implement. Cells highlighted in yellow are for the producer to input expected acres for each enterprise. For tractors, "MFWD" stands for mechanical front wheel drive and "2 WD" denotes two wheel drive, followed by the horse power rating which affects default fuel use. When the tractor selection is highlighted in green/red the tractor hp is low/high for the equipment size selected. John Deere equipment is used as an example, but not endorsed by this research.

1. Enter Expected Acres:

Switchgrass	Miscanthus	E. Sorghum	Total Acres
50	50	50	150

2.

Tractor Name	Tractor Size	Prorated Annual Use Hours			Acre-Based Use Hours	Specified Use Hours	Average Operating Cost \$ per Hour	Capital Recovery \$ per Hour
		Switchgrass	Miscanthus	E. Sorghum				
JD 5075E	MFWD 75	31.6	38.2	21.4	91.2	600	\$15.73	\$11.69
JD 6130D	MFWD 130	3.7	3.2	31.8	38.8	600	\$10.73	\$13.97
JD 6150M	MFWD 150	0.0	0.0	29.2	29.2	600	\$12.34	\$17.75
JD 6190R	MFWD 190	4.9	4.7	22.3	31.9	600	\$31.18	\$41.45

3.

Tillage & Planting Implement/Operation		Tractor Selection	Prorated Annual Use Hours			Acre-Based Use Hours	Specified Use Hours	Fuel Cost \$ per Hour	Capital Recovery \$ per Hour	Total Cost \$ per Hour	Acres per Hour	Total Cost \$ per Acre
			Switchgrass	Miscanthus	E. Sorghum							
Disk	Disk 1 — 14 ft	JD 6130D	0.8	0.5	7.7	9.0	200	\$11.46	\$13.17	\$32.17	6.5	\$4.96
	Disk 2 — 24 ft	JD 6190R	0.4	0.3	4.5	5.2	200	\$20.73	\$22.45	\$54.58	11.1	\$4.90
Planter	No-Till Grain Drill 1 — 12 ft	JD 6130D	1.0	N/A	N/A	1.0	150	\$14.19	\$14.94	\$39.47	5.1	\$7.75
	Grain Drill 2 — 12 ft	JD 6130D	1.0	N/A	N/A	1.0	150	\$16.37	\$14.94	\$42.79	5.1	\$8.40
Veggie Planter	Veggie Planter 1 — 4 Row	JD 5075E	N/A	2.3	N/A	2.3	150	\$8.18	\$8.63	\$24.48	1.5	\$16.83
	Veggie Planter 2 — 8 Row	JD 6190R	N/A	0.3	N/A	0.3	150	\$20.73	\$17.60	\$43.39	12.4	\$3.50
Cultipacker	Cultipacker 1 — 12 ft	JD 6130D	0.6	0.4	N/A	1.0	300	\$14.19	\$7.95	\$26.55	8.0	\$3.30
	Cultipacker 2 — 20 ft	JD 6150M	0.4	0.2	N/A	0.6	300	\$16.37	\$12.65	\$34.90	13.4	\$2.61
Field Cultivator	Field Cultivator 1 — 12 ft	JD 6150M	N/A	N/A	5.8	5.8	100	\$16.37	\$13.64	\$36.66	8.7	\$4.24
	Field Cultivator 2 — 12 ft	JD 6150M	N/A	N/A	5.8	5.8	100	\$16.37	\$13.64	\$36.66	8.7	\$4.24
Chisel Plow	Chisel Plow 1 — 10 ft	JD 6190R	N/A	N/A	9.7	11.3	150	\$20.73	\$12.27	\$40.10	5.2	\$7.78
	Chisel Plow 2 — 16 ft	JD 6130D	N/A	N/A	6.1	7.1	150	\$14.19	\$14.15	\$36.53	8.2	\$4.43
Row Conditioner	Row Conditioner 1 — 13 ft	JD 6130D	N/A	N/A	8.8	8.8	100	\$14.19	\$10.01	\$29.13	5.7	\$5.14
	Row Conditioner 2 — 21 ft	JD 6190R	N/A	N/A	5.5	5.5	100	\$20.73	\$15.33	\$42.00	9.2	\$4.58
Disk Bedder	Disk Bedder 1 — 4R-38	JD 6150M	N/A	N/A	7.2	7.2	160	\$16.37	\$11.36	\$33.42	6.9	\$4.82
	Disk Bedder 2 — 6R-30	JD 6190R	N/A	N/A	6.3	6.3	160	\$20.73	\$14.44	\$41.78	8.0	\$5.22
Para-Till	Para-Till 1 — 2 Shank	JD 5075E	N/A	0.0	N/A	0.0	100	\$8.18	\$3.61	\$18.27	1.9	\$9.85
	Para-Till 2 — 3 Shank	JD 6190R	N/A	0.0	N/A	0.0	100	\$20.73	\$11.83	\$40.07	3.4	\$11.79
Row Planter	Row Planter 1 — 4R-30	JD 6130D	N/A	N/A	14.4	14.4	150	\$14.19	\$8.15	\$28.92	3.5	\$8.34
	Row Planter 2 — 6R-30	JD 6150M	N/A	N/A	8.9	8.9	150	\$16.37	\$16.19	\$44.56	5.6	\$7.91
Fertilizer/Lime Application	Fertilizer/Lime Application — 40 ft	JD 5075E	0.2	0.1	2.1	2.5	800	\$8.18	\$9.93	\$8.57	23.8	\$0.36

Harvesting Implement/Operation		Tractor Selection	Prorated Annual Use Hours			Acre-Based Use Hours	Specified Use Hours	Fuel Cost \$ per Hour	Capital Recovery \$ per Hour	Total Cost \$ per Hour	Acres per Hour	Total Cost \$ per Acre
			Switchgrass	Miscanthus	E. Sorghum							
Mower	Disk Mower Conditioner (Yr 2) — 9 ft	JD 5075E	6.2	8.8	12.1	27.0	200	\$4.09	\$8.86	\$31.16	8.2	\$3.79
	Disk Mower Conditioner (Yr 3+)	N/A	4.3	6.1	8.4	18.7	600	\$12.82	\$12.00	\$42.57	11.9	\$3.59
	SP Mower Conditioner — 235 hp (Yr 2) — 13 ft	N/A	4.3	6.1	8.4	18.7	600	\$12.82	\$12.00	\$42.57	11.9	\$3.59
Hay Rake	Hay Rake 1 (Yr 2) — 17 ft	JD 5075E	0.0	0.0	0.0	0.0	200	\$8.18	\$8.30	\$33.26	9.9	\$3.36
	Hay Rake 1 (Yr 3+)	N/A	0.0	0.0	0.0	0.0	200	\$8.18	\$8.30	\$33.26	9.9	\$3.36
Baler	Baler 1 (Yr 2) — 1250 lbs — 5 x 6 ft	JD 5075E	14.5	25.1	0.0	39.6	200	\$4.09	\$13.32	\$41.22	1.5-4.5	\$9.19-27.57
	Baler 1 (Yr 3+)	N/A	14.5	25.1	0.0	39.6	200	\$4.09	\$13.32	\$41.22	1.5-4.5	\$9.19-27.57
	Baler 2 (Yr 2) — 2100 lbs — 3 x 4 x 9.5 ft	JD 6190R	14.5	25.1	0.0	39.6	200	\$10.37	\$42.48	\$87.39	5.7-17.2	\$5.07-15.22
	Baler 2 (Yr 3+)	N/A	14.5	25.1	0.0	39.6	200	\$10.37	\$42.48	\$87.39	5.7-17.2	\$5.07-15.22
Bale Hauler	Bale Hauler 1 (Yr 2) — 14 — 5 x 6 ft (Lrg Rd)	JD 5075E	12.1	20.9	0.0	33.0	200	\$4.09	\$7.42	\$27.49	1.8-5.4	\$5.11-15.32
	Bale Hauler 1 (Yr 3+)	N/A	12.1	20.9	0.0	33.0	200	\$4.09	\$7.42	\$27.49	1.8-5.4	\$5.11-15.32
	Bale Hauler 2 (Yr 2) — 16 — 3 x 4 x 9 ft (Lrg Sq)	JD 5075E	6.3	10.9	0.0	17.2	200	\$4.09	\$12.86	\$34.77	3.4-10.3	\$3.37-10.1
	Bale Hauler 2 (Yr 3+)	N/A	6.3	10.9	0.0	17.2	200	\$4.09	\$12.86	\$34.77	3.4-10.3	\$3.37-10.1
Self-propelled Forage Harvester	Forage Harvester 1 (Yr 2) — 375 hp	N/A	0.0	0.0	15.8	15.8	300	\$40.92	\$102.14	\$193.54	3.2-9.5	\$20.35-61.05
	Forage Harvester 1 (Yr 3+)	N/A	0.0	0.0	15.8	15.8	300	\$40.92	\$102.14	\$193.54	3.2-9.5	\$20.35-61.05
	Forage Harvester 2 (Yr 2) — 800 hp	N/A	0.0	0.0	0.0	0.0	300	\$0.00	\$0.00	\$0.00	0-0	\$0-0
	Forage Harvester 2 (Yr 3+)	N/A	0.0	0.0	0.0	0.0	300	\$0.00	\$0.00	\$0.00	0-0	\$0-0

4. Custom Operations

Operation	Benchmark	Producer
Veggie Planting (\$/acre)	\$15.35	\$15.35
Para-Tilling (\$/acre)	\$14.17	\$14.17
Mowing (\$/acre)	\$9.23	\$9.23
Planting (\$/acre)	\$9.90	\$9.90
Baling (\$/bale)	\$14.64	\$14.64
Bale Hauling (\$/bale)	\$5.78	\$5.78
Forage Harvesting (\$/acre)	\$44.99	\$44.99

Please do not use copy and paste when modifying information across a range of cells. Special formatting was applied to allow for at least some error checking and is voided if using copy and paste.

Disclaimer: The information provided within represents estimates that are a result of a set of complex calculations that are described in more detail in the user manual. Changes in parameter values and its implications on returns are estimates and the user should use their own reasonable judgment to reflect whether the direction of change in returns is appropriate before acting on the results. As such, this software is provided "as is" and without warranties as to performance or merchantability. Further, statements may have been made to you about this software. Any such statements do not constitute warranties and shall not be relied on by the user in deciding whether to use the program or act on its results. This program is provided without any expressed or implied warranties whatsoever. Because the diversity of conditions and hardware under which this program may be used, no warranty of merchantability or warranty of fitness for a particular purpose is offered. The user is advised to test the program thoroughly before relying on it. The user assumes the entire risk of using the program. The University of Arkansas will not be liable for any claim or damage brought against the user by any third party, nor will the University of Arkansas be liable for any consequential, indirect or special damages suffered by the user as a result of the software.

Notes:

1. Enter expected acres for each crop. The 'Total Acres' are automatically calculated and are therefore locked.
2. Open tractor userforms by clicking on the command buttons found in the top, left column.
3. Open implement userforms by clicking on the command buttons found in the left column below the tractor userforms.
4. Enter expected prices in dollars (\$) per acre or dollars (\$) per bale for custom operations in the cells highlighted in yellow. Cells highlighted in green reflect 'Benchmark' default prices. Note that custom operations are not used in the benchmark budgets but can be selected by the user.

Tractor Selection Userform

The user may select up to four (4) tractors for various field operations (Fig. 12 (1)). **Warning:** *changing the quantity of tractors will cause the userform settings to reset to the previously user-saved settings.* The user may select from a preselected list of tractor sizes (Fig. 12 (2)). Tractor choices are cab tractors of either two wheel drive (2 WD) or mechanical front wheel drive (MFWD) followed by the horsepower rating. For example, the tractor selection depicted as “2 WD 50” indicates a 50 hp rated tractor with a 2 wheel drive train. The user assigns a name to each tractor by typing the desired name into the appropriate text box located in the tractor selection userforms (Fig. 12 (3)). Notice the caption in the upper, left corner of the tractor specification frame will change to the assigned tractor name. This is done so the user knows what tractor to select in the machinery selection userforms.

The user may check the check box (Fig. 12 (4)) if they wish to use the default purchase price, purchase hours, expected hours at salvage, and salvage value. Textboxes will be locked if the check box is checked. If the user wishes to customize data in the textboxes, they may uncheck the check box. This will clear the default values from the text boxes to allow the user to enter customized data. The user has the option to either select ‘Standard Use Hours’ to use pre-selected standard annual use hours or provide a ‘User-Specified’ amount (Fig. 12 (5)). ‘Standard Use Hours’ are based on default values provided by the Mississippi State Budget Generator (v. 6) and drive ‘Benchmark’ values used in the budgets. Allowing the user to specify alternative purchase price, salvage value, useful life and annual use hours is thus provided for the user to provide operation-specific detail, which may include the use of used equipment. The ‘Benchmark’ uses new equipment with standard annual use hours and standard age at salvage.

Figure 12. Tractor Selection Userform

The screenshot displays the 'Tractor' userform with four tractor specification frames.

- 1.** A 'Select Quantity' dropdown menu is located at the top left.
- 2.** Each tractor frame has a 'Select Tractor' dropdown menu.
- 3.** An 'Assign Tractor Name' text box is present in each frame.
- 4.** A checkbox labeled 'Use Suggested Retail Price and Salvage Value' is in each frame.
- 5.** A section titled 'Select Desired Annual Use Hours' with radio buttons for 'Standard Use Hours' and 'User-Specified' (with a text input for hours/year).
- 6.** 'Reset to Saved Settings' buttons are located above each tractor frame.
- 7.** A 'Cancel' button is at the bottom right.
- 8.** A 'Save' button is at the bottom right.

 The first frame shows a JD 5075E tractor with a purchase price of \$47,900.00 and expected salvage value of \$8,635.35. The second frame shows a JD 6130D tractor with a purchase price of \$114,000.00 and expected salvage value of \$17,996.22. The third frame shows a JD 6150M tractor with a purchase price of \$143,000.00 and expected salvage value of \$14,451.43. The fourth frame shows a JD 6190R tractor with a purchase price of \$167,000.00 and expected salvage value of \$16,876.84.

Notes:

1. Select a quantity between ‘1’ and ‘4’. Depending on the quantity specified, one to four tractor specification frames will appear with a set of controls for each tractor selection. **Warning:** *changing the quantity will cause the userform settings to reset to the previously user-saved settings.*
2. Select from a preselected list of tractor sizes.
3. Type desired tractor name into the text box. The caption in the top left will display the new tractor name.
4. Check the check box if using the default purchase price, purchase hours, expected hours at salvage, and salvage value. If customizing data, uncheck check box to enter customized data into the textboxes provided.
5. Select ‘Standard Use Hours’ to use standard use hours per year or ‘User-Specified’ to enter customized use hours.
6. Click the ‘Reset to Saved Settings’ button above the top, right corner of each tractor frame to reset a tractor to previously user-saved settings.
7. Click the ‘Cancel’ command button to exit the userform without saving any changes.
8. Click the ‘Save’ command button to apply all desired changes to the spreadsheet and exit the userform.

Save or Cancel in Userforms

After selecting the desired options within the userform, the user must click the ‘**Save**’ button in the top, right corner of the userform to apply changes to the workbook (Fig. 12 (8)).

Warning: *clicking ‘Save’ in the userform will **not** result in saving the workbook in its entirety. In order to permanently save all changes made in the userform and throughout the spreadsheet, the user must save the workbook as described in the ‘Saving Files’ section.*

Implement/Equipment Selection Userforms

The user may select a quantity of ‘1’ or ‘2’ of each implement provided in the ‘Machinery’ tab (Fig. 13 (1) and Fig. 14 (1)). **Warning:** *changing the quantity of implements will cause the userform settings to reset to the previously user-saved settings.* If the user selects a quantity of ‘1’, one implement specification frame will appear with one set of controls. If the user selects a quantity of ‘2’, two frames will appear with a set of controls for both implements. Further, if the user selects a quantity of ‘2’, two text boxes will also appear at the top of the userform to provide an estimate of acreage allotted to each implement (Fig. 14 (2)). Since both pieces of equipment are expected to cover 100% of the acreage, the acreage allotment is automatically calculated for the second implement.

The user may change the size (width in feet or horsepower) of the implement by using the drop-down lists provided within each implement specification frame (Fig. 14 (3)).

The user may check the check box if they wish to use the default purchase price, purchase hours, expected hours at salvage, and salvage value (Fig. 14 (4)). Textboxes will be locked if the check box is checked. If the user wishes to customize this data, they may uncheck the check box. This will clear the default values from the text boxes allowing the user to enter customized data. *Note: the user must enter a value for all textboxes. If there is no expected value, the user should enter “0” in the corresponding text box.*

The user may either select ‘Standard Use Hours’ to use pre-selected standard annual use hours or select ‘User-Specified’ amount to clear the standard annual use hours from the text box (Fig. 14 (5)) and specify the desired annual use. In the ‘Machinery’ selection worksheet (Fig. 11), acre-based annual use hours are prorated across all years of stand life for switchgrass and miscanthus and added to the use hours for energy sorghum to provide a sense of machine use given the acreage of crops specified.

The user may select a tractor for a particular implement from the list of named tractors specified earlier by the user (Fig. 16 (6)). Error checking is in place to prevent the user from selecting a tractor that is not available for field operations. If the user changes tractor selections *after* implement selection userforms have been completed, any implements associated with a tractor that is no longer available will be displayed as “No Tractor” in red, bold, italicized letters (Fig. 15) to alert the user of the error. The user may correct this error by reopening the implement selection userform and selecting a tractor from the updated list of available tractors in the ‘Select Tractor’ drop-down list (Fig. 14 (6)).

Figure 13. Implement Selection Userform before User Modifications

Notes:

On initial use, the userform appears as a mostly empty box. Once the user selects the desired quantity, more options will appear. Subsequent initialization will display the userform with expanded options.

Figure 14. Implement Selection Userform after User Modification with Two Implements Selected

Notes:

1. Select a quantity of '1' or '2'. If '1', one implement specification frame will appear with one set of controls. If '2', two frames will appear with a duplicate set of controls for both implements. **Warning:** changing the quantity will cause the userform settings to reset to the previously user-saved settings.
2. If '2', two text boxes will appear at the top of the userform. Enter the percentage of total acres allocated for the first implement. The second text box will automatically calculate the percentage of use for the second implement and is therefore locked.
3. Select the size (width in feet or horsepower) using the drop-down list provided.
4. Check the check box if using the default purchase price, purchase hours, expected hours at salvage, and salvage value. If customizing data, uncheck check box to enter customized data into the textboxes provided.
5. Select 'Standard Use Hours' to use standard use hours per year or 'User-Specified' to enter customized use hours.
6. Select tractor from drop-down list of named tractors as pre-selected by the user when entering tractor selections.
7. Select 'Standard Fuel Use' to use pre-calculated fuel use rate (gallons per hour) or 'User-Specified' to enter a customized rate.
8. Enter the percentage of total acres expected for both 'Switchgrass' and 'Miscanthus'. The 'Energy Sorghum' text box will automatically calculate the percentage of use for energy sorghum and is therefore locked.
9. Click the 'Reset to Saved Settings' button in the top, right corner of each implement frame to reset an implement to the previously saved settings. This will only reset the implement settings for the one implement. To reset both implements, click the 'Reset to Saved Settings' command buttons within each implement frame.
10. Click the 'Cancel' command button to exit the userform without saving any changes.
11. Click the 'Save' command button to apply all desired changes to the spreadsheet and exit the userform.

Figure 15. Tractor Selection Error for ‘Disk 2’

Tractor Name		Tractor Size	Prorated Annual Use Hours			Acre-Based Use Hours	Specified Use Hours	Fuel Cost \$ per Hour	Capital Recovery \$ per Hour			
Tractor	JD5075E	MFWD 75	27.1	80.4	143.8	251.3	600	\$20.00	\$11.69			
	JD6105D	MFWD 105	5.6	22.1	22.3	50.0	600	\$38.47	\$18.24			
	JD6130D	MFWD 130	23.7	47.7	225.5	296.9	600	\$26.18	\$27.95			
	Tillage & Planting Implement/Operation											
Tractor Selection		Prorated Annual Use Hours			Acre-Based Use Hours	Specified Use Hours	Fuel Cost \$ per Hour	Capital Recovery \$ per Hour	Total Cost \$ per Hour	Acres per Hour	Total Cost \$ per Acre	
Disk	Disk 1 — 14 ft	JD6130D	2.6	4.5	30.8	200	300	\$26.48	\$18.22	\$44.70	5.5	\$8.13
	Disk 2 — 14 ft	No Tractor										

Notes:

Implements associated with a tractor that is no longer allocated for use will display “No Tractor” in red with bolded and italicized font in place of the tractor name and all calculations to the left of the userform will be cleared from the display. The user may correct this error by reopening the implement selection userform and selecting a tractor from the list of available tractors.

Additional error checking is in place to notify the user if a tractor with horsepower that falls above or below the recommended horsepower for the associated implement is selected. If the tractor horsepower is higher than the recommended horsepower, the assigned name of the tractor selected will be displayed in red with bolded and italicized font (Fig. 16 (1)). If the tractor horsepower is lower than the recommended horsepower, the assigned name of the tractor selected will be displayed in green with bolded and italicized font (Fig. 16 (2)). The user may correct this error by reopening the implement selection userform and selecting a tractor with the recommended horsepower. The user may also adjust fuel use of the tractor. These recommended horsepower requirements are based on values from John Deere, Farm King, and the Mississippi State Budget Generator (v. 6). *Note: the applied conditional formatting is designed to alert the user if selecting a tractor with higher or lower than the recommended horsepower, but does not prevent the user from doing so.*

Figure 16. Tractor Selection Mismatch for ‘Disk 1’ and ‘Disk 2’

Tillage & Planting Implement/Operation	Tractor Selection	Prorated Annual Use Hours			Acre-Based Use Hours	Specified Use Hours
		Switchgrass	Miscanthus	E. Sorghum		
Disk	Disk 1 — 14 ft	1. <i>JD6190M</i>	1.5	30.8	33.9	200
	Disk 2 — 24 ft	2. <i>JD5075E</i>	0.9	18.0	19.8	200

Notes:

1. If the tractor horsepower is higher than the recommended horsepower, the assigned name of the tractor selected will be displayed in red with bolded and italicized font. Correct this error by reopening the implement selection userform and selecting a tractor of lesser horsepower. The user may lower fuel use assuming the field operation can be performed at low RPM.
2. If the tractor horsepower is lower than the recommended horsepower, the assigned name of the tractor selected will be displayed in green with bolded and italicized font. Correct this error by reopening the implement selection userform and selecting a tractor with more horsepower. The user may also increase fuel use assuming the tractor works at high RPM and draws more fuel given a heavy workload.

Fuel Use

The user may either select ‘Standard Fuel Use’ to use pre-calculated fuel use rate (gallons per hour based on the chosen tractor) or enter a ‘User-Specified’ value to clear the default fuel use rate from the text box (Fig. 14 (7)).

Crop Allocation

If a user has more than one piece of equipment of a similar type (e.g. a 14’ and a 24’ disk), the user needs to enter the percentage of total acres the user expects to use a particular

implement for both ‘Switchgrass’ and ‘Miscanthus’. The ‘Energy Sorghum’ text box is filled automatically with the remaining percentage (Fig. 14 (8)).

Variations among Implement Selection Userforms

Some of the implement selection userforms contain additional controls to allow the user a greater set of options specific to a selected implement. These userforms include the planter, mower, baler, and bale hauler and are briefly discussed below.

‘Planter’ and ‘Mower’ Selection Userforms

The ‘Planter’ and ‘Mower’ selection userforms contain drop-down lists allowing the user to select the type of implement desired for the operation. The user may choose between a grain drill and no-till grain drill for the planting operations and a disk mower, disk mower conditioner, and self-propelled mower conditioner for the mowing operations.

‘Baler’ and ‘Bale Hauler’ Selection Userforms

The ‘Baler’ and ‘Bale Hauler’ selection userforms contain additional option buttons and a text box to allow the user to select default values or set field speeds specific to baling operations and ‘Time per Load’ specific to bale hauling operations.

Further, ENCAP is programmed to associate the bale weight with the appropriate bale size for the selected bale hauler, therefore, the user should be mindful of the designated bale sizes when selecting the appropriate hauler size(s) in the ‘Bale Hauler’ selection userform. The 10 and 14 bale capacity haulers are designated for large and medium round bales, respectively, and the 16 bale hauler is designated for a large square baler only. When the user selects the desired baler size(s), the size selection drop-down list provided in the bale hauler userform will display the appropriate bale hauler sizes. However, because the user has the option to make changes to the baler userform after the bale hauler sizes have been selected, additional error checking has been applied to alert the user of a baler/bale hauler selection mismatch (Fig. 17). The user may correct the mismatch by adjusting either the baler(s) or bale hauler(s) size selection drop-down lists provided in the userforms.

Figure 17. Baler/Bale Hauler Selection Mismatch for 'Bale Hauler 1'

Baler	Baler 1 (Yr 2) — 1250 lbs — 5 x 6 ft	JD6105D	7.2	22.9	22.3	52.4	200	\$4.04	\$14.95	\$32.28 – 34.34	2.2 - 4.5	\$7.2 – 15.32
	Baler 1 (Yr 3+)									\$33.31 – 36.41	1.5 - 3	\$11.14 – 24.36
	Baler 2 (Yr 2) — 2100 lbs — 3 x 4 x 9.5 ft	JD6190M	7.2	22.9	22.3	52.4	200	\$3.20	\$42.48	\$67.51 – 68.04	8.6 - 17.2	\$3.92 – 7.9
	Baler 2 (Yr 3+)									\$67.77 – 68.58	5.7 - 11.5	\$5.9 – 11.95
Bale Hauler	Bale Hauler 1 (Yr 2) — 16 — 3 x 4 x 9 ft (Lrg Sq)	JD6190M	3.1	9.9	9.7	22.7	200	\$10.37	\$20.30	\$39.11 – 40	5.2 - 10.3	\$3.79 – 7.74
	Bale Hauler 1 (Yr 3+)									\$39.56 – 40.9	3.4 - 6.9	\$5.74 – 11.88
	Bale Hauler 2 (Yr 2) — 10 — 4 x 5 ft (Med Rd)	JD6190M	9.9	31.3	30.5	71.6	200	\$10.37	\$16.64	\$36.13 – 38.95	1.6 - 3.3	\$11.02 – 23.75
	Bale Hauler 2 (Yr 3+)									\$37.54 – 41.77	1.1 - 2.2	\$17.17 – 38.21

Notes:

Conditional formatting (bolded and italicized red font) has been applied to alert the user to an equipment selection mismatch between the baler(s) and bale hauler(s). The user may correct the error by adjusting either the baler(s) or bale hauler(s) size selection drop-down lists provided in the userforms.

Custom Hire

Various operations may be substituted by hiring a custom operator to perform the operation (Fig. 18). However, if an operation is not used or is hired out for custom work, the user still needs to think about an implement size and tractor that would be best for benchmark comparisons.

Otherwise, the software uses the equipment complement as provided with the software. Selection is thus required for calculations of the ‘Benchmark’ operation as custom operations from the ‘Machinery’ tab are not utilized in the budgets for the ‘Benchmark’. This allows the user to determine if the custom rate they are being charged compares favorably to either the ‘Benchmark’ or another scenario they may develop for their own operation. ‘Benchmark’ custom rates are based on information provided by University of Arkansas Cooperative Extension Service budgets (Flanders et al., 2015), Oklahoma State University (Doye and Sahs, 2012), and Haankuku et al. (2014).

Figure 18. Custom Operations as Available in 'Machinery' Worksheet

Custom Operations		
Operation	Benchmark	Producer
Veggie Planting (\$/acre)	\$15.35	\$15.35
Para-Tilling (\$/acre)	\$14.17	\$14.17
Mowing (\$/acre)	\$9.23	\$9.23
Planting (\$/acre)	\$9.90	\$9.90
Baling (\$/bale)	\$14.64	\$14.64
Bale Hauling (\$/bale)	\$5.78	\$5.78
Forage Harvesting (\$/acre)	\$44.99	\$44.99

Notes:

Enter expected prices in dollars (\$) per acre or per bale for custom operations in the cells highlighted in yellow. Cells highlighted in green reflect ‘Benchmark’ prices. Note, the ‘Benchmark’ budget uses owned equipment for cost calculations and these pieces of machinery should, therefore, be reviewed to reflect appropriate size and type of equipment by the user.

VII. Crop Production Budget Worksheets and Operation Specifications

Operation and Operating Input Use Descriptions

All budget worksheets, ‘Switchgrass’, ‘Miscanthus’ and ‘Energy Sorghum’, portray field operations and input use on a line by line basis to allow the user to see when and where costs are incurred. From left to right, the budgets are designed in a color coded manner (Figs. 19 to 21). The age of the stand or year in the stand life (‘Yr.’) is in the first column (except for ‘Energy Sorghum’ as it is an annual crop). The second column displays the operation performed (‘Operation/Operating Input’) using data from the ‘Inputs’ or ‘Machinery’ tab. The third column displays the ‘Size/Unit’ and the time of the year for operation (‘Month’) is shown under the fourth column. The following four columns display information pertaining to equipment use only. These columns summarize labor in hours per acre and fuel, repair and maintenance (‘R&M’), and ‘Capital Recovery’ in dollars (\$) per hour. For equipment, the ‘Cost in \$ per Unit’ column will display the equipment costs in dollars (\$) per acre. The next two columns are the ‘Amount’ (yellow) of the operation/operating input used and the ‘Cost in \$ per Unit’. If the user wishes not to employ an operation provided, they may enter a “0” in the amount column for that operation (Fig. 19 (4)). The ‘Producer’ (light gray) and ‘Benchmark’ sections (green) give a ‘Total Cost’ for the operation and a prorated cost for the operation based on the life of the stand (‘PV of Total Cost’) to determine an annual equivalent cost as described section II of this manual. The ‘Benchmark’ operation descriptions and input use are available to the right in the cells shaded in green and only change when equipment is changed as described below and in the previous ‘Machinery Selection’ section.

Changing Land Type and Harvesting Equipment Defaults

The 'Switchgrass' budget worksheet (Fig. 19) allows the user to select land type, as production practice recommendations differ whether switchgrass is planted on crop or pasture land. A similar option exists for 'Energy Sorghum', as production can occur under irrigated or dryland conditions. Both switchgrass and miscanthus are assumed to grow under dryland conditions.

Warning: *clicking on the buttons near the top that specify land or irrigation type will reset all input use quantities and planting field operations to default values. Proceed cautiously (Fig. 19 (3), 20, and 21 (1)).*

After land type selections, in the case of switchgrass, or level of irrigation, on energy sorghum, have been made, the user should proceed by accepting or modifying application amounts and/or number of field trips highlighted in the yellow cells in the middle, left portion of the screen. A quantity of zero (0) should be entered for any operation and/or operating input the user does not wish to use for a respective enterprise. The following subsections provide detailed information by the age of the stand and crop.

Switchgrass Establishment Year Specifics

As stated in the introduction, the establishment year for switchgrass is considered a growing year for the stand. This year does not include a harvest because it could i) limit the productive life of the stand; ii) change the onset of full yield potential; and iii) lead to the harvest of a crop that would likely include a significant portion of competing growth of uncontrolled weeds or other crops.

Field preparation includes disking, addition of fertilizer and lime, application of various weed and pest controls, and the planting of seed. Default values for these input selections vary by the land type chosen above. Specification of operations occurs in the light blue boxes that include drop-down lists. The user may choose an application method of fertilizer and lime (custom or using the owner's equipment), planting equipment used (no-till or grain drill), and the selection of weed and pest control to apply.

The user may also change values in yellow cells to specify fertilizer rates, weed and pest control chemical application rates, number of times the operation is performed per acre, an 'Opportunity Cost of Foregone Profit', and the 'Replant Charge'. The 'Opportunity Cost of Foregone Profit' is the estimated value of profit per acre the user would have achieved had they not established switchgrass on that acre. ENCAP allows the user to decide whether or not to include the 'Opportunity Cost of Foregone Profit'. If the end goal is to obtain a breakeven price or cost of production, the user may wish to include this opportunity cost. If the budget is used to develop a forecast of cost of production as a baseline for comparison against other crops, it is better to avoid specifying this opportunity cost, as the breakeven price takes establishment year into account. The specified 'Replant Charge' is a percentage that determines what percent of the acreage planted may need to be replanted given poor establishment. This percentage is applied to the 'Total Specified Expenses' for the establishment year.

Switchgrass Harvest Specifics (Year 2 and Years 3 to End of Stand Life)

The next three sections in the budget include the harvest years. The first of the three sections is the fertilizer application method and rate. The user may select the application method using the light blue drop-down lists as well as the application amount in the cells highlighted in yellow. Costs are calculated as a subtotal for the current year and discounted to calculate the 'PV of Total Cost'. The fertilizer application method and quantities chosen in 'Year 2' are also used for fertilizer applications in 'Years 3 to the end of stand life' as specified by the user near the bottom of the worksheet (Fig. 19 (6)). Guidance on the type and the amount of fertilizer to apply are provided in the 'Inputs' tab and discussed in section V, under 'Fertilizers and Lime'.

Specific to switchgrass is the option to specify a 'Double' or 'Single' harvest by checking the 'Double Harvest' check box. This doubles the 'Amount' column for field operations as two harvest operations are performed (Fig. 19 (5)). Total yield does not change but can be modified by the user in the designated yield box discussed below. A subtotal is calculated for the year and a 'PV of Total Cost' is calculated as a prorated value for the life of the stand.

'Year 3 to end of stand life' harvest costs are different from 'Year 2' harvest costs because the yield and subsequent field speed of equipment changes. The user specifies yields and potentially different harvest equipment for 'Year 2' versus 'Year 3 to the end of stand life' by entering those values into cells highlighted in yellow at the bottom portion of the budget tabs (Fig. 19 (6 & 7)). Hence, if the life of the stand is 10 years, 'Year 2' harvest may be performed with a baler, whereas harvest charges for the remainder of the stand life may be based on the use of a forage harvester. The costs for 'Years 3 to end of stand life' are also discounted to the present and are larger than the discounted 'Year 2' total as more years are included in the 'Year 3 to end of stand life' calculation.

Benchmark recommendations for switchgrass harvest operations include mowing, followed by baling and bale hauling. Raking is not required when using a disk mower conditioner. However, raking can still be performed to combine swaths to lessen the number of turns needed with the baler. If the user wishes to use the forage harvester harvesting option, one pass of the hay rake prior to forage harvesting is recommended again to provide a larger swath that would also be easier to pickup with the forage harvester. *Note: the user may split harvesting operations between a baler and a forage harvester, however, the combined 'amount' of passes indicated for both harvesting options should not exceed one (1).* Conditional formatting (red, bolded font) has been applied within each of the enterprise budgets ('Switchgrass', 'Miscanthus', and 'Energy Sorghum'), shown in Figure 20 (2)), to alert the user when these combined 'amounts', or number of field passes, have exceed one (1).

Miscanthus Options

Many of the same user options exist for miscanthus as for switchgrass, except default values differ and operations are not specified by land type (Fig. 20). Planting of plugs can occur on both crop and pasture land using either an operator-owned vegetable planter or custom

veggie planting. As discussed in section V, the labor multiplier for planting plugs using the veggie planter may be customized in the 'Inputs' tab (Fig. 8 (3)).

Similar to switchgrass, benchmark recommendations for miscanthus harvest operations include mowing, followed by baling and bale hauling. Again, no raking is required with baling for the same reasons as outline above. The default recommendation with the forage harvester is to use a rake. Given the length of stalks of miscanthus, raking may be difficult to perform.

Energy Sorghum Options

The 'Energy Sorghum' budget worksheet (Fig. 21) is different from the 'Switchgrass' and 'Miscanthus' budget tabs because this crop is not a perennial. This obviates the need for stand life and differential yield by age of stand assumptions. Using the irrigated production method also allows the user to specify the amount of irrigation applied (Fig. 21 (2)).

Unlike switchgrass and miscanthus, benchmark recommendations for energy sorghum harvest operations include mowing and forage harvesting. Baling is considered unlikely as energy sorghum requires lengthy in-field drying periods to achieve safe baling moisture content. Rocateli (2010) suggests that 10 to 15 days of in-field drying are not unusual. Further, raking of energy sorghum swaths often proves difficult given high yields and the length of the thick pithy stalks. Therefore, mowing followed by forage harvesting with no raking or baling is the default for harvesting energy sorghum.

Yield Specifics, Baling, Storage, Transport, and Yield Losses

In addition to having the option to specify yields in dry ton per acre by year of harvest in the stand life (Fig. 19 (7)), the user also has the option to specify yield losses (Fig. 19 (6)). Dry yield is defined as the amount of yield at 0% moisture. To calculate dry yield, the user should multiply the 'as is' yield in tons per acre at the observed moisture content by $(1 - MC \text{ w.b.})$, where w.b. stands for wet basis or the weight of water as a fraction of the 'as is' sample. For example, if a producer expects an 'as is' yield of six tons per acre on the basis of the # of bales harvested, for example, they should multiply the 'as is' yield by $(1 - MC \text{ w.b.})$. For baled hay, MC contents between 15 and 20% are considered safe for storage. Assuming 18% moisture content, the dry yield is 4.9 dry ton per acre, which means that of the six tons harvested 'as is', 1.1 tons is water. The user may refer to the 'SHYNE' worksheet for guidance on moisture content at time of cutting (Fig. 24 (5)), which is helpful when making decisions about forage harvesting. The impact of differential in-field drying delays on moisture content is also discussed in Popp et al. (2015). The user may refer back to Fig. 10 (7), to get a sense of yield expectations for switchgrass using different levels of fertility as a function of switchgrass price and nitrogen fertilizer cost.

Baling, storage, transport, and ultimate particle size reduction losses also occur as a result of fine-sized particles falling to the ground during baling, yield losses as a result of bale handling to the staging area, loading to a vehicle for transport to the end user, and finally potential losses as a result of grinding. The latter ought to be included when making comparisons between biomass harvested and baled material. These losses are specified by the user near the bottom of the




budget sheet, in the cell highlighted in yellow, to make the end material comparable in terms of ‘effective’ yield of chopped biomass as would be obtained using a forage harvester (Fig. 19 (6)). *Note: the ‘Benchmark’ uses a 10% default value for dry matter yields, however, users pursuing both baling and forage harvesting methods across harvest years are encouraged to modify the loss percentage near the bottom of the sheet in the cell highlighted in yellow to achieve desired results.*

Breakeven Price

The ‘Breakeven Price per dry ton’ section near the top of each budget worksheet calculates the crop value per dry ton that is needed for the user to cover the prorated costs for the life of the stand. This breakeven price changes with stand life, yields, and yield losses during and after harvest. It is the price above which the operator would earn a profit after covering all costs, excluding land charges. The output near the bottom of the budget worksheet also reports the ‘PV of Total Specified Expenses’, which is the sum of ‘PV of Total Cost’ for subsections of the budget and represents average annual cost in today’s dollars (Fig. 19 (8)). The ‘Average Yield Net of Losses’ is calculated as the average annual dry matter yield in relation to the stand life net of yield losses. ‘PV of Profit over Useful Life’ is the estimated profit over the given stand life using the user-specified price for the biomass paid. When this value is equal to zero (0), the breakeven price has been achieved and all estimated costs for the life of the stand have been covered. *Note: this breakeven price does not cover land charges.*

Calculations for the loss/gain per acre are averaged over the span of the life of the stand. Switchgrass and miscanthus production budgets use an average yield by taking into account losses associated with baling, staging, loading/unloading, storage, and processing as well as yield changes over time. These gains/losses per acre, as well as the present value (PV) of cost, are displayed in the bottom portion of the budget tabs. Changes to input costs, output price, equipment, and field operations are automatically updated to aid the producer with sensitivity analyses.


Saving Scenarios for Sensitivity Analysis

At the top of each budget worksheet, the user may use the command buttons to navigate between budgets and other worksheets. Also at the top of each budget worksheet are command buttons to save scenarios as , , or  (Fig. 19 (2)). These command buttons allow the user to save three different scenarios for comparison in the ‘Results’ worksheet against each other and their respective ‘Benchmark’ values as described in section VIII of this manual.

Printing Budgets


The final two buttons near the top of the budget worksheet are the print options (Fig. 19 (9)). The ‘Print Producer’ button allows the user to print the production budget only showing ‘Producer’ calculations using user-specified quantities and prices. The ‘Print Producer & Benchmark’ button allows the user to print the entire sheet as displayed on the screen. This selection includes the ‘Producer’ selections along with the ‘Benchmark’ settings.

Figure 19. 'Switchgrass' Production Budget Worksheet on Pasture Land



**Division of Agriculture
Research & Extension
University of Arkansas System**

Main Menu
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Machinery
Miscanthus
Energy Sorghum
Results
SHYNE



**ENCAP
ENERGY CROP
ANALYSIS & PLANNING**

Cropland Switchgrass Production Budget for Circle C

Use the command buttons to the right to select the terrain that will be converted to switchgrass production. Cells highlighted in light blue are drop-downs for the producer to choose a different operation/operating input. Cells highlighted in yellow are for the producer to alter the amount of application. Cells highlighted in sky blue with bold and italicized font are used to highlight amounts that are from different from the 'Benchmark' data. The user may save up to three (3) scenarios for a comparison of summary statistics under 'Results' by clicking the the SAVE(1-3) button(s) near the top right. CAUTION! Switching between cropland and pasture will reset values to defaults.

2. Save (1) Save (2) Save (3)
 Use "SAVE (#)" buttons to save the current scenario for comparison to other saved scenarios and their respective 'Benchmark' values.


3. Cropland Print Producer 9.
Pasture Print Producer and 'Benchmark'

Breakeven Price per dry ton: \$38.41										Producer		Benchmark				
Yr.	Operation/Operating Input	Size/Unit	Month	Labor (hrs/acre)	Fuel (\$/hr)	R&M (\$/hr)	Capital Recovery (\$/hr)	Amount	Cost \$/unit	Total Cost	PV of Total Cost	Total Cost	PV of Total Cost	Amount	Operation/Operating Input	
Establishment Year on Cropland	1. Field Preparation		Sep					4. 1.00	\$10.96	\$10.96	\$1.10	\$10.96	\$1.10	1.00	Chisel Plow	
	Spring Field Preparation		Mar					2	\$1.74	\$3.48		\$3.48		2.00	Fertilizer Application	
	Lime	lbs/acre			0.04	8.18	9.93	9.93	2000.00	\$0.03	\$56.60		\$56.60	2000.00	Lime	
	Triple Super Phosphate, 0-45-0	lbs/acre						67	\$0.31	\$20.80		\$20.80	67.00	Triple Super Phosphate, 0-45-0		
	Potash Fertilizer, 0-0-60	lbs/acre						1	\$0.30	\$0.30		\$0.30	67.00	Potash Fertilizer, 0-0-60		
	Disk				0.12	16.10	16.69	35.62	1	\$9.96	\$9.96		\$9.96	1.00	Disk	
	Subtotal								\$110.97	\$110.97	\$11.10	\$110.97	\$11.10			
	Pre-Plant Weed Control		Mar					1.00	\$6.00	\$6.00		\$6.00		1.00	Custom Ground Herbicide	
	Custom Ground Herbicide Glyphosate	5/acre pt						2.00	\$4.75	\$9.50		\$9.50		2.00	Glyphosate	
	Subtotal								\$15.50	\$15.50	\$1.55	\$15.50	\$1.55			
Year 1	Planting		Apr					1.00	\$5.73	\$5.73		\$5.73		1.00	Cultipacker	
	Cultipacker				0.10	15.28	8.46	20.60	1.00	\$17.32	\$17.32		\$17.32	1.00	Planter	
	Planter				0.20	15.28	23.01	36.65	1.00	\$10.00	\$80.00		\$80.00	8.00	Seed	
	Seed	lbs/acre						8.00				\$103.05	\$10.31			
	Subtotal								\$103.05	\$103.05	\$10.31	\$103.05	\$10.31			
	Post Plant Weed Control		May					1.00	\$6.00	\$6.00		\$6.00		1.00	Custom Ground Herbicide	
	Custom Ground Herbicide Ally (Cimarron)	5/acre oz a.i.						0.50	\$29.50	\$14.75		\$14.75		0.50	Ally (Cimarron)	
	Subtotal								\$20.75	\$20.75	\$2.08	\$20.75	\$2.08			
	Operating Interest	%							7.75%	\$28.21	\$2.82		\$28.21	\$2.82		
	Total Specified Expenses (Est Year)									\$289.45	\$28.21	\$2.82	\$289.45	\$28.21	\$2.82	Operating Interest
Year 2	Opportunity Cost of Foregone Profit for Est.								\$0.00	\$0.00		\$0.00	\$0.00			
	Replant Charge	% of Cost						25%		\$72.36		\$72.36		25%	Replant Charge	
	Fertilizer		Apr					1.00	\$1.74	\$1.74		\$1.74		1.00	Fertilizer Application	
	Fertilizer Application Urea, 46-0-0	lbs/acre			0.04	8.18	9.93	9.93	130.00	\$0.29	\$37.12		\$37.12	130.00	Urea, 46-0-0	
	Triple Super Phosphate, 0-45-0	lbs/acre						50.00	\$0.31	\$15.53		\$15.53	50.00	Triple Super Phosphate, 0-45-0		
	Potash Fertilizer, 0-0-60	lbs/acre						140.00	\$0.30	\$42.07		\$42.07	140.00	Potash Fertilizer, 0-0-60		
	Subtotal								\$96.45	\$96.45	\$65.60	\$96.45	\$65.60			
	Harvest		Nov					Double Harvest	\$6.23	\$6.23		\$6.23		1.00	Mower	
	Mower				0.10	16.91	9.46	20.86	1.00	\$0.00	\$0.00		\$0.00	0.00	Hay Rake	
	Hay Rake							1.00	\$16.21	\$16.21		\$16.21	1.00	Baler		
Baler				0.14	14.46	31.85	55.80	1.00	\$5.01	\$5.01		\$5.01	5.82	Twine		
Twine							1.00	\$7.26	\$7.26		\$7.26	1.00	Bale Hauler			
Bale Hauler	5/bale			0.14	8.18	7.90	22.05	1.00	\$0.00	\$0.00		\$0.00	0.00	Forage Harvester		
Forage Harvester							0.00				\$34.71	\$3.27				
Subtotal								\$34.71	\$34.71	\$3.27	\$34.71	\$3.27				
Operating Interest	%							7.75%	\$4.56	\$0.43		\$4.56	\$0.43	7.75%	Operating Interest	
Total Specified Expenses (Year 2)									\$135.72	\$135.72	\$13.57	\$135.72	\$13.57			
Years 3 - 10	Harvest		Nov					Double Harvest	\$7.11	\$7.11		\$7.11		1.00	Mower	
	Mower				0.12	16.91	9.46	20.86	1.00	\$0.00	\$0.00		\$0.00	0.00	Hay Rake	
	Hay Rake							1.00	\$0.00	\$0.00		\$0.00	1.00	Baler		
	Baler				0.21	14.46	31.85	55.80	1.00	\$24.32	\$24.32		\$24.32	8.74	Twine	
	Twine							1.00	\$7.51	\$7.51		\$7.51	1.00	Bale Hauler		
	Bale Hauler	5/bale			0.21	8.18	7.90	22.05	1.00	\$10.89	\$10.89		\$10.89	1.00	Forage Harvester	
	Forage Harvester							0.00	\$0.00	\$0.00		\$0.00	0.00	Forage Harvester		
	Subtotal								\$49.83	\$49.83	\$29.19	\$49.83	\$29.19			
	Operating Interest	%							7.75%	\$4.92	\$2.88		\$4.92	\$2.88	7.75%	Operating Interest
	Total Specified Expenses (Years 3 - 10)									\$151.20	\$151.20	\$15.12	\$151.20	\$15.12		
<div style="display: flex; justify-content: space-between; align-items: flex-end; font-size: 0.7em;"> <div style="width: 30%;"> <div style="border: 1px dashed red; padding: 2px; margin-bottom: 5px;"> 8. PV of Total Specified Expenses \$137.56 Average Yield Net of Losses 4.784 PV of Price \$35.51 PV of Profit over Useful Life \$414.86 Average Profit PV \$41.49 Average Revenue per acre: \$239.20 </div> <div style="border: 1px dashed red; padding: 2px;"> 6. Stand Life (yrs): 10 Percent of Yield Loss: 0.00% </div> </div> <div style="width: 30%; text-align: center;"> Capital Recovery Rate: 6.00% Fuel (\$/gal): \$2.48 Operator Labor (\$/hr): \$9.25 Harvest Labor (\$/hr): \$8.00 </div> <div style="width: 30%;"> <div style="border: 1px dashed red; padding: 2px; margin-bottom: 5px;"> 7. Year 2 field yield in Dry Ton-Y: 4.00 Year 3 - 10 field yield in Dry Ton-Y: 6.00 </div> <div style="border: 1px dashed red; padding: 2px;"> Avg. Dry Weight of Bale: 1374 Switchgrass Price: \$50.00 </div> </div> </div> <div style="display: flex; justify-content: space-between; align-items: flex-end; margin-top: 10px;"> Breakeven Price per dry ton: \$38.41 Average Yield Net of Losses 4.784 tons per acre Year 2 field yield in Dry Ton-Y: 4 tons per acre Year 3 - 10 field yield in Dry Ton-Y: 6 tons per acre Stand Life (yrs): 10 Breakeven Price: \$38.41 </div>																

Notes:

- Select different options via drop-down lists line by line.
- 'Save' up to three different scenarios among each crop production budget for comparison in 'Results'.
- Select 'Crop Land' or 'Pasture' to show different field preparation recommendations and options.
- Enter a zero (0) in the 'Amount' column for an implement the user does not intend to use for an operation.
- Check the 'Double Harvest' check box if expecting a double harvest. Labor, Fuel, R&M, and Capital Recovery are lower for a double harvest as yields are lower and hence field speed is higher, however, the total cost increases from a single to double harvest.
- Specify the useful life of the stand or 'Stand Life' and 'Percent Yield Loss' during and after harvest.
- Enter the dry tons per acre expected for 'Year 2' and 'Year 3' onward.
- The 'Average Yield Net of Losses' is the average of yield prorated across all years of the stand life, including the establishment year. The 'PV of price' is the crop price received discounted to today's dollars over the life of the stand. The 'PV of Profit over Useful Life' is the sum total of annual profits in today's dollar. The 'Average Profit per Acre' is the annualized average return per acre and should equal zero (except rounding error) when the user-specified crop price in the 'Inputs' tab equals the 'Breakeven Price per dry ton'.
- Print the user-specified 'Producer' and 'Producer and Benchmark' sections section of the budget for comparison.

Figure 20. 'Miscanthus' Production Budget Worksheet



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University of Arkansas System

Main Menu


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Machinery

Switchgrass

Energy Sorghum

Results



ENCAP
ENERGY CROP
ANALYSIS & PLANNING

Save (1)

Save (2)

Save (3)

Miscanthus Production Budget for Circle C

Using the command buttons to the right, the user may accept the 'Benchmark' settings to reset potential changes to the 'Benchmark' values. Cells highlighted in light blue are dropdowns for the producer to choose a different operation/operating input. Cells highlighted in yellow are for the producer to alter the amount of application. Cells highlighted in sky blue with bold and italicized font are used to highlight amounts that are from different from the 'Benchmark' data. The user may save up to three (3) scenarios for comparison summary statistics under 'Results' by clicking the SAVE (1-3) button(s) near the top right.

1. **Accept "Benchmark"**

Print Producer


Print Producer and 'Benchmark'

Breakeven Price per dry ton: \$55.48										Producer		Benchmark						
Yr.	Operation/ Operating Input	Size/ Unit	Month	Labor (hrs/acre)	Fuel (\$/hr)	R&M (\$/hr)	Capital Recovery (\$/hr)	Amount	Cost \$/unit	Total Cost	PV of Total Cost	Total Cost	PV of Total Cost	Amount	Operation/Operating Input			
Establishment Year	Fall Field Preparation		Sep															
	Chisel Plow			0.16	17.46	12.37	26.42	1.00	\$10.96	\$10.96	\$0.73	\$10.96	\$0.73	1.00	Chisel Plow			
	Spring Field Preparation		Mar															
	Fertilizer Application			0.04	8.18	9.93	9.93	2.00	\$1.74	\$3.48		\$3.48		2.00	Fertilizer Application			
	Lime	lbs/acre						2000.00	\$0.03	\$56.60		\$56.60		2000.00	Lime			
	Urea, 46-0-0	lbs/acre						150.00	\$0.29	\$42.83		\$42.83		150.00	Urea, 46-0-0			
	Triple Super Phosphate, 0-45-0	lbs/acre						155.00	\$0.31	\$48.13		\$48.13		155.00	Triple Super Phosphate, 0-45-0			
	Potash Fertilizer, 0-0-60	lbs/acre						115.00	\$0.30	\$34.56		\$34.56		115.00	Potash Fertilizer, 0-0-60			
	Disk			0.12	16.10	16.69	35.62	1.00	\$9.96	\$9.96		\$9.96		1.00	Disk			
									Subtotal	\$195.54	\$13.04	\$195.54	\$13.04					
Custom Ground Herbicide	lbs/acre	Mar					1.00	\$6.00	\$6.00		\$6.00		1.00	Custom Ground Herbicide				
Glyphosate	pt						2.00	\$4.75	\$9.50		\$9.50		2.00	Glyphosate				
								Subtotal	\$15.50	\$1.03	\$15.50	\$1.03						
Year 2	Planting		Apr															
	Cultipacker			0.10	15.28	8.46	20.60	1.00	\$5.73	\$5.73		\$5.73		1.00	Cultipacker			
	Veggie Planter			0.53	14.46	5.62	26.23	1.00	\$37.77	\$37.77		\$37.77		1.00	Veggie Planter			
	Seed	3' row x 2'						7000.00	\$0.25	\$1,750.00		\$1,750.00		7000.00	Seed			
									Subtotal	\$1,793.51	\$119.57	\$1,793.51	\$119.57					
	Post-Plant Weed Control		May															
	Custom Ground Herbicide	\$/acre						1.00	\$6.00	\$6.00		\$6.00		1.00	Custom Ground Herbicide			
	Ally (Cimarron)	oz a.i.						0.50	\$29.50	\$14.75		\$14.75		0.50	Ally (Cimarron)			
								0.00	\$0.00	\$0.00		\$0.00		0.00				
									Subtotal	\$20.75	\$1.38	\$20.75	\$1.38					
Operating Interest	%							7.75%	\$233.78	\$15.59	\$233.78	\$15.59	7.75%	Operating Interest				
Total Specified Expenses (Est Year)									\$2,270.04		\$2,270.04			Total Specified Expenses (Est Year)				
Opportunity Cost of Foregone Profit for Est Year									\$0.00	\$0.00	\$0.00	\$0.00						
Replant Charge	% of Cost							2%	\$45.40	\$3.03	\$45.40	\$3.03	2%	Replant Charge				
Years 3 - 15	Fertilizer		Apr															
	Fertilizer Application			0.04	8.18	9.93	9.93	1.00	\$1.74	\$1.74		\$1.74		1.00	Fertilizer Application			
	Urea, 46-0-0	lbs/acre						215.00	\$0.29	\$61.38		\$61.38		215.00	Urea, 46-0-0			
	Triple Super Phosphate, 0-45-0	lbs/acre						75.00	\$0.31	\$23.29		\$23.29		75.00	Triple Super Phosphate, 0-45-0			
	Potash Fertilizer, 0-0-60	lbs/acre						200.00	\$0.30	\$60.10		\$60.10		200.00	Potash Fertilizer, 0-0-60			
									Subtotal	\$146.51	\$90.79	\$146.51	\$90.79					
	Harvest		Nov															
	Mower			0.11	16.91	9.46	20.86	1.00	\$6.64	\$6.64		\$6.64		1.00	Mower			
	Hay Rake							0.00	\$0.00	\$0.00		\$0.00		0.00	Hay Rake			
	Baler			0.18	14.46	31.85	55.80	1.00	\$20.26	\$20.26		\$20.26		1.00	Baler			
Twine	\$/bale						8.41	\$0.86	\$7.23		\$7.23		8.41	Twine				
Bale Hauler			0.18	8.18	7.90	22.05	1.00	\$9.08	\$9.08		\$9.08		1.00	Bale Hauler				
Forage Harvester			0.13	40.92	30.55	82.40	1.00	\$21.96	\$21.96		\$21.96		1.00	Forage Harvester				
								Subtotal	\$65.18	\$4.10	\$65.18	\$4.10						
Operating Interest	%							7.75%	\$7.15	\$0.45	\$6.72	\$0.42	7.75%	Operating Interest				
Total Specified Expenses (Year 2)									\$218.83		\$196.44			Total Specified Expenses (Year 2)				
Years 3 - 15	Harvest		Nov															
	Mower			0.16	16.91	9.46	20.86	1.00	\$9.91	\$9.91		\$9.91		1.00	Mower			
	Hay Rake							0.00	\$0.00	\$0.00		\$0.00		0.00	Hay Rake			
	Baler			0.35	14.46	31.85	55.80	1.00	\$40.53	\$40.53		\$40.53		1.00	Baler			
	Twine	\$/bale						16.82	\$0.86	\$14.47		\$14.47		16.82	Twine			
	Bale Hauler			0.35	8.18	7.90	22.05	1.00	\$18.15	\$18.15		\$18.15		1.00	Bale Hauler			
	Forage Harvester							0.00	\$0.00	\$0.00		\$0.00		0.00	Forage Harvester			
									Subtotal	\$83.06	\$46.25	\$83.06	\$46.25					
	Operating Interest	%							7.75%	\$7.69	\$4.28	\$7.69	\$4.28	7.75%	Operating Interest			
	Total Specified Expenses (Year 3 - 15)									\$237.25		\$237.25			Total Specified Expenses (Years 3 - 15)			
<table style="width: 100%; font-size: 0.7em;"> <tr> <td style="width: 33%;"> PV of Total Specified Expenses \$300.22 Average Yield Net of Losses 8.28 PV of Price \$32.68 PV of Profit over Useful Life -\$444.62 Average Profit PV -\$29.64 Average revenue per acre \$414.00 </td> <td style="width: 33%;"> Capital Recovery Rate: 6.00% Fuel (\$/gal - P²): \$2.48 Operator Labor (\$/hr - P¹): \$9.25 Hired Labor (\$/hr): \$8.00 Stand Life (years): 15 Percent of Yield Loss: 8.00% </td> <td style="width: 33%;"> Avg. Dry Weight of Bale: 1,189 Miscanthus Price (Net of Losses): \$50.00 Year 2 field yield in Dry Ton-Y: 5 Year 3 - 15 field yield in Dry Ton-Y: 10 Breakeven Price per dry ton: \$55.48 </td> </tr> </table>																PV of Total Specified Expenses \$300.22 Average Yield Net of Losses 8.28 PV of Price \$32.68 PV of Profit over Useful Life -\$444.62 Average Profit PV -\$29.64 Average revenue per acre \$414.00	Capital Recovery Rate: 6.00% Fuel (\$/gal - P ²): \$2.48 Operator Labor (\$/hr - P ¹): \$9.25 Hired Labor (\$/hr): \$8.00 Stand Life (years): 15 Percent of Yield Loss: 8.00%	Avg. Dry Weight of Bale: 1,189 Miscanthus Price (Net of Losses): \$50.00 Year 2 field yield in Dry Ton-Y: 5 Year 3 - 15 field yield in Dry Ton-Y: 10 Breakeven Price per dry ton: \$55.48
PV of Total Specified Expenses \$300.22 Average Yield Net of Losses 8.28 PV of Price \$32.68 PV of Profit over Useful Life -\$444.62 Average Profit PV -\$29.64 Average revenue per acre \$414.00	Capital Recovery Rate: 6.00% Fuel (\$/gal - P ²): \$2.48 Operator Labor (\$/hr - P ¹): \$9.25 Hired Labor (\$/hr): \$8.00 Stand Life (years): 15 Percent of Yield Loss: 8.00%	Avg. Dry Weight of Bale: 1,189 Miscanthus Price (Net of Losses): \$50.00 Year 2 field yield in Dry Ton-Y: 5 Year 3 - 15 field yield in Dry Ton-Y: 10 Breakeven Price per dry ton: \$55.48																
<table style="width: 100%; font-size: 0.7em;"> <tr> <td style="width: 33%;"> Average Yield Net of Losses: 8.28 tons per acre Year 2 field yield in Dry Ton-Y: 5 tons per acre Year 3 - 15 field yield in Dry Ton-Y: 10 tons per acre Stand Life (years): 15 Breakeven Price: \$55.22 </td> <td style="width: 33%;"></td> <td style="width: 33%;"></td> </tr> </table>																Average Yield Net of Losses: 8.28 tons per acre Year 2 field yield in Dry Ton-Y: 5 tons per acre Year 3 - 15 field yield in Dry Ton-Y: 10 tons per acre Stand Life (years): 15 Breakeven Price: \$55.22		
Average Yield Net of Losses: 8.28 tons per acre Year 2 field yield in Dry Ton-Y: 5 tons per acre Year 3 - 15 field yield in Dry Ton-Y: 10 tons per acre Stand Life (years): 15 Breakeven Price: \$55.22																		

Notes:

1. Select 'Accept Benchmark' to accept the average benchmark amounts and prices for producer amounts and prices.
2. The user may split harvesting operations between a baler and a forage harvester, however, the combined 'amount' of passes indicated for both harvesting options should not exceed one (1). Conditional formatting (red, bolded font) has been applied to alert the user when these combined 'amounts' exceed one (1).

Figure 21. Irrigated 'Energy Sorghum' Production Budget Worksheet



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ENCAP
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Save (1)

Save (2)

Save (3)

Use "SAVE (#)" buttons to save the current scenario for comparison to other saved scenarios and their respective 'Benchmark' values.

Irrigated Energy Sorghum Production Budget for Circle C

Using the command buttons to the left, select the irrigation or dryland option for energy sorghum production. Cells highlighted in light blue are drop-downs for the producer to choose from different operation/operating inputs. Cells highlighted in yellow are for the producer to alter the amount of application. Cells highlighted in sky blue with bold and italicized font are used to highlight amounts that are from different from the 'Benchmark' data. The user may save up to three (3) scenarios for comparison summary statistics under 'Results' by pressing the the SAVE(1-3) button(s) near the top right. **CAUTION!** Switching between irrigated and dryland will reset values to defaults.

Breakeven Price per dry ton: \$42.97

Producer

Benchmark

Operation/Operating Input	Size/Units	Month	Labor (hrs/acre)	Fuel (\$/hr)	R&M (\$/hr)	Capital Recovery (\$/hr)	Amount	Cost \$/unit	Total Cost	Total Cost	Amount	Operation/Operating Input	
Fall Field Preparation													
Disk		Nov	0.12	16.10	16.69	35.62	1.00	\$9.96	\$9.96	\$9.96	1.00	Disk	
Chisel Plow			0.16	17.46	12.37	26.42	1.00	\$10.96	\$10.96	\$10.96	1.00	Chisel Plow	
Subtotal										\$20.92			
Seedbed Preparation, Fertilizer and Planting													
Fertilizer Application		Mar	0.04	8.18	9.93	9.93	2.00	\$1.74	\$3.48	\$3.48	2.00	Fertilizer Application	
Lime	lbs/acre						2000.00	\$0.03	\$56.60	\$56.60	2000.00	Lime	
Urea, 46-0-0	lbs/acre						111.00	\$0.29	\$31.69	\$31.69	111.00	Urea, 46-0-0	
Triple Super Phosphate, 0-45-0	lbs/acre						60.00	\$0.31	\$18.63	\$18.63	60.00	Triple Super Phosphate, 0-45-0	
Potash Fertilizer, 0-0-60	lbs/acre						90.00	\$0.30	\$27.05	\$27.05	90.00	Potash Fertilizer, 0-0-60	
Field Cultivator		Apr	0.12	16.37	11.18	27.28	1.00	\$7.87	\$7.87	\$7.87	1.00	Field Cultivator	
Disk Bedder			0.14	18.55	9.81	25.80	1.00	\$9.19	\$9.19	\$9.19	1.00	Disk Bedder	
Row Conditioner			0.14	17.46	8.23	25.35	1.00	\$9.17	\$9.17	\$9.17	1.00	Row Conditioner	
Row Planter			0.19	15.28	14.29	24.33	1.00	\$12.91	\$12.91	\$12.91	1.00	Row Planter	
Seed (Concept treated)	lbs/acre						9.92	\$10.58	\$104.98	\$104.98	9.92	Seed (Concept treated)	
Atrazine	lb a.i.						2.00	\$3.94	\$7.88	\$7.88	2.00	Atrazine	
Dual II Magnum	pt						1.50	\$13.63	\$20.45	\$20.45	1.50	Dual II Magnum	
Subtotal										\$309.89			
Post Plant Custom Work													
Custom Ground Herbicide	\$/acre	May					1.00	\$6.00	\$6.00	\$6.00	1.00	Custom Ground Herbicide	
Atrazine	lb a.i.						2.00	\$3.94	\$7.88	\$7.88	2.00	Atrazine	
Fertilizer Application			0.04	8.18	9.93	9.93	1.00	\$1.74	\$1.74	\$1.74	1.00	Fertilizer Application	
Urea, 46-0-0	lbs/acre						200.00	\$0.29	\$57.10	\$57.10	200.00	Urea, 46-0-0	
Custom Air Insecticide							0.00	\$7.00	\$0.00	\$0.00	0.00	Custom Air Insecticide	
Baythroid XL 1 EC							0.00	\$1.53	\$0.00	\$0.00	0.00	Baythroid XL 1 EC	
Irrigation pipe	\$/acre						1.00	\$10.30	\$10.30	\$10.30	1.00	Irrigation pipe	
Furrow Irrigation	ac-inch		0.03	2.48	0.19	23.17	6.00	\$0.98	\$29.06	\$29.06	6.00	Furrow Irrigation	
Subtotal										\$112.08			
Harvest													
Mower		Aug	0.20	16.91	9.46	20.86	1.00	\$12.35	\$12.35	\$12.35	1.00	Mower	
Baler							0.00	\$0.00	\$0.00	\$0.00	0.00	Baler	
Twine							0.00	\$0.86	\$0.00	\$0.00	0.00	Twine	
Bale Hauler							0.00	\$32.47	\$0.00	\$0.00	0.00	Bale Hauler	
Forage Harvester			0.32	40.92	30.55	82.40	1.00	\$52.72	\$52.72	\$52.72	1.00	Forage Harvester	
Subtotal										\$65.06			
Operating Interest								7.75%	\$7.63	\$7.60	7.75%	Operating Interest	
Total Specified Expenses										\$515.58	\$515.68	Total Specified Expenses	

Capital Recovery Rate: 6.00%

Fuel (\$/gal): \$2.48

Operator Labor (\$/hr): \$9.25

Hired Labor (\$/hr): \$8.00

Avg. Dry Weight of Bale: 1189

Field Yield in Dry Ton-Y: 12

Breakeven Price per dry ton: \$42.97

Field Yield in Dry Ton-Y: 12 tons per acre

Break Even Price: \$42.97

Notes:

1. Select 'Irrigated Sorghum' or 'Dryland Sorghum'.
2. Specify amount of furrow irrigation when the 'Irrigated Sorghum' production method is selected.

VIII. Results

The 'Results' worksheet (Fig. 22) displays the total cost per acre for each biomass crop and their harvest scenario as saved using the 'Save' command buttons in the budget sheets. This worksheet accounts for acres harvested as specified in the 'Machinery' worksheet, variable input prices, field operations performed, and operating inputs used. The 'Results' sheet thus contains simplified summaries of production costs for switchgrass, energy sorghum, and miscanthus per acre across a number of production alternatives. Both switchgrass and miscanthus are broken down by production costs per year of stand life since both crops are perennials.


The first section describes 'Establishment Costs', which focuses on the amount of the three different fertilizers applied (urea, triple super phosphate, and potash) and their respective costs per acre. The next two sections describe post establishment fertilizer and harvest options including equipment complement and harvest cost in dollar (\$) per acre. At the bottom of each biomass harvest scenario is the 'Breakeven Price Required', 'Stand Life', and 'Average Yield Net of Losses'. These three different scenario values are expected to provide guidance for investment and sales decisions.

Since energy sorghum is an annual crop, production costs are for one year of production *only*. Important input use parameters focus on the amount of fertilizer applied and the different harvest methods. 'Total Specified Expenses' are shown as dollar (\$) per acre while the 'Breakeven Price' and 'Yield' for the different scenarios are also provided for comparison with switchgrass and miscanthus.

Note: harvested moisture content may still vary significantly across these commodities as costs are reported on a dry matter basis. Nonetheless, moisture content is important because refineries will incur differential transport and drying costs pending moisture content and refining method used. While analysis of moisture content at time of cutting is made available in the 'SHYNE' worksheet, analysis of such costs is beyond the scope of this manual.

The user may clear each scenario by clicking the 'Clear' command button directly above each scenario (Fig. 22 (1)). In addition, the user may print each section by clicking the 'Print' command button for each crop (Fig. 22 (2)).

Figure 22. 'Results' Worksheet Comparing Switchgrass with Energy Sorghum and Miscanthus



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Print Comparison

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SHYNE



ENCAP
ENERGY CROP
ANALYSIS & PLANNING

Producer Description

Establishment Year
Fall Field Preparation
Lime
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60
Establishment Costs (\$/acre)
Year 2 - 10 Fertilizer
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60

Harvest Year 2

Harvests Costs (\$/acre)

Harvest Year 3

Harvest Costs (\$/acre)
Breakeven Price Required
Stand Life
Average Yield net of losses

Print Comparison

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SHYNE

Clear

Clear

Clear

Saved Scenario 1
Production comparison of Switchgrass on Cropland.

Producer	Benchmark
Amount	Amount
2000	2000
67	67
67	67
\$291.03	\$291.03

Saved Scenario 2
Production comparison of Switchgrass on Pasture.

Producer	Benchmark
Amount	Amount
2000	2000
67	67
67	67
\$371.75	\$246.60

Saved Scenario 3
Production comparison of Switchgrass on Pasture.

Producer	Benchmark
Amount	Amount
2000	2000
67	67
67	67
\$371.75	\$246.60

Benchmark Description

Establishment Year
Fall Field Preparation
Lime
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60
Establishment Costs (\$/acre)
Year 2 - 10 Fertilizer
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60

Harvest Year 2

Harvests Costs (\$/acre)

Harvest Year 3

Harvest Costs (\$/acre)
Breakeven Price Required
Stand Life
Average Yield net of losses

Producer Description

Establishment Year
Fall Field Preparation
Lime
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60
Establishment Costs (\$/acre)
Year 2 - 10 Fertilizer
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60

Harvest Year 2

Harvests Costs (\$/acre)

Harvest Year 3

Harvest Costs (\$/acre)
Breakeven Price Required
Stand Life
Average Yield net of losses

Print Comparison

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Inputs

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Switchgrass

Miscanthus

Energy Sorghum

SHYNE

Clear

Clear

Clear

Saved Scenario 1
Production comparison of Miscanthus.

Producer	Benchmark
Amount	Amount
2000	2000
150	150
155	155
115	115
\$2,314.02	\$2,314.02

Saved Scenario 2
Production comparison of Miscanthus.

Producer	Benchmark
Amount	Amount
2000	2000
150	150
155	155
115	115
\$2,314.02	\$2,314.02

Saved Scenario 3
Production comparison of Miscanthus.

Producer	Benchmark
Amount	Amount
2000	2000
150	150
155	155
115	115
\$2,314.02	\$2,314.02

Benchmark Description

Establishment Year
Fall Field Preparation
Lime
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60
Establishment Costs (\$/acre)
Year 2 - 10 Fertilizer
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60

Harvest Year 2

Harvests Costs (\$/acre)

Harvest Year 3

Harvest Costs (\$/acre)
Breakeven Price Required
Stand Life
Average Yield net of losses

Producer Description

Seedbed Preparation, Fertilizer & Planting
Lime
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60

Harvest

Total Specified Expenses (\$/acre)
Breakeven Price Required
Yield

Print Comparison

Main Menu

Inputs

Machinery

Switchgrass

Miscanthus

Energy Sorghum

SHYNE

Clear

Clear

Clear

Saved Scenario 1
Production comparison of Irrigated Energy Sorghum.

Producer	Benchmark
Amount	Amount
2000	2000
111	111
60	60
90	90

Saved Scenario 2
Production comparison of Energy Sorghum.

Producer	Benchmark
Amount	Amount
2000	2000
91	91
60	60
90	90

Saved Scenario 3
Production comparison of Dryland Energy Sorghum.

Producer	Benchmark
Amount	Amount
2000	2000
91	91
60	60
90	90

Benchmark Description

Seedbed Preparation, Fertilizer & Planting
Lime
Urea, 46-0-0
Triple Super Phosphate, 0-45-0
Potash Fertilizer, 0-0-60

Harvest

Total Specified Expenses (\$/acre)
Breakeven Price Required
Yield

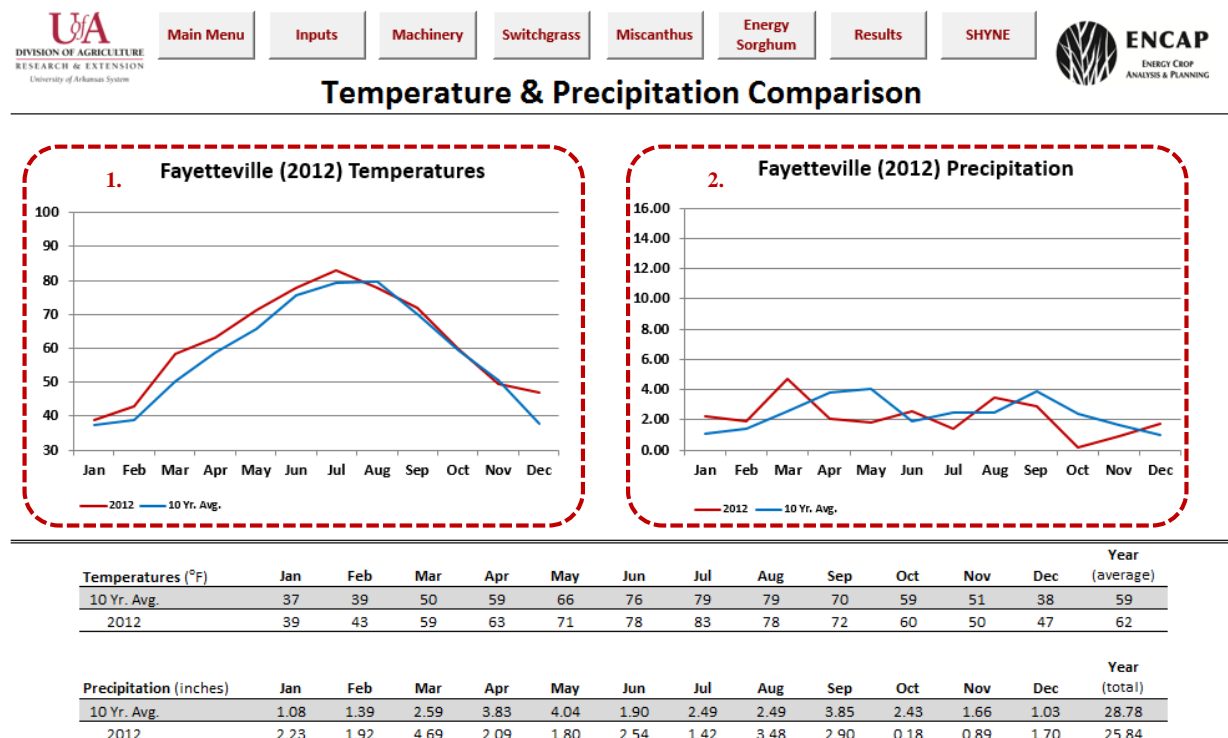
Notes:

1. Print each comparison section by clicking the 'Print' command button for each crop.
2. 'Energy Sorghum' scenario 2 has been cleared by clicking the 'Clear' button above scenario 2. Click the 'Save (2)' button in the 'Energy Sorghum' budget to repopulate.

VIII. Weather

Users have the option of eight locations and five years (Fig. 10 (6)) for calculation: Fayetteville, AR, Jonesboro, AR, Pine Tree, AR, Winnsboro, LA, New Franklin, MO, Haskell, OK, Stillwater, OK, and Woodward, OK and 2009 through 2013, depending on the location selected in the 'Inputs' tab. The graphs provided display the recorded temperatures (Fig. 23 (1)) and precipitation (Fig. 23 (2)) for the selected location and year as well as a 10-year average for each graph. Detailed information on the soil conditions of each location is provided in Section V.

Figure 23. 'Weather' Worksheet



Notes:

1. Graph provides temperatures for each month of the user-specified year as well as a 10-year average.
2. Graph provides precipitation for each month of the user-specified year as well as a 10-year average.

IX. Switchgrass Harvest Date, Yield and Nutrient Concentration Estimator (SHYNE)

The Switchgrass Harvest Date, Yield and Nutrient Concentration Evaluation (SHYNE) worksheet (Fig. 23) allows producers and refinery managers to assess the importance of harvest date on yield as well as nutrient replacement costs and nutrient concentrations in the harvested biomass. This worksheet uses user-specified inputs costs per ton from the ‘Inputs’ tab for Urea, Triple Super Phosphate, potash fertilizer, and poultry litter, if applied (Fig. 24 (1)). In addition, SHYNE uses the user-specified opportunity cost for delayed sales receipts, a six month post-harvest storage loss rate, and the expected price of switchgrass to be received from a biorefinery (Fig 24 (1)).

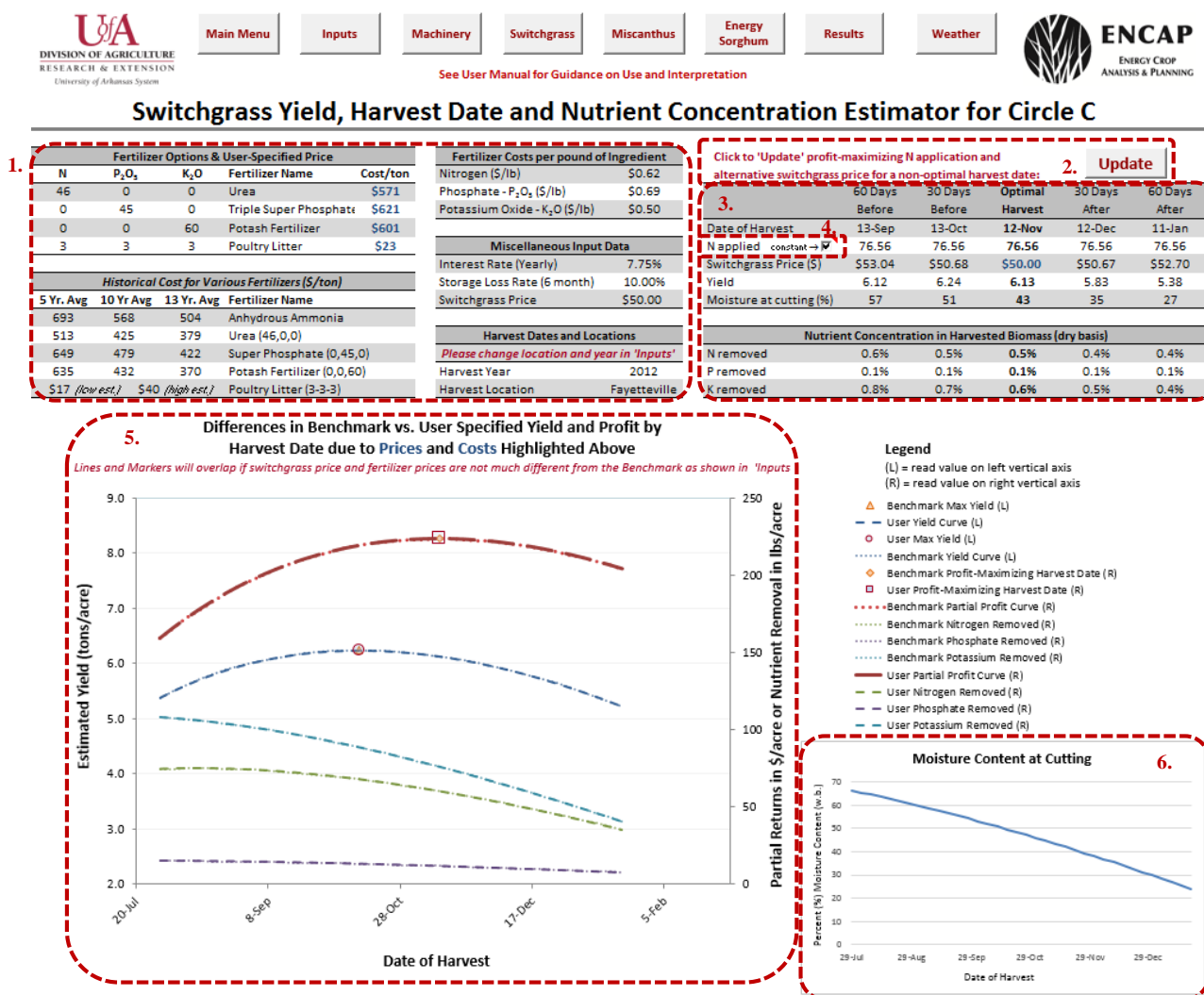
Using these parameters, SHYNE calculates the optimal harvest date to maximize partial returns for the producer by setting yield potential by calculating appropriate urea and litter application rates to meet nitrogen needs in the spring as well as estimating the cost of replacing nutrients removed in the biomass harvested under the conditions for a particular production location and year (Fig. 24 (3)). Partial returns are calculated as switchgrass sales less relevant expenses for the harvest date calculation. These expenses include cost of nutrients that need to be replaced, the opportunity cost of interest foregone, and the post-harvest storage losses avoided with delayed sale. The opportunity cost of interest foregone and the post-harvest storage losses avoided with delayed sale are relative to the harvest date associated with maximum seasonal yield.

The user may also use SHYNE to determine the switchgrass price premium needed to either match partial returns associated with the ‘Optimal Harvest Date’ or quantify losses associated with an earlier or later than ‘Optimal Harvest Date’ (Fig. 24 (3)). To match partial returns associated with the optimal harvest date, the user should apply different amounts of nitrogen in the spring given an alternative, higher switchgrass price the refinery pays to modify the harvest date. To estimate losses without modifying the spring application of nitrogen, in case the alternative harvest date is announced after spring fertilizers have already been applied, the user may uncheck the check box found in Fig. 24 (4), *N applied constant →* ☐. This holds the amount of N applied constant, and estimates the alternative switchgrass price, yield, nutrient removal, and nutrient concentrations using the assumption that N application does not differ in the spring when the harvest date is changed. *Note: the model does not account for harvest-speed driven changes in fuel, labor cost, repairs and maintenance, capital recovery, and twine cost as a result of different yields across harvest date. These differences from cost levels at the optimum harvest date are expected to play a relatively minor role (<\$2 per acre or approx. \$0.3 to \$0.5 per ton). This section of SHYNE thus provides the user with alternative fertilizer needs and an estimate of losses with an alternative harvest date, or alternatively, the price premium needed to advance or delay harvest.*

The large graph (Fig. 24 (6)) located in the bottom-half portion of the screen is provided to show nutrient removal rates by date, the yield expectation by harvest date as indicated by the yield curve, and the shape of the partial return curve needed to optimize the harvest date with the assumption that N applied does not change with harvest date. In addition, the smaller graph (Fig. 24 (5)) located in the bottom-right corner of the screen is provided to show percent moisture content (w.b.) across harvest dates. The moisture content graph (Fig. 24 (6)) is provided to allow

a user to determine the date during the harvest window in which a direct cut system with a forage harvester may be feasible. The interested reader is referred to Lindsay et al. (2015) where such an analysis is performed.

Figure 24. Switchgrass Harvest Date, Yield and Nutrient Concentration Estimator (SHYNE)



Notes:

1. Tables provide a summary of user-specified data from 'Inputs'.
2. Click 'Update' to match profit at profit-maximizing N application and harvest date to alternative dates.
3. Profit-maximizing, or 'Optimal Harvest' switchgrass yield, price, fertilizer, and nutrient concentration estimations, provided in bolded text, are compared to early and delayed harvest dates to match partial returns or quantify losses associated with alternate harvest dates.
4. Estimate losses without modifying the spring application of nitrogen by unchecking the check box.
5. Graph provides nutrient removal rates by date, yield expectation by harvest date as indicated by the yield curve, and the shape of the partial return curve needed to optimize harvest date and calculate price premia.
6. Graph displays percent moisture content (w.b.) across harvest dates.

IX. Conclusion

ENCAP is a useful tool for producers interested in participating in the renewable fuels feedstock market, because it provides the opportunity for developing breakeven cost of production estimates using varying production methods. Default values are provided for benchmarking and

the 'Results' worksheet allows for multiple comparisons of user-defined options. This spreadsheet program thus may guide investment decisions for farming equipment and help determine potential profitability when producers are approached with pricing and delivery contracts for energy crops. The use of 'SHYNE' in conjunction with production budgets further provides estimates that may be needed to determine the cost of producing switchgrass.

If modified correctly, this program should aid producers by providing information about relative changes in profitability and the required breakeven prices. However, this tool is not intended to verify economic performance of an operation, but as a planning and forecasting tool for purposes of 'what if' and sensitivity analyses. As all values presented in each tool are estimates, the user should not expect to flawlessly achieve the modeled outcome.

This model predominately provides the most recently available data for switchgrass. As more information becomes available, updates to the program for miscanthus and energy sorghum are likely.

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APPENDIX

All costs (\$/budget unit) are calculated by multiplying a **price** (specified as \$ per unit of measure) by a **quantity** (specified as the unit of measure per budget unit, i.e. acre for crop enterprises). The following cost calculations are differentiated between tillage/planting and harvest equipment.

A. Costs of Tillage & Planting

Within each of the biomass production budget tabs, calculations for the different operations of field preparation, fertilizer/lime application and harvest contain calculations for labor, fuel, repair and maintenance (R&M), and capital recovery. While each calculation is different for each operation, field preparation and application methods utilized the same method of calculation for determination of these values.

Equation 1 shows the calculation to determine labor as the amount of hours spent on one acre with any implement used for tillage and planting. Calculations for labor in hours per acre were determined using Table A1 provided below.

$$1) \text{ Hours/acre} = 43,560 / (\text{FS} \cdot \text{MW} \cdot 5280) \cdot \text{FEP},$$

where FS, MW, and FEP are field speed in miles per acre, machine width in feet, and field efficiency percentage in decimal form (5,280 represents feet in one mile and 43,560 is the number of square feet in one acre). FS and FEP are typical values from Table A1 and MW is implement dependent.

Equation 2 shows the calculation to acquire fuel used per acre. This calculation is based upon the use of diesel tractors.

$$2) \text{ Fuel/hour} = 0.044 \cdot \text{HP},$$

where 0.044 is a coefficient determined from the American Society of Agricultural Engineers (ASAE) and HP is the horsepower of the tractor being used for that particular operation.

Equation 3 shows the calculation for repair and maintenance as a cost per acre. The ASAE describes repair and maintenance as a function of the equipment's list price, useful life in hours and repair costs as the percentage of list price specific to a particular piece of equipment.

$$3) \text{ R\&M/hour} = ((\text{RF} \cdot \text{PP}) / \text{ULHR}),$$

where RF is the repair factor or the fraction of the purchase price of the equipment that is spent over the useful life for repair and maintenance (Table A1), PP¹ is the user-defined purchase price, and ULHR are useful life hours over the life of the equipment. ULHR is calculated as the total use hours at salvage less the use hours at time of purchase.

¹ Purchase Prices were collected from John Deere's Agriculture, Hay and Forage Equipment as well as Williams Tractor via personal communication.

Equation 4 shows the calculation for capital recovery as depreciation and the opportunity cost of capital invested in the equipment. Capital recovery represents the annual equivalent amount paid for an investment if the equipment was amortized over a specific period with an expected salvage value.

4) Annual Capital Recovery/hour =

$$(((PP - SV) \cdot (DR / (1 - (1 + DR)^{-ULYR})) + (SV \cdot DR))) / AH),$$

where SV, DR, ULYR, and AH are salvage value, annual discount rate, useful life in years, and annual use hours, respectively. Note, ULYR changes with AH and ULHR. SV is calculated as a percentage of PP. This percentage, often referred to as the remaining value coefficient RV, is a function of the age of the equipment expressed in hours of equipment use at time of salvage or its ULHR as per ASAE D497.7.

Table A1. Field Efficiency, Field Speed, and Repair and Maintenance Cost Parameters

	Field Efficiency (FEP)	Field Speed (FS)	Estimated Life (ULHR)	Total Life R&M Cost (RF)
<u>Machine</u>	<u>Typical %</u>	<u>Typical MPH</u>	<u>Hours</u>	<u>% of list price</u>
TRACTORS				
2 Wheel Drive	—	—	12,000	100
4 Wheel Drive	—	—	16,000	0.80
TILLAGE & PLANTING				
Moldboard Plow	85	4.5	2000	100
Heavy-duty disk	85	4.5	2000	60
Tandem disk harrow	80	6.0	2000	60
Chisel Plow	85	5.0	2000	75
Field Cultivator	85	7.0	2000	70
Roller Packer	85	6.0	2000	40
Rotary Hoe	80	12.0	2000	60
Row Crop Cultivator	80	5.0	2000	80
Grain Drill	70	5.0	1500	75
Row Crop Planter	65	5.5	1500	75

Source: ASAE D497.7 Standards 2011 Table 3

B. Costs of Harvesting

While harvesting equipment uses the same methods for calculating fuel, R&M, and capital recovery on a per acre basis as tillage and planting equipment, labor calculations vary with each harvest equipment selection as yields affect harvesting speed. These harvest calculations for labor, fuel, R&M, and capital recovery use the cost parameters provided in Table A2 below. Using the labor calculations for specific harvest equipment, equations 2 - 4 may be utilized to calculate fuel, R&M, and capital recovery with the use of Table A2 factors.

The calculations for labor in hours per acre for the selected mower (disk mower, disk mower conditioner, or self-propelled mower conditioner), hay rake, baler, bale hauler, and self-propelled forage harvester are provided in equations 5 - 9, respectively.

$$5) \text{ Labor}_{\text{Mower}} = 1 / (\text{FS} \cdot \text{MW} \cdot \text{FEP} \cdot \text{MW} / 5,280 \cdot 43,560)$$

where FS, MW, and FEP are field speed in miles per acre, machine width in feet, and field efficiency percentage in decimal form. 5,280 represents feet in one mile and 43,560 is the number of square feet in one acre. Field speed in miles per hour is linearly interpolated between 3 miles per hour for yields of 15 tons/acre or more and 10 miles per hour for yields of 3 tons/acre or less using the range of typical harvesting speeds for rotary mowers and self-propelled windrowers as from Table A2. Field efficiency percentages are typical values found in Table A2 that account for the fraction of time mowing instead of accessing the field, overlap, turning, stopping, etc. Machine width is implement dependent. Acres per hour are then a function of field speed, machine width, and field efficiency. For example, if an 8 foot mower has a maximum field speed (FS) of 10 miles/hour, an 80% FEP, and 3 or less dry tons/acre yields, its available hours/acre equals 7.76 acres/hour. When the yield reaches 6 dry tons/acre, the FS is then prorated to 8.25 miles per hour leading to 6.4 available acres/hour.

Note: a disk mower requires 2 hp/ft of MW and a disk mower conditioner requires 3.3 hp/ft of MW. These horsepower requirements seem quite low to the authors of this manual. Using the hp/ft measure, only provides an estimate of horsepower needs that are not subject to yield. The user thus needs to make sure they have sufficient horsepower for the type of mower selected.

$$6) \text{ Labor}_{\text{Hay Rake}} = 1 / \text{Max Acres per Hour},$$

where ‘Max Acres per Hour’ is the product of the FEP, FS, and ‘Acres per Mile’. ‘Acres per Miles’ is calculated as 5,280 multiplied by the implement width (in feet) and divided by 43,560. The values 5,280 and 43,560 represent the number of feet in one mile and the number of square feet in one acre, respectively. FS and FEP are shown in Table A2. The spreadsheet assumes field speed is not limited by yield or tractor horsepower pulling the rake, but is affected by the width of the rake.

$$7) \text{ Labor}_{\text{Baler}} = Y / (\# \text{ of bales per hour} \cdot \text{Size in Dry Ton})$$

where ‘# of bales per hour’ is defined by the user in the ‘Baler’ selection userform and ‘Size in Dry Ton’ is calculated as bale weight in tons multiplied by (1 – MC), where safe MC is moisture content at time of harvest and assumed to be 82%.

$$8) \text{ Labor}_{\text{Bale Hauler}} = (Y / \text{BW}_{\text{Avg}}) / (\# \text{ of bales per load} \cdot \text{Max Loads per Hour})$$

where ‘BW_{Avg}’ is the weighted average dry bale weight based on the user-specified crop mix for different balers chosen as well as the acreage in those crops. ‘Max Loads per Hour’ is calculated by dividing the 60 minutes in an hour by the ‘Minutes per Load’ as defined by the user in the ‘Bale Hauler’ selection userform.

Note: the 10 and 14 bale capacity haulers are designated for large and medium round bales, respectively, and the 16 bale hauler is designated for a large square baler only.

9) $\text{Labor}_{\text{Forage Harvester}} = Y / (\text{HP} / \text{hph/ton} \cdot \text{FEP})$

where HP is the horse power of the self-propelled forage harvester and hph/ton is the power requirement per unit (ton) of material feed rate. A 375 hp forage harvester processing a 12 dry ton per acre crop with an hph/ton of 5.3 thus can process $375 / 5.3 \cdot \text{FEP}$ tons per hour, or approximately 50 dry ton/hour. Therefore, the machine takes 0.24 hrs/acre, or approximately 15 minutes per acre to harvest. Hence, a forage harvester processes 4 acres per hour at a yield of 12 dry tons per acre.

Table A2. Speed Parameters, Field Efficiency, Field Speed, and Repair and Maintenance Cost Parameters.

	Requirement Parameters		Field Efficiency (FEP)	Field Speed (FS)	Estimated Life (ULHR)	Total Life R&M Cost (RF)
<u>Machine</u>	<u>hp/ft</u>	<u>hph/ton</u>	<u>Typical %</u>	<u>Typical MPH</u>	<u>Hours</u>	<u>% of List Price</u>
Forage Harvester (SP)	—	5.3 ^a	70	—	4000	50
Windrower (SP)	3.3 ^b	—	80	3-8	3000	55
Disk Mower Conditioner	3.3	—	80	5-12	2500	100
Disk Mower	2.0	—	80	5-12	2000	175
Hay Rake	0.8	—	80	6.0	2500	60
Round Baler	—	2.2	— ^c	—	1500	90
Bale Hauler	—	—	— ^d	—	3000	50 ^e

Source: ASABE D497.7 Standards 2011 Table 2 and 3

Notes:

^a Average hph/ton of 5.3 for corn silage, wilted alfalfa, and direct cut rounded to the nearest tenth assuming dry matter.

^b Set to Disk Mower Conditioner hp/ft of 3.3.

^c User specifies number of bales per hour in the Baler selection userform.

^d User specifies number of loads per hour in the Bale Hauler selection userform.

^e Set to 50 by Dr. M. Popp from 80 for field wagons per ASABE.

The amount of twine used per bale is determined by the user-specified bale size and expected yield. The cost of twine per bale is determined by the purchase price of the twine, amount of twine per box purchased, and the number of feet used to wrap each bale. Equations 10 and 11 show the amount of twine used per bale in feet and twine cost per bale in dollars.

10) $\text{Twine/bale} = Y \cdot 2000 / \text{BW}$

where Y is the dry yield at harvest as specified by the user and BW is bale weight in dry tons. Yield is represented in tons with 2000 pounds per ton.

$$11) \text{Twine cost/bale} = PP / (\text{twine per box} / \text{feet per bale})$$

where P represents purchase price of the twine and twine per box is represented in feet.

Feet per bale is calculated by multiplying the bale circumference by the number of times the twine wraps one bale.

Costs per Acre

The rates of labor for each implement, equations 1, and 5 - 9, are displayed in the crop production budgets as hours per acre, and multiplied by the cost of labor, fuel, R&M, and capital recovery in dollars (\$) per hour to determine a total cost per acre. Equations 11 and 12 calculate the cost of labor and fuel in dollars (\$) per hour before multiplying by the labor rate of hours per acre.

$$12) \text{Labor Costs per Hour} = (1 \cdot OL + (LM - 1) \cdot HL),$$

where OL is the operator labor cost, HL is the hired labor cost, and LM is the labor multiplier. These values are specified by the user in the 'Inputs' tab and discussed in Section V, under 'Wage Rates and Labor Multipliers'.

$$13) \text{Fuel Costs per Hour} = \text{fuel/hour} \cdot F$$

where F is the cost of fuel in dollars per gallon as specified by the user in 'Inputs' and fuel use/hour is driven by the horse power of the power unit used for the field operation. If the operator wishes to hire out this production process, the fuel use is not shown.