



# **PAM**

## **PALMER AMARANTH MANAGEMENT**



User Manual  
2017

Version 2.0

By

Karen Lindsay, Michael Popp, Muthukumar Bagavathiannan, Jason Norsworthy

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## **I. Introduction**

The Palmer Amaranth Integrated Management Model (PAM) was developed using the Microsoft Excel® software platform to assist cotton, corn, and/or soybean producers, consultants, distributors, and extension personnel, in adopting integrated management tactics for the management of Palmer amaranth and promoting long-term economic viability of crop production through the minimization of adverse economic, human health, and environmental impacts associated with herbicide resistance.

The PAM software serves as a valuable decision-support tool for guiding integrated management of Palmer amaranth by utilizing existing research knowledge and providing a greater understanding of the long-term biological (seedbank size and persistence) and economic (improved cost-benefit analysis) implications of various management choices. Decision support will allow improved crop production and profitability through adoption of IPM tactics that preserve the long-term utility of available herbicide options, and minimize the human health risks and environmental impacts associated with herbicide resistance.

### ***Study Species: Palmer Amaranth***

Palmer amaranth is a pigweed native to the southern United States and considered to be both aggressive and invasive with a growing resistance to glyphosate and ALS-inhibitor herbicides (Legleiter and Johnson 2013; Sprague 2013). Palmer amaranth is one of the most problematic herbicide-resistant weeds causing great losses to cotton, corn, and soybean production in the Southern US (Riar et al. 2013; Webster and Nichols 2012). In addition to being a predominant weed in the Southern region, Palmer amaranth is also a growing concern in other agriculturally important regions in the country, particularly the Southwestern (Rios et al. 2014), Midwestern (Jhala et al. 2014), and Northcentral (Sprague 2012) states. In places such as Texas, the spread of resistant Palmer amaranth has been very rapid within the past few years from the Pan Handle to the Gulf Coast regions (Smith 2012). Palmer amaranth is currently infesting crop lands in at least 30 US states (Heap 2016).

Palmer amaranth is regarded as the most troublesome weed in crop production in the United States (Van Wyken 2016). This species is widely considered invasive and threatens the profitability and sustainability of U.S. agriculture. The ability for rapid growth, high seed production, high genetic diversity, tolerance to adverse conditions, and high tendency for evolving herbicide resistance have further enabled the dominance of Palmer amaranth in agricultural systems (Ward et al. 2013).

### ***Use Caveats***

This model uses default values that are based on a review of published scientific literature and expert opinions as well as user-specifications based on existing operations. Estimates using these parameters lead to results that are function of a set of complex calculations performed in this model.

Input values pertaining to commodity prices, various production costs, and weed management options based on default values may be customized to suit operation specific parameters. Input

values for some of the difficult-to-assess variables are extrapolated based on simple indicators. For instance, initial Palmer amaranth seedbank densities are derived based on the plant population densities observed in the previous (existing) cropping seasons.

Changes in parameter values and its implications on economic returns are only 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, the outputs are only intended to provide trends in likely changes to Palmer amaranth seedbank and economic returns.

## **II. Purpose**

PAM was designed to provide producers and researchers with a planning tool to allow for the evaluation of the effectiveness of various Palmer amaranth management options on long-term Palmer amaranth seedbank dynamics and economic returns. PAM integrates agronomic, biological, and economic information to help the user understand the long-term implications of adopting a given management strategy, or a lack thereof, and thereby make informed management decisions.

The PAM model is intended for use as an educational tool by extension agents, crop consultants, growers, and any personnel interested in understanding the benefits of integrated weed management. PAM is **not** an herbicide resistance simulation model; however, it adequately accounts for any pre-existing resistance and the likelihood for developing resistance under any chosen strategy.

### ***Core Components***

PAM has three integral components: 1) population dynamics of Palmer amaranth, 2) management, and 3) economics. These components interact with each other in delivering output for comparison of alternative strategies.

#### ***Population Dynamics***

The population dynamics sub-model simulates the life cycle of Palmer amaranth from seeds in the soil seedbank to seedbank replenishment at the end of the growing season, described in its simplest form as:

$$N(t+1) = N_t * \sum a * \sum (1-b)$$

where  $N(t+1)$  is the future population size in the next time step,  $N_t$  is the current population size,  $a$  represents additive factors to population abundance, and  $b$  indicates subtractive factors.

PAM tracks the size of soil seedbank and aboveground Palmer amaranth density at different stages in a growing season. The model accounts for seed production as influenced by factors such as seedling emergence pattern, crop competition, and density-dependence. Palmer amaranth typically shows a prolonged seedling emergence pattern (Jha 2008), with emergence commencing in April and continuing up to September in the Southern US. As a result, the aboveground population is structured into various cohorts to represent differences

in competitive ability and fecundity. Additionally, the effects of density-dependence (both intra- and inter-specific) on survival, growth, and fecundity are captured in the population dynamics sub-model.

### *Management*

The management component of the model represents various crop and weed management options considered in the model. The crop management choices may have a direct or indirect influence on weed population dynamics. For example, different tillage patterns (no-till or shallow tillage) will have different outcomes on the seedbank distribution and subsequent emergence and dynamics. Efficacies are assigned for each crop/management option based on its effects on overall weed control. Ultimately, the crop and weed management choices affect and interact with long-term weed population dynamics as well as economic returns.



### *Economics*


The economic considerations of PAM are designed to reflect Southern US crop production practices. One of the key considerations of PAM is to allow the user to recognize the extent of long-term benefits through short-term compromises in profit. In particular, the economic value of proactive resistance management strategies is demonstrated, highlighting the savings that would otherwise be spent on additional weed control options if resistance was allowed to evolve. PAM employs partial and capital budgeting techniques to evaluate various proactive strategies surrounding Palmer amaranth management.

Net returns are calculated each year and are based on proceeds from commodity sales and expenses incurred. PAM uses 'Net Present Value' (NPV) analysis as a dollar received or spent today is different from a dollar received or spent in the future given potential interest earnings forgone (Robinson and Barry 1996). The goal is to maximize the sum of all earnings over a 10-year period in today's dollars and choose the strategy with the highest amortized 10-year net cashflows or NPV. Specifying different interest rates to reflect differences in risk and/or different crop yield improvement over time (apart from yield effects due to weed control) demonstrates the sensitivity of outcomes to interest rate and yield growth expectations. Similar sensitivity analyses may also be performed using different input cost and output price trend expectations.

### ***Model Implementation***

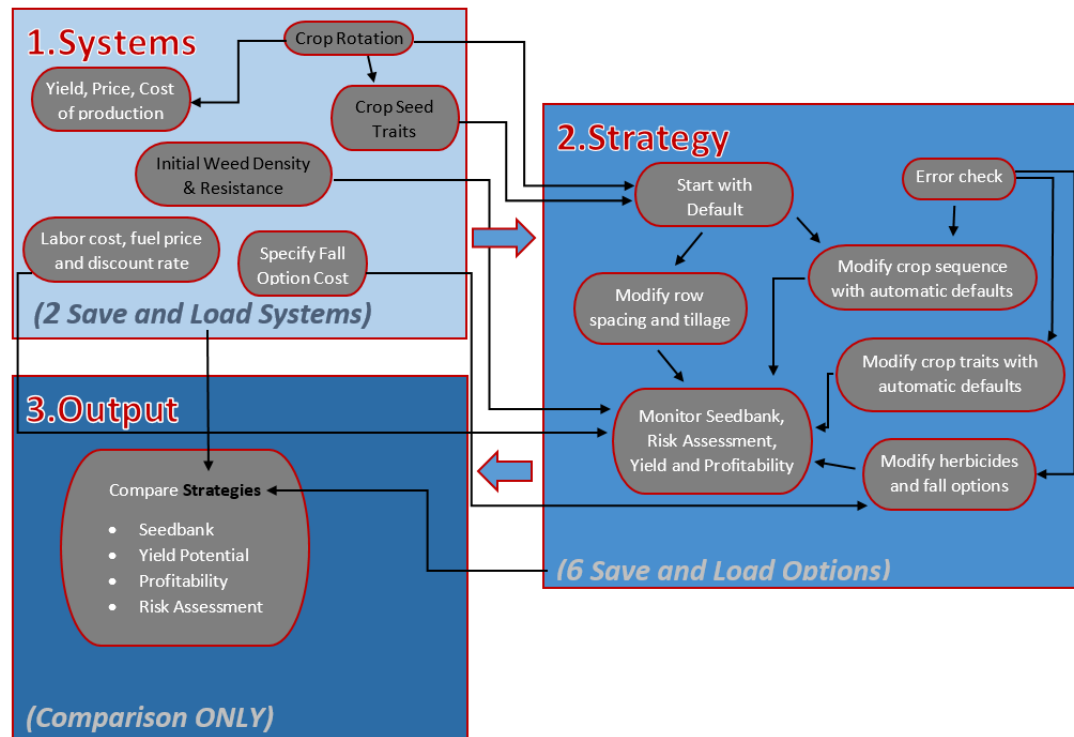
PAM follows three progressive steps: **1) define the current user system** to capture crop rotation, initial weed density and resistance as well as setting price, yield and cost expectations and crop traits; **2) analyze strategic options** by modifying a range of crop production and weed management options from a default strategy that is automatically generated from system choices; **3) comparing results** of strategies developed. As such, the user may customize various parameters to represent individual production circumstances and build a number of integrated (chemical and non-chemical) strategies for making comparisons using this tool.

This program is divided into several worksheets, which include 'Title', 'Systems', 'Strategy', and 'Output'. These worksheets are navigable by left-mouse clicking the arrow buttons,  , at the top of each screen and are discussed in greater detail in later sections. Although the model

is designed to move sequentially through each worksheet, returning to previously visited worksheets is possible by left-clicking the 'Back' button, . **Caution: Values in subsequent worksheets are based on the settings currently shown in other worksheets.** These are either defaults, user saved or merely user modified. Default values are designed as a *starting point* for strategic modifications. Default strategies, for example, require user attention before they may be saved for comparison to other strategies.

The model flow chart provided in Figure 1 is designed to assist with understanding the flow of information between worksheets, 'Systems', 'Strategy', and 'Output'.

**Figure 1. Model Flow Chart**



### ***Saving User Modifications for Comparison***

PAM allows for the saving of user modifications for later recall. Saved information may also be cleared in select worksheets. **Warning:** *employing the 'Save' and 'Load' features throughout this model will not result in saving the workbook in its entirety; in order to save changes made to the model, the workbook must be saved as described in section III.* Detailed instructions for saving, loading, and clearing saved modifications are included in Sections V through VII.

The flow chart in Figure 2 is designed to assist in understanding the implications of saving and loading saved modifications between worksheets, 'Systems', 'Strategy', and 'Output'. Selections made in the 'Systems' worksheet help to develop a default strategy in the 'Strategy' worksheet and a drop-down in the 'Strategy' worksheet to allow the user to toggle between saved systems. **Note:** *System changes that are saved after strategies have been saved are automatically applied to those saved strategies.*



```

graph TD
    subgraph "1. Systems"
        S_Save[SAVE Systems (2)  
Modifications are updated throughout the model]
        S_Load[LOAD Saved Systems  
Automatic updates throughout model]
        S_Current[Current system  
Provides Default parameters]
        S_Save --> S_Current
        S_Load --> S_Current
    end

    subgraph "2. Strategy"
        St_Default[Default Strategy  
RESET STRATEGY]
        St_Current[Current Strategy  
Available for comparison with Saved Strategies in 3.Output  
Modifications to saved systems are applied to Saved Strategies]
        St_Save[SAVE Strategies (6)]
        St_Load[LOAD Saved Strategies]
        St_Clear[Clear (X) Saved Strategies]
        St_Default --> St_Current
        St_Current --> St_Save
        St_Current --> St_Load
        St_Clear --> St_Save
    end

    subgraph "3. Output"
        O_Compare[Compare  
Current or Saved Strategies (6)  
Seedbank  
Yield Potential  
Profitability  
Resistance Risk]
    end

    S_Current --> St_Default
    St_Current --> O_Compare
    O_Compare --> S_Current

```

**1. Systems**

**SAVE** Systems (2)  
Modifications are updated throughout the model

**LOAD** Saved Systems  
Automatic updates throughout model

**Current system**  
Provides Default parameters

(2 Save and Load Options)

**2. Strategy**

**Default Strategy**  
**RESET STRATEGY**

**Current Strategy**  
Available for comparison with Saved Strategies in 3.Output  
Modifications to saved systems are applied to Saved Strategies

**SAVE** Strategies (6)

**LOAD** Saved Strategies

Clear (X) Saved Strategies

(6 Save and Load Options)

**3. Output**

**Compare**  
Current or Saved Strategies (6)

- Seedbank
- Yield Potential
- Profitability
- Resistance Risk

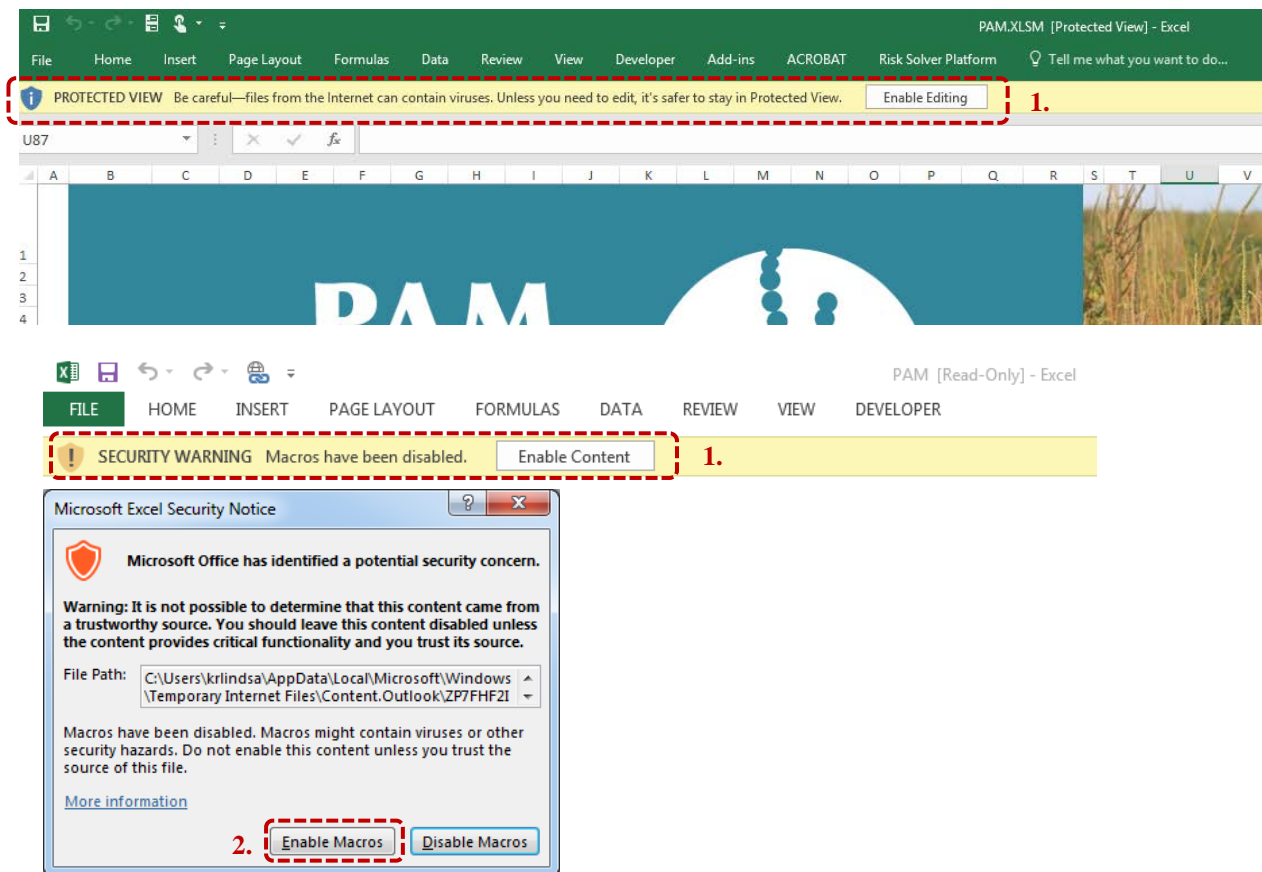
(Comparison ONLY)

## *Installation*

The file may be saved to any directory or file folder by right-clicking the file name and using the 'Save As' option; however, a flash drive should **not** be used 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.*

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**Figure 3.** Initial File Installation Message for Excel 2016 (top) and Excel 2010-13 (below)



Notes:

1. If prompted, enable macro content when first installing the software by left-clicking the 'Enable Content or Enable Editing' button.
2. If prompted, enable macros by left-clicking the 'Enable Macros' button.

Upon following the initial installation prompts, a welcome banner (Figure 4) will appear. This banner will disappear after several seconds or may be hidden by clicking the 'Exit' button near the bottom, right corner of the banner. **Note:** the 'X' button located in the top, right corner of the banner has been disabled.

**Figure 4.** Welcome Banner

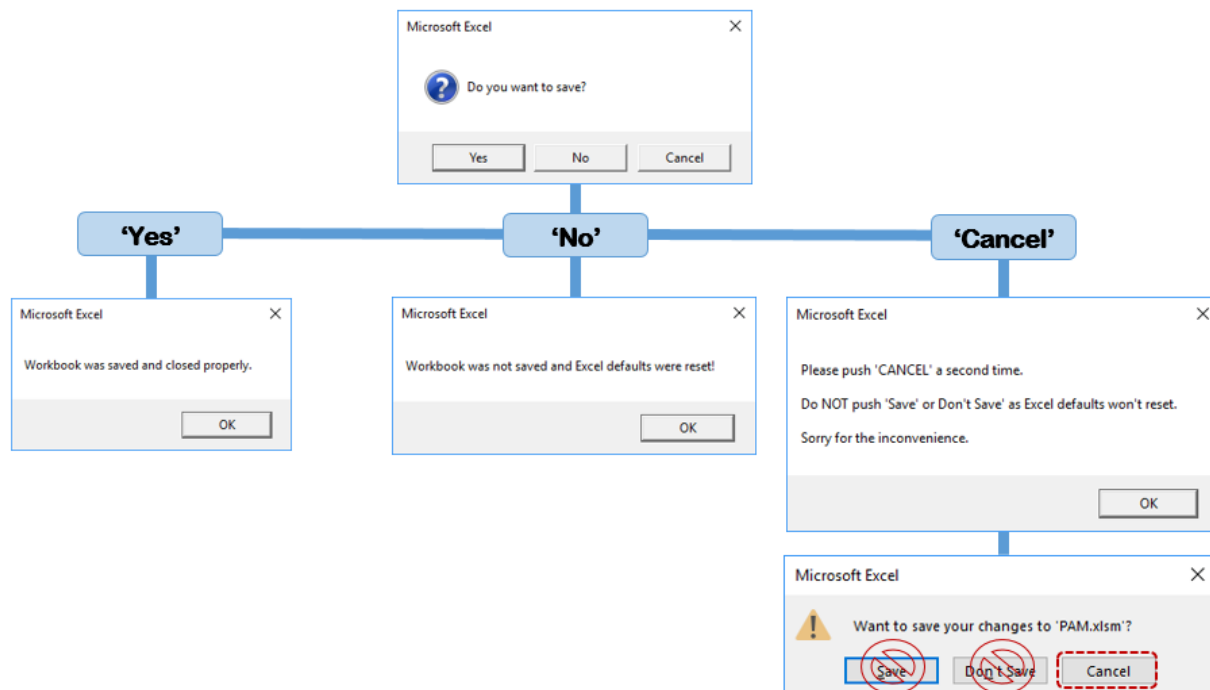


Note: Welcome banner will disappear after several seconds or may be hidden by clicking the 'Exit' button in the bottom, right corner of the banner.

### ***Saving and Exiting Files***

PAM is an Excel® program compatible with Excel® 2010 – 2016 with a **‘.xslm’** file extension. PAM works in full screen mode, therefore, the user will be prompted to either save the file and exit, exit the file without changes, or cancel exiting to return to PAM. This process is initiated by clicking on the ‘X’ near the top right to exit the program and save. The flow chart provided in Figure 5 is designed to assist in understanding the implications of selecting ‘Yes’ to exit PAM and save changes, ‘No’ to exit PAM without saving changes, or ‘Cancel’ if the user has changed their mind and does not wish to exit PAM.

**Figure 5.** PAM Exit Flow Chart



*This process also restores Excel® default features that were disabled to allow the full screen mode to work properly. It is advisable to run PAM without other spreadsheets open in Excel® at the same time for that reason. Note further that, if PAM should close improperly, reloading and exiting PAM normally will restore Excel® default program features.*

Several versions of PAM may be maintained on the user’s computer or device by renaming alternate versions of the file after having closed Excel®. ***Please use only one version at a time.*** The user may always revert to the original file by downloading it online, if needed.

### ***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 (conditional) formatting has been applied to check for potential user errors in all cells the user is allowed to change. *Should the user use the copy and paste feature, PAM’s integrity cannot be ensured and the user is therefore advised to use the ‘Undo’ feature in Excel that may be activated by pressing the <CTRL> and <Z> buttons simultaneously or revert to*


downloading another copy of the program. Figure 6 provides a screenshot of Copy and Paste warnings found throughout the program.

**Figure 6.** Example of DO NOT Copy and Paste Warning


	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Weed Control Costs (\$/acre)	\$147.35	\$268.78	\$158.80	\$164.77	\$273.78	\$125.89	\$159.77	\$273.78	\$158.80	\$163.79
Spring Seedbank (100/250q ft)	131.5	1.5	34.2	1.1	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Yield (bu or lb/acre)	1,200	219	60	1,200	220	60	1,200	220	60	1,200
Net Returns (\$/acre)	\$172.41	\$166.88	\$160.01	\$144.99	\$186.19	\$227.72	\$159.99	\$156.19	\$160.01	\$165.97
<b>DO NOT Use Copy and Paste when editing the cells below</b>										
Choose options	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Crop rotation	Cotton	Corn	Soybean, F.S	Cotton	Corn	Soybean, F.S	Cotton	Corn	Soybean, F.S	Cotton
Specific crop trait	Glytoil/LibertyLink	Roundup Ready	Xtend	LibertyLink	Conventional	Enlist	Glytoil/LibertyLink	Roundup/LibertyLink	Xtend	Enlist
Row Spacing (Soybeans ONLY)			Wide Row			Wide Row			Wide Row	
Soil preparation	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till

Note: For example, if you wanted to change the Soil preparation row (bottom row above) from ‘No-till’ to ‘Shallow Till’, do not copy ‘Shallow Till’ from one crop year to another (others). Always use the drop-down list for each change.

## Navigating Worksheets

To simplify the use of the software, PAM is divided into different worksheets that may be accessed by left-clicking the blue ‘Back’ or ‘Next’ arrow buttons, , located at the top of each screen. **Note:** this user manual and its accompanying spreadsheet use the terms ‘screen’, ‘worksheet, and ‘sheet’ interchangeably.

## Tutorials

The user may access tutorial userforms at any time by left-clicking the help button, , found in the top, right corner of each worksheet. Where applicable, the user may left-click the ‘Next’ button to view additional tutorials relevant to the currently opened worksheet. **Note:** the ‘X’ button, located in the top, right corner of the userform has been disabled. The user may exit the tutorial at any time by left-clicking the ‘Exit’ button found in the bottom, right corner of each tutorial userform.

## Controls

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

### Command Buttons

Command buttons, also referred to as ‘buttons’, contain macros that allow the user to access userforms, navigate across worksheets, load default values, compare strategies, or save and load saved information across worksheets. These buttons provide easy access to different screens and an easy way to revert to program defaults. **Warning:** macro commands **cannot be reversed** using the ‘Undo’ feature in Excel that may be activated by pressing the <CTRL> and <Z> buttons simultaneously 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 and consider implications of moving forward before permanently altering the spreadsheet.

### *Drop-down Lists*

Drop-down lists are located throughout the program and may 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. 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.

### *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. They do not affect the operation of the spreadsheet, but add information for the user.

### *Conditional Formatting*

Conditional formatting (error checking) has been applied to various cells throughout this program to indicate when a change has occurred that may lead to potential errors in the way the program operates. This conditional formatting will change the appearance of those formatted cells when a potential error is made and will return to its original state when the necessary corrections are made. In some cases, the color or font a cell changes to show a deviation from default values (e.g. modifications in the ‘Systems’ worksheet). While formatting within the ‘Systems’ worksheet highlights the changes to default values, it does not affect the performance of the software. Highlights in the ‘Strategy’ worksheets, however, typically require corrective action.

### *Userforms*

Userforms may be accessed by left-clicking on command buttons throughout the spreadsheet program. These userforms allow the user to make specifications based on user-specifiable production parameters. Figure 7 is an example of the ‘Calculate Total Specified Expenses’ userform found in the ‘Systems’ worksheet. Section V provides greater detail on properly entering data in userforms found within the ‘Systems’ worksheet.

**Note:** after selecting the desired options within each userform, the user must click the ‘**Save**’ button in the lower right corner of the userform to save the desired changes to the workbook.

**Note:** the ‘X’ button, located in the top, right corner of the userform has been disabled. Exit the userform at any time by left-clicking either the ‘Exit’ or ‘Cancel’ button found in the bottom, right corner of each userform. **Warning:** clicking ‘Save’ in the userform will not

result in saving the workbook in its entirety; in order to save changes made to the model, the workbook must be saved as described in section III. **Warning:** changes made in a userform, like command button macros, **cannot be reversed** using the ‘Undo’ feature in Excel® that may be activated by pressing the <CTRL> and <Z> buttons simultaneously.

### Text Boxes

Userforms contain text boxes to allow users to specify various inputs using textboxes. 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, similar to entering data into an active cell within a worksheet.

**Figure 7.** Example Userform

Calculate Total Specified Expenses for Cotton Year 1: X

Enter expected price paid for the following inputs in \$/acre: [Use Default Values](#)

Fertilizer:	\$210.97	Fuel & Energy:	\$64.48	Cash Rent for Land:	\$1.00
Insecticide:	\$67.48	Machinery R&M:	\$38.45		
Fungicide/Nematicide:	\$0.00	Irrigation:	\$6.24		

Enter the operating interest rate for 50% of the above operating expenses: 4.75 %  
Note: Interest is automatically calculated for 6 months

Enter expected yield-specific harvest cost incurred at time of harvest:

Hauling:	\$0.09	lbs/acre
Drying/Storage:	\$10.50	lbs/acre
Checkoff fees:	\$4.83	lbs/acre

[Calculate Costs](#)

[Save](#)

[Cancel](#)

## IV. Title

The first worksheet that appears upon initial install of PAM is the 'Title' worksheet shown in Figure 8. This sheet provides a brief introduction to PAM as well as credits and additional information, which may be accessed by left-clicking the blue 'Credits' or 'Info' buttons found in the green column to the right of the 'Title' sheet. Additionally, a series of introductory tutorials are available by left-clicking the '?' button (Figure 8 (3)). Navigate to the next worksheet by left-clicking on the blue 'START' button (Figure 8 (4)).



**Figure 8.** ‘Title’ Worksheet



A decision-support tool to evaluate the effectiveness of Palmer amaranth management strategies in the row-crop production systems of the southern United States

The model operates in three simple steps:

**1. Define System    2. Build Strategy    3. Compare Output Results**



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**A Decision-Support Tool**

**What is PAM ?**

PAM is a decision-support tool that allows the user to evaluate the effectiveness of various Palmer amaranth management options on long-term Palmer amaranth seedbank dynamics and economic returns. PAM integrates agronomic, biological and economic information to assist the user understand the long-term implications of adopting a given management strategy or a lack thereof and thereby make informed-management decisions.

The PAM model is intended for use as an educational tool by extension agents, crop consultants, growers and any personnel interested in understanding the benefits of integrated weed management. The user can customize various parameters to represent individual production circumstances and build a number of integrated (chemical and non-chemical) strategies for making comparisons using this tool.

PAM is not a herbicide resistance simulation model, but it adequately accounts for any pre-existing resistance and the likelihood for developing resistance under any chosen strategy.

**5.**

**Contact**

For assistance, further information, questions and feedback  
Muthu Bagavathianann  
Jason Norsworthy  
e-mail: muthu@tamu.edu;  
jnorswor@uark.edu

**Copyright & Disclaimer**

The user acknowledges and agrees as conditions of use that:

(a) PAM and all associated content are the copyright of the University of Arkansas, Texas A&M AgriLife Research, the University of Western Australia (UWA) and the Department of Agriculture and Food Western Australia (DAFWA). Material contained in PAM must not be reproduced, or modified and distributed, in whole or in part or in any manner whatsoever without the written permission of the copyright holders.

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(c) The copyright holders are not liable for any loss or damage (including direct, consequential or economic) which may result directly or indirectly from the use of PAM or information in any associated content.

Requisite Supporting Software: This version of PAM requires Microsoft Excel® for Windows® version 2010 or later.

**6.**

**BACK**

**Notes:**

1. Left-click the ‘Info’ button to view information on what PAM is, contact and copyright information and a disclaimer.
2. Left-click the ‘Credits’ button to view PAM’s credits and acknowledgements banner.
3. Left-click the ‘?’ button for help.
4. Left-click the ‘START’ button to begin making modifications to the ‘Systems’ worksheet.
5. Left-click the green envelope to send questions or feedback to developers.
6. Left-click the ‘Back’ arrow button to return to the ‘Title’ worksheet.

## V. 'Systems' Worksheet

The 'Systems' worksheet in Figure 9, allows for the customization of the model's default parameters based on current production practices.

**Figure 9.** 'Systems' Worksheet

**1. DEFINE Systems**

13. Print 12. ? 11. BACK NEXT PAM PALMER AMMANATH MANAGEMENT

1. System: **Diverse Traits**  
 System 1: **Corn/Cotton/Soybean** [SAVE] [LOAD]  
 System 2: **Diverse Traits** [SAVE] [LOAD]

2. Enter operator name: **Jason Norsworthy**

3. Select the typical duration of crop rotation: (number of years in rotation) **3**

4. Select a typical crop rotation (a), enter expected yield (b) and price received (c), and calculate the total specified expenses (d) for each crop in the rotation:  
 (Click on the 'Calculate Costs' buttons below to determine total specified expenses)

	Year 1	Year 2	Year 3
a. Typical Rotation	Cotton	Corn	Soybean FS
b. Expected Yield	1200 lbs/acre	220 bu/acre	60 bu/acre
c. Expected Price	\$0.65 \$/cwt	\$4.00 \$/bu	\$10.00 \$/bu
d. Total Specified Expense	\$430.24 per acre	\$410.04 per acre	\$226.39 per acre

5. Select up to four crop traits for each crop to create a default rotation (in the order specified here – blanks are interpreted as conventional):

Year	Cotton	Corn	Soybean FS
Year 1	Glytoli/LibertyLink	Roundup Ready	Xtend
Year 2	LibertyLink	Conventional	Enlist
Year 3	Glytoli/LibertyLink	Roundup/LibertyLink	Xtend
Year 4			
Year 5			
Year 6			
Year 7			
Year 8			
Year 9			
Year 10			

6. Specify prices and rates for Fall options: [Specify Fall Options]

7. Enter other expenses associated with herbicide application:

Labor (\$/hr)	\$10.50
Fuel (\$/gal)	\$2.48
Amortization Rate (%)	5%

8. Select weed density: (plants per 250 square feet) **High (8-15)**

9. Enter the extent of pre-existing resistance:

Roundup	High
ALS Chemistry	High
PPO	High

### Notes:

- The current 'System' actively displayed is shown in blue text on the top, right corner of the worksheet. Conditional formatting indicates the system displayed is NOT a saved system when the font changes from blue to red, italicized font. Once the changes are saved as one of the two saved systems or a previously saved system is loaded, the font will return to blue. See Figures 12 and 13 for further information.
- Enter the name of the operation or operator.
- Select the typical duration of crops in rotation using the drop-down list provided. Choosing a 1-year rotation will remove the year 2- and year 3-options. This may be reversed by choosing a 2- or 3-year rotation then re-entering crop choices and recalculating total specified expenses.
- Select a typical crop for each year in rotation.
  - Enter the expected yield for each crop in the rotation or use the default provided.
  - Enter the expected price received for each crop in the rotation or use the default provided.
  - Calculate the total specified expenses for each crop using the userforms provided by left-clicking the gray buttons found below each respective year titled 'Calculate Total Specified Expenses' (See Figure 10).
- Select up to four crop traits for each crop in the rotation. This information is used to create default parameters in the 'Strategy' worksheet that is accessed by pressing the 'Next' button (See note 11). Each row represents a year for the crop in the rotation.
- Specify prices and rates for fall options using the userform provided by left-clicking on the gray button titled 'Specify Fall Options' (See Figure 11).
- Enter other expenses associated with herbicide applications such as labor, fuel, and the amortization rate.
- Select weed density per 250 square feet.
- Enter expected resistance levels for Roundup, ALS Chemistry, and PPO applications.
- Save and load up to two systems by clicking the blue 'Save' or 'Load' buttons located to the right of each saved system name. See Figures 12 and 13 for instructions on saving and loading systems.
- Navigate back to the 'Title' sheet by left-clicking the 'Back' arrow located at the top, left corner of the 'Systems' worksheet or navigate forward to the 'Strategy' worksheet by left-clicking the 'Next' arrow located at the top, right corner of the worksheet.
- Click the '?' button for help.
- Click the 'Print' button to print the area currently displayed on the screen.



### Calculate Total Specified Expenses Userforms

The ‘Calculate Total Specified Expenses’ (TSE) userforms (Figure 10) allow for the specification of acre-based input and yield-specific harvest expenses as well as operating interest for each crop. Default values are based on recommendations provided by University of Arkansas Cooperative Extension Service publications (Flanders et al. 2015). **Note:** the TSE calculated in the userforms **do not include weed control and seed costs at expected yield**. Note that weed control costs include cost of fall options and extra charges for narrow row planting and shallow tillage. If the expected yield is changed, the TSE amount will change color to reflect that yield-dependent costs have changed from the default values.

**Figure 10.** ‘Calculate Total Specified Expenses’ Userform

Calculate Total Specified Expenses for Cotton Year 1:

Enter expected price paid for the following inputs in \$/acre: [Use Default Values](#)

Fertilizer:	\$210.97	Fuel & Energy:	\$64.48	Cash Rent for Land:	\$1.00
Insecticide:	\$67.48	Machinery R&M:	\$38.45		
Fungicide/Nematicide:	\$0.00	Irrigation:	\$6.24		

Enter the operating interest rate for 50% of the above operating expenses: 4.75 %

Note: Interest is automatically calculated for 6 months

Enter expected yield-specific harvest cost incurred at time of harvest:

Hauling:	\$0.09	lbs/acre
Drying/Storage:	\$10.50	lbs/acre
Checkoff fees:	\$4.83	lbs/acre

[Calculate Costs](#)

**Total Specified Expenses:**  
(exc. weed control and seed costs at expected yield)  
**\$430.24**

[Save](#)  
[Cancel](#)

#### Notes:

1. Enter expected price paid for production inputs in dollar (\$) per acre or click the ‘Use Default Values’ button to restore program defaults.
2. Enter the operating interest rate for 50% of the operating expenses listed above. The interest rate entered should be the annual interest rate as the program adjusts interest costs for the period needed. Fifty percent (50%) of operating expenses are used because timing of expenses are not all at the start of using an operating credit line.
3. Enter expected yield-specific harvest costs incurred at time of harvest.
4. Click the ‘Calculate Costs’ button to calculate the total specified production expenses given user-specifications provided within the userform. The TSE shown will change as any subsequent changes are made within the userform.
5. Click ‘Save’ to exit the userform and apply the changes or ‘Cancel’ to exit the userform without applying changes to the model.

### Specify Fall Options Userform

The ‘Specify Fall Options’ userform (Figure 11) allows for the specification of cost and quantity for fall field practices such as moldboard plough, cereal rye and cover crop mix, and windrow burn. Broadcast or drill seed planting methods for fall cover crops may also be specified. Default values are based on recommendations provided by expert opinion.

**Figure 11.** ‘Specify Fall Options’ Userform

The screenshot shows a 'Fall Options' userform with the following elements and callouts:

- 1.** 'Select Moldboard Plough Price:' section with radio buttons for 'Use Default Cost' and 'User-Specified Cost' (set to \$15.00 \$/acre).
- 8.** 'Use Default Value' button located to the right of the first section.
- 2.** 'Select Cereal Rye Cover Cost and Quantity:' section with radio buttons for 'Use Default Quantity and Cost' and 'User-Specified Quantity and Cost' (Quantity: 90 lbs/acre, Cost: \$0.63 \$/lb).
- 3.** 'Select Broadcast or Drill Seed:' dropdown menu set to 'Broadcast'.
- 4.** 'Select Cover Crop MixCost and Quantity:' section with radio buttons for 'Use Default Quantity and Cost' and 'User-Specified Quantity and Cost' (Quantity: 12 lbs/acre, Cost: \$2.44 \$/lb).
- 5.** 'Select Planting Method:' dropdown menu set to 'Broadcast'.
- 6.** 'Select Windrow Burn Cost:' section with radio buttons for 'Use Default Cost' and 'User-Specified Cost' (set to \$0.00 \$/acre).
- 7.** 'Save' and 'Cancel' buttons at the bottom right.

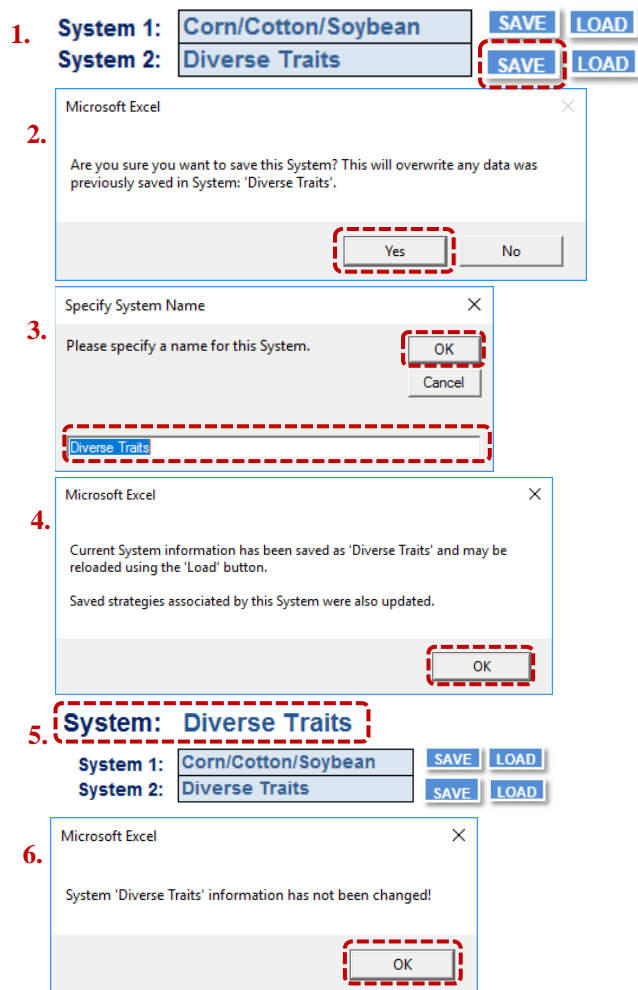
Notes:

1. Select ‘Use Default Cost’ to use the default custom rate for the moldboard plough fall option or ‘User-Specified Cost’ to customize the cost of moldboard plough. Next, enter the user-specified cost in dollars (\$) per acre in the textbox provided.
2. Select ‘Use Default Quantity and Cost’ to use the default quantity and cost for the ‘Cereal Rye Cover Crop’ fall option or ‘User-Specified Quantity and Cost’ to customize the quantity and cost of the ‘Cereal Rye Cover Crop’. Next, enter the user-specified seed quantity in pounds (lbs) per acre and cost in dollars (\$) per pound of seed in the textboxes provided.
3. Select planting method, ‘Broadcast’ or ‘Drill Seed’, for the ‘Cereal Rye Cover Crop’ fall option from the drop-down list provided.
4. Select ‘Use Default Quantity and Cost’ to use the default quantity and cost for the ‘Cover Crop Mix’ fall option or ‘User-Specified Quantity and Cost’ to customize the quantity and cost of the ‘Cover Crop Mix’, then enter the user-specified seed quantity in pounds (lbs) per acre and cost in dollars (\$) per pound of seed in the textboxes provided.
5. Select planting method, ‘Broadcast’ or ‘Drill Seed’, for the ‘Cover Crop Mix’ fall option from the drop-down list provided.
6. Select ‘Use Default Cost’ to use the default cost of fall windrow burn or enter a ‘User-Specified Cost’ to customize the cost of windrow burn in dollars (\$) per acre in the textbox provided.
7. Click ‘Save’ to apply the changes made within the userform or click ‘Cancel’ to exit the userform without applying changes.
8. Click the ‘Use Default Values’ button to restore program defaults.

Up to two default systems may be saved by clicking the blue ‘Save’ or ‘Load’ buttons located to the right of each saved system name. **Be aware** that default values are designed to be a *starting point* for strategic modifications and do not limit selections in subsequent worksheets. In addition to serving as default parameters from which to build strategies for comparison, information from saved systems will be associated with saved strategies (See also section VI). **Note:** *Once a strategy has been saved, any subsequent changes made to the saved system associated with that strategy will be automatically updated to that strategy. Use caution when returning to and/or editing previously saved systems after saving strategies.*

Follow the steps provided in the notes for Figures 12 and 13 to save or load systems.

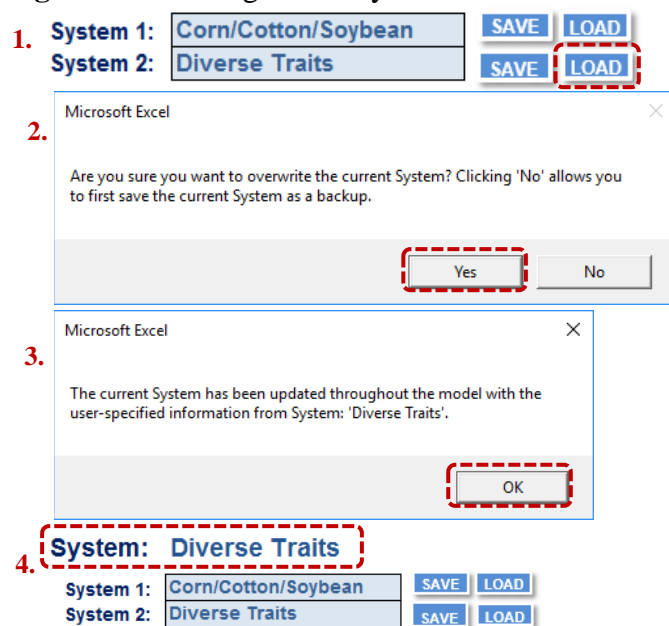
**Figure 12. Saving Systems**



**Notes:**

1. Left-click the blue 'Save' button to the right of either of the two saved system names to save the system that is currently displayed in the 'Systems' worksheet.
2. Upon left-clicking the blue 'Save' button, a message box will appear asking if it is okay to overwrite any previously saved data. Follow steps 3 through 5 if 'Yes' or skip to step 6 if 'No'.
3. If 'Yes' was selected in step 2, enter a name for the saved system by typing the desired alpha-numeric name into the text box provided, or do nothing to keep the previously saved system name (highlighted in blue). Left-click the 'OK' button to continue.
4. Upon left-clicking the 'OK' button, another message box will appear stating the current system information has been saved and may be reloaded using the 'Load' button. Left-click the 'OK' button to continue.
5. The name of the saved system is now displayed next to the 'Save' and 'Load' buttons.
6. If 'No' was selected in step 2, a message box will appear stating the previously saved system has not been changed. Left-click 'OK' to continue.

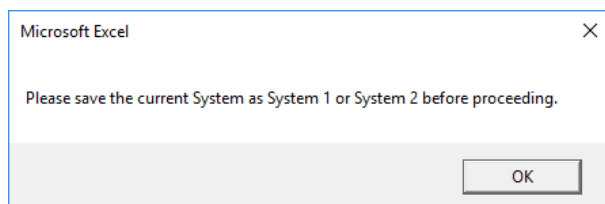
**Figure 13. Loading Saved Systems**



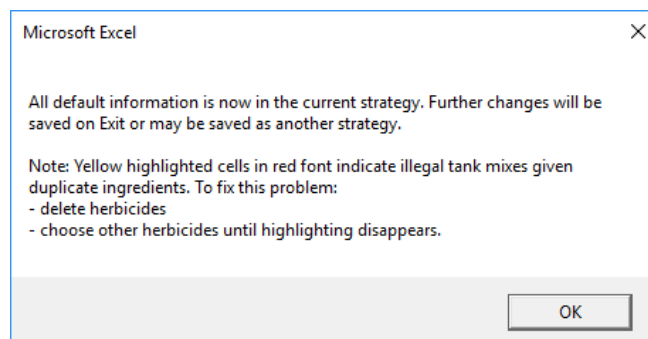
Notes:

1. Left-click the blue 'Load' button to the right of either of the two saved system names to load any of the two saved systems in the 'Systems' worksheet.
2. Upon left-clicking the blue 'Load' button, a message box will appear asking if it is okay to overwrite currently displayed system. Follow steps 3 through 5 if 'Yes' or do nothing if 'No'.
3. If 'Yes' was selected, a message box will appear stating the current system displayed in the 'Systems' worksheet has been updated with the user-specified information from the system loaded. Left-click 'OK' to continue.
4. The loaded system is now displayed in 'Systems' with the name of the system displayed in blue font next to the 'Save' and 'Load' buttons.

The 'Systems' worksheet requires the user to save the currently selected user selections as one of the two saved systems before moving forward to the 'Strategy' worksheet to ensure proper management of saved changes in subsequent worksheets or the following message will appear:



Upon saving the current system, the user may left-click the 'Next' button near the top, right portion of the screen to move to the 'Strategy' worksheet. Upon entering the 'Strategy' worksheet, the following message will appear indicating that default values are now loaded:



## VI. 'Strategy' Worksheet

The 'Strategy' worksheet, shown in Figure 14, allows the user to load the default strategy based on the user specifications entered in the 'Systems' worksheets or customize and save up to six strategies for comparison in the 'Output' worksheet discussed in section VII. A key point to remember is that the 'Reset Strategy' button will not necessarily result in a good strategy recommendation that requires no attention from the user. Below is a list of values to observe when modifying strategies.

**'Weed Control Costs'** in *US dollars per acre* (Figure 14 (6)), are estimated as the sum of costs incurred towards herbicides as well as fall weed management options. Weed control costs are based on prices provided by University of Arkansas Cooperative Extension Service publications (Scott et al. 2015).

**'Spring Seedbank'** in *000' per 250 square feet* (Figure 14 (6)), is the amount of total Palmer amaranth seed present in the soil seedbank in spring immediately prior to the beginning of seedling emergence. The 'Spring Seedbank' is estimated based on the number of Palmer amaranth escapes observed in a 250 square feet area during previous year, after accounting for potential seed losses between fall and spring. Values '<0.100' indicates that seedbank levels are depleted to <100 seed/250 square feet. Parameter values for seedbank dynamics and seedling emergence were obtained from published literature shown in the References section.

***Note:** Values reported for 'Spring Seedbank' DO NOT equate to the number of emerged seedlings that spring. This is because seedling emergence is only a fraction of the amount of seed present in the soil. PAM accounts for the fact that Palmer amaranth seedlings emerge in a number of flushes (i.e. cohorts) over a prolonged period.*

**'Yield'** per acre (Figure 14 (6)) is a product of expected yield specified by the user in the 'Systems' worksheet and the % yield reduction calculated as a function of Palmer amaranth density. Additional functions were included to calculate the impact of the timing of weed emergence relative to the crop and intra-specific weed density on crop yield. Expected yields are based on yields provided by University of Arkansas Cooperative Extension Service publications (Flanders et al. 2015).

**'Net Returns'** in *US dollars per acre* (Figure 14 (6)) are estimated as the yield times the expected price, less total specified expenses as well as weed control costs that vary with changes to options in the 'Strategy' worksheet. The **'Resistance Risk'** calculator (Figure 14 (8)) illustrates the overall risk of resistance for the combination of management options selected. However, it does not predict resistance for any specific herbicide chemistry. The risk of resistance evolution is estimated as a score (out of 100) using a 23-parameter model, with a weighed importance value assigned to each parameter based on expert knowledge and assumptions. Parameters include total seedbank size, use of residual herbicides, number of crop trait rotations, diversity of herbicide mechanism of action, and fall options such as moldboard ploughing, planting cover crops, and windrow burning (soybean only). For several of these parameters, a higher importance value was assigned for the first four years of the simulation, as near-term production and weed management practices will have a much larger impact on the risk of resistance evolution. ***Note:** PAM is not a resistance simulation software, but provides*

an educated estimation on the likely risk of resistance evolution for the management options selected by the user over the period of simulation.

‘Amortized 10Yr Net Cashflows (NPV) in US dollars per acre (Figure 14 (9)), is the sum total of discounted annual net returns for Years 1 through 10. This will change if the discount rate is changed in the ‘Systems’ worksheet with all other production practices held the same.

Figure 14. ‘Strategy’ Worksheet

**2. BUILD Strategy** Amortized 10 Yr Net Cashflows (NPV) \$1,585

1. RESET STRATEGY 2. System: Diverse Traits 3. Strategy: Default 4. Strategy 1: Non-Diverse Option Strategy 2: Not Saved Strategy 3: Not Saved Strategy 4: Diverse Options Strategy 5: Not Saved Strategy 6: Not Saved

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Weed Control Costs (\$/acre)	\$169.35	\$133.73	\$144.22	\$186.77	\$138.73	\$137.89	\$181.77	\$138.73	\$144.22	\$185.79
Spring Seedbank ('000/250 sq ft)	131.5	1.9	34.2	9.6	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Yield (bu or lb/acre)	1200	218	60	1200	220	0	1200	220	1200	1200
Net Returns (\$/acre)	\$160.41	\$201.83	\$179.39	\$122.99	\$321.24	\$218.72	\$137.99	\$221.24	\$179.39	\$142.97

DO NOT Use Copy and Paste when editing the cells below

Choose options	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
Crop rotation	Cotton	Corn	Soybean FS	Cotton	Corn	Soybean FS	Cotton	Corn	Soybean FS	Cotton
Specific crop trait	Glytol/LibertyLink	Roundup Ready	Xtend	LibertyLink	Conventional	Enlist	Glytol/LibertyLink	Roundup/LibertyLink	Xtend	Enlist
Row Spacing (Soybeans ONLY)	Wide Row	Wide Row	Wide Row	Wide Row	Wide Row	Wide Row	Wide Row	Wide Row	Wide Row	Wide Row
Soil preparation	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	Shallow Till
Burn Down	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D
For burn down of fall cover crop/weeds	Dicamba	Dicamba	Dicamba	Dicamba	Dicamba	Dicamba	Dicamba	Dicamba	Dicamba	Dicamba
Preplant (Cotton ONLY)	Prowl			Prowl			Prowl			Enlist Duo
Preemergence	Cotoran	Acuron	Authority MTZ	Cotoran	Acuron	Authority MTZ	Cotoran	Acuron	Authority MTZ	Cotoran
	Gramoxone	Atrazine	Boundary	Gramoxone	Atrazine	Boundary	Gramoxone	Atrazine	Boundary	Gramoxone
Postemergence 1	Dual Magnum	2,4-D	Prefix	Dual Magnum	2,4-D	Enlist Duo	Dual Magnum	2,4-D	Prefix	Dual Magnum
	Liberty	Acuron	Roundup	Liberty	Acuron	Liberty	Liberty	Acuron	Roundup	Enlist Duo
Postemergence 2 (Cotton ONLY)	Dual Magnum			Dual Magnum			Dual Magnum			Dual Magnum
	Liberty			Liberty			Liberty			Enlist Duo
Layby (Cotton ONLY)	Dirac			Dirac			Dirac			Dirac
	MSMA			MSMA			MSMA			MSMA
Fall	MB Prowl		Windrow Burn			Windrow Burn			Windrow Burn	
	Cover Crop Mix	Cereal Rye Cover	Cereal Rye Cover	Cereal Rye Cover	Cereal Rye Cover	Cover Crop Mix	Cereal Rye Cover	Cereal Rye Cover	Cereal Rye Cover	Cereal Rye Cover

WARNING: Inappropriate Tank Mix

Crop traits used too frequently: Roundup/LibertyLink

Notes:

- Reset the displayed strategy at any time by left-clicking the ‘Reset Strategy’ button in the top, left corner of the worksheet. The default is based on the crop rotation and order of crop traits specified in the ‘Systems’ worksheet. The default also populates ‘Fall’ options in the bottom rows.
- If desired, change the ‘System’ by selecting from the drop-down list provided.
- The name of the current ‘Strategy’ actively displayed on the worksheet is shown in blue font near the top, left corner of the worksheet. If the name is shown in red, italicized font, the strategy displayed is NOT a saved strategy or the default. Once the changes are saved, a previously saved strategy is loaded, or the worksheet is reset to the default strategy, the font will return to blue. **Caution:** An exception to this rule is when the ‘Systems’ worksheet has been accessed and the user returns to ‘Strategy’ which resets the strategy to the default.
- Save and load up to six strategies by clicking the blue ‘Save’ or ‘Load’ command buttons located to the right of each saved strategy name. See Figures 17 and 18 for instructions on saving and loading strategies.
- Modify the cells provided. Instructions for selecting data in these cells are provided in the notes for Figure 15.
- ‘Weed Control Costs (\$/acre)’, ‘Spring Seed Bank (‘000/250 sqft)’, ‘Yield (bu or lb/acre)’, and ‘Net Returns (\$/acre)’ are provided in the blue cells located at the top of the ‘Strategy’ worksheet for Years 1 through 10.
- Error messages and conditional formatting are based on the current strategy. See Figure 16 for further explanation.
- Left-click the pink ‘Risk Assessment’ button to get a description of the risk assessment provided. Left-click the green ‘Palmer Amaranth Escapes’ button to show timing of Palmer Amaranth escapes for critical information about when to add weed control measures.
- The amortized 10 Year Net cashflows (NPV) (\$/acre) of the currently displayed strategy is a key statistic for monitoring profitability across all years. Red font with pink highlighting shows negative NPV over the 10 year period.
- Left-click the ‘Print’ command button to print the area currently displayed on the screen.
- Left-click the ‘?’ command button for help.
- Navigate ‘Back’ to the ‘Systems’ page to modify crop rotation and crop trait options or use the ‘Next’ button to navigate forward to the ‘Output’ worksheet located near the top, right corner of the worksheet.



[illegible]

Choose options		Yr 1
Crop rotation	1.	Cotton
Specific crop trait		Cotton
Row Spacing (Soybeans ONLY)		Corn
Soil preparation		Soybean_FS
		Soybean_Double

Be sure to update crop trait below!

Choose options		Yr 1	Yr 2
Crop rotation		Soybean_FS	Corn
Specific crop trait	2.	Glytol/LibertyLink	Roundup Ready
Row Spacing (Soybeans ONLY)		Wide Row	
Soil preparation		Shallow Till	
		Select Crop trait Do NOT leave blank.	

Choose options		Yr 1	Yr 2
Crop rotation		Soybean_FS	Corn
Specific crop trait		LibertyLink	Roundup Ready
Row Spacing (Soybeans ONLY)	3.	Wide Row	
Soil preparation		Shallow Till	
		Select Row Spacing Do NOT leave blank.	
Burn Down		2,4-D	

Choose options		Yr 1	Yr 2
Crop rotation		Soybean_FS	Corn
Specific crop trait		LibertyLink	Roundup Ready
Row Spacing (Soybeans ONLY)		Wide Row	
Soil preparation	4.	Shallow Till	Shallow Till
Burn Down		2,4-D	
		Dicamba	
		Select Spring Soil Preparation Shallow tillage includes tillage with a field cultivator or light disk as well as hipping beds.	
Preplant			Do NOT leave blank.

Choose options		Yr 1	Yr 2
Burn Down	5.	2,4-D	2,4-D
		2,4-D	2,4-D
		Dicamba	
		Gramoxone	
		Liberty	
		Roundup	
		Valor	
Preplant			
		(Cotton ONLY)	

1. Modify the crop in rotation for Years 1 through 10 by left-clicking

- display the drop-down menu of crops available for selection. The available crops include 'Cotton', 'Corn', 'Soybean\_FS' for full-season soybean, or 'Soybean\_Double' for double cropped soybean. A message will appear reminding the user to change the crop trait selection to an appropriate selection for the selected crop.
2. Modify the specific crop trait for each crop rotation selected for Years 1 through 10 by left-clicking the arrow located to the right of the cell to display the drop-down menu of crop traits available for selection. The available crop traits will vary depending on the crop. A message will appear stating the cell cannot be left blank, this comment box will disappear once the cursor is moved away from the cell. Upon crop change, subsequent crop trait specific herbicide options for each timing period will be automatically updated and shown in alphabetical order. These cells may be modified at any time (see note 5). See Figure 16 for further explanation of applied error checking.
3. If the crop selected for rotation is either full-season or double-cropped soybean, select the desired row spacing by choosing among either 'Wide Row' or 'Narrow Row' spacing. If cotton or corn is selected, this cell will automatically clear and will be locked from user access.
4. Modify the soil preparation for each crop selected for Years 1 through 10 by left-clicking the arrow located to the right of the cell to display the drop-down menu of soil preparation options available for selection. The available soil preparation choices include 'Shallow-Till' or 'No-Till'.
5. Modify the herbicides applied to each crop selected for Years 1 through 10 by left-clicking the arrow located to the right of the cell to display the drop-down menu of crop trait specific herbicide options available. See Figure 16 for further explanation of applied error checking.

Conditional formatting has been applied to the modifiable cells throughout the ‘Strategy’ worksheet to prevent the user from making a selection that is not appropriate for a designated crop in rotation and crop trait option. As an example, the strategy shown in Figure 16 shows the

types of conditional formatting that may appear throughout the ‘Strategy’ worksheet. Use the error messaging provided at the bottom of the worksheet as a guide. The formatting styles (cell highlighting, bolding and italicizing, etc.) will coordinate with the formatting styles of the error messages. **Caution:** Please remember to modify each cell separately and **DO NOT use Copy and Paste across cells** because it alters the error checking applied and renders the software unreliable.

**Figure 16.** Example Conditional Formatting in ‘Strategy’ Worksheet

DO NOT Use Copy and Paste when editing the cells below											
Choose options	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	
Crop rotation	Soybean F5	Corn	Soybean F5	Corn	Corn	Corn	Corn	Corn	Soybean F5	Cotton	
Specific crop trait	<b>2.</b> Glytoli/LibertyLink	Roundup/LibertyLink	LibertyLink	Roundup/LibertyLink	Roundup/LibertyLink	Roundup/LibertyLink	Roundup/LibertyLink	Roundup/LibertyLink	LibertyLink	Glytoli/LibertyLink	
Row Spacing (Soybeans ONLY)	Wide Row	Narrow Row	Narrow Row						Narrow Row		
Soil preparation	No-till	No-till	No-till	Shallow Till	Shallow Till	Shallow Till	Shallow Till	No-till	No-till	No-till	
Burn Down	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	2,4-D	
For burn down of fall cover crops/weeds	Dicamba	Gramoxone	Dicamba					Gramoxone	Gramoxone	Gramoxone	
Preplant (Cotton ONLY)										Reflex	
Pre emergence	<b>3.</b> <b>Coltran</b>	Corvus	Boundary	<b>4.</b> <b>Atrazine</b>	Atrazine		<b>5.</b> <b>Atrazine</b>	Corvus	Boundary	Coltran	
	Gramoxone			<b>Bicep II Magnum</b>	Bicep II Magnum		<b>Atrazine</b>			Gramoxone	
Post emergence 1	<b>Dual Magnum</b>	Capreno	Liberty	Roundup	Roundup	Roundup	Roundup	Capreno	Liberty	Dual Magnum	
	Liberty	Atrazine	Prefix	Atrazine	Atrazine	Atrazine	Atrazine	Liberty	Prefix	Liberty	
Post emergence 2 (Cotton ONLY)										Dual Magnum	
										Liberty	
Layby (Cotton ONLY)										Dirax	
										MSMA	
Fall	<b>1.</b> Windrow Burn										
	MB Plough										
	Cover Crop Mix			Cereal Rye Cover	Cereal Rye Cover	Cover Crop Mix	Cereal Rye Cover				
<b>WARNING: Inappropriate Tank Mix</b> <b>Improper Crop Trait Selection</b> <b>Improper Herbicide Selection</b> <b>Duplicate Selections</b>											
<b>Crops planted too frequently:</b> <b>6.</b> <b>Corn</b> <b>LibertyLink</b> <b>Roundup/LibertyLink</b>											
<b>Varieties planted too frequently:</b>											

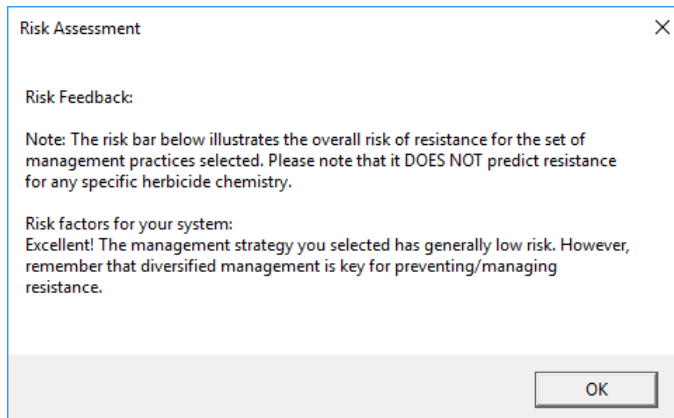
Notes:

- The messages provided near the bottom of the worksheet coordinate with conditional formatting in the cells above to indicate potential errors or otherwise flag strategy decisions that may lead to increased risk of resistance or lowered profitability.
- Conditional formatting (italicized, red, bold font with orange highlighting) has been applied to indicate when the crop trait selected is not appropriate for the crop in rotation. Left-click the specific crop trait to select from the list of available crop traits for the selected crop in rotation to correct the error.
- Conditional formatting (italicized, yellow, bold font with red highlighting) indicates the herbicide option is a mismatch with the selected crop trait, which may happen when the user changes crops and does not update the crop trait. Left-click the herbicide option and select from the list of available herbicide options for the updated specific crop trait selected to correct the error.
- Conditional formatting (italicized, bold font with light yellow highlighting) indicates when two of the herbicide options selected result in improper tank mixes at their full-labeled rates. Left-clicking one of the two highlighted herbicide options to select a different herbicide option or clear one of the two herbicides selected.
- Conditional formatting (italicized, red, bold font with pink highlighting) indicates when the herbicide option selected is duplicated within an application time. Correct this by left-click the herbicide option to select a different herbicide option or delete the duplicate to correct this error.
- If either a crop or a crop trait is used too frequently, the name of the crop or crop trait in question will appear in bright yellow, italicized, bold font with gray highlighting. The Roundup/LibertyLink and LibertyLink warnings appear to show reliance on too few herbicide options. A crop rotation (corn in years four through eight) with too much emphasis on a particular single crop is also flagged here.



The user may wish to either maximize economic returns by maximizing NPV or lower the risk of evolution resistance. This risk is graphically represented using red/green meter to the right of the ‘Strategy’ worksheet (Figure 14(8)) and can be defined by left-clicking the pink ‘Risk Assessment’ button near the top, right of the worksheet. The ‘Risk Assessment’ shown in Figure 17 is based on the default strategy using the ‘Diverse Traits’ system.

**Figure 17. Risk Assessment Definition**



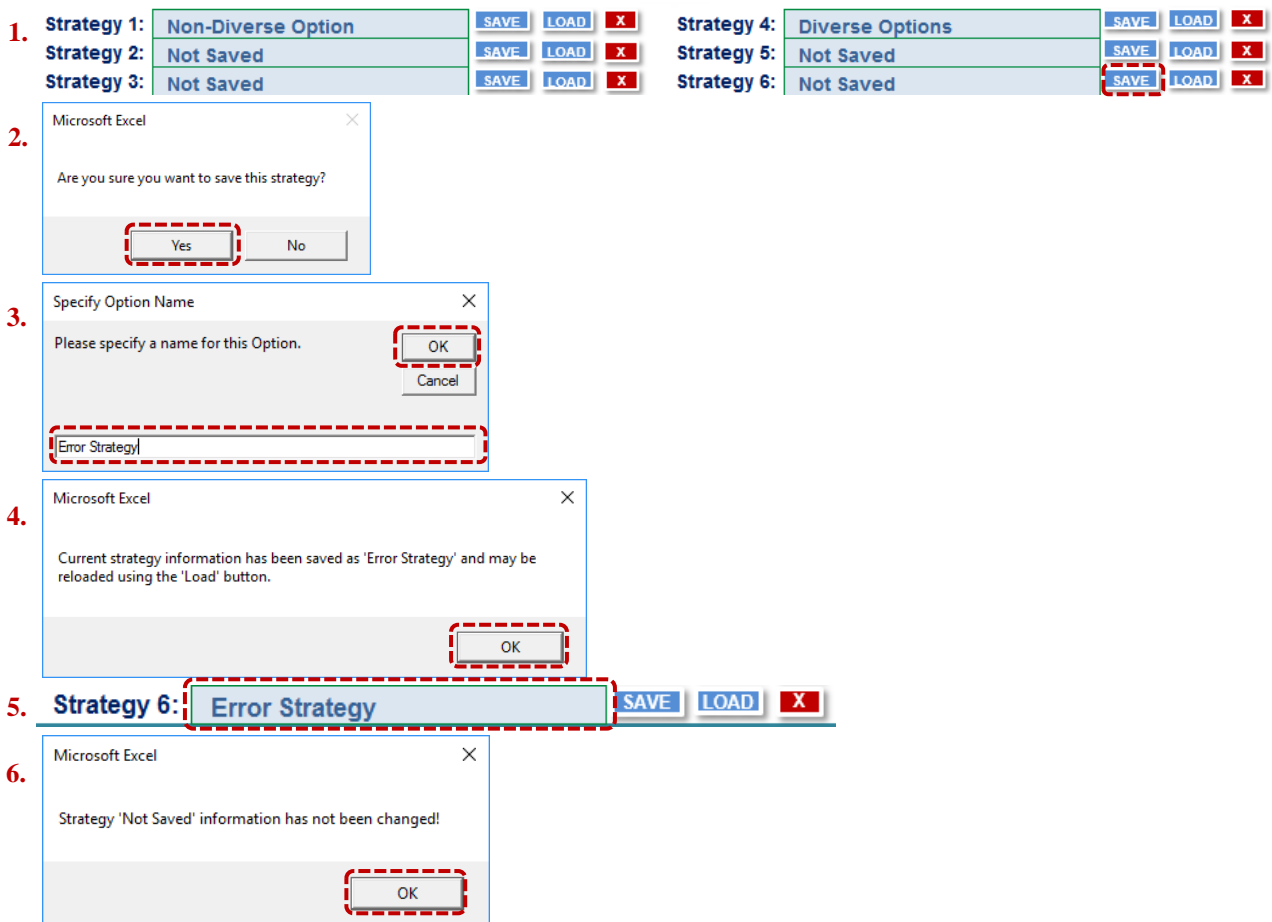
Further, left-clicking the green ‘Palmer Amaranth Escapes’ button near the top, right of the screen allows the user to see information about timing of critical attention to weed control by year. The ‘Palmer Amaranth Escapes’ screen shown in Figure 18 is also based on the default system using the ‘Diverse Traits’ system.

**Figure 18. Year and Within Year Timing of Palmer Amaranth Escapes**

	MidApril	EarlyMay	MidMay	EarlyJun	MidJun	EarlyJul
Year1	0	0	0	0	1	6
Year2	0	0	2	11	5	2
Year3	0	0	3	1	7	17
Year4	0	0	0	0	0	0
Year5	0	0	0	0	0	0
Year6	0	0	0	0	0	0
Year7	0	0	0	0	0	0
Year8	0	0	0	0	0	0
Year9	0	0	0	0	0	0
Year10	0	0	0	0	0	0

Follow the steps provided in Figures 19 through 21 to save, load, or clear strategies:

**Figure 19. Saving Strategies**

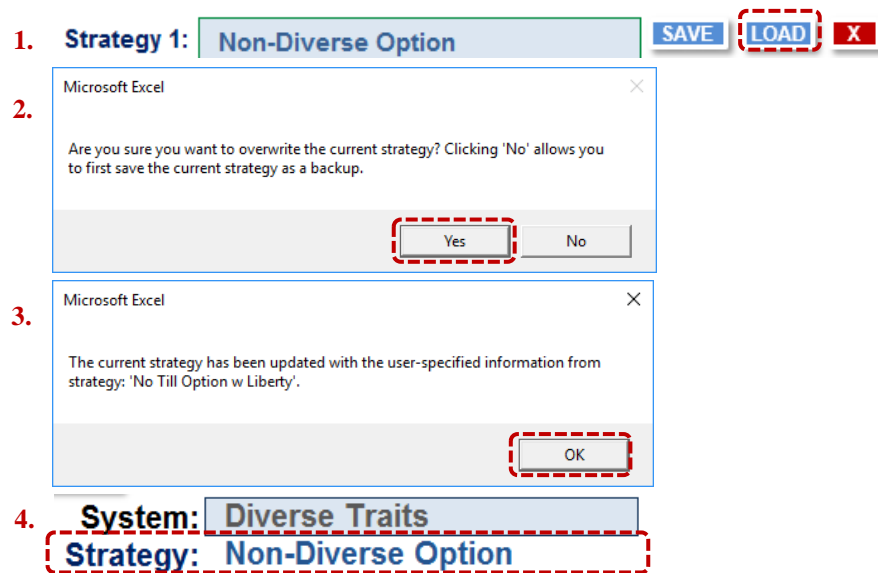


Notes: Assuming choices in Figure 16 were not fixed, the following strategy will be saved as the 'Error Strategy', although any modifications by the user may be saved.

1. Left-click the blue 'Save' button to the right of any of the six saved strategy names to save the strategy that is currently displayed in the 'Strategy' worksheet and select 'Strategy 6'.
2. Upon left-clicking the blue 'Save' button, a message will appear as a failsafe to ensure the save button was not clicked by mistake. Follow steps 3 through 5 if 'Yes' or skip to step 6 if 'No'.
3. If 'Yes' is selected in step 2, enter a name for the saved strategy by typing the desired alphanumeric name into the text box provided and left-click the 'OK' button to continue.
4. Upon left-clicking the 'OK' button, another message will appear stating the current strategy information has been saved and may be reloaded using the 'Load' button. Left-click 'OK' to continue.
5. The name of the saved strategy is now displayed in the gray-shaded cell to the left of the 'Save' and 'Load' buttons.
6. If the 'No' button was selected in step 2, a message will appear stating the previously saved strategy has not been changed. Left-click 'OK' to continue.

Saved strategies may be recalled at any time by left-clicking the 'Load' button to the right of the saved strategy name field (Figure 20 (1)). **Caution:** When a saved strategy is loaded, the saved system associated with the loaded strategy will be automatically updated in the 'Systems' worksheet and shown in Figure 14(2).

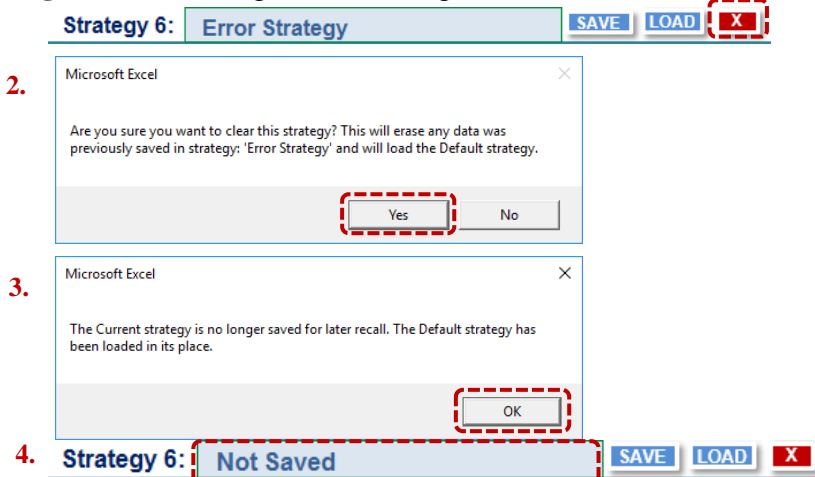
**Figure 20. Loading Saved Strategies**



Notes:

1. Left-click the blue 'Load' button to the right of any of the six saved strategy names to load any of the six saved strategies to the 'Strategy' worksheet. Loading Strategy 1 will restore the program to its original condition.
2. Upon left-clicking the blue 'Load' button, a message box will appear asking if it is okay to overwrite the currently displayed strategy. The user will follow steps 3 through 4 if 'Yes' or do nothing further if 'No'.
3. If 'Yes' is selected in step 2, another message will appear stating the current strategy displayed in the 'Strategy' worksheet has been updated with the user-specified information from the strategy the user loaded. Left-click 'OK' to continue.
4. The loaded strategy is now displayed in 'Strategy' with the name of the strategy displayed in blue font to the right and below the 'Reset Strategy' button located at the top, left corner of the worksheet.

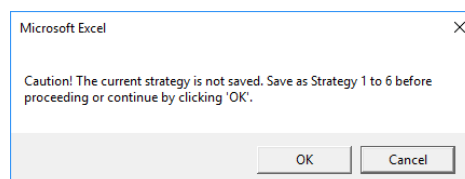
**Figure 21. Clearing Saved Strategies**



Notes:

1. Left-click the red 'X' button to the right of any of the six 'Load' buttons to clear any of the six saved strategies.
2. Upon left-clicking the red 'X' button, a message will appear asking if it is okay to clear the saved strategy. Follow steps 3 through 4 if 'Yes' or do nothing further if 'No'.
3. If 'Yes' is selected in step 2, another message will appear stating the saved strategy has been cleared. Left-click 'OK' to continue.
4. "Not Saved" is now displayed in the strategy name field. Please load the 'Non-Diverse Option' after this step.

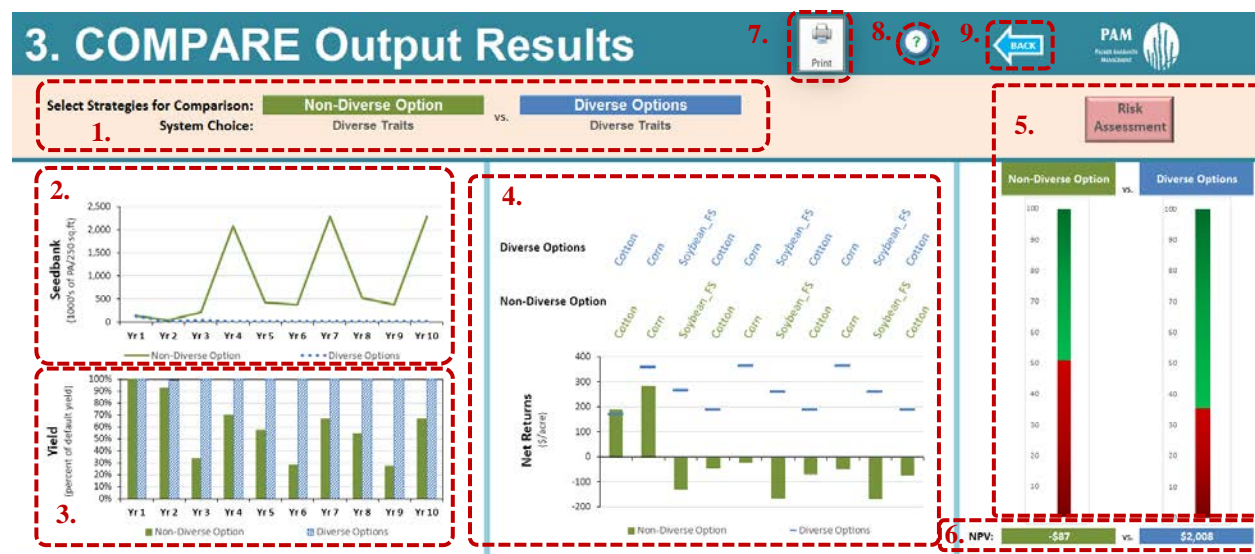
The 'Strategy' worksheet does not require the user to save the currently selected user options as one of six strategies before moving forward to the 'Output' worksheet. This is to allow comparisons in the 'Output' page of the current settings in the 'Strategy' page even if it has not been saved. The message box to the right appears when clicking on 'Next' near the top, right of the 'Strategy' page. Clicking 'Cancel' returns the user to the 'Strategy' page so changes may be saved.



## VII. 'Output' Worksheet

The 'Output' worksheet, shown in Figure 20, allows the user to compare two of the six strategies saved in the 'Strategy' worksheet. Specifically, the 'Output' worksheet allows for a 10 year comparison of 'Seedbank' (in 000's of palmer amaranth seeds per 250 square feet), annual yield potential, and annual 'Net Returns' (in dollars (\$) per acre) as well as the net present value (NPV) and the risk of developing herbicide resistance for each of the two strategies selected for comparison.

Figure 22. 'Output' Worksheet



Notes:

1. Select two strategies for comparison to display the drop-down list of the six saved strategies and the current strategy. Conditional formatting is applied to highlight when strategies are using different 'Systems'. Pink highlighting with red, italicized font (not shown above) will appear when the user compares the same strategy.
2. A 10 year comparison of the seedbank (000's palmer amaranth seeds/250 sqft) is shown for each of the two strategies selected for comparison.
3. A 10 year comparison of the yield potential as a percent of the default yield is shown for each of the two strategies selected for comparison.
4. A 10 year comparison of the net returns (dollars (\$)/acre) is shown for each of the two strategies selected for comparison.
5. The resistance risk is shown for each of the two strategies selected for comparison.
6. The net present value (NPV) (\$/acre) is shown for each of the two strategies selected for comparison.
7. Left-click the 'Print' button to print the area currently displayed on the screen.
8. Left-click the '?' button for help.
9. Navigate back to the 'Strategy' worksheet by left-clicking the 'Back' arrow located at the top, left corner of the 'Output' worksheet.

## VIII. Conclusion

The PAM model is intended for use as an educational tool by extension agents, crop consultants, producers, and any personnel interested in understanding the benefits of integrated weed management. Various parameters may be customized to represent individual production circumstances and build a number of integrated (chemical and non-chemical) strategies for making comparisons.

### *Assumptions and Limitations*

The PAM software is **not** a forecast model and is only intended to illustrate long-term biological and economic trends associated with certain management choices. Further, PAM is not an herbicide resistance simulation model, but it adequately accounts for any pre-existing resistance and the likelihood for developing resistance under any chosen strategy. PAM is a deterministic model and any year-to-year and field to-field variations in parameter values are not accounted for. The model is only expected to provide an average response for a given strategy. The model assumes a single farm that is already equipped with basic equipment; therefore, fixed costs, including capital costs are not included in the calculations.

The PAM software does not automatically recommend a management program, but the goal of this tool is to facilitate the users understanding of the benefits of IPM approach based on trial and error. The PAM model is expected to be a powerful educational tool for teaching the value of sound IPM strategies in managing Palmer amaranth, by illustrating generalized long-term trends in biology and economics. The software is only intended to be a demonstration-based, decision-support tool that highlights general trends.

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