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Economic Risk Analysis of Rice Cultivars under Organic and Conventional Management

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Abstract

Several studies evaluate the agronomics of crop cultivars grown under both organic and conventional management. Most studies focus on yield differences or mean yield rankings between conventional and organic management. Their findings have been mixed for the most part. None of these studies use economic analysis to identify the best cultivars for either system. This study uses simulation and stochastic efficiency with respect to a function (SERF) to obtain ordinal rankings of rice cultivars for both organic and conventional management based on risk efficiency. The SERF analysis reveals the most dominant cultivars grown under conventional management do not match the most dominant cultivars grown under organic management. These results imply that rice cultivars ideal for conventional systems may not be ideal for organic systems, and that rice cultivars used in organic production systems should be adapted to organic rather than conventional management.

Organic production is defined by the U.S. Department of Agriculture (USDA) as an ecological production system that fosters cycling of resources, promotes ecological balance, and conserves biodiversity (Green et al. 2009). Organic crops are grown without the use of synthetic fertilizers, pesticides, or any other prohibited substances, and must be certified organic by an accredited organic certifying agency (USDA-AMS, 2012). A field is eligible for certified organic status if no prohibited materials have been applied for a period of 36 months (USDA-AMS, 2012). In 2015, certified organic farms in the U.S. operated 1.78 million ha (4.4 million ac), up 20% from the previous year (USDA-NASS, 2016). Slightly more than half of this land was used to produce crops, with the rest devoted to pasture and rangeland.

Most crops grown under organic management consist of cultivars selected in conventional, high-input breeding programs. According to Lammerts van Bueren et al. (2011), an estimated 95% of organic agriculture worldwide is based on use of crop varieties bred for the conventional high-input sector. These cultivars may lack important traits desired for organic production, such as increased competitiveness against weeds and disease resistance. Thus many argue for the need to select organic crop cultivars adapted to organic rather than conventional conditions (Lammerts van Bueren et al. 2011; Wolfe et al. 2008).

Several studies evaluate the agronomics of crop cultivars grown under both organic and conventional management (Burger et al., 2008; Kitchen et al., 2003; Kirk, 2009; Kokare et al, 2014; Murphy et al, 2007; Przystalski et al, 2008; Pswarayi et al, 2014; Vlachostergios and Roupakias 2008). Crop yields are the general focus of most of these studies, with the objective of determining if cultivars performing well under conventional management would likewise perform well under organic management. Many of these studies find the top yielding cultivars in conventional management differ from those in organic management and conclude the need for direct selection of cultivars from organic rather than conventional systems. Some studies find little difference in top yielding cultivars between the two management systems and conclude direct selection in organic systems to be less important. None of these studies use economic analysis in choosing the best cultivars for either system.

This study compares the rankings of alternative rice cultivars under both organic and conventional management using rice grain yield and milling yield data from a three-year organic – conventional rice cultivar research trial conducted at Beaumont, Texas. Thirteen different rice cultivars with four different market designations (flour, medium grain, long grain, and aromatic) were evaluated in the trial under both organic and conventional management. Rice grain yields and milling yield adjusted rice prices were simulated and used to create net return distributions for each rice cultivar under both management strategies. Stochastic Efficiency with Respect to a Function (SERF) was used to obtain ordinal rankings of rice cultivars for both organic and conventional management.

Data Used in the Analysis

This study uses data from a three-year organic – conventional rice cultivar research trial conducted at Beaumont, Texas. The study was conducted during the years 2009, 2010, and 2011, and collected data on both rice grain yields and rice milling yields for 13 different rice cultivars. Milling yields for a particular rice cultivar consist of the total milling yield percent (percent of whole kernels plus percent of broken kernels) and percent whole kernels. The difference between total milling yield percent and whole kernel percent is broken kernel percent. Whole kernels are more valuable than broken kernels, and the higher the whole kernel percent, the better the milling quality for a particular rice cultivar and the better the rice price the farmer receives. All data in the study were replicated four times. Descriptions for each of the 13 rice cultivars evaluated in the research trial are given in Table 1.

The first four cultivars listed in Table 1 (PI312777, PI338046, Rondo, and Tesanai2) are weed-suppressive in nature, and are generally proposed as viable alternatives for low-input management systems like organic management. However, these rice cultivars tend to have significantly lower milling yields than weed non-suppressive rice cultivars and are often relegated to the rice flour market. The remaining nine rice cultivars are classified as long grain cultivars (Cocodrie, Colorado, Cybonnet, Presidio, and Wells), medium grain cultivars (Bengal and Jupiter) or aromatic cultivars (Jazzman and Sierra). These nine cultivars are weed non-suppressive and have been specifically breed for conventional high-input rice management systems in Louisiana, Texas, and Arkansas.

Simulated Rice Grain Yields by Cultivar

Rice grain yield distributions by rice cultivar and management strategy (conventional, organic) were simulated using Simulation and Econometrics To Analyze Risk (SIMETAR©) (Richardson, Schumann, and Feldman, 2008). Multivariate empirical distributions (MVEs) were used to simulate rice grain yield distributions of 500 iterations each for the thirteen cultivars under both conventional and organic management. A MVE distribution simulates random values from a frequency distribution made up of actual historical data and has been shown to appropriately correlate random variables based on their historical correlation (Richardson et al. 2000). Parameters for the MVE include the means, deviations from the mean or trend expressed as a fraction of each variable, and the correlation among variables. The MVE is used in instances where data observations are too few to estimate parameters for another distribution (Pendell et al. 2006). The MVE distribution is also a closed-form distribution, in that it eliminates the possibility of simulated values exceeding values observed in history (Ribera, Hons, and Richardson, 2004). Rice grain yield data in the study were replicated four times for all thirteen rice cultivars under organic and conventional management, and all replicated data were used in the simulations. Percent deviations from the mean were used in the MVE distribution simulations.

Simulated rice grain yield summary statistics are presented by cultivar and management in Table 2. There is very little difference in mean grain yields by cultivar between conventional and organic management. Only in four instances were mean grain yields statistically different between conventional and organic management when comparing the original research trial data, and these significant differences occurred with Rondo and Tesannai2 in favor of organic management and with Colorado and Sierra in favor of conventional management (data not shown). Similar comparisons between organic and conventional rice yields are reported in De Ponti et al. (2012), who report an average organic to conventional relative rice yield of 94% and a range in relative organic to conventional rice yields from 86 to 105% from seven studies in the literature.

Simulated Rice Milling Yields by Cultivar

Milling yield adjusted rice price distributions by rice cultivar and management were generated using total milling yield (whole kernel percent plus broken kernel percent) and whole kernel milling yield replications by rice cultivar and management from the research trial. Multivariate empirical distributions of total milling yields (whole kernel plus broken) and whole kernel milling yields were simulated for each rice cultivar under organic and conventional management using the replicated data. Broken kernel milling yield distributions were calculated by subtracting whole kernel yields from total yields.

Summary statistics of simulated rice whole kernel and broken yields are presented by rice cultivar and management in Table 3. Rice whole kernel yields are smaller and broken kernel yields are larger on average for the weed-suppressive rice cultivars (PI312777, PI338046, Rondo, and Tesanai2) under both organic and conventional management. These rice cultivars have lower milling quality relative to the nine weed non-suppressive rice cultivars. Conversely, rice whole kernel yields are larger and broken kernel yields are smaller on average for the medium grain rice cultivars (Bengal and Jupiter), indicating the two medium grain cultivars have higher milling quality than the other rice cultivars evaluated in the study.

Stochastic Milling Yield Adjusted Rice Prices

Milling yield adjusted rice price distributions by rice cultivar and management strategy were calculated using the following formula:

(1) $P_{ijkt} = (WP_t * WY_{ijk}) + (BP_t * BY_{ijk})$

where P_{ijkt} = Rice price for cultivar i, management j, iteration k; and rice type t; i = 1 to 13 rice cultivars; j = the two management strategies (conventional; organic), k = 1 to 500 simulated iterations, t = four different rice types (conventional, aromatic, organic, and organic aromatic), WP_t = the whole kernel price for rice type t ($/lb); WY_{ijk} = whole kernel yield for rice cultivar i, management j, and iteration k; BP_t = broken kernel price for rice type t ($/lb), and BY_{ijk} = broken kernel yield for rice cultivar i, management j, and iteration k.

Whole kernel prices (WP_t) and broken kernel prices (BP_t) by rice type in equation (1) were calculated using the following equations:

(2) $$WP_t = \frac{RP_t}{55 + 0.52\ (70 - 55)}$$

(3) $BP_t = 0.52 * WP_t$

Each of the four values for WP_t in equation (2) were calculated assuming an industry standard milling yield of 55/70 (70% total milling yield; 55% whole kernel yield) and assuming the broken kernel price is 52% of the value of the whole kernel price. The 52% represents the ratio of the average of the Texas brewers price to the average Texas long grain milled price for the months of August through October 2017 (USDA AMS 2018). Conversely, each broken kernel price (BP_t) was calculated in equation (3) as 52% of the whole kernel price.

Rice farm prices, whole kernel prices, and broken kernel prices for the four different rice types are presented in Table 4. The conventional farm price of $0.1233/lb represents the average farm price for Texas for the period 2014 – 2016 (USDA, NASS 2017) while the organic farm price and the organic aromatic farm rice price of $0.2500/lb and $0.3000/lb, respectively were obtained from personal communication with Doguet's Rice Milling Company located in Beaumont, Texas. The organic farm price is roughly twice that of the conventional farm price. Organic aromatic rice has a $0.05/lb premium over organic non-aromatic rice. The aromatic rice farm price of $0.1480 was estimated as the conventional farm price multiplied by the ratio of the organic aromatic farm price to the organic (non-aromatic) farm price. The whole kernel and broken prices in Table 4 and the simulated whole kernel and broken kernel percents were used in formula (1) to calculate milling yield adjusted rice price distributions by cultivar and management.

The weed-suppressive cultivars in the study have much lower milling quality relative to the weed non-suppressive rice cultivars, and in many instances this milling quality would be deemed unacceptable by rice mills. Therefore, additional price discounts were applied to milling yield adjusted rice prices for all thirteen rice cultivars based on percent broken kernels for each simulated iteration. Rice price discounts by grade for U.S. Grades 3 - 6 were obtained from the crop year loan discounts for rice reported for 2017 by the Farm Service Agency (USDA-FSA, 2018). Broken kernels falling between 7 and 15% received a $0.003/lb price discount (Grade 3); broken kernels falling between 15 and 25% received a $0.006/lb price discount (Grade 4); broken kernels falling between 25 and 35% received a $0.01/lb price discount (Grade 5), and broken kernels falling between 35 and 50% received a $0.02/lb price discount (Grade 6).

Summary statistics of simulated milling yield adjusted rice prices by rice cultivar and management are presented in Table 5. Average rice prices tend to range in order from lowest to highest for both conventional and organic management as follows: weed-suppressive (flour) < long grain < medium grain < aromatic. Average rice prices under conventional management range from $0.0969 to $0.1116/lb for the weed-suppressive (flour) rice cultivars; from $0.1122 to $0.1215/lb for the long grain rice cultivars; from $0.1249 to $0.1267/lb for the medium grain rice cultivars; and from $0.1368 to $0.1398/lb for the aromatic rice cultivars. Average rice prices under organic management range from $0.1954 to $0.2021/lb for the weed-suppressive (flour) rice cultivars; from $0.2370 to $0.2548/lb for the long grain rice cultivars; from $0.2625 to $0.2696 for the medium grain rice cultivars, and from $0.2859 to $0.3033 for the organic aromatic rice cultivars.

Stochastic Net Returns

Stochastic net returns above variable and fixed expenses were calculated by rice cultivar and management using the following equation:

(4) $NR_{ijkt} = (P_{ijkt} * Y_{ijk}) - V_j - (H * Y_{ijk}) - F_j$

where NR_{ijkt} = the net return to variable and fixed expenses for cultivar *i*, management *j*, iteration *k*, and rice type *t* ($/acre); Y_{ijk} = the simulated grain yield for cultivar *i*, management *j*, and iteration *k* (lb/acre); V_j = the preharvest variable production expenses for management *j* ($/acre);

H = custom harvest expenses per pound ($/lb); F_j = the fixed expenses for management j ($/acre), and P_{ijkt} is the same as defined above.

Average variable and fixed production expenses for conventional and organic management are presented in Table 6. Production expenses for conventional rice are based on the 2017 Texas rice budget for first crop rice in Jefferson-Liberty Counties (Texas A&M AgriLife Extension, 2017), while production expenses for organic rice were developed based on phone conversations with organic rice producers.

Some expenses are larger for organic rice production than for conventional rice production, namely seed cost, water cost, diesel, and machinery labor. More rice seed is generally applied in an organic rice system to maintain a good plant stand, and rice is planted via water seeding. The fertilizer expense for organic rice in Table 6 is due exclusively to chicken litter, which is the primary mode of fertility used in organic rice systems. Flood is the most effective means of controlling weeds and reducing disease damage in an organic rice system. Approximately one-third more water is applied to organic rice than to conventional rice. Machinery expenses are also generally greater for organic rice due to more land preparation relative to conventional management. Total production expenses for organic rice are lower than those for conventional rice due to the absence of synthetic pesticides (herbicide, insecticide, and fungicide) in the organic budget.

Summary statistics of simulated rice net returns above total specified costs are presented by rice cultivar and management in Table 7. Net returns to organic management are much larger than net returns to conventional management, due primarily to the price premium for organic rice. The order of magnitude in net returns by cultivar differs on average between conventional and organic management. Under conventional management, the medium grain cultivar Jupiter has the largest mean net return, followed by the aromatic cultivar Sierra and the two long grain cultivars Cocodrie and Presidio. Under organic management, the weed-suppressive cultivar Tesanai2 has the largest mean net return, followed by the medium grain Jupiter, the aromatic cultivar Jazzman, and the long grain cultivar Wells.

Risk Analysis

Stochastic Efficiency with Respect to a Function (SERF) was used to rank rice cultivars by management according to risk attitudes. The SERF method orders a set of risky alternatives in terms of certainty equivalents (CEs) calculated for specified ranges of risk attitudes (Hardaker et al. 2004). A CE is equal to the amount of certain payoff an individual would require to be indifferent between that payoff and a risky investment. For a rational decision maker who is risk averse, the CE is typically less than the expected (mean) monetary value and greater than or equal to the minimum monetary value of a stream of monetary outcomes (Hardaker et al. 2004). Risky outcomes with higher CEs are preferred to those with lower CEs. Thus graphical mapping of CEs of risky outcomes over a range of absolute risk aversion coefficients facilitates ordinal rankings for decision makers with different risk attitudes.

A utility function must be specified to calculate CEs. The utility function used most often with SERF analysis is the negative exponential utility function. This function is recommended by Hardaker et al. 2004 because it is a CARA (constant absolute risk aversion) function, and it can act as a reasonable approximation of the actual but unknown utility function. This function is appropriate provided the range of risky alternatives is small relative to the decision maker's wealth (Tsiang 1992). The negative exponential utility function also conforms to the hypothesis that decision makers prefer less risk to more given the same expected return (Williams et al. 2012).

An appropriate range of absolute risk aversion coefficients (ARACs) must be specified for calculating CEs with the negative exponential utility function. The ARAC represents a decision maker's degree of risk aversion. Decision makers are risk averse if ARAC > 0, risk neutral if ARAC = 0, and risk preferring if ARAC < 0. The ARAC values in this analysis ranged from 0 (risk neutral) to 0.0038 (strongly risk averse). The upper ARAC value was calculated using the following formula suggested by Hardaker et al. (2004):

$$(4) \quad ARAC_w = \frac{r_r(w)}{w}$$

where $r_r(w)$ = the relative risk aversion coefficient with respect to a specified level of wealth (w), and $ARAC_w$ equals the absolute risk aversion coefficient with respect to w. In this analysis, $r_r(w)$ was set to 4 (very risk averse) as proposed by Anderson and Dillon (1992), and w was estimated as the average net return to production expenses for all thirteen rice cultivars under organic management ($1040/acre). The SERF procedure in SIMETAR© is used to calculate CEs by rice cultivar and management using the ARAC ranges specified above and a negative exponential utility function. Mappings of CEs across ARAC values are then compared to determine the most dominant rice cultivar-weed management combinations to obtain ordinal rankings of rice cultivars for both organic and conventional management.

SERF Analysis of Rice Cultivars under Conventional and Organic Management

Certainty equivalents by rice cultivars under conventional management are mapped across ARACs in Figure 1. Absolute risk aversion coefficients in Figure 1 range from 0.000 (risk neutral) to 0.0038 (strong risk aversion), and combinations having the locus of points of highest CE values are risk preferred to other combinations. Based in this criteria, the rice cultivars that are most dominate under conventional management are the medium grain cultivar Jupitar, the aromatic cultivar Sierra, the long grain cultivar Cocodrie, and the long grain cultivar Presidio.

The mappings of CEs across ARACs for these four rice cultivars are higher than those for the other remaining nine cultivars evaluated in the analysis. The CE mappings for the four most dominate cultivars cross one another, indicating no one dominant rice cultivar dominates the other four across all levels of absolute risk aversion. The aromatic cultivar Sierra dominates all other rice cultivars but Jupiter across all ranges of ARAC. Jupiter dominates Sierra for ARAC values between 0 and 0.0022, but beyond this point (or as decision makers become more risk averse than ARAC = 0.0022), Sierra dominates Jupiter.

Ordinal rankings of cultivar CEs across ARAC values is more complicated for many of the remaining nine rice cultivars. Of these, the weed-suppressive cultivar Tesanai2 and the long grain cultivar Cybonnet dominate all of the other remaining nine cultivars across most levels of absolute risk aversion. Cybonnet dominates all of the remaining nine cultivars except Tesanai2. Tesanai2 dominates Cybonnet up to the point where ARAC = 0.0030. Beyond this point, Cybonnet dominates Tesanai2. The weed-suppressive cultivar Rondo is dominated by all other rice cultivars under conventional management, as its mapping of CE values across ARACs is lower relative to CE mappings for the other 11 rice cultivars.

Certainty equivalents by rice cultivars under organic management are mapped across ARACs in Figure 2. As in the case of conventional management, four rice cultivars are most dominate based on ordinal rankings of CE mappings across ARAC values. However, the ordering of dominance is much more pronounced for the four most dominant cultivars under organic management. The weed-suppressive cultivar Tessani2 is the most dominant, followed in order by the medium grain cultivar Jupiter, the aromatic cultivar Jazzman, and the long grain cultivar Wells. Following these four cultivars, the next most dominant cultivars are the long grain cultivars Presidio and Cybonent. Presidio dominates Cybonent at approximately ARAC =

0.018. Beyond this, Cybonent dominates Presidio under organic management. The long grain cultivar Colorado is dominated by all other rice cultivars under organic management, as its mapping of CE values across ARACs is lower relative to CE mappings for the other 11 rice cultivars.

Summary and Conclusions

Several studies evaluate the agronomics of crop cultivars grown under both organic and conventional management. Most studies focus on yield differences or mean yield rankings between conventional and organic management. Their findings have been mixed for the most part, and none of these studies use economic analysis to identify the best cultivars for either system. This study uses simulation and stochastic efficiency with respect to a function (SERF) to obtain ordinal rankings of rice cultivars for both organic and conventional management based on risk efficiency. The analysis uses data from a three-year organic-conventional rice research trial conducted in Beaumont Texas during 2009, 2010, and 2011. Rice grain yields and rice milling yields are used to construct distributions of net returns above total specified expenses for the thirteen rice cultivars under both organic and conventional management. SERF analysis is used to identify and rank dominant rice cultivars for both organic and conventional management. The study was conducted to determine if rice cultivars selected under conventional management would work equally well under organic management.

The results of the SERF analysis indicate that the most dominant cultivars grown under conventional management do not match the most dominant cultivars grown under organic management. The top four cultivars grown under organic management were the weed-suppressive cultivar Tesani2, followed by the medium grain cultivar Jupiter, the aromatic cultivar Jazzman, and the long grain cultivar Wells. Conversely, the top four cultivars grown under conventional management were medium grain Jupiter, the aromatic cultivar Sierra, and the two long grain cultivars Cocodrie and Presidio. These results imply that rice cultivars ideal for conventional systems may not be ideal for organic systems. Rice cultivars used in organic production systems should be adapted to organic rather than conventional management.

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Table 1. Rice Cultivars Evaluated at the Conventional – Organic Cultivar Trial, Beaumont, Texas, 2009 – 2011.

Cultivar	Origin	Type	Market
PI312777	Philippines	Allelopathic germplasm	Flour Market
PI338046	Philippines	Allelopathic germplasm	Flour Market
Rondo	China	Atypical long grain	Flour Market
Tesanai2	China	Allelopathic medium grain	Flour Market
Bengal	Louisiana	Conventional medium grain	Medium Grain
Jupiter	Louisiana	Conventional medium grain	Medium Grain
Cocodrie	Louisiana	Conventional long grain	Long Grain
Colorado	Texas	Conventional long grain	Long Grain
Cybonnet	Arkansas	Conventional long grain	Long Grain
Presidio	Texas	Conventional long grain	Long Grain
Wells	Arkansas	Conventional long grain	Long Grain
Jazzman	Louisiana	Aromatic, Jasmine like	Aromatic
Sierra	Texas	Aromatic, basmati like	Aromatic

Table 2. Summary Statistics of Simulated Rice Grain Yields by Rice Cultivar under Conventional and Organic Management

Cultivar	Mean [a] (lbs/acre)	SD [b] (lbs/acre)	CV [b]	Minimum (lbs/acre)	Maximum (lbs/acre)
			Conventional Management		
PI312777	6,104	560	9.2	4,899	6,736
PI338046	6,003	615	10.3	5,225	7,366
Rondo	6,189	1,269	20.5	3,779	7,743
Tesanai2	7,724	1,697	22.0	5,869	12,262
Bengal	5,544	1,912	34.5	2,241	8,332
Jupiter	6,823	2,070	30.3	2,714	9,207
Cocodrie	6,804	1,017	14.9	5,259	8,903
Colorado	6,219	568	9.1	5,316	7,209
Cybonnet	5,918	1,009	17.1	4,637	7,663
Presidio	6,370	1,182	18.6	3,835	7,977
Wells	5,882	564	9.6	4,863	6,809
Jazzman	5,037	1,286	25.5	2,951	7,286
Sierra	5,740	1,087	18.9	3,984	7,276
			Organic Management		
PI312777	7,121	660	9.3	6,286	8,829
PI338046	7,050	697	9.9	5,643	8,192
Rondo	7,736	1,500	19.4	5,999	10,022
Tesanai2	10,269	1,276	12.4	7,951	12,321
Bengal	5,659	893	15.8	3,222	7,177
Jupiter	7,158	1,220	17.0	5,144	9,018
Cocodrie	5,959	1,201	20.2	4,167	7,610
Colorado	4,499	1,193	26.5	1,897	6,106
Cybonnet	6,053	1,006	16.6	4,212	7,809
Presidio	6,378	1,297	20.3	4,069	8,570
Wells	7,279	1,353	18.6	5,144	8,835
Jazzman	6,126	1,354	22.1	3,520	8,356
Sierra	4,752	960	20.2	3,448	6,243

[a] Summary statistics calculated from 500 simulated iterations

[b] SD = Standard Deviation; CV = Coefficient of Variation.

Table 3. Summary Statistics of Simulated Rice Whole Kernel and Broken Kernel Yields by Rice Cultivar under Conventional and Organic Management.

Cultivar	Mean (%)	SD (%)	CV	Minimum (%)	Maximum (%)	Mean (%)	SD (%)	CV	Minimum (%)	Maximum (%)
	Whole Kernel Yields, Conventional Management					Broken Kernel Yields, Conventional Management				
PI312777	49.6	4.2	8.4	45.7	60.0	19.3	3.3	17.3	10.5	22.3
PI338046	46.1	3.8	8.2	41.5	54.3	22.2	3.0	13.4	15.3	24.5
Rondo	41.5	6.5	15.7	31.0	52.3	21.7	5.0	22.8	13.2	30.2
Tesanai2	43.5	11.1	25.6	21.5	55.8	24.8	9.5	38.2	14.9	42.9
Bengal	60.3	4.8	8.0	53.3	69.2	8.6	2.8	32.8	2.4	12.6
Jupiter	61.6	3.0	4.8	55.0	66.6	8.1	1.4	17.4	5.0	10.7
Cocodrie	54.0	3.9	7.3	50.1	61.2	13.2	2.9	21.6	7.8	15.6
Colorado	51.1	6.6	13.0	42.9	61.4	16.1	5.3	32.7	8.4	22.6
Cybonnet	57.5	3.9	6.7	53.0	64.3	9.3	2.4	26.0	4.7	12.7
Presidio	58.3	2.4	4.1	54.6	61.5	9.8	0.9	8.7	8.6	10.9
Wells	53.9	4.6	8.6	48.6	61.8	13.0	3.0	23.2	7.8	15.8
Jazzman	53.8	5.4	10.0	47.5	63.8	10.2	2.7	26.2	3.8	13.4
Sierra	53.6	1.5	2.9	50.9	55.8	15.7	0.6	4.1	14.2	16.7
	Whole Kernel Yields, Organic Management					Broken Kernel Yields, Organic Management				
PI312777	35.3	8.1	22.9	26.5	55.0	34.3	7.3	21.4	15.9	41.9
PI338046	35.4	7.5	21.2	26.0	47.4	33.9	6.5	19.2	23.3	41.8
Rondo	36.4	6.1	16.8	26.8	46.7	31.1	4.9	15.9	22.6	38.7
Tesanai2	37.7	12.3	32.7	23.5	59.2	31.5	11.3	35.8	12.2	44.0
Bengal	61.3	5.7	9.3	45.7	66.4	10.6	3.9	36.8	6.6	21.6
Jupiter	64.6	3.4	5.2	59.8	69.5	6.7	2.3	34.6	3.5	9.8
Cocodrie	53.2	3.1	5.8	47.2	57.8	14.2	2.4	17.1	8.4	17.7
Colorado	53.5	4.4	8.2	47.5	61.4	14.8	3.1	20.7	9.4	18.7
Cybonnet	60.0	3.6	6.1	51.6	64.6	9.1	0.8	9.2	7.2	10.3
Presidio	59.2	5.7	9.6	45.3	63.6	7.3	0.9	12.2	6.2	9.4
Wells	53.2	2.8	5.2	47.8	56.3	17.9	0.7	3.7	16.9	20.2
Jazzman	59.4	1.6	2.8	57.8	62.9	9.1	0.7	8.2	7.8	10.3
Sierra	52.1	3.9	7.6	44.6	56.9	17.3	1.6	9.0	15.3	19.8

[a] Summary statistics calculated from 500 simulated iterations

[b] SD = Standard Deviation; CV = Coefficient of Variation.

Table 4. Farm Prices, Whole Kernel Prices, and Broken Kernel Prices by Rice Type.

Rice Type	Farm Price ($/lb)	Whole Kernel Price ($/lb)	Broken Kernel Price ($/lb)
Conventional	0.1233	0.1964	0.1019
Aromatic	0.1480	0.2357	0.1223
Organic	0.2500	0.3982	0.2067
Organic Aromatic	0.3000	0.4778	0.2480

Note: Whole and broken kernel prices are based on an industry standard 55/70 milling yield (70% total milling yield; 55% whole kernel milling yield). Broken kernel prices are 52% of the value of whole kernel prices.

Table 5. Summary Statistics of Simulated Rice Prices by Rice Cultivar under Conventional and Organic Management

Cultivar	Mean [a] ($/lb)	SD [b] ($/lb)	CV [b]	Minimum ($/lb)	Maximum ($/lb)
			Conventional Management		
PI312777	0.1116	0.0060	5.4	0.1030	0.1255
PI338046	0.1071	0.0045	4.2	0.1002	0.1163
Rondo	0.0969	0.0098	10.1	0.0804	0.1132
Tesanai2	0.1015	0.0178	17.5	0.0660	0.1217
Bengal	0.1249	0.0078	6.2	0.1144	0.1383
Jupiter	0.1267	0.0051	4.0	0.1159	0.1359
Cocodrie	0.1154	0.0060	5.2	0.1082	0.1251
Colorado	0.1122	0.0091	8.1	0.1012	0.1261
Cybonnet	0.1200	0.0062	5.2	0.1125	0.1311
Presidio	0.1215	0.0040	3.3	0.1154	0.1265
Wells	0.1152	0.0069	6.0	0.1057	0.1263
Jazzman	0.1368	0.0104	7.6	0.1236	0.1551
Sierra	0.1398	0.0034	2.5	0.1326	0.1448
			Organic Management		
PI312777	0.1954	0.0222	11.4	0.1721	0.2461
PI338046	0.1964	0.0221	11.2	0.1698	0.2310
Rondo	0.1973	0.0186	9.4	0.1667	0.2268
Tesanai2	0.2021	0.0325	16.1	0.1646	0.2579
Bengal	0.2625	0.0157	6.0	0.2205	0.2786
Jupiter	0.2696	0.0101	3.7	0.2554	0.2841
Cocodrie	0.2370	0.0141	6.0	0.2023	0.2534
Colorado	0.2389	0.0139	5.8	0.2137	0.2612
Cybonnet	0.2548	0.0153	6.0	0.2173	0.2731
Presidio	0.2491	0.0225	9.0	0.1940	0.2664
Wells	0.2429	0.0109	4.5	0.2191	0.2548
Jazzman	0.3033	0.0074	2.4	0.2928	0.3167
Sierra	0.2859	0.0151	5.3	0.2543	0.3037

[a] Summary statistics calculated from 500 simulated iterations

[b] SD = Standard Deviation; CV = Coefficient of Variation.

Table 6. Average Rice Variable and Fixed Expenses under Conventional and Organic Management (2017 Dollars)

Expense Item	Conventional	Organic
	($/Acre)	
Variable Expenses:		
Seed	37.10	53.00
Custom Air Seeding	---	9.00
Survey Levees	6.00	6.00
Fertilizer	77.00	100.00
Custom Fertilizer Application	39.06	---
Herbicides	104.98	---
Insecticides	3.62	---
Fungicides	30.60	---
Custom Pesticide Application	27.00	---
Water Cost	54.00	72.00
Irrigation Labor	9.00	12.00
Diesel Fuel	21.75	27.06
Gasoline	1.58	1.58
Machinery Labor	21.03	25.84
Repairs & Maintenance	21.43	23.12
Rice Drying	21.03	22.52
Rice Hauling	87.62	93.82
Sales Commissions	4.95	5.29
Interest on Credit Line	6.51	5.17
Total Variable Expenses	*574.25*	*456.40*
Total Fixed Expenses	*62.12*	*73.63*
Total Costs Per Acre	*636.37*	*530.03*

Table 7. Summary Statistics of Simulated Rice Net Returns Above Total Costs by Rice Cultivar under Conventional and Organic Management

Cultivar	Mean [a] ($/acre)	SD [b] ($/acre)	CV [b]	Minimum ($/acre)	Maximum ($/acre)
			Conventional Management		
PI312777	46	65	139.9	-108	199
PI338046	10	63	603.9	-95	198
Rondo	-36	119	-332.3	-288	211
Tesanai2	125	218	174.2	-243	743
Bengal	69	208	302.4	-307	476
Jupiter	217	226	104.5	-257	559
Cocodrie	137	103	75.6	-50	425
Colorado	62	85	137.1	-82	253
Cybonnet	78	106	135.5	-86	337
Presidio	135	129	95.1	-150	340
Wells	47	64	138.0	-97	212
Jazzman	72	152	210.5	-210	470
Sierra	174	130	74.8	-54	396
			Organic Management		
PI312777	852	194	22.8	558	1,601
PI338046	847	201	23.7	446	1,333
Rondo	976	303	31.1	482	1,680
Tesanai2	1,478	418	28.3	774	2,541
Bengal	975	240	24.6	244	1,459
Jupiter	1,392	320	23.0	811	1,987
Cocodrie	895	278	31.0	359	1,380
Colorado	585	270	46.2	-37	1,074
Cybonnet	1,024	258	25.2	430	1,580
Presidio	1,064	329	30.9	307	1,716
Wells	1,225	314	25.6	624	1,680
Jazzman	1,339	392	29.3	559	2,084
Sierra	865	271	31.4	409	1,373

[a] Summary statistics calculated from 500 simulated iterations

[b] SD = Standard Deviation; CV = Coefficient of Variation.

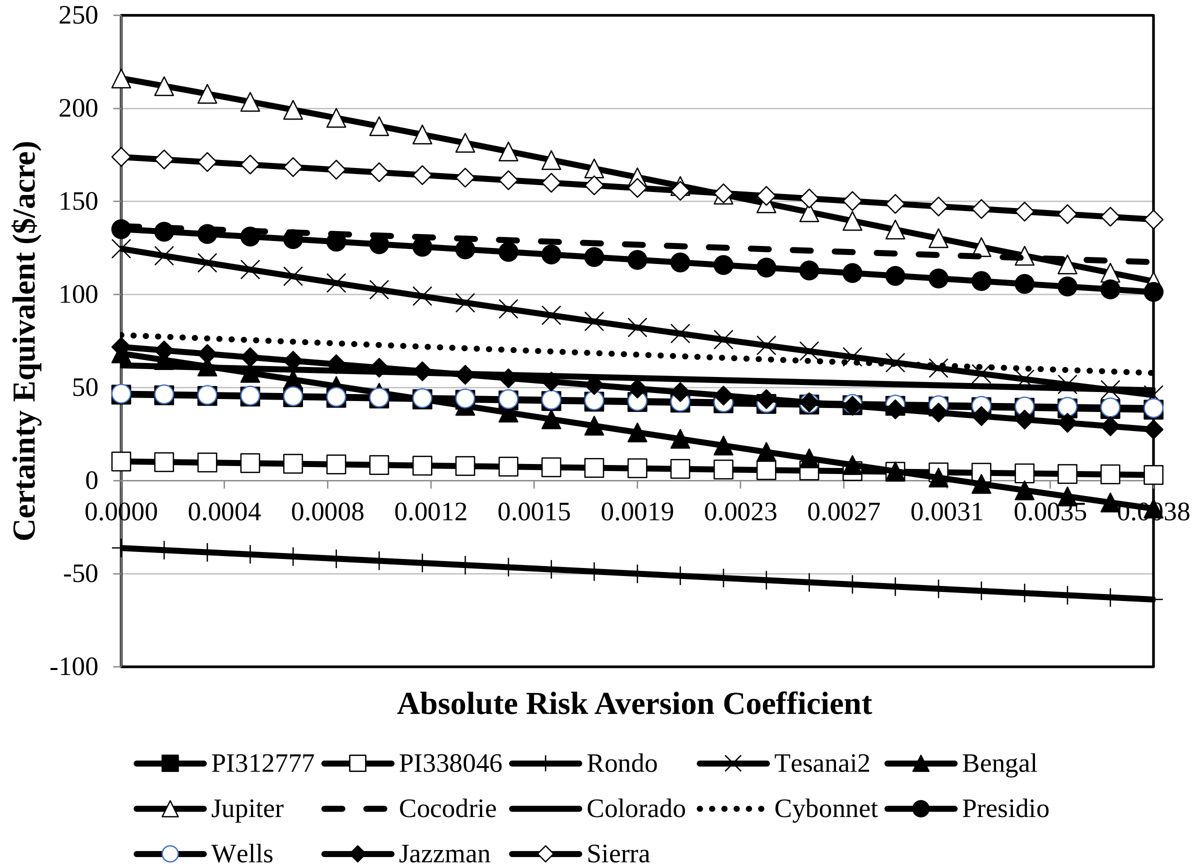

Figure 1. Stochastic Efficiency with Respect to a Function Results of Conventional Rice Cultivar Certainty Equivalents over an Absolute Risk Aversion Range of 0.000 to 0.038, Assuming a Negative Exponential Utility Function

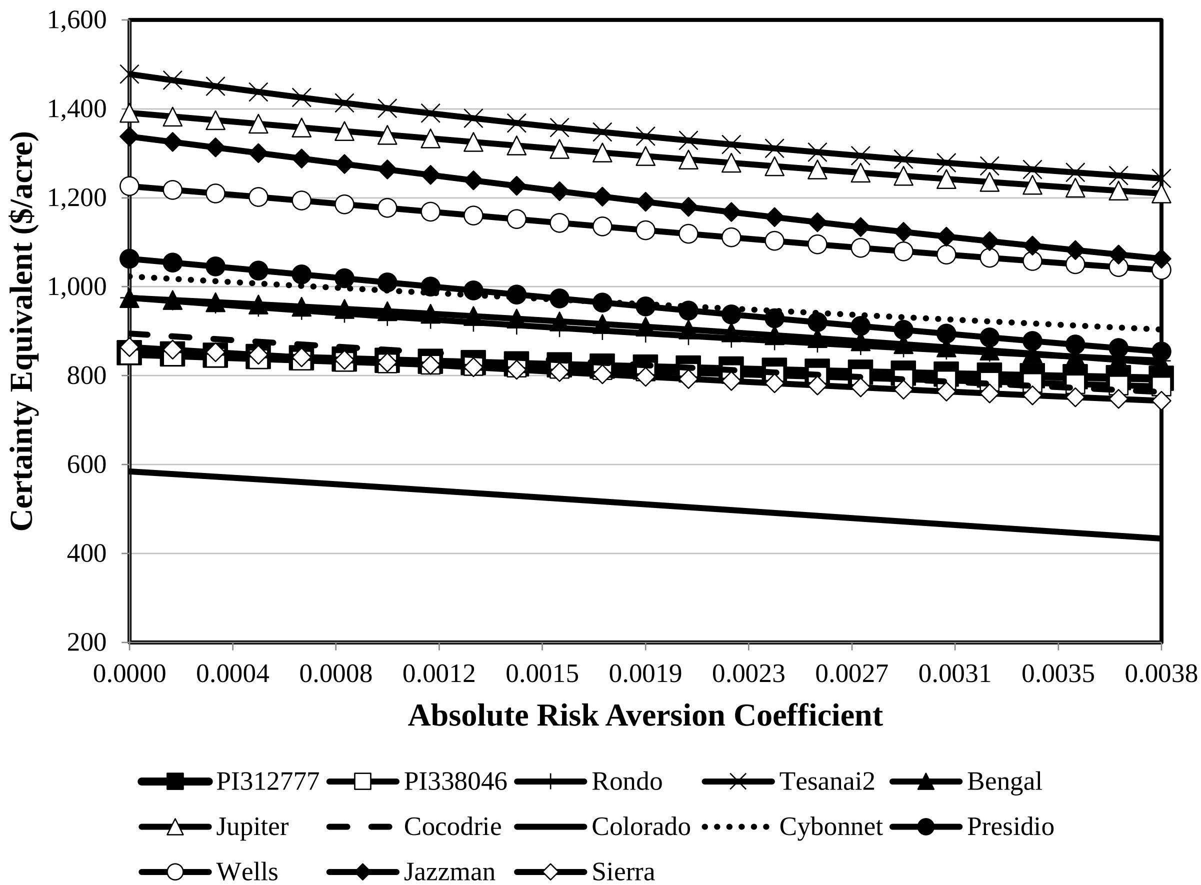

Figure 2. Stochastic Efficiency with Respect to a Function Results of Organic Rice Cultivar Certainty Equivalents over an Absolute Risk Aversion Range of 0.000 to 0.038, Assuming a Negative Exponential Utility Function