An Interactive Economic Decision Support Tool for Risk and Return Analysis of Organic Apple Production

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ADDITIONAL INDEX WORDS. apple cost of production, breakeven points, sensitivity analysis, present value

SUMMARY. Numerous apple (*Malus × domestica*) research experiments have shown that organic apples can be both profitable and sustainable, especially in the Pacific northwestern United States. However, there is limited published research on the profitability of organic apple orchards in the southern U.S. region. Surveys of southern U.S. stakeholders have indicated that great opportunities exist for markets of both fresh and processed fruit, but significant challenges still exist. These challenges include a lack of information available on the economic impacts of different organic production practices and the potential returns available from organic production. In response to these challenges, we developed a user-friendly interactive economic decision support tool using spreadsheet software to simulate organic apple production in Arkansas and across the southern United States. The purpose of this interactive economic decision support tool is 2-fold: 1) to assist producers in the evaluation of costs, returns, and risks associated with their organic apple orchard and 2) to assess changes to cost, return, and risk as expected costs, prices, and/or yields change. The production budget components of the interactive economic decision support tool estimate variable and fixed costs, gross revenues, and net returns for 18 years of production. In addition, this interactive economic decision support tool provides economic analyses regarding: 1) the operation's breakeven (price and yield) points, 2) sensitivity analyses or "what if" scenarios related to changes in costs and returns, and 3) risk assessment by calculating the probability of obtaining a positive net present value (NPV) over the life of the organic apple orchard. This manuscript describes the development of this interactive economic decision support tool and provides an example of how it works.

Currently, producers are assigning greater importance to consumer-related fruit quality traits rather than disease resistance traits because of the better understanding of the impact of marketing on production (Yue et al., 2013). In recent years, eating locally grown produce has become increasingly popular (Chamberlain et al., 2013; Denver and Jensen, 2014). Several studies have shown that consumers are willing to pay a premium for locally grown (Bond et al., 2006; Wang et al., 2010; Yue and Tong, 2009) and certified organic food (Bernard and Bernard, 2010; Biing-Hwan et al., 2008; Yue and Tong, 2011). Local farms and small businesses are motivated by

these higher price premiums and hence interested in analyzing production cost efficiencies to take advantage of these niche market opportunities (Biing-Hwan et al., 2008; Carpio and Isengildina-Massa, 2009; Yue and Tong, 2011).

The market for organic foods has increased substantially in the last decade (Smith et al., 2009) as has the land dedicated to organic food production [U.S. Department of Agriculture (USDA), 2013a]. For instance, the number of organic certified cropland has increased from 1.22 million acres in 2000 to 3.08 million acres in 2011 (USDA, 2013a). The U.S.

Certified Organic Production Survey showed that the value of certified organic sales totaled \$3.53 billion in 2011. The top five states—California, Washington, Oregon, Texas, and Wisconsin—accounted for over 62.8% of the total certified organic product value of sales (USDA, 2012).

Although the harvested 13,363 acres of certified organic apples represented only 0.43% of the certified organic cropland acreage in the United States in 2011, certified organic apples represented 3.4% of the total sales (\$121.4 million) of all organic produce that year (USDA, 2012). These acres produced 282.2 million pounds of organic apples. Fresh market sales (244.9 million pounds) accounted for \$113.7 million, whereas processing sales (37.2 million pounds) accounted for \$7.6 million. Washington State accounted for 84.0% of those certified organic apple sales, followed by California (10.2%), Arizona (2.0%), Michigan (1.2%), and Colorado (1.1%). The southern U.S. states lag behind these states in both acres harvested and certified organic apple sales (USDA, 2012).

Peck et al. (2010) reported that a price premium would be needed to offset the higher variable costs of producing disease-resistant apples under an organic fruit production system in the northeastern United States. Mon and Holland (2006) have shown that organic apples can be both profitable and sustainable in the Pacific northwestern United States. However, there is limited published research on organic apple orchard profitability in the southern U.S. region. Surveys of southern U.S. stakeholders indicated that great opportunities exist (e.g., expanding population base in the south, strong tradition of fruit production in the region, strong agricultural heritage, and strong local foods awareness) for markets of both fresh and processed fruit, but significant challenges exist. These challenges include a lack of information available on the economic impacts of different

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Funding for this research was provided by the Southern Sustainable Agriculture Research and Education Program Grant and the U.S. Department of Agriculture, Organic Agriculture Research and Extension Initiative.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
0.4536	lb	kg	2.2046
1.1209	lb/acre	kg·ha ⁻¹	0.8922
2.2417	ton(s)/acre	Mg·ha ⁻¹	0.4461

organic production practices and the potential returns available from organic production (Rom et al., 2007).

In response to these challenges, an apple interactive economic decision support tool (AIEDST) was developed to assist producers in making informed decisions regarding organic apple production in the southern United States. The objectives of this manuscript are to 1) describe the development of this interactive economic decision support tool and 2) provide an example of how it works. This example does not represent any particular orchard and is not intended to be a definitive guide of how to grow organic apples. However, it can be helpful in understanding the investment requirements of and potential returns from comparable organic orchards.

Materials and methods

Development of an interactive organic apple budget

A user-friendly AIEDST was developed using spreadsheet software (Excel 2010; Microsoft Corp., Redmond, WA) to simulate organic apple production in the southern United States. This interactive economic decision support tool was designed to represent a 1-acre organic apple orchard using establishment, planting, and production practices information gathered at the Arkansas Agriculture Experiment Station (AAES) located in Fayetteville as default values. This interactive economic decision support tool is both easy to use and to customize.

The AIEDST needs very little user information to calculate cost and revenue streams over the life of the orchard. Navigation is conducted through a series of screens that gather or display detailed information about the current or potential organic apple orchard. The sequence of these screens is as follows: 1) Main menu—this welcome screen provides access to help menus, a complete user guide, and a user input form (Fig. 1). 2) Initial input—orchard information related to cultivar name, planting density, expected yield (pounds per tree), expected production usage (percentage of expected fresh market fruit and percentage of expected processing market fruit), expected market price for each fruit quality (dollars per pound), wages (dollars per hour),

Fig. 1. Screen capture of the main menu of the organic apple budget (interactive economic decision support tool). Users can click on the quick start icon to get basic information of how to use the tool; click on the start icon to use the tool, click on the help icon to obtain overall information divided by topics or click on the user guide icon to open a complete guide that covers everything the user needs to know to start using this tool.

and average discount and inflation rates (percentage) are entered. The default values used are presented in Figure 2. “Demo” and “Help” icons are available to assist in completing the form. Once completed, a full budget (dollars per acre) is calculated. 3) Summary output—This screen provides a snapshot of all production activity costs, gross revenues, and net returns for an 18-year life of an orchard. Figure 3 shows this information through year 7 (apple trees are considered mature at this point). From this screen, it is possible to navigate throughout the AIEDST to return to the “Main Menu,” edit the “Initial Input,” view a specific year (e.g., soil preparation, establishment, production year 1), modify information, and view economic analyses (discussed below). 4) Production years input—The AIEDST calculates costs and revenues based on a representative set of activities that occur in any given year on an organic apple orchard. These screens provide a detailed description of the default values for activities and prices (based on AAES farm data and local prices) used to estimate gross revenues and total cost calculations for each year. Figure 4 displays a snapshot of year 3. These default activities, quantities, or prices

can be changed to better reflect a producer’s operation. 5) Economic output—This screen presents a graphical representation of the total costs (i.e., variable and fixed costs), gross revenues, and net returns (Fig. 5). Breakeven, sensitivity, and risk analyses can also be accessed from this screen. This screen is explained further in the example below.

ECONOMIC ANALYSES. Specific economic assumptions are included in this manuscript, but these assumptions may not fit every production situation as production costs and revenues are highly variable for any particular organic apple operation. Each farm should develop their own budget to reflect their production goals, costs, and market prices. In the example presented in this manuscript, it is assumed that the basic overhead costs of an organic apple orchard, such as land, buildings, organic certifications, and taxes, are covered by the farm business. Only new expenses associated with the production of organic apples are included. However, overhead costs can be added to the AIEDST in the other expenses categories if desired. In this manuscript, it is assumed that producers market apples direct to consumers.

Cultivar Name Generic Apple Demo

Planting Distance (ft)	Yield (lb/tree)	Production Usage (%)	Market Price (\$/lb)	Wages (\$/h)	Rates (%)
In Row: 6	Year 1: 15	Fresh Fruit: 80	Fresh Fruit: 1.00	Management: 15	Discount Rate: 7.0
Between Row: 12	Year 2: 35	Processing: 10	Processing: 0.15	Labor: 10	Inflation Rate: 1.5
Trees/acre: 606	Year 3: 45	Culled: 10	Full Production Price		
	Full Production Yield	100			

Fill all the gray boxes with your own information. You can click "Demo" to use a generic example. You can also enter yield and price for each year of production by clicking the green box "Yield & Price". For more information on how to fill this form click "Help" and look for topic 2 (Initial Input).

Run Cancel Demo Help

Fig. 2. Screen capture of the initial user input form of the organic apple budget (interactive economic decision support tool). Here the user enters cultivar name, planting distance (feet), total yield (pounds) per tree, expected percentage usage of fresh fruit, processing fruit and culled fruit, expected market price for fresh fruit and processed fruit (dollars per pound), management and labor wages (dollars per hour), and constant discount and inflation rates (percent). All the information in the gray boxes is required to calculate the budget, except the cultivar name, which is optional. "Demo" and "Help" icons are available to assist in filling the form. By clicking on the "Run" icon, the tool will control if there is missing information. If the initial input was not entered correctly or there is missing information, a warning message asking to correct the data will appear. If there is no missing information and the information has been entered correctly, the application will show a screen with a summary of the budget; 1 ft = 0.3048 m, 1 tree/acre = 2.4711 trees/ha, 1 lb = 0.4536 kg, \$1.00/lb = \$2.2046/kg.

Cultivar: Generic Apple Demo		Main Menu Economics Edit Input Navigation Help Net Returns Calculator						
U of A DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System		ORGANIC APPLE BUDGET: SUMMARY						
Production Activities	Soil Preparation	Establishment	Maintenance	Production Year 1	Production Year 2	Production Year 3	Production Year 4	
Gross Returns	\$ -	\$ -	\$ -	\$ 6,128.00	\$ 13,363.25	\$ 16,057.30	\$ 15,006.83	
Variable Costs	\$ 2,853.83	\$ 8,028.80	\$ 1,011.64	\$ 4,159.23	\$ 4,266.91	\$ 4,148.73	\$ 4,853.25	
Fertilizer	\$ 54.00	\$ 30.13	\$ 56.32	\$ 78.95	\$ 98.38	\$ 114.93	\$ 128.89	
Harvest	\$ -	\$ -	\$ -	\$ 429.58	\$ 695.50	\$ 787.40	\$ 735.89	
Interests on Operating Capital	\$ 69.61	\$ 195.82	\$ 24.67	\$ 27.76	\$ 87.11	\$ 81.98	\$ 100.42	
Labor	\$ 168.00	\$ 2,415.13	\$ 567.39	\$ 556.78	\$ 520.36	\$ 486.31	\$ 738.56	
Nutrient Analysis Tests	\$ -	\$ 95.33	\$ 89.10	\$ 83.27	\$ 77.82	\$ 72.73	\$ 67.97	
Other Expenses	\$ 359.22	\$ 537.14	\$ 274.16	\$ 391.53	\$ 365.92	\$ 341.98	\$ 524.20	
Pest Management	\$ -	\$ -	\$ -	\$ 2,591.36	\$ 2,421.83	\$ 2,263.39	\$ 2,557.32	
Rental Machinery & Equipment	\$ 2,203.00	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Supplies	\$ -	\$ 164.02	\$ -	\$ -	\$ -	\$ -	\$ -	
Tree Stocks	\$ -	\$ 4,591.21	\$ -	\$ -	\$ -	\$ -	\$ -	
Fixed Costs	\$ 1,975.51	\$ 5,042.88	\$ 2,811.35	\$ 2,875.99	\$ 2,687.84	\$ 2,512.00	\$ 2,773.76	
Machinery System	\$ 1,780.51	\$ 1,664.03	\$ 1,555.17	\$ 1,453.43	\$ 1,358.35	\$ 1,269.48	\$ 1,186.43	
Irrigation System	\$ -	\$ 175.57	\$ 164.08	\$ 153.35	\$ 143.32	\$ 133.94	\$ 125.18	
Trellis System	\$ -	\$ 485.55	\$ 453.78	\$ 424.10	\$ 396.35	\$ 370.42	\$ 346.19	
Management	\$ 195.00	\$ 2,717.73	\$ 638.31	\$ 845.11	\$ 789.83	\$ 738.15	\$ 1,115.96	
Total Cost (\$/ac)	\$ 4,829.34	\$ 13,071.68	\$ 3,822.98	\$ 7,035.22	\$ 6,954.75	\$ 6,660.73	\$ 7,627.01	
Net Returns (\$/ac)	\$ (4,829.34)	\$ (13,071.68)	\$ (3,822.98)	\$ (907.22)	\$ 6,408.49	\$ 9,396.58	\$ 7,379.82	

Fig. 3. Screen capture of the summary screen form of the organic apple budget (interactive economic decision support tool). The summary screen is a snapshot of all production activity costs, gross revenues, and net returns for each year. From this screen, the user can navigate across the application. For instance, the user can return to the main menu, edit the initial input, go to a specific year to modify or enter new information, or go to the economics component of this tool; \$1.00/acre = \$2.4711/ha.

TOTAL COSTS. Total costs describe the total economic costs of producing organic apples over 18 years. Total costs are the sum of variable costs plus fixed costs (Baumol

and Blinder, 2006). Variable costs vary according to the quantity of yield produced and include inputs such as labor, field operations, harvest, and raw materials. In the AIEDST, variable

costs are broken down into 10 categories; fertilizer, harvest, interest on operating capital, labor, nutrient analysis tests, other expenses, pest management, rental of machinery and

Cultivar: Generic Apple Demo							Main Menu	Economics	Summary	Edit Input	Navigation	Clear All	Help
<div> <div> DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System </div> </div>							ORGANIC APPLE BUDGET: PRODUCTION YEAR 3						
Production Activities	Unit	Quantity	Your Quantity	Unit Price (\$/unit)	Your Price (\$/unit)	Total (\$/acre)							
Gross Returns						\$ 22,521.20							
Fresh Market	lb.	21,780.00		1.02		22,106.70							
Processing Market	lb.	2,722.50		0.15		414.50							
Nutrient Analysis Tests						\$ 105.60							
Soil	unit	1.00		-		-							
Foliar	unit	2.00	1.00	10.40	15.00	15.00							
Compost Test, Nutrient Analysis	unit	2.00		20.30		40.60							
Fertilizer Test, Nutrient Analysis	unit	2.00		20.30	25.00	50.00							
				-		-							
Fertilizer						\$ 175.00							
Organic Fertilizer (i.e., Poultry litter, etc.)	ton/ac	7.56	5.00	21.32	35.00	175.00							

Fig. 4. Screen capture of an input screen form (production year 3) of the organic apple budget (interactive economic decision support tool). Navigating to any input screen will reveal detailed descriptions of the variable and fixed costs of production based on the default values used. The user may enter his/her own values by placing new values in the “your quantity” or “your price” columns. Once any new values are entered, calculations are automatically updated. This tool calculates costs and revenues based on a representative set of activities that occur in any given year on an apple orchard; 1 lb = 0.4536 kg, \$1.00/lb = 2.2046/kg, 1 ton/acre = 2.2417 Mg·ha⁻¹, \$1.00/acre = \$2.4711/ha.

Fig. 5. Screen capture of the economics screen of the organic apple budget (interactive economic decision support tool). By clicking on the “economics” icon (from any screen), a graphical representation of the gross revenues, total cost of production, net returns, variable, and fixed costs (dollars per acre) associated with the information entered in the “user input” form (Fig. 2) and all the other screens will be displayed. From this screen, breakeven, sensitivity, and risk analyses can be conducted; \$1.00/acre = \$2.4711/ha, \$1.00/lb = \$2.2046/kg, 1 lb/acre = 1.1209 kg·ha⁻¹, 1 lb = 0.4536 kg.

equipment, supplies, and tree seed stock. Harvest variable costs include the cost of labor and custom work directly associated with harvest. Total variable costs are the cash costs per year required to grow and harvest organic apples.

Fixed costs are independent of yield and include inputs (capital) that cannot be varied in the short term. Fixed costs include depreciation on capital investments in machinery, irrigation equipment, and trellis systems as well as management overhead. These costs do not change as the level of production changes and would be incurred even if organic apples were not produced.

Total costs (dollars per acre) of production are calculated for 1 acre each production year. Total costs for each production year are calculated using the following equation:

$$TC_t = \left(TFC_t + \sum_k^n (UVC_{kt} \times Q_{kt}) \right) \quad [1]$$

where TC_t is the total cost per year t , TFC_t is the total fixed cost per year t , and UVC_{kt} are the unit variable costs for activity k for n activities per year t ; Q is each activity quantity per year t .

The budget used as the core of this interactive economic decision support tool can be modified for the first 7 years (first 3 years establishment and first 4 years production). Production costs for years 8 and beyond are assumed to be the same than those of year 7 (apple trees are considered mature at this point). These total production costs will be revisited in the risk analysis below.

GROSS REVENUES. Gross revenues are estimated by multiplying expected market price (dollars per pound) for each fruit quality (e.g., fresh market fruit or processing market fruit) and expected yield (pounds per acre) for each fruit quality (e.g., fresh market fruit or processing market fruit) for each year of production. Annual gross revenues of production are calculated for 1-acre each production year t using the following equation:

$$GR_t = ((Y_{EFM_t} \times P_{EFM_t}) + (Y_{EPM_t} \times P_{EPM_t})) \quad [2]$$

where GR is the expected gross revenues per year t , Y_{EFM} is the expected

yield to be sold in the fresh market in year t , P_{EFM} is the expected price to be received for fresh market fruit in year t , Y_{EPM} is the expected yield to be sold in the processing market in year t , and P_{EPM} is the expected price to be received for processing fruit in year t . Expected yields for each fruit quality are estimated as follows:

$$Y_{EFM_t} = (TY_t \times EFM_t) \times TA \quad [2.1]$$

$$Y_{EPM_t} = (TY_t \times EPM_t) \times TA \quad [2.2]$$

where TY is the expected total yield per year t , EFM is the expected percentage of fresh market fruit produced in year t , EPM is percentage of processed market fruit produced in year t , and TA is the total number of trees per acre. All these yield values are input that the user needs to enter and can be modified or changed at any time. It is important to point out that there will always be some percentage of culls or drops. In this analysis, this value is assumed to be 10%. However, the AIEDST allows the user to enter expected fresh market and processed market percentages for each year of production. These two percentages must be equal to 100% or less each year. If the total of both percentages is greater than 100%, a message will appear asking to correct the input. If the total of both percentages is less than 100%, it is assumed that the difference is culled fruit.

NET RETURNS. Net returns (dollars per acre) are estimated each year by subtracting total cost (dollars per acre) from gross revenues (dollars per acre).

Net returns for each production year t (NR_t) are calculated using the following equation:

$$NR_t = GR_t - TC_t \quad [3]$$

FUTURE VALUES. The AIEDST could be used by a producer to estimate costs and revenues across the life of an orchard before determining whether to undertake the operation. As a result, all future costs and revenues are unknown. One way to estimate the values of costs and revenues that occur in the future is to increase current values annually by an expected inflation rate using the following equation:

$$FV_t = PV_t \times (1 + I) \quad [4]$$

where FV is future cash flows occurring at time t , PV is the present value (explained below), and I is the inflation rate in decimal form.

PRESENT VALUES. Present value is a future amount of money that has been discounted (using an average discount rate) to reflect its current value, as if it existed today. Present value calculations are used to make comparisons between cash flows and production years, as they do not occur at simultaneous times (Baumol and Blinder, 2006). The soil preparation year is assumed as the starting year ($t = 0$). After this year, all the calculations are adjusted by the average discount rate to estimate present values. Present values for variable and fixed costs, gross revenues, and net returns were estimated using the following equation:

$$PV = \sum_{t=1}^n \left(\frac{FV_t}{(1 + d)^t} \right) \quad [5]$$

where PV is the present value of future cash flows (FV) occurring at time t , that must be discounted over the course of n years using d , the discount rate.

Net present value was used to estimate the profitability of an organic apple orchard that lasts 18 years (3 years to establishment, 15 years in production) as annual net returns (gross revenue – total costs) are discounted to the present. Hence, the PV of future net returns received over the life of the orchard represents the sum total of profitability expressed in today's dollars for making the decision to invest in the orchard:

$$NPV = \sum_{t=1}^{18} \left(\frac{NR_t}{(1 + d)^t} \right) \quad [6]$$

where NPV is the net present value, NR is the net returns, t is time period, and d is the discount rate for one compounding period (in this case, annually).

The inflation rate (i) is used to adjust the value of future cash flows. Then the discount rate (d) is used to determine the PV of future cash flows. Both of these rates are entered by the user and can be updated at any time. Note that year 0 is included to represent cash flows occurred in the

Table 1. Summary of expected total yield of a generic organic apple cultivar in pounds per tree and pounds per acre used as default values for 1 acre (0.4 ha) [606 trees/acre (1497.5 trees/ha), 6 × 12 ft (1.8 × 3.7 m)] for fresh market fruit (80% of the total yield) and processing market fruit (10% of the total yield) over 15-year productive life of an orchard.

Yr ^z	Production yr	Expected total production		Fresh market (80%)		Processing market (10%)	
		(lb/tree) ^y	(lb/acre) ^y	(lb/tree)	(lb/acre)	(lb/tree)	(lb/acre)
4	1	15	9,075	12	7,260	1.5	908
5	2	35	21,175	28	16,940	3.5	2,118
6	3	45	27,225	36	21,780	4.5	2,723
7	4	45	27,225	36	21,780	4.5	2,723
8	5	45	27,225	36	21,780	4.5	2,723
9	6	45	27,225	36	21,780	4.5	2,723
10	7	45	27,225	36	21,780	4.5	2,723
11	8	45	27,225	36	21,780	4.5	2,723
12	9	45	27,225	36	21,780	4.5	2,723
13	10	45	27,225	36	21,780	4.5	2,723
14	11	45	27,225	36	21,780	4.5	2,723
15	12	45	27,225	36	21,780	4.5	2,723
16	13	45	27,225	36	21,780	4.5	2,723
17	14	45	27,225	36	21,780	4.5	2,723
18	15	45	27,225	36	21,780	4.5	2,723

^zThe lifespan of the orchard is assumed to be 18 years [first 3 years to establish the orchard—soil preparation (year 1), maintenance (year 2), establishment (year 3)—and 15 years in production (years 4–18)]. Apple trees are considered mature after year 7 or in production year 4.

^y1 lb = 0.4536 kg, 1 lb/acre = 1.1209 kg·ha⁻¹.

Table 2. Default constant market prices and wage costs values for a generic organic apple cultivar for each year of production for 1 acre (0.4 ha) over 15-year productive life of an orchard.

Activity	Default value
Fresh market fruit (\$/lb) ^z	1.00
Processed market fruit (\$/lb)	0.15
Management wages (\$/h)	15.00
Labor wages (\$/h)	10.00
Inflation rate (%)	1.50
Discount rate (%)	7.00

^z\$1.00/lb = \$2.2046/kg.

soil preparation year that need not be discounted. The PV of net returns or NPV is used in the risk assessment component of the AIEDST. The larger the NPV, the better is the investment (Baumol and Blinder, 2006). Given our assumptions, a negative NPV implies that total costs cannot be covered using revenue streams generated by the orchard.

BREAKEVEN ANALYSIS. Although obtaining positive NPV is the main goal, it is often important to know if/when the production of the organic apple orchard will just cover the total costs of production or breakeven. It is also important to know the payback period, which is the time it takes to breakeven. The breakeven point can be calculated by determining the yields needed to generate sufficient revenue to cover total costs holding all else constant. The same can be done to determine the market price for fresh and processed apples

holding yields constant. The AIEDST calculates how much revenue is needed and how many years it takes to get that amount of revenue (given expected fresh and processed market yields and prices) to cover the total costs of production. Hence the breakeven point is defined as the dollar value at which the PV of total costs is equal to the PV of gross revenues (Albright et al., 2006). Finally, the tool also calculates the amount of time needed from the start of the project until discounted inflows begin to exceed discounted outflows. This point in time is known as the payback period, and the sooner this breakeven year is reached, the more desirable the investment. This point is reached when cumulative gross revenue is equal to cumulative total cost.

To calculate these breakeven points, it is necessary to estimate: 1) cumulative total costs Eq. [1] and

gross revenue Eq. [2] summed and discounted over the life of the orchard, and 2) expected revenue (e.g., expected market production) for each fruit quality Eq. [7]. Expected revenue (MR_{jt}) is equal to expected market yield (Y_{jt}) per acre (e.g., yield per tree × number of trees per acre) times expected market price (P_{jt}); where j represents either the fresh or processed market fruit (see Eq. [7]).

$$MR_{jt} = \sum_{t=3}^{18} (Y_{jt} \times P_{jt}) \quad [7]$$

So, the breakeven yield (BEY) is calculated by dividing the cumulative total costs of operating the orchard for 18 years Eq. [1] by the expected average market price (P_j) over the life of the orchard times the ratio between expected revenue Eq. [7] and total gross revenues Eq. [2]. Hence the breakeven price for fresh and processed fruit is calculated by allocating total costs on the basis of revenue generated in each market as follows:

$$BEY_j = \left(\frac{\sum_{t=0}^{18} TC_t}{P_{jt}} \right) \times \left(\frac{MR_{jt}}{\sum_{t=3}^{18} GR_t} \right) \quad [8]$$

Likewise, the breakeven price (BEP) is calculated by replacing P_{jt} with the expected average market yield (Y_{jt}) over the life of the orchard

in Eq. [8]. The resulting values will be the average annual price per pound (for each quality) that must be attained for apples to breakeven over the course of 18 years of production (3 years to establishment, 15 years in production). All these values are updated automatically if any input is changed (e.g., yields, market prices, management and labor wages, inflation and discount rates, etc.) and, hence, changes to yield or price expectations can be used to conduct sensitivity or what-if analyses.

SENSITIVITY ANALYSIS. A sensitivity analysis (or “what-if” analysis) is a technique used to determine how different values of an input will affect the final product (Albright et al., 2006). The AIEDST enables the producer to instantly see the effect of a change in one or more of the inputs on the economic feasibility of the organic apple orchard to make better planning and investing decisions. For instance, the producer might like to know how the total costs, gross revenues, and net returns will be affected if a change occurs (e.g., unexpected lower/higher yields, lower/higher prices, or both). Once the desired values have been changed, the tool will calculate new values for gross revenues and net returns. A graphical representation of both scenarios is displayed side by side to facilitate comparisons.

RISK ANALYSIS. In addition to a sensitivity analysis, the AIEDST includes a risk analysis component that simulates the effects of production and price risks. Risk analysis is defined here as a technique that calculates the probability of obtaining a NPV

greater than a specific dollar target (Albright et al., 2006). The producer can set this target. The AIEDST needs information on “minimum,” “most likely,” and “maximum” yield (pounds per tree) and price (dollars per pound) for each fruit quality for each year of production to use them as the parameters of a triangular distribution. The decision support tool’s default values will be used for calculation if full production yield and price values are not updated. Once the risk analysis input information is recorded, the AIEDST will calculate stochastic NPVs for the orchard using the probability density functions for the price and yield distributions entered and simulating returns 100 times each year assuming a triangular distribution. From these simulations, the likelihood of NPV exceeding a specific dollar target can be calculated. It also calculates the range of NPV and graphically displays the distribution.

USING THE TOOL—AN EXAMPLE. Default values for important variables are presented in Tables 1–3. For this example, a hypothetical 1-acre organic apple orchard has been established in northwestern Arkansas. It is assumed that before planting, the site had not been used for several years. The area was leveled and graded to improve drainage and access to the site. The soil was tilled following the application of horse manure. Incorporation of lime at a rate of 1.5 tons/acre is applied to adjust soil pH. Horse manure is applied at a rate of 2 tons/acre to increase soil fertility. The AIEDST assumes that the lifespan of the orchard is 18 years. For

instance, it takes 3 years to establish the orchard and the orchard is expected to be in production for 15 years (C.R. Rom, unpublished data).

Establishment and planting conditions were assumed to be very similar to those reported by Choi et al. (2011) and Rom et al. (2008, 2010). For instance, a disease-resistant apple cultivar Enterprise was chosen for this study. Trees were grafted onto ‘M.26’ dwarfing rootstock. Irrigation included rotary sprinklers suspended from a drip line between trees. Trees were planted 6 ft between trees and 12 ft between rows for an approximate density of 606 trees/acre in a vertical axis training system. Trees were trained to a 12-ft-tall vertical axis with a two-wire trellis system for tree support and training. The row middles were seeded with tall fescue (*Festuca arundinacea*) cultivar K-31 and winter wheat (*Triticum aestivum*) nursery to minimize soil erosion and suppress weeds.

The AIEDST allows for two fruit qualities: fresh market and processing. Fresh market fruit is perfect fruit, free from damage caused by disease, insects, hail, fruit russet, etc. Processed fruit includes all the apples that are marketable but have blemishes, but not rotten; typically includes insect stings, fruit russet, and misshapen fruit (USDA, 2002). According to Slattery et al. (2011), U.S. apple producers sell their lower quality apples to processors at lower prices and sell their higher quality apples for fresh market consumption at higher prices. A profit-maximizing producer would want to sell 100% his/her production in the fresh market. However, since

Table 3. Risk analysis expected yield and price default values (baseline scenario) for 1 acre (0.4 ha) [606 trees/acre (1497.5 trees/ha), 6 × 12 ft (1.8 × 3.7 m)] for fresh market fruit (80% of the total yield) and processing market fruit (10% of the total yield) over 15-year productive life of an organic apple orchard assuming a target amount of \$90,000/acre (\$222,394.8/ha)^z per acre over the entire life of the orchard, discount rate of 7.0% and inflation rate of 1.5%^y.

Expected yield	Fresh market yield (lb/tree per yr) ^x			Processing market yield (lb/tree per yr)		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
Production yr 1	4	12	16	0.5	1.5	2.0
Production yr 2	12	28	36	1.5	3.5	4.5
Production yr 3	16	36	48	2.0	4.5	6.0
Full production yr 4–yr 15	16	36	48	2.0	4.5	6.0

Expected price	Fresh market price (\$/lb) ^x			Processing market price (\$/lb)		
	Minimum	Most likely	Maximum	Minimum	Most likely	Maximum
All production years	0.5	1.0	1.2	0.07	0.15	0.20

^zAssuming a net present value of \$5000/acre (\$12,355.3/ha) each year for 18 years (3 years establishment and 15 years in production).

^yThe discount rate was based on the U.S. Department of Agriculture (2014b) economics and the inflation rate was based on U.S. Department of Labor (2014) statistics.

^x1 lb = 0.4536 kg, \$1.00/lb = \$2.2046/kg.

Table 4. Expected present values of variable costs, fixed costs, total costs, gross revenues and net returns for organic apple assuming a constant total yield of 45 lb (20.4 kg) per tree (80% fresh market and 10% processing market) each year and a constant price of \$1.00/lb (\$2.205/kg) for fresh fruit and \$0.15/lb (\$0.331/kg) for processing fruit.

Yr	Production yr	Present value (\$/acre) ^z				
		Variable costs	Fixed costs	Total costs	Gross returns	Net returns
1 (Soil preparation)	Establishment years	2,854	1,976	4,829	—	(4,829)
2 (Establishment)		8,029	5,043	13,072	—	(13,072)
3 (Maintenance)		1,012	2,811	3,823	—	(3,823)
4	1	4,159	2,876	7,035	6,128	(907)
5	2	4,267	2,688	6,955	13,363	6,408
6	3	4,149	2,512	6,661	16,057	9,397
7	4	4,853	2,774	7,627	15,007	7,380
8	5	4,558	2,592	7,150	14,025	6,875
9	6	4,279	2,423	6,702	13,108	6,406
10	7	4,017	2,264	6,281	12,250	5,969
11	8	3,771	2,116	5,887	11,449	5,562
12	9	3,524	1,978	5,502	10,700	5,198
13	10	3,293	1,848	5,142	10,000	4,858
14	11	3,078	1,727	4,805	9,345	4,540
15	12	2,877	1,614	4,491	8,734	4,243
16	13	2,688	1,509	4,197	8,163	3,966
17	14	2,512	1,410	3,923	7,629	3,706
18	15	2,348	1,318	3,666	7,130	3,464
	Total	66,267	41,479	107,746	163,087	55,341

^z\$1.00/acre = \$2.4711/ha.

Table 5. Summary of expected breakeven yield points for 1 acre (0.4 ha) of a generic organic apple cultivar assuming a constant total yield of 45 lb/tree per year with 80% of the fruit sold in the fresh market and 10% in the processing market; for different fresh market prices and a constant average price of \$0.15/lb each year for fruit sold in the processing market^z.

Breakeven points	Avg fresh market price (\$/lb) ^z						
	\$0.70	\$0.80	\$0.90	\$1.00	\$1.10	\$1.20	\$1.30
Fresh market yield (lb/tree per year) ^z	16.50	14.48	12.91	11.64	10.60	9.73	8.99
Processed market yield (lb/tree per year)	2.03	1.78	1.59	1.43	1.30	1.20	1.11
Years to breakeven (net present value = \$0)	18	18	18	18	18	18	18
Dollars to breakeven (\$/acre) ^y	\$107,746						

^z\$1.00/lb = \$2.2046/kg, 1 lb = 0.4536 kg.

^yDollars to breakeven equals to cumulative fresh market yield (lb/tree per year of production) times constant average fresh market price (\$/lb) plus cumulative processed market yield (lb/acre per year of production) times constant average processed market price (\$/lb). For instance, for a constant fresh market price of \$0.70/lb, the calculation is the following: Cumulative total gross revenues = [(16.50 lb/tree per year × 15 years × 606 trees/acre × \$0.70/lb) + (2.03 lb/tree per year × 15 years × 606 trees/acre × \$0.15/lb)] = \$107,746/acre (\$266,251.1/ha) = cumulative total costs. This is the threshold producers need to exceed to breakeven; \$1/acre = \$2.4711/ha, 1 lb/acre = 1.1209 kg·ha⁻¹, 1 tree/acre = 2.4711 trees/ha.

fruit quality variations is normal and expected, it is assumed that the greater percentage of production (≈80%) will be sold in the fresh market and the lesser amount in the processing market (≈10%). There will always be some percentage (here assumed to be ≈10%) of culls or drops (C.R. Rom, unpublished data).

Default marketable yields were based on estimates from the Economic Research Service (USDA, 2013b). The expectation for organic production should be a yield similar to conventional production (Reganold et al., 2001). The reported national average conventional apple yield in 2010 was 26,900 lb/acre

(USDA, 2013b). The default yield value used in this tool is 45 lb/tree per year and hence the total yield per acre in this example was estimated to be 27,225 lb/acre per year, with 80% (21,780 lb/acre) delivered to the fresh market and 10% (2,723 lb/acre) delivered to the processing market. The 10% culled fruit was not included, as it did not have any economic value.

Starting in year 7 (production year 4—apple trees are considered mature at this point), it was assumed organic apples would be harvested for sale. The weekly national fruit and vegetable retail report (10 Jan. 2014) was chosen as the starting prices for

organic apple to be sold in the fresh market and for processing usage (USDA, 2014a). The average wholesale price for fresh organic apples used as default in this example is \$1.00/lb and \$0.15/lb for processing fruit. These prices are representative of the south-central United States (USDA, 2014a). However, a range of fresh market prices (e.g., \$0.50/lb to \$2.00/lb) are used in the sensitivity analysis to show the tool's flexibility to allow changes in prices to reflect different marketing venues (e.g., direct market). It is expected that most producers in the southeastern United States would be interested in the direct market; the authors of this

Table 6. Summary of years to breakeven for different fresh market prices assuming a constant yield of 45 lb (20.4 kg) per tree per year with 80% of the fruit sold in the fresh market and 10% in the processing market; and a constant average price of \$0.15/lb each year for fruit sold in the processing market.

Constant avg market price		Expected yield (15-yr) ^z		Years to breakeven (years)	Dollars to breakeven (\$/acre) ^v
Fresh fruit (\$/lb) ^y	Processed fruit (\$/lb)	Fresh fruit (lb/acre per life time) ^x	Processed fruit (lb/acre per life time) ^w		
\$0.70	\$0.15			14	\$91,469
\$0.80	\$0.15			10	\$70,134
\$0.90	\$0.15			8	\$57,152
\$1.00	\$0.15	307,340	38,418	7	\$50,002
\$1.10	\$0.15			7	\$50,002
\$1.20	\$0.15			6	\$42,375
\$1.30	\$0.15			6	\$42,375

^zApple production starts in year 4 (production year 1). Apple trees are considered mature after year 7 or in production year 4.

^y\$1.00/lb = \$2.2046/kg.

^xThis represents an average of 33.81 lb/tree each year for fresh market fruit. For instance, (33.81 lb/tree × 606 trees/acre × 15 years) = 307,340 lb/acre; 1 lb = 0.4536 kg, 1 tree/acre = 2.4711 trees/ha, 1 lb/acre = 1.1209 kg·ha⁻¹.

^wThis represents an average of 4.23 lb/tree each year for processed fruit. For instance, (4.23 lb/tree × 606 trees/acre × 15 years) = 38,418 lb/acre.

^vDollars to breakeven is the point or the year when cumulative GR = GR_{yr1} + GR_{yr2} + ... [See Eq. [2] or green line (Fig. 5)] begins to exceed cumulative TC = TC_{yr1} + TC_{yr2} + ... [See Eq. [1] or red line (Fig. 5)]; \$1.00/acre = \$2.4711/ha.

Fig. 6. Screen capture of the breakeven analysis screen of the organic apple budget (interactive economic decision support tool); \$1.00/lb = \$2.2046/kg, 1 lb/acre = 1.1209 kg·ha⁻¹, \$1.00/acre = \$2.4711/ha.

manuscript are not aware of any packinghouses in the southern United States for organic apples.

Once the initial costs and revenues were calculated, three additional types of analyses were conducted.

First, two types of breakeven analyses were conducted: the year and dollar amount needed to breakeven for

Table 7. Expected present values of net returns for different apple yields and prices per pound; assuming 50% of the total yield is sold in the fresh market and 10% in the processing market. A constant price of \$0.15/lb of organic apple for the processing market was assumed for the 15-year productive life of the orchard.

\$/lb ^y	Net present values of net returns (\$/acre) ^z								
	Total yield per tree (lb/tree) ^y								
	20	25	30	35	40	45	50	55	60
0.5	(75,429)	(70,858)	(66,287)	(61,716)	(57,145)	(52,573)	(48,002)	(43,431)	(38,860)
0.6	(70,319)	(64,769)	(59,219)	(53,669)	(48,119)	(42,568)	(37,018)	(31,468)	(25,918)
0.7	(65,209)	(58,680)	(52,151)	(45,622)	(39,093)	(32,563)	(26,034)	(19,505)	(12,976)
0.8	(60,099)	(52,591)	(45,083)	(37,575)	(30,067)	(22,558)	(15,050)	(7,542)	(34)
0.9	(54,985)	(46,499)	(38,013)	(29,527)	(21,041)	(12,552)	(4,066)	4,420	12,906
1.0	(49,879)	(40,413)	(30,947)	(21,481)	(12,015)	(2,547)	6,919	16,385	25,851
1.1	(44,769)	(34,324)	(23,879)	(13,434)	(2,989)	7,458	17,903	28,348	38,793
1.2	(39,655)	(28,232)	(16,809)	(5,386)	6,037	17,464	28,887	40,310	51,733
1.3	(34,545)	(22,143)	(9,741)	2,661	15,063	27,469	39,871	52,273	64,675
1.4	(29,435)	(16,054)	(2,673)	10,708	24,089	37,474	50,855	64,236	77,617
1.5	(24,316)	(9,957)	4,402	18,761	33,120	47,480	61,839	76,198	90,557
1.6	(19,209)	(3,870)	11,469	26,808	42,147	57,485	72,824	88,163	103,502
1.7	(14,099)	2,219	18,537	34,855	51,173	67,490	83,808	100,126	116,444
1.8	(8,985)	8,311	25,607	42,903	60,199	77,496	94,792	112,088	129,384
1.9	(3,874)	14,401	32,676	50,951	69,226	87,501	105,776	124,051	142,326
2.0	1,236	20,490	39,744	58,998	78,252	97,506	116,760	136,014	155,268

^zNet present values were used to estimate the profitability of an organic apple orchard that lasts 18 years (3 years to establish the orchard; 15 years in production) as annual net returns (gross revenue – total costs). The present value of future net returns received over the life of the orchard represents the sum total of profitability expressed in today's dollars using a constant discount rate of 7%. Given our assumptions, a negative net present value implies that total costs cannot be covered using revenue streams generated by the orchard; \$1.00/acre = \$2.4711/ha.

^y1 lb = 0.4536 kg, \$1.00/lb = \$2.2046/kg.

Table 8. Expected present values of net returns for different apple yields and prices per pound; assuming 60% of the total yield is sold in the fresh market and 10% in the processing market. A constant price of \$0.15/lb of organic apple for the processing market was assumed for the 15-year productive life of the orchard.

\$/lb ^y	Net present values of net returns (\$/acre) ^z								
	Total yield per tree (lb/tree) ^y								
	20	25	30	35	40	45	50	55	60
0.5	(70,684)	(65,204)	(59,723)	(54,243)	(48,763)	(43,283)	(37,803)	(32,322)	(26,842)
0.6	(64,551)	(57,896)	(51,241)	(44,586)	(37,931)	(31,276)	(24,622)	(17,967)	(11,312)
0.7	(58,417)	(50,588)	(42,758)	(34,929)	(27,099)	(19,270)	(11,441)	(3,611)	4,218
0.8	(52,284)	(43,280)	(34,276)	(25,272)	(16,268)	(7,264)	1,740	10,744	19,748
0.9	(46,150)	(35,972)	(25,793)	(15,615)	(5,436)	4,743	14,921	25,100	35,279
1.0	(40,017)	(28,664)	(17,311)	(5,957)	5,396	16,749	28,102	39,456	50,809
1.1	(33,884)	(21,356)	(8,828)	3,700	16,228	28,755	41,283	53,811	66,339
1.2	(27,750)	(14,048)	(345)	13,357	27,059	40,762	54,464	68,167	81,869
1.3	(21,617)	(6,740)	8,137	23,014	37,891	52,768	67,645	82,522	97,399
1.4	(15,484)	568	16,620	32,671	48,723	64,775	80,826	96,878	112,930
1.5	(9,350)	7,876	25,102	42,328	59,555	76,781	94,007	111,234	128,460
1.6	(3,217)	15,184	33,585	51,986	70,387	88,787	107,188	125,589	143,990
1.7	2,916	22,492	42,067	61,643	81,218	100,794	120,369	139,945	159,520
1.8	9,050	29,800	50,550	71,300	92,050	112,800	133,550	154,300	175,050
1.9	15,183	37,108	59,032	80,957	102,882	124,807	146,731	168,656	190,581
2.0	21,316	44,416	67,515	90,614	113,714	136,813	159,912	183,011	206,111

^zNet present values were used to estimate the profitability of an organic apple orchard that lasts 18 years (3 years to establish the orchard; 15 years in production) as annual net returns (gross revenue – total costs). The present value of future net returns received over the life of the orchard represents the sum total of profitability expressed in today's dollars using a constant discount rate of 7%. Given our assumptions, a negative net present value implies that total costs cannot be covered using revenue streams generated by the orchard; \$1.00/acre = \$2.4711/ha.

^y1 lb = 0.4536 kg, \$1.00/lb = \$2.2046/kg.

seven fresh market prices ranging from \$0.70/lb to \$1.30/lb and the breakeven yield needed for the range of fresh market prices. Second, sensitivity analyses were also conducted to assess expected NPV for 495

combinations of prices, yield, and fresh/processing market sales of apples. Third, risk analyses estimated the probability of obtaining a NPV equal or greater than \$90,000 per acre over the full life of the orchard.

Results and discussion

Under the assumptions used in this example, a producer would incur a capital investment of over \$21,700 per acre distributed in the

Table 9. Expected present values of net returns for different apple yields and prices per pound; assuming 70% of the total yield is sold in the fresh market and 10% in the processing market. A constant price of \$0.15/lb of organic apple for the processing market was assumed for the 15-year productive life of the orchard.

Net present values of net returns (\$/acre) ^z									
Total yield per tree (lb/tree) ^y									
\$/lb ^x	20	25	30	35	40	45	50	55	60
0.5	(65,938)	(59,549)	(53,160)	(46,770)	(40,381)	(33,992)	(27,603)	(21,214)	(14,825)
0.6	(58,782)	(51,023)	(43,263)	(35,504)	(27,744)	(19,985)	(12,225)	(4,466)	3,294
0.7	(51,627)	(42,497)	(33,367)	(24,237)	(15,107)	(5,977)	3,153	12,282	21,412
0.8	(44,471)	(33,971)	(23,471)	(12,970)	(2,470)	8,030	18,530	29,031	39,531
0.9	(37,315)	(25,445)	(13,574)	(1,704)	10,167	22,038	33,908	45,779	57,649
1.0	(30,160)	(16,919)	(3,678)	9,563	22,804	36,045	49,286	62,527	75,768
1.1	(23,004)	(8,393)	6,218	20,830	35,441	50,052	64,664	79,275	93,887
1.2	(15,849)	133	16,115	32,096	48,078	64,060	80,042	96,023	112,005
1.3	(8,693)	8,659	26,011	43,363	60,715	78,067	95,419	112,772	130,124
1.4	(1,538)	17,185	35,907	54,630	73,352	92,075	110,797	129,520	148,242
1.5	5,618	25,711	45,804	65,897	85,989	106,082	126,175	146,268	166,361
1.6	12,774	34,237	55,700	77,163	98,626	120,090	141,553	163,016	184,479
1.7	19,929	42,763	65,596	88,430	111,264	134,097	156,931	179,764	202,598
1.8	27,085	51,289	75,493	99,697	123,901	148,105	172,309	196,513	220,717
1.9	34,240	59,815	85,389	110,963	136,538	162,112	187,686	213,261	238,835
2.0	41,396	68,341	95,285	122,230	149,175	176,120	203,064	230,009	256,954

^zNet present values were used to estimate the profitability of an organic apple orchard that lasts 18 years (3 years to establish the orchard; 15 years in production) as annual net returns (gross revenue – total costs). The present value of future net returns received over the life of the orchard represents the sum total of profitability expressed in today's dollars using a constant discount rate of 7%. Given our assumptions, a negative net present value implies that total costs cannot be covered using revenue streams generated by the orchard; \$1.00/acre = \$2.4711/ha.

^y1 lb = 0.4536 kg, \$1.00/lb = \$2.2046/kg.

Table 10. Expected present values of net returns for different apple yields and prices per pound; assuming 80% of the total yield is sold in the fresh market and 10% in the processing market. A constant price of \$0.15/lb of organic apple for the processing market was assumed for the 15-year productive life of the orchard.

Net present values of net returns (\$/acre) ^z									
Total yield per tree (lb/tree) ^y									
\$/lb ^x	20	25	30	35	40	45	50	55	60
0.5	(61,192)	(53,894)	(46,596)	(39,298)	(32,000)	(24,702)	(17,403)	(10,105)	(2,807)
0.6	(53,014)	(44,150)	(35,286)	(26,421)	(17,557)	(8,693)	171	9,035	17,900
0.7	(44,836)	(34,406)	(23,975)	(13,545)	(3,115)	7,315	17,746	28,176	38,606
0.8	(36,658)	(24,662)	(12,665)	(669)	11,328	23,324	35,320	47,317	59,313
0.9	(28,481)	(14,918)	(1,355)	12,207	25,770	39,333	52,895	66,458	80,020
1.0	(20,303)	(5,174)	(3,678)	11,451	26,580	41,708	56,837	71,966	87,095
1.1	(12,125)	4,570	7,632	24,327	41,022	57,717	74,412	91,107	107,801
1.2	(3,947)	14,314	18,942	37,203	55,464	73,725	91,986	110,247	128,508
1.3	4,231	24,058	30,252	50,080	69,907	89,734	109,561	129,388	149,215
1.4	12,409	33,802	41,562	62,956	84,349	105,742	127,136	148,529	169,922
1.5	20,586	43,546	52,873	75,832	98,791	121,751	144,710	167,670	190,629
1.6	28,764	53,290	64,183	88,708	113,234	137,759	162,285	186,811	211,336
1.7	36,942	63,034	75,493	101,584	127,676	153,768	179,860	205,951	232,043
1.8	45,120	72,778	86,803	114,461	142,119	169,776	197,434	225,092	252,750
1.9	53,298	82,522	98,113	127,337	156,561	185,785	215,009	244,233	273,457
2.0	61,475	92,266	109,423	140,213	171,003	201,793	232,584	263,374	294,164

^zNet present values were used to estimate the profitability of an organic apple orchard that lasts 18 years (3 years to establish the orchard; 15 years in production) as annual net returns (gross revenue – total costs). The present value of future net returns received over the life of the orchard represents the sum total of profitability expressed in today's dollars using a constant discount rate of 7.0%. Given our assumptions, a negative net present value implies that total costs cannot be covered using revenue streams generated by the orchard; \$1.00/acre = \$2.4711/ha.

^y1 lb = 0.4536 kg, \$1.00/lb = \$2.2046/kg.

first 3 years (soil preparation, establishment, and maintenance) and have recurring expenses ranging from \$3600 to \$7600 per acre per year for the next 15 years of production to establish and cover the annual costs of

this example organic apple orchard (Table 4).

Variable or cash costs comprise 62% of total costs, whereas fixed costs comprise 38%. Almost three-quarters of the variable costs are represented

by two categories: pest management (44%) and labor (29%). Labor in this case includes labor for harvest. These two categories represent 45% of the total cost of production during the entire life of the orchard. Machinery,

Table 11. Risk analysis output for 100 simulated present values of net returns (\$/acre) at different total costs percentage variations for the 15-year productive life of the orchard.

Net present of total cost		Probability of obtaining net present value of at least \$90,000/acre (%) ^y	Net present value range (\$/acre)	
%	(\$/acre) ^z		Low	High
30	\$140,070	11.1	\$64,991	\$71,882
25	\$134,683	15.2	\$69,292	\$76,183
20	\$129,295	21.2	\$73,593	\$80,485
15	\$123,908	29.3	\$77,894	\$84,786
10	\$118,521	39.4	\$82,195	\$89,087
5	\$113,133	48.5	\$86,496	\$93,388
0 ^x	\$107,746	60.6	\$90,797	\$97,689
-5	\$102,359	69.7	\$95,098	\$101,990
-10	\$96,971	78.8	\$99,399	\$106,291
-15	\$91,584	84.8	\$103,700	\$110,592
-20	\$86,197	87.9	\$108,001	\$114,893
-25	\$80,810	96.0	\$112,302	\$119,194
-30	\$75,422	97.0	\$116,604	\$123,495

^x\$1.00/acre = \$2.4711/ha.

^yAssuming a net present value of \$5000/acre each year for 18 years (3 years establishment and 15 years in production).

^zBaseline. Percentages of net present values of total costs are assuming increase/decrease percentages from this value. For instance, 5% increase is calculated as follows (\$107,746/acre $\times$ 1.05 = \$113,133/acre). The baseline scenario assumes a constant yield of 45 lb (20.4 kg) per tree each year with 80% of the fruit sold in the fresh market, 10% in the processed market and 10% being culled. Constant average prices are assumed to be \$1.00/lb (fresh fruit) and \$0.15/lb (processed fruit); \$1.00/lb = \$2.2046/kg. The total cumulative costs are \$107,746/acre and the target net returns during the life time of the orchard is \$90,000/acre. The probability of obtaining a value equal or greater than the target net return during the life of the operation is 60.61%. There is a 95% chance that the true net present average lies between \$90,797/acre and \$97,686.

irrigation, and trellis systems represented 63% of the fixed costs while management overhead accounted for the remaining 37%.

BREAKEVEN ANALYSIS. Table 5 displays the summary of the seven breakeven yield analyses for the 18-year period assuming 80%/10% fresh/processed market sales and constant prices each year for fresh market prices (ranging from \$0.70/lb to \$1.30/lb) and a constant processed market price of \$0.15/lb each year. The lower the price received for fresh market fruit, the higher the expected yield needed to breakeven after 18 years of production.

The higher the price received for the fresh market fruit, the sooner the apple orchard will breakeven (Table 6). In this example, with a constant price of \$1.10/lb or higher and a constant yield of 45 lb/tree per year, the orchard will breakeven after 7 years of production or when the cumulative present value of total gross revenues were equal to the present value of total costs of \$50,002 per acre. In contrast, with a constant price of \$0.70/lb each year, payback will not occur until year 14.

The AIEDST can also estimate the breakeven yields, prices, and payback periods under user-specified

conditions (Fig. 6). For instance, using the tool's default values (Tables 1–3), the orchard will breakeven after 18 years of production, if fresh market and processed market yields over the life of the orchard are at least 104,200 lb/acre (11.64 lb/tree per year) and 13,205 lb/acre (1.43 lb/tree per year), respectively. Likewise, the breakeven prices for fresh market and processed markets are at least \$0.34/lb and \$0.05/lb each year, respectively.

SENSITIVITY ANALYSIS. A per-acre summary of the 18-year NPV for different yield, production usage (i.e., fresh market and processing market), and prices are presented in Tables 7–10. As expected, NPV varies depending on the expected yield per tree and price per pound. 66% of the 576 different yield and price combinations presented in Tables 7–10 are positive. The lower the percentage of fruit sold in the fresh market, the higher the market price needed to produce positive NPV. If, for example, each organic apple tree produces 45 lb/tree per year and only 50% of the total yield is sold in the fresh market, each pound of organic apple needs to be sold at least at \$1.10/lb each year to breakeven (Table 7). If, for example, each organic

apple tree produces 45 lb/tree per year and 80% of the total yield is sold in the fresh market, each pound of organic apple needs to be sold at least at \$0.70/lb each year to breakeven (Table 10). None of the combinations with prices lower than \$0.70/lb each year and total yield less than 40 lb/tree covered establishment and production cost during the entire life of the orchard.

However, positive NPV is somewhat meaningless unless compared with alternative uses for the land employed for the orchard. For example, when each tree in an acre produces 45 lb/tree per year and 80% of the total yield is sold in the fresh market for \$0.70/lb each year (Table 10), a total of only \$7315 per acre is generated over the life of the orchard. This is only \$406 per acre per year. Producers must compare the opportunity costs of several mutually exclusive production alternatives to the expected net returns to truly determine whether the operation is feasible under uncertain yield, price and market allocation conditions. Economic feasibility is described in the risk analysis section.

RISK ANALYSIS. This risk analysis complements the sensitivity analysis because it allows increasing/decreasing the present value of total costs of production by 1% increments. For instance, if the producer expects that the present value of total costs of production is underestimated or overestimated in the tool, the user can adjust the total cost values without changing any specific input in the budget.

In the example, the present value of total costs is estimated to be \$107,746 per acre. Table 11 shows how an increase or decrease in those estimated costs can impact expected range of net returns, as well as the likelihood of reaching a NPV of \$90,000 per acre when it is assumed that 80% of the total yield is sold in the fresh market and fresh market price received by pound will fluctuate from \$0.50/lb to \$2.00/lb using a triangular distribution. The probability of obtaining a NPV of \$90,000 per acre using default values (baseline—example scenario) and a comparison scenario assuming that total costs per acre are 30% less than the baseline scenario (This task was performed by using a sensitivity analysis

Fig. 7. Screen capture of the risk analysis screen of the organic apple budget (interactive economic decision support tool). The baseline scenario assumes a constant yield of 45 lb (20.4) per tree each year with 80% of the fruit sold in the fresh market, 10% in the processed market, and 10% being culled. The mostly likely average prices are assumed to be \$1.00/lb (fresh fruit) and \$0.15/lb (processed fruit); \$1.00/lb = \$2.2046/kg. The total cumulative costs are \$107,746/acre and the target net returns during the lifetime of the orchard are \$90,000/acre. The probability of obtaining a value equal or greater than the target net return (baseline) during the life of the operation is 60.61%. There is a 95% chance that the true net present average lies between \$90,797 and \$97,686 per acre. The comparison scenario was estimated assuming the total costs of production was 30% less than the baseline; \$75,422/acre; \$1.00/acre = \$2.4711/ha.

to increase/decrease the default total costs by 5% increments) is displayed in Fig. 7.

In this example, under the initial present value of total cost calculations, there is a 60.61% probability of generating \$90,000 per acre or more during the entire life of the orchard. Further, given the range of fresh market prices that are randomly drawn 100 times, the range of NPV lies between \$90,797 and \$97,689 per acre. Because this range of prices does not cover all likely prices, Figure 7 suggests that NPV will lie in this range 95% of the time.

The probability of obtaining a NPV greater than \$90,000 per acre for the entire life of the orchard will decrease from 60.61% to 11.11% if total costs are 30% greater (\$140,070 per acre) than initially estimated. Conversely, if total costs are assumed to be 30% less than the initial estimate (\$75,422 per acre) the likelihood of exceeding \$90,000 per acre NPV

increases to 97% as the low end of expected NPV is \$116,604 per acre (Table 11).

Conclusions

We developed a user-friendly interactive economic decision support tool using spreadsheet software to simulate organic apple production in Arkansas and across the southern United States. This interactive economic decision support tool is designed to allow the informed user to model implications of cost, yield, and price changes on net return expectations. Default values from real organic apple orchards are used for soil preparation, establishment, and planting information gathered at the AAES located in Fayetteville, AR.

The production budget components of the AIEDST estimate variable and fixed costs, gross revenues, and net returns for 18 years of production using the tool's default data, information entered by the user or

a combination of both. However, this interactive economic decision support tool is superior to traditional production budgets because it includes additional economic analyses as it: 1) estimates the operation's breakeven (price and yield) points, 2) conducts sensitivity analyses (answering "what if" questions related to changes in costs and returns), and 3) provides a risk assessment of the probability of obtaining targeted NPV.

To avoid drawing unfounded conclusions for any particular organic apple orchard, users of the AIEDST must closely examine the economic assumptions made in each of the input screens, and then adjust the costs (i.e., production activities, units, quantities, costs, and prices) and/or returns as appropriate for their operation. The example presented in this manuscript does not represent any particular orchard and is not intended to be a definitive guide of how to grow organic apples. However, it can be adjusted to reflect individual production situations.

Each apple orchard producer should develop their own budget to reflect their production goals, total costs and expected market prices. Fluctuations in prices which are influenced by market supply and demand are a major risk factor. As shown in Tables 7–10, the profitability of the analyzed orchard is determined by expected yields and prices. Producers must be very conservative in assessing net returns when establishing production or financial plans. Factors such as total production acreages, market demand, marketing costs, organic certifications and regulations (e.g., Food Safety Modernization Act) must be considered when making price predictions. It is expected that an increase in organic production and the consolidation of organic markets will lead to a general decline in the overall price for organic apples.

Although the information provided in this manuscript does not represent any particular organic apple orchard, it can be helpful in estimating the physical and financial requirements of comparable organic orchards since the AIEDST provides economic tools such as breakeven, sensitivity, and risk analyses. These economic tools will help existing and new organic apple producers to evaluate production and marketing decisions, determine potential

returns, prepare budgets, and compare different scenarios.

Literature cited

- Albright, S.C., W.L. Winston, and C.J. Zappe. 2006. Data analysis and decision making with Microsoft Excel. 3rd ed. Thomson South-Western, Taunton, MA.
- Baumol, W.J. and C.I. Blinder. 2006. Economics principles and policy. 10th ed. Thomson South-Western, Kendallville, IN.
- Bernard, J.C. and D.J. Bernard. 2010. Comparing parts with the whole: Willingness to pay for pesticide-free, non-GM, and organic potatoes and sweet corn. *J. Agr. Resource Econ.* 35:457–475.
- Biing-Hwan, L., T.A. Smith, and C.L. Huang. 2008. Organic premiums of US fresh produce. *Renew. Agr. Food Syst.* 23:208–216.
- Bond, J.K., D. Thilmany, and C.A. Bond. 2006. Direct marketing of fresh produce: Understanding consumer purchasing decisions. *Choices Mag.* 21:229–236.
- Carpio, C.E. and O. Isengildina-Massa. 2009. Consumer willingness to pay for locally grown products: The case of South Carolina. *Agribusiness* 25:412–426.
- Chamberlain, A.J., K.M. Kelley, and J. Hyde. 2013. Locally grown and certified organic produce in the mid-Atlantic region of the United States. *HortTechnology* 23:74–81.
- Choi, H.S., C.R. Rom, and M. Gu. 2011. Plant performance, and seasonal soil and foliar nutrient variations in an organic apple orchard under four ground cover management systems. *J. Amer. Pomol. Soc.* 65:66–82.
- Denver, S. and J.D. Jensen. 2014. Consumer preferences for organically and locally produced apples. *Food Qual. Prefer.* 31:129–134.
- Mon, P.N. and D.W. Holland. 2006. Organic apple production in Washington State: An input-output analysis. *Renew. Agr. Food Syst.* 21:134–141.
- Peck, G.M., I.A. Merwin, M.G. Brown, and A.M. Agnello. 2010. Integrated and organic fruit production systems for 'liberty' apple in the northeast United States: A systems-based evaluation. *HortScience* 45:1038–1048.
- Reganold, J.P., J.D. Glover, P.K. Andrews, and H.R. Hinman. 2001. Sustainability of three apple production systems. *Nature* 410:926–930.
- Rom, C.R., H. Friedrich, and J. McAfee. 2007. Organic fruit production: Challenges and opportunities for research and outreach. *Acta Hort.* 737:147–154.
- Rom, C.R., M.E. Garcia, J. McAfee, H. Friedrich, H.S. Choi, D.T. Johnson, J. Popp, and M. Savin. 2010. The effects of groundcover management and nutrient source during organic orchard establishment. *Acta Hort.* 873:105–114.
- Rom, C.R., J. McAfee, H. Friedrich, H.S. Choi, M.E. Garcia, D. Johnson, J. Popp, and M. Savin. 2008. Early performance during establishment of an organic apple orchard in the upper mid-south. *HortScience* 43:609. (abstr.).
- Slattery, E., M. Livingston, C. Greene, and K. Klonsky. 2011. Characteristic of conventional and organic apple production in the United States. *U.S. Dept. Agr. Econ. Res. Serv. FTS-347-01*. 7 Jan. 2014. <<http://www.ers.usda.gov/media/118496/fts34701.pdf>>.
- Smith, T.A., C.L. Huang, and B.H. Lin. 2009. Does price or income affect organic choice? Analysis of U.S. fresh produce users. *J. Agr. Appl. Econ.* 41:731–744.
- U.S. Department of Agriculture. 2002. United States standards for grades of apples. 8 Jan. 2014. <<http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050339>>.
- U.S. Department of Agriculture. 2012. 2011 Certified organic production survey. 27 Jan. 2014. <<http://usda01.library.cornell.edu/usda/current/OrganicProduction/OrganicProduction-10-04-2012.pdf>>.
- U.S. Department of Agriculture. 2013a. Organic production: Table 3. Certified organic and total U.S. acreage, selected crops and livestock, 1995–2011. 28 Jan. 2014. <<http://www.ers.usda.gov/Data/Organic>>.
- U.S. Department of Agriculture. 2013b. U.S. apple statistics: Table 7 - Yield per apple bearing area in the United States, by State, 1980–2010. 19 Dec. 2013. <<http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1825>>.
- U.S. Department of Agriculture. 2014a. Advertised prices for fruits & vegetables at major retail supermarket outlets. 01/04 to 01/16. 10 Jan. 2014. <<http://www.ams.usda.gov/mnreports/fvwretail.pdf>>.
- U.S. Department of Agriculture. 2014b. Price indexes and discount rates: Use of the discount rate in conservation programs and projects. 28 July 2014. <http://www.nrcs.usda.gov/wps/PA_NRCSCConsumption/download?cid=stelprdb1257183&ext=pptx>.
- U.S. Department of Labor. 2014. News release – Consumer price index – Dec. 2013. *USDL-14-0037*. 23 Jan. 2014. <<http://www.bls.gov/news.release/pdf/cpi.pdf>>.
- Wang, Q., J. Sun, and R. Parsons. 2010. Consumer preferences and willingness to pay for locally grown organic apples: Evidence from a conjoint study. *HortScience* 45:376–381.
- Yue, C., R.K. Gallardo, J. Luby, A. Rihn, J.R. McFerson, V. McCracken, D. Bedford, S. Brown, K. Evans, C. Weebadde, A. Sebolt, and A.G. Iezzoni. 2013. An investigation of U.S. apple producers' trait prioritization: Evidence from audience surveys. *HortScience* 48:1378–1384.
- Yue, C. and C. Tong. 2009. Organic or local? Investigating consumer preference for fresh produce using a choice experiment with real economic incentives. *HortScience* 44:366–371.
- Yue, C. and C. Tong. 2011. Consumer preferences and willingness to pay for existing and new apple varieties: Evidence from apple tasting choice experiments. *HortTechnology* 21:376–383.